

# **Cone and Seed Insects of *Western Forest Trees***

by

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The research on cone and seed insects reported in this publication was done in the former Bureau of Entomology and Plant Quarantine. Research on forest insects is now being done in the Forest Service. John M. Miller took leadership in promoting the study of forest cone and seed insects at a time when these pests were of little economic importance. John E. Patterson should be credited with having taken most of the pictures used as illustrations. The author, who assisted with this work for 3 years, wishes to acknowledge the major contributions made by these associates, and is gratified that it is now possible to preserve through publication their work on a forestry subject which inevitably will be of increasing importance as time goes on.

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## CONE AND SEED INSECTS OF WESTERN FOREST TREES

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### INTRODUCTION

Insects that destroy the seeds of forest trees have an important bearing on reforestation. If a high percentage of a seed crop is destroyed in any year, seed collecting may be unprofitable, and nursery establishment and planting will be greatly hampered. Also the loss of seed may seriously threaten the natural reestablishment of commercially valuable tree species on burned or cut-over lands, where timing of seeding may be highly critical.

The importance of developing knowledge of cone and seed infesting insects was first recognized by John M. Miller in May 1912 when he proposed to Dr. A. D. Hopkins, then Chief of the Division of Forest Insect Investigations, Bureau of Entomology, United States Department of Agriculture, that a study should be made of cone and seed insects. Miller pointed out the need to assist the Forest Service in seed-collecting work, so collectors could avoid badly infested, unprofitable areas. This study was approved by Dr. Hopkins in June 1912, and in the rest of 1912 Miller collected a good many seed and cone insects. His first report, dated January 1, 1913, gave the object of the work as furthering information along two general lines: (1) The actual amount of damage occurring in the forest or to stored forest tree seeds and (2) the life histories and habits of the forest-seed insects.

At first the work was centered at Placerville, Calif. In August 1913 Miller moved his headquarters to Ashland, Oreg., where cone and seed insect studies were the principal work of this sub-laboratory. F. D. Sergeant, an agent employed by the Bureau, collected much of the cones and seeds. In August 1914, the force at the Ashland station was augmented by J. E. Patterson, agent, and the writer on his first appointment with the Bureau as entomological ranger. The work was continued through 1915 and 1916 until interrupted by World War I, in July 1917. The period of study thus covered 5 years, and material was obtained from California, Oregon, Washington, Montana, and Colorado. Since then cone and seed insects have been collected only occasionally, in connection with other lines of work.

<sup>1</sup> Maintained at Berkeley, Calif., in cooperation with the University of California.

The work on cone and seed insects at Ashland was so far ahead of its economic usefulness, that for nearly 40 years very little of the copious material collected at that time was assembled or published. Now forest-seed problems and reforestation are of increasing importance. Knowledge of cone- and seed-destroying insects is in great demand in order that steps may be taken for their control. Moreover, control is within the limits of practicability since the development of DDT and other new chemicals which can be released by helicopter or airplane. Therefore, it seems especially appropriate that our present knowledge on cone- and seed-infesting insects be put in such form as to be useful to practicing forest entomologists.

In this report cone and seed insect injury is first discussed by host trees, arranged in alphabetical order. A key to recognition of damage and the associated insects accompanies the host compilation. Then the insects themselves are discussed as to their appearance, hosts, distribution, seasonal history, and parasites. The arrangement here is alphabetical by order, family, genus, and species.

The following general reference books and bulletins briefly discuss a number of the more important cone- and seed-infesting species.

DOANE, R. W., VAN DYKE, E. C., CHAMBERLIN, W. J., and BURKE, H. E.

1936. FOREST INSECTS. New York and London. 463 pp., illus. ESSIG, E. O.

1926. INSECTS OF WESTERN NORTH AMERICA. New York. 1035 pp., illus.

KEEN, F. P.

1923. INSECT ENEMIES OF CALIFORNIA PINES AND THEIR CONTROL. California Dept. Natl. Resources, Div. Forestry Bul. 7, 113 pp., illus.

KEEN, F. P.

1938. INSECT ENEMIES OF WESTERN FORESTS. U. S. Dept. Agr. Misc. Pub. 273, 280 pp., illus. (Rev. 1952).

MILLER, JOHN M.

1914. INSECT DAMAGE TO THE CONES AND SEEDS OF PACIFIC COAST CONIFERS. U. S. Dept. Agr. Bul. 95, 7 pp., illus.

Other literature citations are indicated in the text, by italic numbers in parentheses, and listed under Literature Cited, p. 159.

## WESTERN FOREST TREES AND THEIR CONE AND SEED INSECTS

Western forest trees from which cone and seed insects have been collected or reared are here listed in alphabetical order by genera and species. Under each tree is given a brief discussion of seed damage frequently encountered and a list of insects and parasites reared from each host, grouped by general habits. A key to recognition of the work of destructive species is included. If the same insects do similar work in all cones or seeds of a tree

genus, as in *Abies*, the key is placed under the genus. If a variable group of insects work in the different species of a genus, such as *Pinus*, a key is given for each tree species.

The number of cone collections made from each tree is noted and a number in parentheses before the insect name indicates the number of such collections from which this insect species was taken. This roughly indicates relative abundance, in these collections, in comparison with other insects. An asterisk (\*) before the name indicates insects of economic importance.

Insects not identified as to species are followed by a Hopkins United States serial number identifying the collection. Many species have not been identified or named. Until this is done they can best be identified by the Hopkins United States serial number. Insect species reported by other authors are followed by the author's name and date of publication.

**Abies      Fir**

The seeds of true firs (*Abies*) are destroyed mostly by cone moths, cone maggots, and seed chalcids. The damage is often severe. Since the same insects appear to work in all species of *Abies*, a key to the more destructive forms is given below:

*Key to the Work of Insect Species in Fir Cones and Seeds*

- I. Insects destructive to cones and seeds.
  - A. Caterpillars boring galleries through cones.
    - 1. Causing considerable pitch flow.
      - a. Large yellowish white larvae, up to 14 mm. long, red pupae embedded in resin in cone  
*Barbara colfaciana siskiyouana*, p. 131
    - 2. Throwing out frass but little or no pitch.
      - a. Large reddish-green larvae, with 5 pairs of prolegs, adults gray ..... *Dioryctria abietella*, p. 148
      - b. Large gray-green larvae with 2 pairs of prolegs, adults spotted gray with brown. . . *Eupithecia spermaphaga*, p. 120
    - 3. Little external evidence.
      - a. Small (11 mm.) pink larvae boring in seeds  
*Laspeyresia bracteolata*, p. 137
      - b. Small white larvae boring in seeds Undetermined Tineid
  - B. White footless maggots, boring through cones and seeds.
    - 1. Maggots long and slim, feeding in seeds *Earomyia* spp., p. 71
    - 2. Maggots large and fat, in ragged galleries through cones  
*Hylemya abietis* p. 77
- II. Insects destructive only to seeds.
  - A. Small white footless larvae completely enclosed in seed.
    - 1. Adults black chalcid flies. . . . . *Megastigmus pimus*, p. 106
    - 2. Adults yellow chalcid flies. . . . . *Megastigmus rafni*, p. 108
  - B. Small pink larvae in cell near tip of seeds  
*Dasyneura abiesemia*, p. 60
- III. Insects of minor importance.
  - A. Red maggots loose on cone scales, abundant  
*Rübsaamenia keeni*, p. 66
  - B. Pink maggots in gall pockets in cone scales  
*Dasyneura abiesemia*, p. 60
  - C. Very small white maggots, abundant in wet cones  
*Oscinella conicola*, p. 59



**Abies amabilis Pacific Silver Fir**

(No collections)

No collections were made from Pacific silver fir by the Ashland Laboratory men, but records from other sources indicate that the seeds of this tree are infested with seed chalcids, cone maggots, and cone moths. It is very likely that most of the species recorded from other firs (see white fir) may be found in these cones.

Seed chalcids.

\**Megastignus lasiocarpae* (61) .....p. 105

\**Megastignus pinus* (11) .....p. 106

Cone maggots.

*Earomyia abietum* (52) .....p. 73

Cone moths.

\**Eupithecia columbrata* (54) .....p. 120

\**Eupithecia spermaphaga* (54) .....p. 120

**Abies bracteata Bristlecone Fir**

(3 collections)

Very little collecting has been done from the cones of bristlecone fir, but strangely enough the types of two important insects that infest fir cones were named from early collections made from this tree; that is, *Megastignus pinus* Parfitt in 1857 (64) and *Laspeyresia bracteata* in 1880 (23). Other insects include gall midges (Itonididae), and possibly cone maggots (*Earomyia* sp.?).

Legg (49) states, "Mature trees produce cones only at long intervals and each tree probably has only a dozen or so cones when it does produce. Cones mature September 1. One creature that derives food from the cone while it is on the tree is the larvae of a 'cone maggot,' which burrows into the cone and feeds on the seed. Many seeds do not mature, and with the cone maggots eating the seed on the tree, and rodents on the ground, this rare fir is making its last stand in California's Santa Lucia Mountains."

**Abies concolor White Fir**

(40 collections)

Several species of insects combine to cause very heavy damage to the cones and seeds of white fir. Typical individual counts of seeds show the following ranges of infestation:

Seeds infested or destroyed..... 5 to 55 percent.

"Blighted" or infertile seed..... 35 to 72 percent.

Fertile seed.....0.5 to 60 percent.

In some years about one-third of the seed crop is destroyed early in the season by cone moths and seed chalcids; by the end of the season other insects complete the destruction. In some localities the seed crop is totally destroyed, while in practically no locality does it escape injury.

The most destructive insects of white fir cones and seeds are listed under the following sections I and II, those of minor importance under III, miscellaneous insects under IV, and predatory and parasites under V.

I. Insects destructive to cones and seeds.		Percent of seed destroyed	
Cone moths.			
(27)	* <i>Barbara colfaxiana siskiyouana</i> .....	2-23 .....	p. 131
(17)	* <i>Dioryctria abietella</i> .....	4-18 .....	p. 148
(16)	* <i>Laspeyresia bracteata</i> .....	1-15 .....	p. 137
(12)	* <i>Eupithecia spermaphaga</i> .....	1-18 (rare) p.	120
Cone maggots.			
(20)	* <i>Euromyia</i> spp. ....	0.1-1.3 .....	p. 71
	<i>E. abietum</i> .....		p. 73
	<i>E. barbara</i> .....		p. 75
	<i>E. brevistylata</i> .....		p. 75
	<i>E. longistylata</i> .....		p. 75
(10)	* <i>Hylemya abietis</i> .....	0.1-1.3 .....	p. 77
II. Insects destructive only to seeds.			
Seed chalcids.		1-34	
(22)	* <i>Megastigmus pinus</i> .....		p. 106
(25)	* <i>Megastigmus rafni</i> .....		p. 108
Seed midges.			
(4)	* <i>Dasyneura abiesemia</i> .....	0.1-9 .....	p. 60
III. Insects of minor importance.			
Diptera.			
(25)	Cone and scale midges (Itonididae) .....		p. 60
(1)	<i>Bradysia</i> sp. (Hopkins U. S. No. 12560y) .....		p. 76
(4)	<i>Dasyneura abiesemia</i> .....		p. 60
(2)	<i>Holoneurus strobilophilus</i> .....		p. 64
(2)	<i>Mycodiplosis conicola</i> .....		p. 65
(1)	<i>Mycodiplosis coryloides</i> .....		p. 65
(4)	<i>Oscinella conicola</i> .....		p. 59
(12)	<i>Rübsaamenia keeni</i> .....		p. 66
IV. Miscellaneous insects reared from cones, habits unknown.			
Coleoptera.			
(1)	<i>Henoticus californicus</i> .....		p. 42
Collembola.			
	<i>Achorutes</i> sp. (Hopkins U. S. No. 12560z)		
Diptera.			
(1)	<i>Minettia flaveola</i> .....		p. 71
(1)	<i>Palloptera</i> sp. (Hopkins U. S. No. 13228v) .....		p. 80
(2)	<i>Leptocera</i> sp. (Hopkins U. S. Nos. 14423c, 13228p) .....		p. 80
Lepidoptera.			
(2)	<i>Holcocera</i> sp. (Hopkins U. S. Nos. 11459b, 14212d) .....		p. 117
V. Predators and parasites.			
Coleoptera.			
(4)	<i>Enoclerus humeralis</i> (predaceous) .....		p. 41
Diptera.			
(1)	<i>Goliathocera setigera</i> .....		p. 70
(2)	<i>Lydellohoughia</i> sp. (Hopkins U. S. Nos. 14201j, 12929b) .....		p. 70
Hymenoptera.			
Family Braconidae.			
(2)	<i>Apanteles</i> sp. (Hopkins U. S. Nos. 12560w, 12538t) .....		p. 82
(2)	<i>Bracon rhyacioniae</i> .....		p. 83
(1)	<i>Macrocentrus aegeriae</i> .....		p. 85
Family Encyrtidae.			
(3)	<i>Copidosoma</i> sp. (Hopkins U. S. Nos. 12560kk, 12538k <sup>2</sup> , 13298i) .....		p. 93
Family Eulophidae.			
	<i>Elachertus glacialis</i> , parasite of <i>Barbara colfaxiana</i> .....		p. 94
(8)	<i>Tetrastichus</i> sp. ....		p. 96
Family Eupelmidae.			
	<i>Eupelmus</i> sp. (Hopkins U. S. No. 12564o) .....		p. 96

## V. Predators and parasites.—Continued

## Hymenoptera.—Continued

## Family Eurytomidae.

- (2)
- Eurytoma*
- sp. (Hopkins U. S. Nos. 12503b, 18146a).....p. 98

## Family Ichneumonidae.

- (11)
- Calliephialtes comstockii*
- , parasite of
- Barbara colfaxiana*
- .....p. 86

- (2)
- Campoplex conocola*
- , parasite of
- Barbara colfaxiana*
- p. 88

- (1)
- Eoachus evetriae*
- , parasite of
- Barbara colfaxiana*
- .....p. 89

- (5)
- Glypta cvetriae*
- , parasite of
- Barbara colfaxiana*
- .....p. 89

- Horogenes*
- sp. (Hopkins U. S. No. 12560x).....p. 90

- (1)
- Itoplectis evetriae*
- , parasite of
- Barbara colfaxiana*
- .....p. 90

- (3)
- Pimplopterus conocola*
- , parasite of
- Barbara colfaxiana*
- p. 91

- (2)
- Pimplopterus*
- sp. (Hopkins U. S. No. 12538n2, p2; 13297c).....p. 92

- (4)
- Scambus ephialtoides*
- , parasite of
- Barbara colfaxiana*
- p. 92

- (1)
- Syrphoctonus*
- sp. (Hopkins U. S. No. 12577k).....p. 93

## Family Platygasteridae.

- (1)
- Platygaster gahani*
- , parasite of Itonididae.....p. 114

- (1)
- Platygaster rohweri*
- , parasite of Itonididae.....p. 114

## Family Pteromalidae.

- (3)
- Amblymerus*
- sp. (Hopkins U. S. No. 12538s-2, 13228g, 14201k).....p. 99

- (1)
- Habrocytus*
- sp. (Hopkins U. S. No. 11418d).....p. 99

- (1)
- Hypopteromalus*
- sp. (Hopkins U. S. No. 11418c).....p. 100

- (1) Pteromalid (Hopkins U. S. No. 10894e)

- (6)
- Zacalochlora milleri*
- .....p. 100

**Abies grandis Grand Fir**

## (2 collections)

Several species of insects cause considerable damage to the cones and seeds of grand fir, sometimes destroying 10 to 25 percent of the year's seed crop. The principal damage seems to be done by the seed chalcids and a seed-infesting gall midge.

The principal damaging insects reared from cones are as follows:

## Cone moths.

- (1) \*
- Barbara colfaxiana siskiyouana*
- .....p. 131

- (1) \*
- Dioryctria abietella*
- .....p. 148

- (1) \*
- Laspeyresia*
- sp. (probably
- bracteana*
- ).....p. 137

## Cone maggots.

- (2) \*
- Ecromyia*
- spp. ....p. 71

- E. abietum*
- .....p. 73

- E. longistylata*
- .....p. 75

## Seed chalcids.

- (2) \*
- Megastigmus milleri*
- .....p. 106

- (1) \*
- Megastigmus rufai*
- .....p. 108

- \*
- Megastigmus pinus*
- (56).....p. 106

## Seed midge.

- (2) \*
- Dasyneura abiescmia*
- .....p. 60

## Resin midge.

- (2)
- Rübsaamenia keeni*
- .....p. 66

## Parasites.

## Hymenoptera.

## Family Platygasteridae.

- Platygaster gahani*
- .....p. 114

## Abies lasiocarpa      Subalpine Fir

(1 collection)

Only one collection was made from subalpine fir. It was inadequate to indicate the usual cone damage from insects or the species causing damage. From what was observed, cone damage appears to be small. Records show the following insects from the cones of this fir:

Cone moths.	
* <i>Dioryctria abietella</i> (Canadian record).....	p. 148
Cone maggots.	
(1) * <i>Faromyia aquilonia</i> .....	p. 76
Seed chalcids.	
* <i>Megastigmus lasiocarpae</i> (11) .....	p. 105
* <i>Megastigmus pinus</i> (81) .....	p. 106
Resin midges.	
(1) <i>Rübsaamenia keeni</i> (?) .....	p. 66

## Abies magnifica      California Red Fir

(6 collections)

Several species of insects infest red fir cones but none seems to cause any great amount of damage. Most worthless seeds are the sterile or "blighted seeds." Some cones run as high as 75 percent "blighted seed," none of which seems to be due to insect damage.

Species involved include the following:

Cone moths.	
(1) * <i>Barbara colfaxiana siskiyouana</i> .....	p. 131
(1) * <i>Laspeyresia bracteatana</i> .....	p. 137
(1) * <i>Eupithecia spermaphaga</i> .....	p. 120
(1) * <i>Dioryctria</i> sp. (probably <i>abietella</i> ).....	p. 148
Cone maggots.	
(2) * <i>Faromyia</i> spp. ....	p. 71
<i>E. abietum</i> .....	p. 73
<i>E. barbara</i> .....	p. 75
<i>E. brevistylata</i> .....	p. 75
<i>E. longistylata</i> .....	p. 75
Seed chalcids.	
(3) * <i>Megastigmus pinus</i> .....	p. 106
(3) * <i>Megastigmus rafni</i> .....	p. 108
Seed gall midges.	
(3) * <i>Dasyneura abiesemia</i> .....	p. 60
Other resin midges.	
(1) <i>Holoneurus strobilophilus</i> .....	p. 64
(1) <i>Mycodiplosis conicola</i> .....	p. 65
(1) <i>Mycodiplosis coryloides</i> .....	p. 65
(3) <i>Rübsaamenia keeni</i> .....	p. 66
Parasites.	
Hymenoptera.	
(1) <i>Calliophialtes comstockii</i> .....	p. 86
(1) <i>Platygaster</i> sp. (Hopkins U. S. No. 12572d).....	p. 115
(1) <i>Amblymerus</i> sp. (Hopkins U. S. No. 14209hx), parasite of <i>Megastigmus</i> sp. ....	p. 99
Other insects.	
(1) <i>Eurytoma</i> sp. (Hopkins U. S. No. 11417b).....	p. 98

## Abies magnifica var. shastensis

## Shasta Red Fir

(7 collections)

Several species of insects infest cones of Shasta red fir but none seems to cause much damage. The high percentage of worthless seed found is simply sterile, so-called "blighted seed." Insect damage only amounts to about 7 percent of the seed crop, as far as has been determined, whereas blighted seed amounts to about 65 percent of the crop.

Insects found infesting these cones are as follows:

Cone moths.	
(2) * <i>Barbara colfaxiana siskiyouana</i> .....	p. 131
(1) * <i>Dioryctria abietella</i> .....	p. 148
(1) * <i>Eupithecia spermaphaga</i> .....	p. 120
(3) * <i>Laspeyresia</i> sp. (probably <i>bracteata</i> ) .....	p. 137
Cone maggots.	
(5) * <i>Earomyia</i> spp. ....	p. 71
(Species probably the same as in <i>A. magnifica</i> )	
(2) * <i>Hylemya</i> sp. (Hopkins U. S. Nos. 13299a, 14200b) .....	p. 77
Seed chalcids. (3 to 30 percent infested)	
(7) * <i>Megastigmus pinus</i> .....	p. 106
(3) * <i>Megastigmus rafni</i> .....	p. 108
(1) * <i>Megastigmus nülleri</i> (61) .....	p. 106
Seed gall midge.	
(3) * <i>Dasyneura abiesenia</i> .....	p. 60
Insects of minor importance.	
Gall and resin midges.	
(3) <i>Rübsaamentia keeni</i> .....	p. 66
Miscellaneous insects reared from cones, habits unknown.	
Coleoptera.	
(1) <i>Cryptophagus brevipilis</i> .....	p. 42
Diptera.	
(1) <i>Oscinella conicola</i> .....	p. 59
Lepidoptera.	
(1) <i>Ephestoides gilvescentella</i> .....	p. 155
Predators and parasites.	
Coleoptera.	
Family Cleridae.	
(1) <i>Cymatodera ovipennis</i> .....	p. 40
Hymenoptera.	
Family Braconidae.	
<i>Blacus</i> sp. (Hopkins U. S. No. 14200h) .....	p. 83
<i>Macrocentrus aegeriae</i> .....	p. 85
Family Ichneumonidae.	
(1) <i>Calliephialtes comstockii</i> , parasite of <i>Barbara colfaxiana siskiyouana</i> .....	p. 86
(1) <i>Pimplopterus conocola</i> , parasite of <i>Barbara colfaxiana siskiyouana</i> .....	p. 91
(1) <i>Pimplopterus</i> sp. (Hopkins U. S. No. 13296e) .....	p. 92
(1) <i>Syrphoctonus</i> sp. (Hopkins U. S. No. 14200i) .....	p. 93
Family Platygasteridae.	
(1) <i>Platygaster shastensis</i> , parasite of Itonididae .....	p. 114
Family Encyrtidae.	
(1) <i>Copidosoma</i> sp. (Hopkins U. S. Nos. 14205k, 14200m) .....	p. 93
Family Pteromalidae.	
(3) <i>Amblymerus</i> sp. (Hopkins U. S. No. 14200g) .....	p. 99
(1) <i>Habrocytus</i> sp. (Hopkins U. S. Nos. 14205i, 31666b) .....	p. 99
(1) <i>Hypopteromalus</i> sp. (Hopkins U. S. No. 14205hx), parasite of <i>Megastigmus</i> .....	p. 100

**Abies procera Noble Fir**

(2 collections)

Only two collections were made from noble fir. They did not indicate what damage might be expected from insects. Seed collectors report heavy damage in some years.

The following insects have been found in cones and seed of this tree:

Cone moths.	
(1) * <i>Dioryctria</i> sp. (probably <i>abietella</i> )	p. 148
Seed chalcids.	
(1) * <i>Megastigmus pinus</i>	p. 106
Seed gall midges.	
(1) * <i>Dasyneura abiesemia</i> (?)	p. 60

**Acer circinatum Vine Maple**

One collection of seed from vine maple was made at Waldo, Oreg., in August 1914. One hundred seeds were cut; 78 percent were good seed, 22 percent hollow or immature, and none infested.

**Acer macrophyllum Bigleaf Maple**

(4 collections)

The seeds of bigleaf maple are not heavily infested by insects. One lot of material examined showed 66 percent of good seed, 20 percent hollow, and 14 percent insect infested. The principal damage is done by the larvae of a moth.

I. Insects injuring the seed.	
A. Caterpillars mining the seeds.	
1. Adults large and green (4) * <i>Proteoteras aesculum</i>	p. 147
2. Adults, small gray (1) * <i>Holocera</i> sp. (Hopkins U. S. No. 12548c)	p. 117
II. Miscellaneous insects reared from seeds, habits unknown.	
Coleoptera.	
(1) <i>Melanophthalma distinguenda</i>	p. 45
(1) <i>Notoxus constrictus</i>	p. 36
(1) <i>Ptinus fur</i>	p. 46
Diptera.	
(1) Itonididae (Hopkins U. S. No. 14203d)	p. 60
(1) <i>Leptocera</i> sp. (Hopkins U. S. No. 14203c)	p. 80
III. Parasites.	
Hymenoptera.	
Family Ichneumonidae.	
(2) <i>Calliephialtes nucicola</i>	p. 87
(1) <i>Hemiteles</i> sp. (Hopkins U. S. No. 14296c)	
(1) <i>Scambus</i> sp. (Hopkins U. S. No. 14296c)	p. 93
Family Eulophidae.	
(1) <i>Elachertus glacialis</i>	p. 94

**Castanopsis chrysophylla Golden Chinkapin**

(2 collections)

The acorns of chinkapin are often infested with a caterpillar, which in some localities may destroy 14 percent of the crop. A weevil has also been found in some acorns.

I. Insects injuring the acorns.	
A. *Dirty white caterpillars in seed kernel, adults a bronze, metallic moth (2) <i>Melissopus latiferreanus</i> .....p.	145
B. *White legless curled grubs (1) <i>Circulio</i> sp. (?) (Hopkins U. S. No. 12546a) .....	42

**Chamaecyparis lawsoniana Port-Orford-Cedar**

As far as has been ascertained, only a species of gall midge infests the cones of Port-Orford-cedar. The damage appears to be very slight.

I. Insects injuring seeds.	
A. Small pink maggot found between seeds * <i>Janetiella siskiyou</i> p.	64
II. Parasites.	
Hymenoptera.	
Family Eulophidae.	
(1) <i>Tetrastichus</i> sp. (Hopkins U. S. No. 12544b), parasite of <i>Janetiella</i> .....	96

**Chamaecyparis nootkatensis Alaska-Cedar**

No collecting has been done from the cones and seeds of Alaska-cedar.

**Cupressus Cypress**

Collections from cypresses suggest that the damage to cones and seeds is very slight and that insects cannot be considered a factor in limiting the seed supply. Most collections were made on Monterey cypress, and the same group of insects are probably on other species.

*Key to the Work of Species Involved*

I. Insects destructive to cone scales and seeds.	
A. Caterpillars feeding through cones.	
1. Large greenish-red, purplish, or reddish-brown larvae, cones covered with webs holding reddish larval castings which conceal the larvae. Adults large moths spotted with white. <i>Henricus macrocarpana</i> .....	148
2. Slender gray-white larvae, adult moths gray or copper-colored <i>Laspeyresia cupressana</i> .....	139
3. Pinkish larvae, adult moths greenish <i>Epinotia hopkinsana cupressi</i> .....	136
4. Small white caterpillars. Undetermined tineid moth.	
II. Insects feeding on dry cone scales.	
A. White hairy grubs with thoracic legs. Adult a large brown ptnid beetle <i>Ernobius cupressi</i> .....	33

**Cupressus goveniana Gowen Cypress**

(2 collections)

Only two collections were made from this species, but the damage appeared to be very slight with almost no damage to the seeds.

Cone moths.	
(1) * <i>Henricus macrocarpana</i> .....	148
(1) * <i>Laspeyresia cupressana</i> .....	139

**Cupressus macrocarpa Monterey Cypress**

(5 collections)

Although several species of insects feed upon the cones and in the cone scales, the amount of seed damage is small. Three species of moths cause most of the damage. A large powder-post beetle is frequently found working in the cone scales. Species involved include the following:

Cone moths.	
(5) * <i>Henricus macrocarpana</i> .....	p. 148
(4) * <i>Laspeyresia cupressana</i> .....	p. 139
(3) * <i>Epinotia hopkinsana cupressi</i> .....	p. 136
Cone powder-post beetle.	
(3) <i>Ernobius cupressi</i> .....	p. 33
Other species.	
(2) <i>Holocera</i> sp. (Hopkins U. S. Nos. 13264d, 13313j) .....	p. 117
(2) <i>Enoclerus humeralis</i> clerid .....	p. 41
(2) <i>Enoclerus cupressi</i> clerid .....	p. 40
(1) <i>Tetrastichus</i> sp. (Hopkins U. S. No. 13313i) .....	p. 96
(1) Phaeogenini genus, sp. ? (Hopkins U. S. No. 13264fx), parasite of <i>Laspeyresia cupressana</i> .....	p. 91
(1) <i>Itoplectis</i> sp. (Hopkins U. S. No. 12579k) .....	p. 90
Larvaevoridae.	
<i>Spathimeigenia</i> sp. (Hopkins U. S. No. 12579j)	

**Fraxinus latifolia Oregon Ash**

(3 collections)

The seeds of Oregon ash seem to be very heavily infested with a very small weevil, and with hymenopterous larvae which may be phytophagous or parasitic on the weevil. In some places and years about 70 percent of the seeds are destroyed.

I. Insects destroying the seeds.	
A. Small, white, legless curled weevil grubs	
(3) * <i>Thysanocnemis</i> sp. (Hopkins U. S. Nos. 14202a, 14295a) .....	p. 44
B. Small, white, legless hymenopterous larvae	
(2) * <i>Eurytoma</i> sp. (Hopkins U. S. Nos. 14202e, 14295f) p.	98
II. Miscellaneous insects reared from seeds, habits unknown.	
Coleoptera.	
(1) <i>Epitrix subcrinita</i> .....	p. 40
(1) <i>Diabrotica undecimpunctata</i> .....	p. 40
(1) <i>Anthicus nitidulus</i> .....	p. 36
(1) <i>Notoxus constrictus</i> .....	p. 36
(1) <i>Apten porosicollae</i> .....	p. 42
Diptera.	
(1) <i>Bradysia coprophila</i> .....	p. 76
Hemiptera.	
(1) <i>Triphleps tristicolor</i> .....	p. 80
III. Parasites.	
Hymenoptera.	
<i>Tetrastichus</i> sp. (Hopkins U. S. No. 14295c) .....	p. 96
(1) <i>Paracrius</i> sp. (Hopkins U. S. No. 14295c) .....	p. 95
(1) <i>Habrocytus</i> sp. (Hopkins U. S. No. 14295e) .....	p. 99
(2) Chalcids (Hopkins U. S. Nos. 14202b, 14295bx), parasite of <i>Thysanocnemis</i>	
(1) <i>Itoplectis evetriae</i> .....	p. 90
(1) <i>Eupelmus</i> sp. (Hopkins U. S. No. 14202f, 14295f) .....	p. 96
(1) <i>Hypopteromalus</i> sp. (Hopkins U. S. No. 14202c) .....	p. 100

**Juniperus californica California Juniper**

Caterpillars feeding in flesh of berries and into seeds.

<i>Ithome</i> sp. (Hopkins U. S. No. 14219g) .....	p. 119
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**Juniperus occidentalis      Western Juniper**

(2 collections)

Berries of this tree appear to be pretty heavily infested with a seed-infesting chalcid—about 25 percent of the seeds in some places. Grasshoppers also feed on the berries.

- I. Insects doing primary damage to seeds.
  - A. Small white footless larvae (2) *\*Eurytoma* (near *juniperina*) ..... p. 97
- II. Insects feeding on surface of berries, causing them to wither and crack open      Grasshoppers
- III. Miscellaneous insects.
  - Moths. Tineid, undetermined (Hopkins U. S. No. 12513a5)
  - Parasitic braconid. *Chelonus* sp. (Hopkins U. S. No. 12512a4) p. 83

**Libocedrus decurrens      Incense-Cedar**

(10 collections)

Cones of incense-cedar were very heavily damaged by insects in all localities examined. The principal damage was from two species of moths. In many localities as much as 65 percent of all the seed were destroyed, while hardly a cone did not contain an insect or two.

- I. Insects damaging both cones and seeds.
  - A. Caterpillars that work through seeds.
    - 1. Larvae, small green with red dorsal bands  
(7) *\*Argyresthia libocedrella* ..... p. 120
    - 2. Larvae, white  
(4) *\*Polychrosis* sp. .... p. 147
  - B. Large sawfly larvae with 7 pairs of prolegs.  
(4) *\*Augomonocentrus libocedrii* ..... p. 81
  - C. White footless dipterous maggots.  
(1) Undetermined Diptera (Hopkins U. S. No. 14206c)
  - D. Small pink or red maggots in flower gall.  
(3) *\*Itonididae* ..... p. 60
- II. Parasites.
  - Hymenoptera.
    - Ichneumonidae.
      - (2) *Campoplex argyresthiae*, parasite of *Argyresthia*..... p. 87
    - Braconidae.
      - (1) *Bracon* sp. (Hopkins U. S. No. 10835b) ..... p. 83
    - Encyrtidae.
      - (2) *Pentacnemus* sp. (near *bucculatrieus*) (Hopkins U. S. Nos. 13280fx, 12565g, gg)..... p. 93

**Lithocarpus densiflorus      Tanoak**

(6 collections)

The acorns of tanoak are heavily damaged in some localities by a weevil and acorn moth larvae. These insects probably destroy about 10 percent of the seed crop on the average. However, the damage over a wide area has not been determined.

- I. Insects injuring the acorns.
  - A. Legless grubs in kernels of acorns.
    - Adults yellow weevils. *\*Curculio uniformis*..... p. 43
    - (5) *\*Curculio* sp. .... p. 42
  - B. Caterpillars boring through kernels of acorns.
    - Adults bronze moths. (6) *\*Melissopus latiferreanus*..... p. 145
  - C. White legless larvae in gall pockets in acorns.
    - Undetermined Cynipidae (Hopkins U. S. No. 14291a)

- II. Insects of minor importance.  
 A. Caterpillars in kernels of acorns.  
 Unidentified Pyralidae (Hopkins U. S. No. 14291c)

**Picea Spruce**

Spruce cones are not heavily damaged by insects as a rule, although they are infested with at least two species of moths, a dipterous maggot, gall midges, and seed chalcids. Since many of the same insects appear to infest all spruce cones, a key to their work is given as follows:

*Key to Work of Species Injuring Spruce Cones*

I. Insects injuring the cones and seeds.	
A. Caterpillars working through cones.	
1. Reddish-green larvae boring through scales and seeds.	
<i>Henricus fuscodorsana</i> .....	p. 147
2. Pale yellow to reddish brown larvae boring through scales and seeds.	
<i>Dioryctria abietella</i> .....	p. 148
<i>Dioryctria venicidella</i> .....	p. 154
3. White larvae with black heads, working mostly in axis of cones and into seeds.	
<i>Luspeyresia youngana</i> .....	p. 144
B. Long slim footless maggots forming winding galleries through cones and seeds.	
<i>Euromyia</i> spp. ....	p. 71
II. Insects injuring only the seeds.	
A. Small, white footless maggots completely enclosed in seeds.	
<i>Megastignus piceae</i> .....	p. 106
B. Small, pink maggots in seeds.	
<i>Phytophaga carpophaga</i> .....	p. 65
III. Insects of minor importance.	
A. Light red maggots, 2 to 3 mm. long, loose on cone scales.	
<i>Rübsaumentia keeni</i> .....	p. 66
B. Light yellow larvae in silky cocoons in axis of cones.	
<i>Dasyneura rachiphaga</i> .....	p. 63

**Picea breweriana Brewer Spruce**

(2 collections)

Only two cone collections were made from Brewer spruce, and they produced little insect fauna. A seed chalcid was suspected but none reared. Instead species of *Torymus* n.sp. came out of the seeds.

Parasites reared.

(1) <i>Amblymerus</i> n.sp. ....	p. 99
(1) <i>Torymus</i> n.sp. ....	p. 112

**Picea engelmannii Engelmann Spruce**

(9 collections)

The insect damage to Engelmann spruce cones is not particularly heavy. About 10 percent of the seed are destroyed, principally by a seed-infesting chalcid. A small moth and a dipteran are next in order of importance. Insects reared from the cones include the following species:

Seed chalcid.

(5) * <i>Megastignus piceae</i> .....	p. 106
<i>Megastignus piceae</i> var. <i>montana</i> .....	p. 106

Cone moths.	
	<i>Barbara mappana</i> (Canadian record)..... p. 135
(6)	* <i>Laspeyresia youngana</i> ..... p. 144
	* <i>Dioryctria abietella</i> (Canadian record)..... p. 148
	* <i>Dioryctria reniculella</i> (56)..... p. 154
	<i>Eupithecia albicapitata</i> ..... p. 120
	(Probably also <i>Heuricus fuscodorsana</i> , but not reared)
	* <i>Polychrosis piceana</i> (Canadian record)..... p. 146
Cone maggot.	
(3)	* <i>Earomyia barbara</i> ..... p. 75
Gall midges.	
(7)	Itonididae (2 species)..... p. 60
	* <i>Dasyneura rachiphaga</i> (?)..... p. 63
	* <i>Phytophaga carpophaga</i> ..... p. 65
Miscellaneous insects reared from cones.	
Diptera.	
	<i>Rübsaamenia keeni</i> ..... p. 66
(1)	<i>Pipiza</i> sp. (Hopkins U. S. No. 13272a)
Parasites.	
Hymenoptera.	
Family Braconidae.	
(2)	<i>Bracon rhyacioniae</i> ..... p. 83
Family Ichneumonidae.	
(2)	<i>Calliephialtes comstockii</i> ..... p. 86
(1)	<i>Calliephialtes</i> sp. (Hopkins U. S. No. 12408bx)..... p. 87
(1)	<i>Scambus ephialtoides</i> ..... p. 92
Family Platygasteridae.	
(1)	<i>Platygaster lucida</i> ..... p. 114
Family Pteromalidae.	
(1)	<i>Amblymerus</i> sp. (Hopkins U. S. No. 10849j)..... p. 99
Family Torymidae.	
(4)	<i>Torymus</i> sp. (?) (Hopkins U. S. Nos. 10859ef, 12408d, 12509c, 14284b)..... p. 112

### Picea glauca White Spruce

Cones from white spruce were not included in the Ashland collections. White spruce is found only rarely in western United States but becomes common in western Canada and interior Alaska. Recent studies by Canadian forest entomologists, especially the work of Tripp (75, 76, 77) and notes provided by W. F. McCambridge of the Alaska Forest Research Center, make it desirable to include some information on cone insects of this tree; to tie in with records from other spruces and firs.

Cone moths.	
	* <i>Dioryctria reniculella</i> (56)..... p. 154
	* <i>Laspeyresia youngana</i> (76)..... p. 144
	* <i>Eupithecia albicapitata</i> (Canadian record)..... p. 120
Cone maggots.	
	<i>Earomyia barbara</i> ..... p. 75
	* <i>Hylemya (Pegohylemyia)</i> near <i>anthracina</i> (75)..... p. 79
Gall midges.	
	<i>Dasyneura canadensis</i> (77)..... p. 61
	* <i>Dasyneura rachiphaga</i> (77) Alaska, (Hopkins U. S. No. 33437B)..... p. 63
	* <i>Phytophaga carpophaga</i> (77)..... p. 65
Resin midge.	
	<i>Rübsaamenia keeni</i> (?) (Tripp's species B (77))..... p. 66
Parasites.	
Diptera.	
	Larvaevoridae near <i>Goliathocera</i> (Hopkins U. S. No. 33493a) p. 69
Hymenoptera.	
Family Eulophidae.	
	<i>Aprostocetus</i> sp. (Canadian record, also Hopkins U. S. Nos. 33437F, 33439K, 33445G)

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<i>Elachertus</i> sp. (Canadian record).....p.	94
<i>Hyssopus</i> sp. (Canadian record).....p.	95
<i>Tetrastichus</i> sp. (Hopkins U. S. Nos. 33437E, 33445, 33439G) p.	96
Family Ichneumonidae.	
<i>Calliophialtes</i> sp. (Hopkins U. S. No. 33439C).....p.	87
<i>Ephialtes</i> sp. (Hopkins U. S. No. 33437D).....p.	87
Campoplegini (Hopkins U. S. No. 33439B, similar to specimens recovered from Sitka spruce)	
Family Platygasteridae.	
<i>Platygaster</i> sp. (Canadian record, also Hopkins U. S. Nos. 33437, 33439E).....p.	115
Family Pteromalidae.	
<i>Pachyceras</i> spp. (Hopkins U. S. Nos. 33439H, 33445A, 33437G, 33437H1)	
Family Torymidae.	
Monodontomerinae (Hopkins U. S. Nos. 33439J, 33439L)	
<i>Torymus</i> spp. (Hopkins U. S. Nos. 33445E, 33437C, 33437C1, 33439I, 33439K).....p.	112

**Picea pungens Blue Spruce**

(2 collections)

The cones of blue spruce are not heavily damaged by insects. In the few collections made, only about 3 percent of the seed were destroyed. The chief damage is due to a seed-infesting chalcid and a moth larva. These insects include:

Seed chalcid.	
(1) * <i>Megastigmus piceae</i> .....p.	106
Cone moths.	
* <i>Dioryctria reniculella</i> (56).....p.	154
(1) * <i>Henricus fuscodorsana</i> .....p.	147
(1) * <i>Laspeyresia</i> sp. (probably <i>youngana</i> ) (Hopkins U. S. No. 13306a).....p.	144
Parasites.	
(1) <i>Scambus ephialtoides</i> .....p.	92
(1) <i>Zucalochora milleri</i> .....p.	100

**Picea sitchensis Sitka Spruce**

(11 collections)

The cones of Sitka spruce were not found to be heavily damaged by insects, yet they contain several different species. The greatest damage was done by two species of moth and a species of Diptera, which work throughout the cone, and a seed-infesting chalcid which destroys the seeds. From 15 to 40 percent of the cones were infested, but only about 5 percent of the seed destroyed by insects. Species reared from cones include the following:

Destructive species.	
Seed chalcid.	
(2) * <i>Megastigmus piceae</i> .....p.	106
Cone moths.	
* <i>Laspeyresia bruceatana</i> (Canadian record).....p.	137
(2) * <i>Laspeyresia youngana</i> .....p.	144
(2) * <i>Henricus fuscodorsana</i> .....p.	147
* <i>Polychrosis piceana</i> (Canadian record).....p.	146
Cone maggots.	
(1) <i>Hylemya</i> ( <i>Pegohylemyia</i> ) sp. near <i>anthracina</i> .....p.	79
Gall midges.	
(7) Itonididae (3 or more species).....p.	60
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* <i>Phytophaga carpophaga</i> (?).....p.	65
<i>Rübsaamentia keeni</i> .....p.	66

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Coleoptera.	
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(1) <i>Chyromya</i> sp. (Hopkins U. S. No. 14266e).....	59
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Diptera.	
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(1) <i>Hypostena</i> sp. (Hopkins U. S. No. 12557K).....	70
Hymenoptera.	
Family Braconidae.	
(1) <i>Eubadizon</i> sp. (Hopkins U. S. No. 12557f).....	84
Family Eulophidae.	
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<i>Sarothrus</i> sp. (Hopkins U. S. No. 13231d) .....	113
Family Ichneumonidae.	
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(1) <i>Calliephialtes</i> sp. (Hopkins U. S. No. 33440D).....	87
(2) <i>Scambus ephialtoides</i> .....	92
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**Pinus Pine**

Cone and seed insects affect pine cones to such a variable extent, depending upon the group to which the pines belong, that they will be discussed separately by tree species.

**Pinus attenuata Knobcone Pine**

(17 collections)

The new green cones of knobcone pine are often heavily attacked by a large moth, and up to 50 percent of the cones destroyed. The old cones are attacked by a unique species of cerambycid and a buprestid beetle which do considerable damage.

I. Insects injuring and destroying the cones and seeds.

A. Attacking new cones.

1. Large, 17 mm., greenish-red to dark-brown caterpillars.	
(5) <i>*Dioryctria avranticella</i> .....	152
(1) <i>Dioryctria abietella</i> .....	148
2. Small, 12 mm., white larvae.	
(4) <i>*Eucosma bobana</i> .....	136
(1) <i>Chionodes</i> sp. (Hopkins U. S. No. 14265d).....	119
3. Small dark-brown beetles boring into stems and cones.	
(2) <i>Conophthorus</i> sp. (Hopkins U. S. Nos. 12552d, 13319a) .....	46

I. Insects injuring and destroying the cones and seeds.—Continued

B. Attacking cones 3 or 4 years old.

1. Large cerambycid larvae.	
(12) * <i>Paratimnia conicola</i> .....	p. 38
2. Buprestid larvae, rarer than the above.	
(11) * <i>Chrysophana placida conicola</i> .....	p. 36
3. Small white hairy grubs with thoracic legs.	
(1) <i>Ernobius punctulatus</i> .....	p. 35

II. Miscellaneous insects reared from cones, habits unknown.

Hymenoptera.

Family Formicidae.

(1) <i>Camponotus</i> sp. (Hopkins U. S. No. 10868c) .....	p. 115
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Family Megachilidae.

(2) <i>Osmia</i> sp. (Hopkins U. S. Nos. 10856b, 10868d) .....	p. 116
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III. Parasites and predators.

Coleoptera (Cleridae).

(2) <i>Cymatodera ovipennis</i> .....	p. 40
(1) <i>Cymatodera</i> sp. (Hopkins U. S. No. 10868c) .....	p. 40
(5) <i>Enoclerus eximius</i> .....	p. 41

Hymenoptera.

Family Braconidae.

(2) <i>Doryctes pacificus</i> , parasite of <i>Paratimnia conicola</i> .....	p. 84
(1) <i>Meteorus indagator</i> , parasite of <i>Dioryctria auranti-</i> <i>cella</i> .....	p. 85
(1) <i>Microtypus dioryctriae</i> , parasite of <i>Dioryctria auranti-</i> <i>cella</i> .....	p. 85
(1) <i>Orgilus dioryctriae</i> , parasite of <i>Dioryctria auranti-</i> <i>cella</i> .....	p. 85
(1) <i>Rogus</i> sp. (Hopkins U. S. No. 14265f)	

Family Eulophidae.

(1) <i>Hyssopus thymus</i> , parasite of <i>Dioryctria auranticella</i> p.	95
(1) <i>Elaehertus</i> sp. (Hopkins U. S. No. 14265h) .....	p. 94

Family Gasteruptionidae.

(3) <i>Aulacostethus californicus</i> , parasite of <i>Paratimnia</i> <i>conicola</i> .....	p. 113
(3) <i>Aulacostethus editus</i> , parasite of <i>Paratimnia conicola</i> p.	113

Family Ichneumonidae.

(1) <i>Aoplus</i> sp. (Hopkins U. S. No. 12552e)	
(2) Ichneumonidae sp. (Hopkins U. S. Nos. 13230c, 14290e)	
(1) <i>Callichiptales comstockii</i> , parasite of <i>Dioryctria</i> <i>auranticella</i> .....	p. 86
(1) <i>Pimplopterus dukrumae</i> , parasite of <i>Dioryctria</i> <i>auranticella</i> .....	p. 91
(1) <i>Poemenia americana</i> , parasite of <i>Paratimnia conicola</i> p.	92
(1) <i>Campoplex conicola</i> .....	p. 88
(1) <i>Mesostenus gracilis</i> .....	p. 91

Family Sphecidae.

(2) <i>Passaloeus melanognathus</i> , predatory wasps. ....	p. 116
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Family Sapygidae.

(1) <i>Sapyga pumila</i> , parasitizes bees	
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**Pinus contorta var. contorta Shore Pine**

(1 collection)

The cones of shore pine<sup>2</sup> appear to be subject to very little insect attack. They are occasionally infested with a small scolytid beetle, but the injury is very small in relation to the total cone crop.

<sup>2</sup> Although the varieties *contorta* and *latifolia* are not recognized in the latest "Check List of Trees of the United States," they are treated separately here because their insect fauna appear to be different.

I. Insects injuring the cones and seeds.	
A. Small white footless larvae, working from stem end through cones and destroying scales and seeds. <i>Conophthorus contortae</i> .....	p. 48
B. Slim white round-headed borer in axis of cones. <i>Paratimnia conicola</i> .....	p. 38
II. Miscellaneous insects reared from cones.	
A. Anobiid larva in cones (Hopkins U. S. No. 14208b) .....	p. 31
B. <i>Bracon</i> sp. (Hopkins U. S. No. 14208e) .....	p. 83
<i>Eubadizon</i> sp. (Hopkins U. S. No. 14208f) .....	p. 84

**Pinus contorta var. latifolia      Lodgepole Pine**

(6 collections)

The cones of lodgepole pine seem to be practically free from insect attack. A few instances have been noted of larvae feeding in the cones, but very little damage has been recorded.

I. Insects injuring the cones and seeds.	
A. Caterpillars working through green cones.	
1. Larvae, large, reddish-green, up to 17 mm.	
(3) <i>*Dioryctria abietella</i> .....	p. 148
2. Larvae white, up to 14 mm.	
(2) <i>*Eucosma recissoriana</i> .....	p. 136
3. Larvae dirty white, up to 12 mm. working in pith of cone axis and into seeds.	
(1) <i>Luspeyresia</i> sp. ....	p. 141
II. Miscellaneous insects reared from cones.	
Resin midge. <i>Rübsaamenia keeni</i> .....	p. 66
III. Parasites of cone insects.	
Hymenoptera.	
Family Eulophidae.	
<i>Elachertus</i> sp. (Hopkins U. S. No. 13375bx), external parasite of <i>Eucosma recissoriana</i> .....	p. 94
<i>Euderus</i> sp. (Hopkins U. S. No. 13375bx), external parasite of <i>Eucosma recissoriana</i> .....	p. 95
Family Ichneumonidae.	
(1) <i>Pimplopterus</i> n.sp. (Hopkins U. S. No. 32735c), parasite of <i>Eucosma recissoriana</i> .....	p. 92

**Pinus coulteri      Coulter Pine**

(3 collections)

The three collections made from Coulter pine failed to show any significant damage by insects to cones and seeds.

I. Caterpillars feeding in green cones.	
A. Large reddish green. (1) <i>*Dioryctria</i> sp. ....	p. 148
B. Dirty white larvae in seeds. (1) <i>*Luspeyresia</i> sp. ....	p. 141
II. Insects boring through hard dry cones.	
A. Small curled, white, hairy larvae.	
(1) <i>Ernobius montanus</i> .....	p. 33
B. White flatheaded larvae.	
(1) <i>Chrysophanu placida conicola</i> .....	p. 36
C. Small red larvae in resin patches.	
(2) <i>Rübsaamenia keeni</i> (?) .....	p. 66
III. Parasites.	
Hymenoptera.	
Family Ichneumonidae.	
<i>Campoplex conicola</i> , parasite of <i>Dioryctria</i> sp. ....	p. 88
Family Pteromalidae.	
<i>Systasis</i> sp. (Hopkins U. S. No. 13279f) .....	p. 100
<i>Zacalochlora milleri</i> .....	p. 100
Family Eulophidae.	
<i>Elachertus</i> sp. (Hopkins U. S. No. 13278h) .....	p. 94

**Pinus edulis Pinyon**

(5 collections)

The cones of pinyon are often very heavily infested by insects. Cones in the first year are injured by gall midges (Itonididae), and in the second year by cone moths and cone beetles. Frequently, 90 percent of the cone crop is destroyed. Several species of moths kill the cones both before and after they reach full size, and the cone beetles may finish the work of destruction.

A special study of the damage done to cones and seed of this tree was reported in 1943 (50) and 1944 (51). Collections were made by the Bureau staff between 1912 and 1917.

I. Insects injuring the cones and seeds.	
A. Attacking staminate cones.	
Small yellow-white larvae, 5 mm. long, in maturing catkins.	
<i>Xyela</i> sp. ....	81
B. Attacking first year cones. White maggots. *Itonididae (2 species) (50) ....	
	60
C. Attacking second year cones.	
1. White to pinkish caterpillars. * <i>Eucosma bobana</i> (?) (50) p.	136
<i>Chionodes periculella</i> ..... p.	119
2. Reddish-green caterpillars, up to 17 mm.	
<i>Dioryctria</i> 2 spp. (50)	
probably * <i>Dioryctria abietella</i> .....	148
probably * <i>Dioryctria auranticella</i> .....	152
3. Small white footless grubs and small dark-brown beetles.	
(4) * <i>Conophthorus edulis</i> .....	48
4. Small weevils. * <i>Conotrachelus</i> sp. (50).....	42
D. Secondary species found in insect-infested cones.	
1. Small white maggots, less than 3 mm. long. <i>Osecinella</i> sp.	
(50) .....	59
II. Parasites probably of <i>Conophthorus</i> .	
Hymenoptera.	
Family Pteromalidae. (1) <i>Acerocephala atroviolacea</i> .....	98

**Pinus flexilis Limber Pine**

(6 collections)

The cones of limber pine are attacked principally by a scolytid cone beetle and a cone moth. In some localities and years from 50 to 80 percent of the cone crop is infested or aborted by cone beetles. In other years the infestation may be very light.

I. Insects injuring the cones and seeds.	
A. Small white footless grubs, adults a small brown scolytid beetle. (6) * <i>Conophthorus flexilis</i> .....	
	49
B. Large greenish-red caterpillars working through green cones.	
(3) * <i>Dioryctria abietella</i> .....	148
II. Parasites.	
Hymenoptera.	
Ichneumon (Hopkins U. S. No. 12400cx), parasite of	
<i>Dioryctria</i> sp.	
<i>Acerocephala atroviolacea</i> , parasite of <i>Conophthorus flexilis</i> p.	98
<i>Apanteles</i> sp. (13249d).....	82

**Pinus jeffreyi Jeffrey Pine**

(12 collections)

Sometimes the cones of Jeffrey pine are very heavily damaged by insects. The most destructive is a cone moth, *Hedulia injectiva*



and its relatives *Laspeyresia piperana* and *L. miscitata*. These insects have destroyed up to 60 percent of the seed crop. Occasionally other caterpillars infest green cones, and the ponderosa pine cone beetle was once found attacking these cones.

I. Insects injuring the cones and seeds.	
A. Caterpillars working through cones and seeds.	
1. Dirty white larvae, found mostly in pith and in seeds.	
(12) {	
* <i>Hedulia injectiva</i> .....	p. 141
* <i>Laspeyresia piperana</i> .....	p. 141
* <i>Laspeyresia miscitata</i> .....	p. 141
2. Large reddish-green caterpillar boring pitch-free galleries through cones.	
(1) * <i>Dioryctria</i> sp. (probably <i>abietella</i> ) .....	p. 148
3. Pinkish larvae, up to 15 mm., mining through cone scales.	
(3) * <i>Eucosma bobana</i> .....	p. 136
(1) <i>Holococera</i> sp. ....	p. 117
B. Small white, curled, legless grubs in dead cones, or small brown beetles.	
(1) <i>Conophthorus ponderosae</i> (rare) .....	p. 55
II. Insects of minor importance.	
A. Curled white, hairy grubs with legs. Southern California.	
(1) <i>Ernobius montanus</i> .....	p. 33
B. Bright pink maggots on cone scales.	
(2) Itonididae— <i>Ribsaamani keeni</i> (?) .....	p. 66
C. Small white maggots in wet cones, small black flies.	
(1) <i>Oscinella conicola</i> .....	p. 59
D. Large cells in pith of cone occupied by a nesting bee.	
<i>Osmia coloradensis</i> .....	p. 116
III. Parasites and predators.	
Predators.	
Coleoptera.	
Family Cleridae.	
<i>Cymatodera ovipennis</i> .....	p. 40
Parasites.	
Hymenoptera.	
Family Braconidae.	
(1) <i>Apanteles californicus</i> , parasite of <i>Eucosma bobana</i> p.	82
(2) <i>Apanteles laspeyresiae</i> , parasite of <i>Hedulia injectiva</i> et al. (type) .....	p. 82
(1) <i>Phanerotoma erythrocephala</i> , parasite of <i>Hedulia injectiva</i> et al. (type) .....	p. 86
(2) <i>Phanerotoma laspeyresiae</i> , parasite of <i>Hedulia injectiva</i> et al. (type) .....	p. 86
Family Ichneumonidae.	
(3) <i>Calliephialtes comstockii</i> , parasite of <i>Hedulia injectiva</i> et al. ....	p. 86
(2) <i>Campoplex</i> sp. (Hopkins U. S. Nos. 10831ca, 11477bb) .....	p. 88
(1) <i>Poemenia americana</i> .....	p. 92
(1) <i>Neoxorides borealis</i> .....	p. 91
Family Pteromalidae.	
(5) <i>Zucalochlora milleri</i> , parasite of <i>Hedulia injectiva</i> et al. ....	p. 100
Family Eulophidae.	
(1) <i>Entedon</i> sp. (Hopkins U. S. No. 13276h) .....	p. 94

## Pinus lambertiana      Sugar Pine

(23 collections)

A small brown scolytid cone beetle causes an immense amount of damage to sugar pine cones. In some localities more than 90 percent of the cone crop has been destroyed before it fully matured. Damage varies in different localities and from year to

year (26), in some years being negligible. Several other species of insects have been reared from these cones but as a rule none of them causes serious injury.

I. Insects destroying the cones and seeds.	
A. Small white grubs without legs, brown heads distinct, body curved and wrinkled, feeding through cone axis and scales; adults a small brown beetle, also in cones.	
(20) * <i>Conophthorus lambertiana</i> .....	p. 49
B. Large reddish-green caterpillars feeding through scales of green cones.	
(2) * <i>Dioryctria abietella</i> .....	p. 148
II. Insects of minor importance not injuring the seeds.	
A. Small white hairy grubs with thoracic legs.	
(3) <i>Ernobius pallitarsis</i> .....	p. 33
(10) <i>Ernobius</i> sp. ....	p. 31
B. Small pink maggots on cone scales.	
(11) Itonidae— <i>Rübsaamenia keeni</i> .....	p. 66
C. Small white footless maggots in cones.	
(1) <i>Mycetanus</i> sp. ( <i>costalis</i> Mel. ?) .....	p. 80
(1) <i>Oscinella</i> sp. (Hopkins U. S. No. 10872e) .....	p. 59
D. Small rose-pink caterpillars feeding on frass.	
(1) <i>Chionodes</i> sp. (probably <i>periculetella</i> ) (Hopkins U. S. No. 10871f) .....	p. 119
III. Miscellaneous insects reared from cones, habits unknown.	
Hemiptera.	
(1) <i>Elasmotherus cruciatus</i> .....	p. 80
IV. Parasites and predators.	
Predators.	
(1) <i>Raphidia</i> (Hopkins U. S. No. 10833i) .....	p. 155
Parasites.	
Hymenoptera.	
Family Braconidae.	
(5) <i>Eubadizon</i> sp. (Hopkins U. S. Nos. 10833d, 10871d, 10872d, 10878b, 10890e) .....	p. 84
(1) <i>Spathius catiformis</i> .....	p. 86
Family Ichneumonidae.	
(1) <i>Horogenes</i> sp. (Hopkins U. S. No. 10833d <sup>3</sup> ) .....	p. 90
(1) <i>Campoplex milleri</i> , probably parasite of <i>Dioryctria abietella</i> .....	p. 88
Family Platygasteridae.	
(2) <i>Platygaster rohaveri</i> , probably parasite of Itonididae .....	p. 114
Family Pteromalidae.	
(1) <i>Rhopalicus pulchripennis</i> .....	p. 100
(2) Pteromalid genus ? (Hopkins U. S. Nos. 10833e3, 10871e)	

**Pinus leiophylla var. chihuahuana Chihuahua Pine**

One collection from Chihuahua pine showed less than 1 percent of the cone crop infested. The principal damage was done by a large pine moth, \**Dioryctria erythropasa*.....p. 154

**Pinus monophylla Singleleaf Pinyon**

(4 collections)

From the few collections made from this tree, it appears that, at times, insects cause rather heavy damage—comparable to that in pinyon. Most damage is done by a cone beetle and cone moth.

I. Insects injuring cones and seeds.	
A. Small white curled footless grubs, or small dark-brown beetles riddling interior of cones.	
(2) * <i>Conophthorus monophyllae</i> .....	p. 55
B. Caterpillars, up to 17 mm., burrowing through green cones.	
(1) * <i>Dioryctria albavittella</i> .....	p. 152
C. Small, pink caterpillars, 15 mm., working through frass.	
(1) * <i>Eucosma bobana</i> .....	p. 136
II. Insects of minor importance.	
A. White hairy curled grubs with 3 pairs of thoracic legs, working in dry cone scales.	
(2) <i>Ernobius montanus</i> .....	p. 33
(1) <i>Stephanopachys sobrinus</i> .....	p. 36
B. Small pink maggots in cones.	
(1) Itonididae .....	p. 60
III. Parasites.	
Hymenoptera.	
Family Braconidae.	
(2) <i>Eubadizon</i> sp. (Hopkins U. S. Nos. 31983, 32308c) p.	84
(1) <i>Coeloides scolyti</i> .....	p. 84

## Pinus monticola      Western White Pine

(3 collections)

Very little data have been obtained on the insect damage to the cones of western white pine. Apparently, the damage is very small, the most destructive insects being the cone beetle and a large moth.

I. Insects injuring the cones and seeds.	
A. Small white curled footless grubs, adults small brown scolytid beetles.	
Washington, Idaho, and Canada. * <i>Conophthorus monticolae</i> (31) .....	p. 55
Southern Oregon and California. (1) * <i>Conophthorus lamber-</i> <i>tiana</i> .....	p. 49
B. Large greenish-red caterpillars boring through green cones.	
(1) * <i>Dioryctria</i> sp. (probably <i>abietella</i> ) .....	p. 148
C. Large gray-green larvae with 2 pairs of prolegs, boring through cones. * <i>Eupithecia spermaphaga</i> .....	p. 120
II. Miscellaneous insects reared from cones. (2) Diptera (Hopkins U. S. Nos. 13343c, 13343e)	
III. Parasites.	
Hymenoptera.	
Family Braconidae. <i>Bracon</i> n.sp. near <i>tachypteri</i> Mues. (Hopkins U. S. No. 31674b)	

## Pinus ponderosa      Ponderosa Pine

The cones of ponderosa pine are often very seriously damaged by small scolytid beetles. On isolated trees as much as 92 percent of the cones may be killed, whereas in heavy timber stands the cones destroyed may be almost negligible. Pith moths, *Laspeyresia* spp., also do heavy damage in some localities, infesting up to 100 percent of the cones and destroying as much as 80 percent of the seed in infested cones. A large number of insects of minor importance have also been reared from these cones.

*Key to the Work of Insect Species Involved*

I. Insects destroying the cones and seeds.

A. Small, white curled, wrinkled footless grubs with brown heads working through scales and seeds; adults small, brown scolytid beetles.

1. Through range of coast form of *P. ponderosa* var. *ponderosa* —*Conophthorus ponderosae* .....p. 55

2. Through range of Rocky Mountain form of *P. ponderosa* var. *scopulorum*—*Conophthorus scopulorum* .....p. 58

B. Caterpillars working through cones.

1. Dirty white larvae in pith of cone and in seeds.

*Laspeyresia piperana* .....p. 141

*Laspeyresia miscitata* .....p. 141

*Hedulia injectiva* .....p. 141

2. Large reddish-green to black larvae boring in green cones.

a. Larval hairs short, rarely twice diameter of spiracles. Adults golden yellow. *Dioryctria auranticella*.....p. 152

b. Larval hairs long, distinct, over 5 times diameter of spiracles. Adults gray. *Dioryctria abietella*.....p. 148

3. Small pink larvae working through cone scales. *Eucosma bobana* .....p. 136

4. Large, gray-green larvae with 2 pairs of prolegs. *Eupithecia spermaphaga* .....p. 120

II. Insects working only in seeds.

A. Small white footless grubs with indistinct heads enclosed in seeds; adults large brown chalcid flies with long upturned ovipositors, central California. *Megastigmus albifrons*....p. 103

III. Insects of minor importance.

A. Small white hairy grubs with thoracic legs, adults small shiny-brown beetles. *Ernobius* spp. ....p. 31

B. Small pink maggots found on cone scales. Itonididae spp. *Rübsaamenia keeni* .....p. 66

C. Small, rose-colored caterpillars feeding on frass and scales. *Chionodes periculella* .....p. 119

D. Small yellow-white larvae, 5 to 8 mm. long, feeding in staminate cones. *Xyela* sp.....p. 81

**Pinus ponderosa** var. **ponderosa**<sup>3</sup> Pacific Coast Form (67 collections)

The following insects were reared or collected from the cones of this tree:

I. Insects destroying cones and seeds.

Cone beetles.

(37) \**Conophthorus ponderosae* .....p. 55

Cone moths.

(45) \**Laspeyresia piperana*, *L. miscitata*, and *Hedulia injectiva* .....p. 141

(8) \**Dioryctria auranticella* .....p. 152

(3) \**Dioryctria abietella* .....p. 148

(4) \**Eucosma bobana* .....p. 136

(1) \**Eupithecia spermaphaga* .....p. 120

II. Insects working in seeds.

(10) \**Megastigmus albifrons* .....p. 103

III. Insects of minor importance.

(7) *Ernobius pallitarsis* .....p. 33

(5) *Ernobius punctulatus* .....p. 35

(1) *Ernobius montanus* .....p. 33

(6) *Ernobius* spp. ....p. 31

<sup>3</sup> Although the varieties *ponderosa* and *scopulorum* are not recognized in the latest check list, they are treated separately here, because of important differences in their insect fauna.

## III. Insects of minor importance.—Continued

(11) Itonididae .....	p.	60
<i>Rübsaamenia keeni</i> .....	p.	66
(4) <i>Chionodes periculella</i> .....	p.	119
<i>Xyela</i> sp. ....	p.	81

## IV. Miscellaneous insects reared from cones, habits unknown.

## Coleoptera.

Family Anthicidae.		
(8) <i>Anthicus nitidulus</i> .....	p.	36
(6) <i>Notorus constrictus</i> .....	p.	36
Family Coccinellidae.		
(1) <i>Cleis picta</i> var. <i>contexta</i> .....	p.	41
(1) <i>Hippodamia convergens</i> .....	p.	42
(2) <i>Olla abdominalis</i> .....	p.	42
Family Lathridiidae.		
(5) <i>Corticaria</i> sp. ....	p.	45
(1) <i>Lathridius protensicollis</i> .....	p.	45
Family Ptinidae.		
(3) <i>Ptinus fur</i> .....	p.	46
Family Scarabaeidae.		
(1) <i>Aphodius</i> sp. (Hopkins U. S. No. 13251i)		

## Diptera.

Family Chloropidae.		
(1) <i>Oscinella conicola</i> .....	p.	59
(2) <i>Elachiptera costata</i> .....	p.	59
Family Lonchaeidae.		
(1) <i>Euromyia barbara</i> .....	p.	75
(4) <i>Euromyia</i> sp. (Hopkins U. S. Nos. 10876h, 12534d, 13205f, 13358d) .....	p.	71
Family Sphaeroceridae.		
(2) <i>Leptocera</i> sp. (Hopkins U. S. No. 14423c) .....	p.	80
Family Lauzaniidae.		
(1) <i>Supromyza</i> (?) sp. (Hopkins U. S. No. 13312e) .....	p.	71

## V. Predators and parasites.

## Neuroptera.

(1) <i>Raphidia</i> sp. (Hopkins U. S. No. 12576h) .....	p.	155
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## Coleoptera.

Family Cleridae.		
(8) <i>Cymatodera ovipeennis</i> .....	p.	40
(2) <i>Enoclerus humeralis</i> .....	p.	41

## Diptera.

Family Larvaevoridae.		
(1) <i>Eaorista</i> sp. (Hopkins U. S. No. 13251f) .....	p.	70

## Hymenoptera.

Family Bethylinidae.		
<i>Perisierola</i> sp. (Hopkins U. S. No. 10870a <sup>6</sup> )		
Family Braconidae.		
(2) <i>Allorhogas</i> n.sp. (Hopkins U. S. Nos. 10832ba, 10887g) .....	p.	82
(8) <i>Apanteles laspeyresiae</i> , parasite of <i>Laspeyresia</i> spp. p.		82
(1) <i>Bracon wanthonotus</i> .....	p.	83
(7) <i>Eubadizon</i> sp. (Hopkins U. S. Nos. 10832g, 10875b <sup>6</sup> , 12539L, 13205i, 11472d, etc.) .....	p.	84
(1) <i>Phanerotoma erythrocephala</i> , parasite of <i>Laspeyresia</i> spp. ....	p.	86
(2) <i>Phanerotoma laspeyresiae</i> , parasite of <i>Laspeyresia</i> spp. ....	p.	86
Family Eupelmidae.		
(1) <i>Eupelmus</i> sp. ( <i>limneriae</i> How. ?) (Hopkins U. S. No. 10870e) .....	p.	96
Family Eurytomidae.		
(1) <i>Eurytoma</i> sp. (Hopkins U. S. No. 10875b,) .....	p.	98
Family Ichneumonidae.		
(6) <i>Calliephialtes comstockii</i> , parasite of <i>Laspeyresia</i> spp. ....	p.	86

(2) <i>Campoplex laspeyresiae</i> .....	p.	88
(1) <i>Dicaelotus pacificus</i> .....	p.	89
(1) <i>Gelis tenellus</i> .....	p.	89
(1) <i>Horogenes</i> sp. (Hopkins U. S. No. 12532i) .....	p.	90
Family Eulophidae.		
(6) <i>Tetrastichus</i> sp. (Hopkins U. S. No. 11462ax), parasite of <i>Megastigmus albifrons</i> .....	p.	96
(1) <i>Eulophidae</i> , new genus (Hopkins U. S. No. 10870a <sup>o</sup> ) .....		
Family Pteromalidae.		
<i>Amblymerus veriditer</i> , parasite of <i>Laspeyresia</i> spp. (Rust) .....	p.	98
(2) <i>Caenacis</i> sp. (Hopkins U. S. Nos. 12532g, 13302d) .....	p.	99
(4) <i>Zacalochlora milleri</i> , parasite of <i>Laspeyresia</i> spp. (Rust) .....	p.	100
(1) <i>Halticoptera</i> sp. (Hopkins U. S. No. 12532n) .....		

**Pinus ponderosa var. scopulorum Rocky Mountain Form**

(16 collections)

In some years and in some localities the cones of this tree are heavily infested with insects. They destroy up to 50 percent of the seed crop. The principal destructive insects are the pine seed moths, *Laspeyresia* spp., and the cone beetle, *Conophthorus scopulorum*.

The following insects have been reared or collected from this tree:

I. Insects destroying the cones and seeds.		
Cone beetle.		
(7) * <i>Conophthorus scopulorum</i> .....	p.	53
Cone moths.		
(3) * <i>Laspeyresia piperana</i> (not checked by specialists) .....	p.	141
(2) * <i>Dioryctria auranticella</i> (not checked by specialists) .....	p.	152
(1) * <i>Dioryctria abietella</i> (not checked by specialists) .....	p.	148
II. Insects of minor importance.		
(2) <i>Ernobius</i> spp. ....	p.	31
(3) Itonididae .....	p.	60
<i>Rübsaamenia keeni</i> (?) .....	p.	66
III. Miscellaneous insects reared from cones.		
Coleoptera.		
Family Ptinidae.		
(2) <i>Ptinus fur</i> .....	p.	46
Diptera.		
Family Chamaemyidae.		
(1) <i>Leucopia</i> sp. (Hopkins U. S. No. 12569e) .....	p.	59
IV. Parasites.		
Hymenoptera.		
Family Braconidae.		
(1) <i>Phanerotoma erythrocephala</i> , parasite of <i>Laspeyresia</i> spp. ....	p.	86
(1) <i>Bracon</i> sp. (Hopkins U. S. No. 13348b) .....	p.	83
Family Ichneumonidae.		
(1) <i>Campoplex</i> sp. (Hopkins U. S. No. 10857e) .....	p.	88
(2) <i>Coelichneumon bruneri</i> , parasite of <i>Dioryctria</i> sp. p.	p.	88
Family Pteromalidae.		
(1) <i>Psychophagus omnivorus</i> .....	p.	100

**Pinus radiata Monterey Pine**

(3 collections)

The insect damage in Monterey pine cones is usually negligible, but sometimes a cone moth, *Dioryctria*, may cause heavy damage.

A small cone beetle is occasionally found infesting the cones, and the old hard parts of the cones are sometimes infested with an anobiid, *Ernobius*.

I. Insects injuring the cones and seeds.	
A. Large greenish-red to dark-brown caterpillars, 17 mm. long.	
(1) <i>*Dioryctria auranticella</i> .....	152
B. Small white curled, footless grubs; adults small brown scolytid beetle.	
(1) <i>*Conophthorus radiatae</i> .....	57
II. Insects of minor importance living in dry parts of cones.	
A. Small white grubs with legs, adults brown beetles.	
(3) <i>Ernobius punctulatus</i> .....	35
B. Large larva, without legs. (1) Unidentified cerambycid	
III. Insects reared from cones, habits unknown.	
Coleoptera.	
Family Cryptophagidae. (1) <i>Henoticus californicus</i> .....	42

**Pinus sabiniana      Digger Pine**

(1 collection)

The cones of Digger pine appear to be practically free from insect damage. Borings of lepidopterous larvae have been found, but no damage was recorded.

I. Insects injuring cones and seeds.	
A. Large caterpillar boring through cones. (1) <i>*Dioryctria</i> sp.	
(probably <i>auranticella</i> ) .....	152
B. Small pink maggots in seeds and cones. (1) Itonididae.....	60

**Pinus torreyana      Torrey Pine**

(2 collections)

The mature cones of Torrey pine do not appear to be subject to insect attack. However, the very young ones about 1 inch in diameter are destroyed by cerambycid and lepidopterous larvae. In some years a high percentage of these small cones are destroyed. The species involved were not specifically determined.

I. Insects injuring and destroying small cones.	
(1) Cerambycid larvae (unidentified).	
(1) Small caterpillars (unidentified).	
II. Miscellaneous insects.	
Hibernating in cones.	
Coccinellid beetles.	
(1) <i>Zagloba ornata</i> (Horn.)	
Anthicidae.	
(1) <i>Anthicus</i> sp. (Hopkins U. S. No. 12594h).....	36

**Pseudotsuga menziesii      Douglas-fir**

(74 collections)

The cones of Douglas-fir are infested with a great number of species of insects, the most destructive being a seed chalcid and two species of moths (1). In general about 10 percent of the seed crop is destroyed by these insects, although in different localities

and in different years the damage may vary from practically nothing to 50 percent or more of the seed destroyed. The insect damage is usually heaviest in years when the seed crop is light (35); and in any one year the damage is usually worse in the warmer places (36).

I. Insects destroying the cones and seeds.	
A. Caterpillars working through cones and seeds.	
1. Medium-sized white larvae, causing much pitch flow. Adults a small gray moth.	
(65) * <i>Barbara colfaxiana</i> vars. ....	p. 123
2. Large reddish-green larvae with 5 prolegs, making round holes and larval castings, more or less free from pitch. Adults a gray moth.	
(21) * <i>Dioryctria abietella</i> .....	p. 148
Adults white spotted moths.	
(11) * <i>Henricus fuscodorsana</i> .....	p. 147
3. Large greenish larvae with 2 prolegs, doing similar work to 2.	
(1) * <i>Eupithecia albicapitata</i> .....	p. 120
(3) * <i>Eupithecia spermaphaga</i> .....	p. 120
4. Small white larvae feeding in frass.	
(18) <i>Holcocera augusti</i> .....	p. 117
5. Small pinkish or reddish-brown larvae feeding in frass.	
<i>Holcocera</i> sp. ....	p. 117
6. Small pink larvae feeding on scales and seeds (rare).	
(1) <i>Laspeyresia bracteolata</i> .....	p. 137
(3) <i>Laspeyresia</i> sp. ....	p. 137
7. Larvae unknown.	
<i>Polychrosis piccana</i> (Canadian record) .....	p. 146
B. White long, slim, footless maggots boring through scales and seeds.	
<i>Earomyia barbara</i> .....	p. 75
<i>Earomyia aquilonia</i> (Canada) .....	p. 76
II. Insects destroying only the seeds.	
A. Small white footless larvae, enclosed in seeds. Adult wasps, light yellow.	
(45) * <i>Megastigmus spermotrophus</i> .....	p. 110
III. Insects of minor importance.	
A. Small pink dipterous maggots.	
Found loose in cones.	
<i>Rübsaamenia keeni</i> .....	p. 66
Found in gall pockets in cone scales.	
Ittonididae .....	p. 60
B. Small white beetle larvae in scales. Adults brown.	
(2) <i>Ernobius punctulatus</i> .....	p. 35
(2) <i>Ernobius</i> sp. ....	p. 31
C. Small rose-colored caterpillars feeding on frass and scales.	
(4) <i>Chionodes periculella</i> .....	p. 119
IV. Miscellaneous insects reared from cones, habits unknown.	
Coleoptera.	
Family Anthicidae.	
(3) <i>Anthicus nitidulus</i> .....	p. 36
(2) <i>Notoxus constrictus</i> .....	p. 36
Family Coccinellidae.	
(3) <i>Cleis picta</i> var. <i>contexta</i> .....	p. 41
(1) <i>Hippodamia convergens</i> .....	p. 42
(1) <i>Psyllobora viginti-maculata</i> var. <i>taedata</i> .....	p. 42
Family Cryptophagidae.	
(1) <i>Henoticus californicus</i> .....	p. 42
Family Curculionidae.	
(1) <i>Dirotognathus</i> sp. (Hopkins U. S. No. 11475g) ....	p. 44
Family Lathrididae.	
(5) <i>Corticaria</i> sp. ....	p. 45



## IV. Miscellaneous insects reared from cones, habits unknown.—Continued

## Diptera.

<i>Bradysia pauciseta</i> (Canadian record).....p.	76
(24) Family Itonididae .....	60
<i>Contarinia oregonensis</i> .....	60
<i>Lestodiplosis taxiconis</i> .....	65
<i>Mycodiplosis coryloides</i> .....	65

## Hymenoptera.

## Family Eurytomidae.

(5) <i>Eurytoma</i> sp. (Hopkins U. S. Nos. 10874g, 13310a, 11476b, etc.) (may be seed infesting).....p.	98
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## V. Predators and parasites reared from cones.

## Predators.

## Family Cleridae.

(6) <i>Enoclerus humeralis</i> .....	41
(4) <i>Cymatodera ovipennis</i> .....	40

## Parasites.

## Diptera.

## Family Larvacoridae.

(1) <i>Lydellohonghia</i> sp. (Hopkins U. S. No. 12535d <sup>2</sup> ) p.	70
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## Hymenoptera.

## Family Bethyilidae.

(1) <i>Perisicrola</i> sp. (Hopkins U. S. No. 13209n <sup>2</sup> )	
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## Family Braconidae.

(1) <i>Apanteles</i> sp. (Hopkins U. S. No. 13295d).....p.	82
(1) <i>Aphidius bifasciatus</i> .....	83
(1) <i>Blacus</i> sp. (Hopkins U. S. No. 13209na <sup>2</sup> ).....p.	83
(1) <i>Bracon erucarum</i> .....	83
(6) <i>Bracon rhyacioniae</i> .....	83
(1) <i>Bracon xanthonotus</i> .....	83
<i>Bracon</i> n.sp. (Hopkins U. S. No. 13209nb)	
(1) <i>Eubadizon</i> sp. (Hopkins U. S. No. 14211d).....p.	84

## Family Eulophidae.

*Aprostocetus* sp. (Canadian record)

*Elachertus* sp. (Canadian record).....p.

(1) <i>Hyssopus evetriae</i> , parasite of <i>Barbara colfaxiana</i> p.	95
(1) <i>Tetrastichus strobilus</i> .....	95
(11) <i>Tetrastichus</i> sp. (Hopkins U. S. Nos. 11475c, 13202k, etc.) .....	96

## Family Eupelmidae.

(1) <i>Eupelmus</i> sp. (Hopkins U. S. No. 14292g).....p.	96
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## Family Ichneumonidae.

(9) <i>Calliephialtes comstockii</i> , parasite of <i>Barbara colfaxiana</i> .....	86
(1) <i>Campoplex conocola</i> .....	88
(1) <i>Dicaelotus</i> sp. (Hopkins U. S. No. 13209bd).....p.	89
(2) <i>Exochus evetriae</i> , parasite of <i>Barbara colfaxiana</i> p.	89
(20) <i>Glypta evetriae</i> , parasite of <i>Barbara colfaxiana</i> p.	89
(6) <i>Hopectis evetriae</i> , parasite of <i>Barbara colfaxiana</i> p.	90
(3) <i>Phaeogenes</i> sp. (Hopkins U. S. Nos. 12510, 12535ta, 13209bd) .....	91
<i>Pimplopterus conocola</i> .....	91
(4) <i>Pimplopterus evetriae</i> , parasite of <i>Barbara colfaxiana</i> .....	92

## Family Pteromalidae.

<i>Amblymerus verditer</i> (57) .....	98
(2) <i>Amblymerus</i> sp. (Hopkins U. S. Nos. 10834g, 32333c) .....	99
(14) <i>Zacalochlora milleri</i> .....	100

## Family Sphecidae (predatory wasps).

(1) <i>Passalococcus melanognathus</i> .....	116
(1) <i>Spilomena alboctypta</i> .....	116

## Family Torymidae.

(12) <i>Torymus</i> sp. (Hopkins U. S. Nos. 11475e, 13202k, 10852h <sup>2</sup> , etc.) .....	112
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**Quercus agrifolia California Live Oak**

(1 collection)

The acorns of California live oak are not seriously attacked by insects. Acorn weevils, and one species of gall wasp, have been found in the kernels of the acorns, but their work appears to be scarce.

- I. Insects injuring acorns.
  - A. White grubs, without thoracic legs. Long-beaked weevils.
    - \**Curculio pardus* (Chittenden)
    - \**Curculio uniformis* (Chittenden) ..... p. 43
  - B. Small footless larvae in galls in acorns. Adults brown cynipids.
    - (1) \**Eumayria eldoradensis* ..... p. 112
- II. Parasites of acorn insects.
  - Green chalcid flies. *Torymus* sp. (Hopkins U. S. No. 10867a) ... p. 112

**Quercus kelloggii California Black Oak**

(6 collections)

The acorns of California black oak are heavily infested in some localities by a species of cynipid which forms galls in the kernel of the acorns. A large weevil and a lepidopterous larvae also do considerable damage, in some places infesting up to 95 percent of the acorns and destroying most of the crop.

- I. Insects injuring acorns.
  - A. White curled grubs without thoracic legs. Adults long-beaked yellow weevils.
    - (7) \**Curculio uniformis* ..... p. 43
  - B. Caterpillars feeding in kernels. Adults, bronze moths.
    - (4) \**Melissopus latiferreanus* ..... p. 145
  - C. Small footless larvae in galls in acorns. Adults, brown cynipid wasps.
    - \**Eumayria eldoradensis* (57) ..... p. 112
- II. Insects of minor importance.
  - Small tineid larvae following into acorns after weevils and moths.
    - (6) *Valentinia glandulella* ..... p. 118
    - (1) *Gelechia* sp. (Hopkins U. S. No. 14279L) ..... p. 119
- III. Parasites and predators.
  - Diptera.
    - Family Larvaevoridae.
      - (1) *Myiophasia atra* ..... p. 70
  - Hymenoptera.
    - Family Braconidae.
      - (1) *Agathis acrobasis* ..... p. 82
      - (1) *Apanteles* sp. (Hopkins U. S. No. 14279f) ..... p. 82
      - (1) *Eubadizon* sp. (Hopkins U. S. No. 14279h) ..... p. 84
      - Macrocentrus ancylivorus* ..... p. 85
      - Phanerotoma fasciata* ..... p. 86
    - Family Eulophidae.
      - Elachertus glacialis* ..... p. 94
      - (2) *Tetrastichus chrysopae* ..... p. 95
      - (1) *Hyssopus* sp. (Hopkins U. S. No. 14218 ex) ..... p. 95
    - Family Eurytomidae.
      - (1) *Eudecatoma* sp. (Hopkins U. S. No. 14279e)
    - Family Ichneumonidae.
      - (1) *Horogenes* sp. (Hopkins U. S. No. 13294f) ..... p. 90
      - (1) *Pimpla* sp. (*Pimpla dukranai*) ..... p. 91
    - Family Torymidae.
      - (1) *Torymus* sp. (Hopkins U. S. No. 12561e) ..... p. 112

**Thuja plicata Western Redcedar**

(4 collections)

The seeds of western redcedar are heavily damaged by insects in some years, according to reports of seed collectors. The major damage is caused by a gall midge which attacked the cones' scales and seeds, and sometimes causes 100-percent infestation.

I. Insects injuring seeds.	
A. Small pink maggots in galls at base of scales and in seeds.	
Pupae form in white papery cocoons between scales in places normally occupied by seeds.	
(2) *Undetermined Itonididae (Hopkins U. S. Nos. 13256a, 13262a, 33181) .....	60
II. Insects of minor importance reared from cones, habits unknown.	
Coleoptera.	
(2) <i>Pinus fur</i> .....	46
(1) <i>Microgramme arga</i> .....	46
Hymenoptera.	
(1) <i>Eurytoma</i> sp. (Hopkins U. S. Nos. 13256c, 33181c) .....	98
(3) <i>Torymus</i> sp. (Hopkins U. S. Nos. 13256b, 13262b, 31664b, 33181b) .....	112
(1) <i>Amblymerus</i> n.sp. (Hopkins U. S. No. 31664c) .....	99
(1) <i>Tetrastichus</i> sp. (Hopkins U. S. Nos. 31664d, 33181a) .....	96

**Tsuga heterophylla Western Hemlock**

No western hemlock cones were collected by the Ashland staff. Milliron (61) reports the seeds as being infested with a seed chalcid *Megastigmus tsugae* var. *heterophyllae*. Further collecting is needed to determine amount of damage to these cones and seeds and the insect species involved.

**Tsuga mertensiana Mountain Hemlock**

(4 collections)

Although in some years the seeds of this tree are of very poor quality, the insect damage appears to be very light.

I. Insects injuring the cones and seeds.	
A. Gray caterpillars with 2 prolegs, boring in cones.	
(1) * <i>Eupithecia spermaphaga</i> .....	120
B. Slim white maggots boring in cones and seeds.	
(2) * <i>Earomyia barbara</i> .....	75
C. Large fat maggots boring in cones.	
(1) * <i>Hylemyia</i> sp. (Hopkins U. S. No. 12559e) .....	79
II. Insects injuring seeds only.	
A. Small white footless grubs enclosed in seeds.	
(2) * <i>Megastigmus tsugae</i> .....	111
III. Insects of minor importance.	
A. Small pink maggots found loose on cones scales.	
(1) Itonididae. <i>Rübsaamenia keeni</i> (?) (Hopkins U. S. No. 12559a) .....	66
IV. Miscellaneous insects reared from cones, habits unknown.	
Diptera.	
(1) <i>Goliathocera setigera</i> (Hopkins U. S. No. 12559g) .....	70
V. Parasites and predators.	
Hymenoptera.	
(1) <i>Copidosoma</i> sp. (Hopkins U. S. No. 13344d) .....	93
(1) <i>Sarothrus</i> sp. (Hopkins U. S. No. 13344b) .....	113

(1) <i>Scambus</i> sp. (Hopkins U. S. No. 13344c) . . . . .	p. 93
(1) <i>Tetrastichus</i> sp. (Hopkins U. S. No. 13344e) . . . . .	p. 96
(1) <i>Calliephialtes</i> sp. (Hopkins U. S. No. 12559h) . . . . .	p. 87
(1) <i>Horogenes</i> sp. (Hopkins U. S. No. 12559ix), parasite of <i>Eupithecia spermaphaga</i> . . . . .	p. 90

## BIOLOGY AND HABITS OF CONE AND SEED INSECTS AND THEIR INSECT ENEMIES

In the following section, the cone and seed insects affecting western forest trees are treated individually with such biological and host information as has been gathered concerning them. Most of the notes were obtained during the period 1912-16 when this group of insects was given intensive study by J. M. Miller, F. P. Keen, and J. E. Patterson at the Forest Insect Station at Ashland, Oreg.

Most species were identified by specialists of the U. S. National Museum. For contributions to this phase of the project the writer is especially indebted to the following taxonomists in their respective fields:

- |              |  |
|--------------|--|
| Coleoptera:  | W. S. Fisher, W. H. Anderson, and E. C. Van Dyke (University of California). |
| Diptera:     | C. T. Greene, C. W. Sabrosky, Alan Stone, and R. H. Foote.                   |
| Hemiptera:   | E. H. Gibson.  |
| Hymenoptera: | S. A. Rohwer, A. B. Gahan, and C. F. W. Muesebeck.                           |
| Lepidoptera: | C. Heinrich, A. Busck, and J. F. Gates Clarke.                               |

For convenience of reference the insects discussed are arranged in alphabetical order by order, family, genus, and species.

### ORDER COLEOPTERA BEETLES

#### FAMILY ANOBIIDAE

This is a family of "powder post" or "death watch" beetles, the larvae of which usually work in dry wood or other material and reduce it to a fine powder. They usually attack dead material and hence are of no importance as cone or seed killers.

#### Genus *Ernobius*

The adults of this genus are small dull reddish-brown, semi-cylindrical, more or less elongated beetles with parallel sides, but oval in outline front and rear; length 2.0-5.5 mm. They are all clothed with fine recumbent hairs which are very short and sparse in a few species. The antennae are usually 11-jointed, rarely 10-jointed, and are as long as, or a little longer than, half the body in the male and somewhat shorter in the female. The larvae are white, tapering, curled grubs with six distinct legs, yellowish-brown heads, and minute but distinct brownish spines. The larvae may be confused with those of the cone beetles (*Conophthorus*)

but close examination of the legs and spines will distinguish them. Both the larvae and adults bore in dry twigs and cones of pine and other conifers.

Key to Western Species of *Ernobius*<sup>1</sup>

1. Antennae 10-jointed ..... 2.  
Antennae 11-jointed ..... 3.
2. Hind angles of prothorax undefined, the sides broadly rounding into the base. Length 3 mm. Washington and British Columbia  
*E. gentilis* Fall  
Hind angles of prothorax distinct and a little prominent; sides nearly straight and convergent from base, the margin ill-defined. Length 3-4 mm. California.....*E. trapezoides* Fall
3. Pubescence with intermixed, short erect hairs; sides of pronotum serrate; last joint of maxillary palpi widest at or behind the middle.  
Dark brown, ninth joint of antenna equal to the five preceding in the male, a little longer than the three preceding in the female; last ventral segment more or less evidently bituberculate in the female. Length 2.25-5.2 mm. Oregon, Washington, California .....*E. marginicollis* (Lec.)  
Pubescence without intermixed erect hairs; sides of pronotum not serrate; last joint of maxillary palpi widest toward the apex.... 4.
4. Ninth joint of antenna distinctly shorter than the two preceding joined. Length 4-6 mm. Monterey County, Calif. ....*E. cupressi* Van D.  
Ninth joint of antenna longer..... 5.
5. Ninth joint of antenna shorter than the three preceding united in both sexes; clytra less densely punctate..... 6.  
Ninth joint of antenna longer..... 7.
6. Joints 6-8 of antenna each more than twice as wide as long. Length 4.5 mm. Santa Clara County, Calif. ....*E. socialis* Fall  
Joints 6-8 of antenna always less than twice as long as wide. Length 2.5-4.5 mm. California, Oregon, Washington, and British Columbia .....*E. punctulatus* (Lec.)
7. Ninth joint of antenna as long as the 3 or 4 preceding united..... 8.  
Ninth joint of antenna as long as the 5 or 6 preceding united in the male ..... 12.
8. Sides of prothorax nearly straight and convergent anteriorly, the front angles rounded.  
Ninth joint of antenna equal to the three and one-half preceding united in the female; brown; prothorax not granulate. Length 4.25 mm. California.....*E. convergens* Fall  
Sides of prothorax arcuate, not distinctly convergent anteriorly; front angles well defined..... 9.
9. Blackish, prothorax paler and evidently granulate; ninth joint of antenna equal to the three preceding. Length 3.4 mm. *E. collaris* Fall  
Fusco- or rufotestaceous in color..... 10.
10. Fuscotestaceous; prothorax not granulate; ninth joint of antenna equal to the three preceding; tarsi rather stout...*E. abutaceus* (Lec.)  
Fusco- or rufotestaceous; prothorax granulate; ninth joint of antenna fully equal to the four preceding; tarsi slender..... 11.
11. Front (male) a little less than twice as wide as the longest diameter of the eye and scarcely two and one-half times its width; sixth ventral deeply cleft.....*E. crotchii* Fall  
Front (male) fully twice as wide as the longest diameter of the eye and about three times the width of the latter; sixth ventral broadly emarginate. Length 3.7 mm.....*E. gracilis* Lec.
12. Pronotum granulate-punctate ..... 13.  
Pronotum simply punctate, at least broadly so at middle..... 14.
13. Brown, size larger 5.1-5.2 mm. Arizona.....*E. fissuratus* Fall  
Black, size smaller 2.4-3.6 mm. Arizona, California, British Columbia  
*E. nigrens* Fall

<sup>1</sup> Adapted from key by H. C. Fall (18).

14. Prothorax transversely impressed. Length 2.8-4.1 mm. California, Oregon, Washington, British Columbia.....*E. pallitarsis* Fall  
 Prothorax not at all impressed transversely..... 15.  
 15. Black (female not known). Colorado.....*E. tristis* Lec.  
 Rufotestaceous or brown in both sexes. Length 3.0-4.2 mm. Southern California .....*E. montanus* Fall

***Ernobius cupressi* Van Dyke<sup>5</sup>**

*Description.*—The adults are reddish brown with short golden pubescence. They are larger (length 4 to 6 mm.) and more robust than most members of this genus.

*Host.*—*Cupressus macrocarpa*.

*Distribution.*—Monterey County, Calif.

*Notes.*—Larvae and adults feed in dry dead cones. The principal adult emergence occurs from late May through June and July to the first of August. The insect is also found in dead wood of cypress. The seasonal history was not worked out, but the species appears to have one generation a year. It feeds for the most part on the blighted, dead, dry cones killed by other insects.

***Ernobius montanus* Fall**

*Description.*—Adults are slender reddish to dull-brown beetles, 3 to 5 mm. in length, narrow in front and rounded at rear.

*Hosts.*—*Pinus coulteri*, *P. jeffreyi*, *P. monophylla*, and *P. ponderosa*.

*Distribution.*—Mountains of southern California.

*Notes.*—The larvae (fig. 1) feed in old, dry cones and dead twigs of the host trees. In the winter full-grown larvae may be found in the cones of that year's cone crop. New adult emergence occurs the next year, from the first of July to the middle of August.

***Ernobius pallitarsis* Fall**

*Description.*—The adults of this species are dull, gray-brown beetles, similar to *E. montanus*. They average about 4 mm. in length.

*Hosts.*—Cones and twigs of *Pinus ponderosa* and *P. lambertiana*.

*Distribution.*—California, Oregon, and Montana.

*Damage.*—This species breeds abundantly in the dry aborted cones of the two host trees. It is also found in the axis of normal mature cones and in the pith of dead, dry, flagged terminals of ponderosa pine. The larvae feed on the dry scales and seeds of killed cones and reduce these to powder. They are not responsible for the killing, but are secondary to cone beetles or other insects.

*Life history.*—Eggs are apparently laid in dead or blighted cones in the summer of the year the cones are killed, or in subsequent years if the dead cones are dry and not too far decayed. By August small larvae may be found, as well as parent adults. The larvae may average 3 to 8 per cone. They feed during the fall, winter, and spring. A few parent adults may emerge in the fall. New adults emerge the next spring. This pattern of emergence

<sup>5</sup>*Ernobius conicola* Fisher has been recognized as a synonym by E. O. Essig (17, p. 484).



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FIGURE 1.—Larvae of a powder-post beetle, *Ernobius montanus* Fall, in a dead Jeffrey pine cone.

suggests that this species has one annual generation. Many lots of cones put in rearing showed a heavier emergence in the second and third year after death; either emergence was delayed or there was a reinfestation by emerged adults ovipositing in the same cones from which they emerged.

One lot of sugar pine cones killed by cone beetles in 1914 showed no emergence in 1914 or 1915, but 232 adults emerged in 1916 between June 18 and July 16; then in 1917, 225 adults emerged

between June 20 and July 2. Larvae were still found feeding in the old dry cones in December 1917, in March 1918, and in January 1919. So it is obvious that these larvae may live for several seasons or may reinfest suitable material for several years.

From several lots of material the record of beetle emergence as related to year of death of cone (cone-crop year) was as follows:

*Ernobius beetle emergence*

Lot:	Year of cone killing Number	1st year after death of cone Number	2d year after death of cone Number	3d year after death of cone Number
1 -----	0	1	23	—
2 -----	0	0	27	—
3 -----	1 <sup>1</sup>	10	27	—
4 -----	0	0	4	—
5 -----	0	0	9	5
6 -----	0	128	573	—
7 -----	0	1	321	—
8 -----	0	0	232	225

<sup>1</sup> Parent adults.

Only lot 6 showed any large number of beetles emerging in the first year after the cones were killed. Most emergence occurred in the second year.

***Ernobius punctulatus* (Lec.)**

*Description.*—The adults are reddish-brown, shining beetles, 2.5 to 4.5 mm. long; ninth joint of antennae shorter than the 3 preceding united, and joints 6 to 8 always less than twice as long as wide.

*Hosts.*—Cones of *Pinus attenuata*, *P. ponderosa*, *P. radiata*, and *Pseudotsuga menziesii*.

*Distribution.*—California, Oregon, and Washington.

*Notes.*—Recently killed cones are often infested with these beetles. Larvae have been found in June in 1-inch long cones. They feed on the dead cone tissues during the fall and winter, and adults emerge the following May, June, and July. There appears to be one annual generation.

Damage is not important; these insects do not attack green cones but feed on the tissues of dead cones or those blighted by cone beetle or other insects.

In the rearing notes, this species was often confused with *E. pallitarsis* with which it frequently associates. It apparently has the same general habits and seasonal history.

***Ernobius* spp.**

Other species of the genus were reared from cones of Sitka spruce and Douglas-fir. The species were not determined.

**FAMILY ANTHICIDAE**

The adults of this family are mostly found in flowers, but some are found in rotten wood and others in burrows in sandy places near water. None of them is known to be in any way injurious.



***Anthicus nitidulus* Lec.**

*Description.*—The adults are small brown beetles, 2 mm. in length, with narrow reddish-brown head and prothorax and often with the basal portion of elytra reddish brown or tan in color.

*Hosts.*—Cones of *Pinus ponderosa* (abundant); also in cones of *Pseudotsuga menziesii* and seeds of *Fraxinus latifolia*.

*Distribution.*—California and southern Oregon.

*Notes.*—Adults of this species overwinter in dry cones killed by ponderosa pine cone beetles and in other places. They emerge in large numbers during February, March, and April. Cone-cutting tests showed 4 to 33 adults per cone. The larvae were not found, and it appears that the overwintering is a hibernating habit. For some unknown reason none of these ever emerged from sugar pine cones.

***Notoxus constrictus* Casey**

*Description.*—The adults are small, light-brown beetles 3 to 4 mm. long, with a very peculiar hornlike projection of the prothorax covering the head, which is turned downward nearly at right angles to the body. The wing covers have two brown dots near the base and an irregular, dark brown to black band across the elytra two-thirds of the distance from the base to the apex.

*Hosts.*—Cones of *Pinus ponderosa* and *Pseudotsuga menziesii* and seeds of *Acer macrophyllum* and *Fraxinus latifolia*.

*Distribution.*—California, Oregon, and British Columbia.

*Notes.*—During the winter, adults were found in dead cones of the preceding year. They emerged at varying times but usually from March to May. The larvae were not noted. It is assumed that presence in the cones is a hibernating habit. According to Essig (17, p. 391) a common habit of the adults is to feed on injured fruit in the orchards of California.

**FAMILY BOSTRICHIDAE*****Stephanopachus zobrinus* Casey**

The adults are small, dark-brown beetles 2.5 to 3 mm. in length, with the pronotum extending over the head and covered in front with prominent rugosities. Superficially they look very much like Scolytidae. Very little is known about the habits of this species. Thirteen adults were collected and reared from beetle-killed cones of singleleaf pinyon near Baldwin Lake, San Bernardino National Forest, Calif., by J. E. Patterson and S. T. Carlson, on March 28, 1938. Scattered emergence continued until June 20, 1938. Like other members of the genus, they probably feed on dry cone tissues and reduce them to powder.

**FAMILY BUPRESTIDAE*****Chrysophana placida conicola* Van Dyke flatheaded cone borer**

*Description.*—This is one variety of a common flatheaded borer that has the unique habit of boring in hard dry cones.

The adults are beautiful metallic beetles 12 mm. long and 4 mm.

wide. The thorax is coppery or golden with coppery reflections. The elytra are deep green, with a broad coppery stripe down the center of each elytron. The ventral surface is golden green.

*Hosts.*—Old hard, dry cones of *Pinus attenuata* and *P. coulteri*.

*Distribution.*—Through the range of the hosts in California and southern Oregon. Type locality Mount St. Helena, Calif.

*Character of damage.*—The larvae bore flatly oval mines in old solid cones on living trees (fig. 2). Most of the mining is done around and in the pith. Seeds do not seem to be injured except



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FIGURE 2.—Knobcone pine cone sectioned to show larvae and work of the flatheaded cone borer, *Chrysophana placida conicola* Van D.

incidentally as mines are made. Mines apparently start at the base of the cone on the stem and proceed up and around the pith. The mine eventually extends nearly to the surface of the cone and then the larvae retreats and plugs up the mine to form a pupal cell in the pith. The exit hole is usually near the base of the cone. Several larvae in different stages of development may be found in a cone.

*Seasonal history.*—The seasonal history has not been definitely determined. New adults apparently require several years to develop from the eggs, and cones from 2 to 4 years old contain small, medium, and large larvae and new adults. Adults have been found emerging from cones during March and April. Fresh pupae have been found in July, and newly formed adults in August. In September adults have been noted flying abundantly in a dense young knobcone pine stand and resting on newly formed cones. Large larvae and adults have been found in cones during the fall and winter months. From the evidence at hand, the species does not seem to have a well-defined seasonal cycle. Attack and emergence may occur at almost any time through the spring, summer, and fall months.

*Parasites.*—No predators or parasites of this species have been determined.

#### FAMILY CERAMBYCIDAE

##### *Paratimia conicola* Fisher

##### roundheaded cone borer

*Description.*—This is a unique species which bores in the hard, dry cones of knobcone pine. The adults are slender, rusty-reddish brown beetles 7 to 12 mm. long, with nearly black pronotum and antennae three-fourths as long as the body.

*Host.*—Cones of *Pinus attenuata* and *P. bolanderi*.<sup>6</sup>

*Distribution.*—Southern Oregon and California throughout the range of the host trees.

*Character of damage.*—The larvae bore through the dry cones of the host trees (fig. 3) after the cones have matured, even those 8 years or more old. Several larvae or adults, at least 5, may be found in a single cone. One record showed 32 percent of the seed destroyed. The mines of this species appear to go out much farther in the scales than do those of *Chrysophana*. The two species are often found working together in the same cones. Exit holes are found more toward the top of the cones, and adults face upward toward the tip.

*Life history.*—Although 12 different collections and rearings of this species were made, the records are not sufficient to reconstruct the life history. Larvae and adult beetles were found during the winter months. Emergence often occurred in March and April. Small larvae were also found in April. The time required for the species to mature was not determined.

*Parasites and predators.*—Several parasites and predators were found associated with this beetle. They include:

<sup>6</sup> A California coastal form of *Pinus contorta* var. *contorta*.



FIGURE 3.—Knobcone pine cone sectioned to show larva and tunnels of the roundheaded cone borer, *Paratimia conicola* Fisher.

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Hymenoptera

Family Gasteruptiidae

*Aulacostethus californicus* Townes Reared from *Paratimia*.

*Aulacostethus editus* (Cress.) Pupae found in pupal cell of *Paratimia*.

Family Ichneumonidae

*Poemenia americana* (Cress.) Pupae in cells of *Paratimia*.

Family Spheoidea

*Passaloeus melanognathus* Roh. A predatory wasp.

Coleoptera

Family Cleridae

*Cymatodera ovipennis* Lec. Adults collected from galleries of host.

*Enoclerus eximius* Mann. Adults collected from galleries of hosts.

The extent of parasitism was not determined, but these same species were repeatedly reared from *Paratimia* infested cones. (See discussion of these species under Hymenoptera in the annotated list.)

***Phymatodes nitidus* Lec.**

This cerambycid is a shiny, dark reddish-brown beetle with two conspicuous oblique white bands across the elytra. Length, 5-7 mm. The larvae work in the wood of limbs and trunks of dead or dying Monterey cypress, incense-cedar, redwood, giant sequoia, and related cupressine trees. According to a record furnished by Dr. E. G. Linsley, it has been found mining in redwood cones.

**FAMILY CHRYSOMELIDAE**

***Diabrotica undecimpunctata undecimpunctata* Mann.**

One adult of this species was reared from a lot of stems and seeds of Oregon ash. It probably was a stray which normally feeds on leaves.

***Epitrix subcrinita* (Lec.)**

These small black flea beetles were reared from a lot of caged stems and seeds of Oregon ash; they emerged early in October. Nothing is known concerning their habits on ash, other than that they feed on ash leaves.

**FAMILY CLERIDAE**

The beetles of this family are important predators of various insects, particularly other beetles. The following were reared from cones and seeds.

***Cymatodera ovipennis* Lec.**

*Description.*—The adults are light-brown beetles 7-11 mm. long with narrow pronotum and tapering wing covers crossed by a pale band. Their long legs give them an antlike appearance. They apparently prey on a wide variety of insects as they have been reared from a large number of host trees.

*Habitat.*—*Abies magnifica* var. *shastensis*. *Pinus attenuata*, *P. jeffreyi*, *P. ponderosa* (abundant), and *Pseudotsuga menziesii*.

*Hosts.*—*Cymatodera* has been found in the galleries of *Paratimia conicola*; also, feeding on the ponderosa pine cone moth *Laspeyresia piperana* (Kearf.); probably preys on other species.

*Distribution.*—Throughout California and southern Oregon.

*Notes.*—Very little was learned of this species' seasonal history or habits. Larvae and adults were found in cones where they were preying upon *Laspeyresia* and *Paratimia*. Adults emerged from January to May.

***Enoclerus cupressi* Van Dyke**

*Description.*—The adults are black, pubescent beetles about 7 mm. long with red dots at the base of each elytron and a broad red band across the middle.

*Hosts.*—Reared from cones of Monterey cypress infested with various species of cone moths, such as *Lespeyresia cupressana* (Kearf.), *Henricus macrocarpa* (Wlshm.), *Epinotia hopkinsana cupressi* (Hein.), and *Ernobius cupressi* Van Dyke. Larvae and adults were found hunting through the cones for their prey. Emergence of adults occurred from February to June.

*Distribution.*—Found only on the Monterey peninsula in the native groves of Monterey cypress.

***Enoclerus eximius* Mann.**

*Description.*—The adults of this species have black pronotums, and red elytra, with a central spot of black and with broad bands of black on the apex crossed with a narrower gray band. Length, 6–8 mm.

*Hosts.*—Larvae and adults were found preying upon *Paratimonia conicola* and *Chrysophana placida* in *Pinus attenuata* cones. Normally it preys upon ptinid beetles in trees with relatively soft wood, such as alder, California laurel, and poplar.

*Distribution.*—Through California and southern Oregon.

***Enoclerus humeralis* Schaeffer**

*Description.*—A small black species with red spots at the humeri of the elytra. Length about 4 mm. The larvae are small and pink.

*Hosts.*—This species was reared in large numbers from cones of *Abies concolor* and *Pseudotsuga menziesii*; a few emerged from cones of *Pinus ponderosa*, *Picea sitchensis*, and *Cupressus macrocarpa*.

The number of cone insects preyed upon by this species was not determined. It was definitely found feeding in a cocoon of *Barbara colfaxiana siskiyouana* (Kearf.) in white fir cones and on *Laspeyresia* species in ponderosa pine cones. It was presumed to feed on other cone insects. Emergence of adults occurred mostly from late May through June and July.

### FAMILY COCCINELLIDAE

A few ladybird beetles were reared from insect-infested cones where they were probably hibernating. They normally prey on aphids and scales, which are not found in cones. The following species emerged from cones:

***Cleis picta* var. *contexta* Muls.**

*Description.*—The adults are small, nearly hemispherical ladybird beetles, pale yellow in color with brown mottling on the elytra, or plainly drab in color; black spots on the pronotum. Length, 3–4 mm.

*Hosts.*—These beetles emerged in large numbers from caged cones of *Pseudotsuga menziesii* infested with cone moths. Emergence was from March 15 to April 15, of the year following cone maturity. This was probably a hibernating habit as the species feeds primarily on aphids. It was also reared from beetle-killed cones of *Pinus ponderosa*.

***Hippodamia convergens* Guér. convergent lady beetle**

The adults are medium-sized ladybird beetles, 5-8 mm. long, greenish brown to orange usually with six black spots in each elytron; the pronotum black, rimmed with a yellow band and two oblique white marks. One adult emerged from a lot of beetle-killed ponderosa pine cones and another from Douglas-fir cones. This is a common species in North America, often hibernating in large quantities at high altitudes.

***Olla abdominalis* (Say)**

A pale grayish yellow, nearly hemispherical beetle with numerous small black spots. Length 5 mm. Emerged from beetle-killed cones of ponderosa pine in October and again in April at Placerville, Calif.

***Psyllobora viginti-maculata* var. *taedata* Lec.**

The adults are small, 2.0-2.5 mm. long, light-brown beetles with irregular darker markings. It is a common species in the West. One adult emerged from Douglas-fir cones from southern Oregon.

**FAMILY CRYPTOPHAGIDAE*****Cryptophagus brevipilis* Casey**

The adults are small light-brown beetles, 2 mm. long. The habits are unknown. Nineteen adults emerged from May 20 to June 16 from one lot of Shasta red fir cones collected in southern Oregon.

***Henoticus californicus* (Mann.)**

These are very small shiny light-brown beetles, 1.5 mm. long, which emerged from cones of white fir, Douglas-fir, and Monterey pine in California and southern Oregon during June and August. Habits of the larvae were not determined.

**FAMILY CURCULIONIDAE*****Apion porosicolle* Gemm.**

These small black weevils, 2.5 mm. long, emerged in October from seeds of Oregon ash at Ashland, Oreg., a few days after the material was collected. Their habits were not determined. They were probably feeding on stems and leaves.

***Conotrachelus* sp.**

Little (50) reports that the "larvae of small weevils (of this genus) are common and destructive in second year pinyon cones in June and July."

***Curculio* spp. (= *Balaninus* spp.) nut and acorn weevils**

Nuts and acorns of various western hardwoods are frequently infested by the curled white legless grubs of the genus *Curculio* (6). The adults are medium-sized, yellow, brown, or nearly black weevils with robust bodies, long legs, and prominent slender, curved, or nearly straight beaks. The adults appear in the summer. With their beaks they gnaw holes in the shells of new acorns or nuts and place their eggs through these into the nut. The larvae

feed on the meat and destroy the seed. They mature about the time the nuts begin to fall. The winter is passed in the larval stage, either within the acorn or in the ground. Pupation occurs the next spring in the ground and the adults emerge in the summer from July to October. Rearing records indicate that a part of the brood may hold over as full-grown larvae and not pupate and emerge until the second summer.

Several species of *Curculio* have been described from the Western States; of these, only *Curculio uniformis* (Lec.) was reared at the Ashland Laboratory.

***Curculio uniformis* (Lec.)**

filbert weevil

*Description.*—The adults are light brown speckled with darker brown and recumbent scales. Length, 5 to 7 mm. The overall color is bright bay or tan. They may destroy from 20 to 60 percent of the acorn crop.

*Hosts.*—Reared from acorns of *Quercus dumosa*, *Q. chrysolepsis*, *Q. kelloggii*, *Q. wislizenii*, *Q. agrifolia*, *Q. garryana*, *Q. lobata*, and *Lithocarpus densiflora*. Reported in literature from other oaks within its range and from filberts and hazel nuts.

*Distribution.*—California and southern Oregon. Also reported in literature from Washington, Utah, and New Mexico.

*Seasonal history.*—The adult female makes a small hole in an acorn, along the line at the top of the cup, with her beak. In this, 1 or 2 eggs are deposited. These are smooth, nearly white, nearly transparent and slightly pointed at one end. They measure about 0.71 x 0.51 mm. or 0.81 x 0.50 mm. Oviposition occurs in August and September. The larvae develop and feed on the kernel (fig. 4). By November they are full grown, and late in the month they abandon the acorns and enter the ground to pupate. They may be found from about 1 inch below the surface to as much as 6 inches below in leaf mold under the oak trees. Emergence occurs in the summer of the following year. There is one generation annually.

*Parasites and predators.*—None was reared from this species.

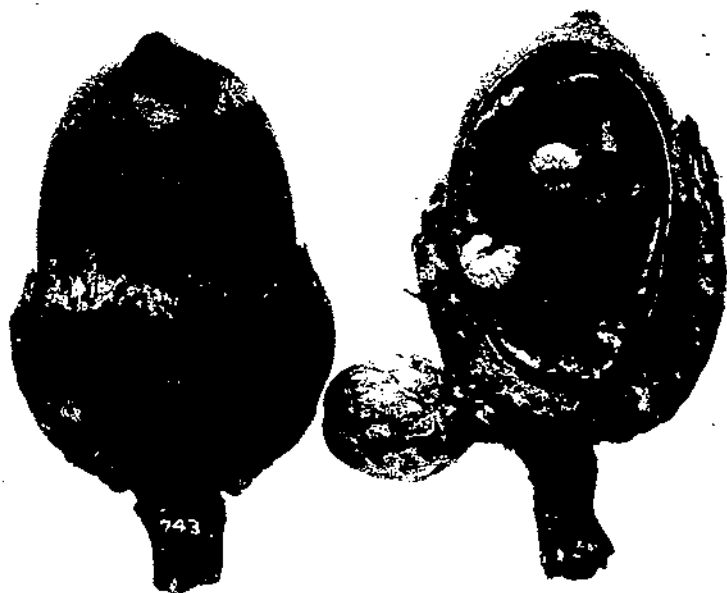
*Control.*—The grubs may be killed in acorns by fumigation with methyl bromide without injuring the fertility of the seed. Recommended dosage under 27- to 29-inch vacuum at 70° F. is 4 pounds per 1,000 cubic feet for 2 hours. At 50° to 70°, increase exposure to 4 hours.

***Curculio aurivestis* Chittn.**

Another *Curculio*, similar to *C. uniformis*, is 6.8 mm. long and 3.0 mm. wide, with bright golden-yellow, dense vestiture, strongly irregularly banded with brown on the prothorax and with the ventral surface pale ochreous. It has an extremely long slender beak. The type locality is Mount Wilson, Calif., but according to records of the United States National Museum this species has been reared from acorns from California, Oregon, and Washington.

Chittenden (6) has described and reported 3 other species of *Curculio* from local areas in central and southern California, and





EPG-1966

FIGURE 4.—The filbert weevil, *Curculio uniformis* (Lec.), and its damage in California black oak acorns,  $\times 2$ .

14 additional species from oaks in Arizona, New Mexico, Colorado, Utah, and Texas.

***Dirotognathus* sp.**

These small rusty-brown weevils, 2–3 mm. long, emerged from one lot of Douglas-fir cones collected near Placerville, Calif. Emergence of eight weevils occurred between April 15 and May 15. Nothing is known concerning their habits. (Collection: Hopkins U. S. No. 11475g.)

***Thysanocnemis* n. sp. near *helvola* Lec. ash seed weevil**

**Description.**—The adults are small, chunky, golden-yellow weevils 3 mm. long. They breed in the seeds of ash and destroy the kernel. Counts showed 45–50 percent of the seed crop destroyed.

**Host.**—Reared from *Fraxinus latifolia*, probably attacks other species of ash within its range.

**Distribution.**—California and western Oregon.

**Seasonal history.**—Adults attack the new crop of seeds in late summer. Larvae feed and develop in the seeds (fig. 5). When full grown, they leave the seeds and drop to the ground to pupate. Some may do this in the fall, but one February full-grown larvae were found in the seeds and leaving to pupate. Emergence occurs late in June and through July.

**Parasites.**—They are heavily parasitized by an undetermined chalcid.

**Collections.**—Hopkins U. S. Nos. 14202a, 14295a, 15779a.

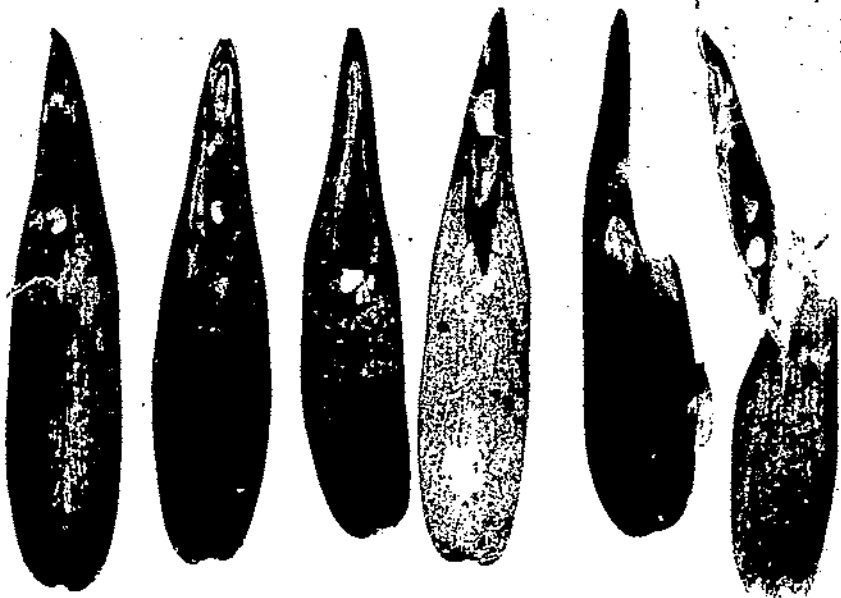


FIGURE 5.—Seeds of Oregon ash infested with larvae of the ash seed weevil, *Thysanocnemis* sp.

BRQ 2156

#### FAMILY LATHRIDIIDAE

The beetles of this family are, for the most part, scavengers occurring under bark and stones or in vegetable debris, especially decaying leaves, but some of the species are also found in drugs and other commercial products. The food habits of many of the larvae are unknown. Some feed upon various molds. (78).

##### *Corticaria* sp.

The adults are very small, brown beetles about 1.5 mm. in length, which occurred in and emerged from cones of ponderosa pine and Douglas-fir, in southern Oregon. Adults were found in cones in the fall and winter of the year the cones matured. They emerged in March and April of the following year. Eggs, larvae, and pupae were not found. Apparently this was a hibernating habit. From 1 to 2 adults were found per cone. (Collections: Hopkins U. S. Nos. 12532r-3, 12534f, 13205d, 14224d from ponderosa pine; 10808c-3, 10874h, 12584i, 14220m from Douglas-fir.)

##### *Lathridius protensicollis* (Mann.)

These are also small brown beetles about 2 mm. in length. Five adults emerged from one lot of ponderosa pine cones collected from Silver Lake, Oreg. As they emerged in January in the laboratory from cones collected in August, it is assumed that they were hibernating in the cones.

##### *Melanophthalma distinguenda* (Com.)

These small brown beetles emerged in the middle of October from bigleaf maple seeds collected and caged 2 weeks before.

The species of this genus feed on molds and hence are not true cone insects.

***Microgramme arga* (Reitt.)**

These small beetles were reared from dry cones of western redcedar collected at Wind River, Wash., August 13, 1915, by J. E. Patterson. On November 17, 1916, 26 adult beetles emerged. Their habits were not determined.

**FAMILY PTINIDAE**

***Ptinus fur* L.**

**white-marked spider beetle**

The adults of this species are small, 2-4 mm. long, reddish-brown beetles densely covered with short yellow hairs and with four white bands on the elytra. It is a common storeroom pest and was reared from several lots of cones, including ponderosa pine (Pacific Coast and Rocky Mountain forms), western redcedar, and bigleaf maple, from California, Oregon, and Colorado. Nothing was learned of its larval habits, but it is known to feed on dry vegetable and animal material of many kinds.

**FAMILY SCOLYTIDAE**

***Conophthorus* spp.**

**cone beetles**

Pine cones that dry and wither before they are half grown are often called "blighted cones." Cone beetles are usually the cause of this type of damage, which is distinguished by the dying of the immature cones soon after starting their second year's growth. These blighted cones are less than half the size of a normal cone and are withered and faded. In some years from 25 to 75 percent of the cone crop of some pines have been killed by these beetles over large areas.

The adults are small, dark, often shining, cylindrical beetles from 1.25 to 4.00 mm. in length. The cones are killed by the attack of the adult, which bores a small tunnel into the base of the cone stem and then through the axis of the cone. In this tunnel the eggs are deposited singly in niches at intervals on each side. The niches are then packed with sawdust. The larvae are small, white, curled, wrinkled, legless grubs from 2.0 to 4.5 mm. long. They feed on the scales, seeds, and tissues of the withering cone and often completely honeycomb the interior. On completing their development, they transform to pupae and then to new adults, within the same cone where they overwinter. There is one generation a year.

This group of small beetles belonging to the Family Scolytidae represents a unique genus, for all of the species have this cone-boring habit. Some also bore into and kill terminal twigs. All of the western species have been described by A. D. Hopkins under the genus *Conophthorus* (37).

These beetles are lacking in conspicuous parasites and predators. So far only a few records of rearings from infested cones suggest parasitism, but none has been conclusive.

Miller (59) suggested that the ponderosa- and sugar-pine cone beetles might be controlled if the fallen infested cones containing the overwintering broods of beetles be raked up and burned during

September, October, and November, particularly on burned or cutover areas where seed supply was needed. This obviously would be a laborious and expensive undertaking, and no one has determined whether it would be practical or effective.

Now that DDT and similar chemicals are available, it has been suggested (46) that an aerial spraying during the period of attack in May and June might offer protection to the new second-year cones during this vulnerable period.

A general discussion of cone beetles has been given by Miller (58), Keen (45, 46), and by Doane, Van Dyke, Chamberlin, and Burke (12).

Key to Western Species of *Conophthorus*

(Adapted from Hopkins (37))

The Genus *Conophthorus* Hopk. is distinguished from *Pityophthorus* Eichh. by the absence of sutural septa in the antennal club.

1. Elytral declivity with striae 1, 2, and 3 punctured; interspace 3 smooth;
  - Head, prothorax, base of elytra, and ventral area dark; remainder of elytra red. Length 1.25-2.75 mm. Cones of *Pinus edulis*
    - C. edulis* Hopk.
  - Elytral declivity with stria 1 not punctured, 2 and 3 approximate and faintly punctured; interspace 3 rarely without granules. . . . . 2.
2. Elytra with stria and interspatial punctures equal or subequal in size and density on dorsal and lateral areas. . . . . 3.
  - Elytra with stria and interspatial punctures unequal in size and density, those of the interspaces smaller and sparsely placed, especially on the dorsal area. . . . . 5.
3. Interspaces 3 of elytral declivity with distinct granules, the declivity not strongly impressed;
  - Elytra with stria punctures in obscure to distinct rows on dorsal area; declivity with interspaces 1 smooth, 3 granulate; pronotum dark, elytra reddish; length 3.50-3.85 mm. Cones of *Pinus ponderosa*. Pacific Coast region. . . . . *C. ponderosae* Hopk.
4. Interspaces 3 of the elytral declivity without granules, or obscure. . . . . 4.
  - Elytral declivity not strongly impressed;
    - Pronotum dark; elytra reddish brown; front broad. In cones of *Pinus ponderosa scopulorum*. Colorado, Arizona, and New Mexico
      - C. scopulorum* Hopk.
    - Elytral declivity strongly impressed;
      - Pronotum dark; elytra dark reddish. Length 3.50-3.90 mm. In cones of *Pinus engelmannii*. Arizona. . . . . *C. apachecae* Hopk.
5. Elytra with stria punctures in obscure rows on lateral area. . . . . 6.
  - Elytra with stria punctures in distinct rows on lateral area. Black, shining; declivity with interspace 1 smooth. Length 2.85-3.95 mm. In cones of *Pinus lambertiana*. Southern Oregon and California
    - C. lambertianae* Hopk.
6. Pronotum with punctures of posterior area fine; punctures of elytra distinct; those of the striae rather dense. . . . . 7.
  - Pronotum with punctures of posterior area coarse. . . . . 8.
7. Declivity with interspaces 1 granulate; pubescence moderately long, erect. Black, shining, front broad. Length 2.40-3.60 mm. In cones of *Pinus radiata*. Monterey County, Calif. . . . . *C. radiatae* Hopk.
  - Declivity with interspace 1 smooth, except toward apex, pubescence long.
    - Blackish brown, shining. Length 3.10 mm. In cones of *Pinus contorta*. Coastal Oregon. . . . . *C. contortae* Hopk.
    - Pronotum black; elytra black to reddish brown. Length 2.95-3.45 mm. In cones of *Pinus monticola*. Idaho and Canada
      - C. monticolae* Hopk.

8. Elytra with punctures of dorsal area fine, not impressed.  
 Declivity with interspaces 1 smooth. Black, shining. Length 2.95-  
 3.20 mm. In cones of *Pinus monophylla*. California  
*C. monophyllae*. Hopk.  
 Elytra with punctures of dorsal area coarse, impressed.  
 Dull black. Length 3.15 mm. In cones of *Pinus flexilis*. Colorado  
*C. flexilis* Hopk.

***Conophthorus apacheae* Hopk. Apache-pine cone beetle**

This species was described by A. D. Hopkins (37) from cones of Apache pine in the Chiricahua Mountains, Ariz. It is similar in most respects to *C. ponderosae* and like *C. scopulorum* is doubtfully distinct from *C. ponderosae*. No collections of this species have been recorded by us and hence no biological information is available. It may be assumed to have the same life history and habits as *C. ponderosae*.

***Conophthorus contortae* Hopk. lodgepole cone beetle**

*Description*.—A cylindrical, blackish-brown, shining beetle 3.1 mm. long (37).

*Host*.—Cones of *Pinus contorta* var. *contorta*. So far, not found in lodgepole pine, *Pinus contorta* var. *latifolia*.

*Distribution*.—Newport, Oreg. Probably to be found through the coastal range of shore pine in California, Oregon, and Washington.

*Character of damage*.—A rare species of little or no importance. It attacks and breeds in killed or blighted cones of shore pine.

*Life history*.—Seasonal history has not been determined. Adults are found in blighted cones in October. Probably second-year cones are attacked by parent adults in the spring, larvae develop in blighted cones during the summer, transform to new adults before fall, overwinter in the cones, and emerge the following spring.

***Conophthorus edulis* Hopk. pinyon cone beetle**

*Description*.—This is the smallest of the cone beetles, averaging from 1.25 mm. to 2.75 mm. in length. The head, prothorax, base of elytra, and ventral area are dark; the remainder of elytra is dark red (37).

*Host*.—Cones of *Pinus edulis*.

*Distribution*.—Arizona, New Mexico, and Colorado. Probably throughout the range of pinyon.

*Character of damage*.—These beetles attack small cones in their second year, abort them so that they are only one-fourth to one-half normal in size, and then riddle the interior (fig. 6). The cone dies and turns brown early and does not open its scales in the autumn. The damage is heavy at times, up to 90 percent of the cones being destroyed on some areas (50, 51).

*Life history*.—Parent adults attack small second-year cones in May and June. They first bore into the stalk at the base and extend egg galleries into the axis of the cone where eggs are laid. Larvae develop during July and August and pupate in August. New adults form in late August and overwinter in the cones, feeding on the dead tissue and honeycombing the interior. From



FIGURE 6.—Pinyon cones infested with the pinyon cone beetle, *Conophthorus edulis* Hopk.

5 to 20 adults may be found in each cone. They emerge the following spring in April and May, leaving several small round holes, one-thirty-second inch in diameter, in the outside of the cone.

*Parasites.*—A small black pteromalid wasp *Aceroccephala atroviolacea* Crawford, 3 mm. long, with a purple luster, has been reared from cones infested with *C. edulis* and is presumed to be parasitic on this cone beetle.

***Conophthorus flexilis* Hopk.**

**limber-pine cone beetle**

*Description.*—A dull black, cylindrical beetle about 3 mm. long. Larvae same as other *Conophthorus* (37).

*Host.*—Cones of *Pinus flexilis*.

*Distribution.*—Southern Rocky Mountain region, and possibly through the range of the host tree. Type locality: Mount Manitou, Colo. Also reared from Boulder and Cheyenne Mountain, Colo., and from Shell, Wyo.

*Damage.*—Heavy damage, up to 80 percent of cones killed on 1 tree and 60 percent of the crop infested, has been reported in some years; 5 percent reported infested in other years. Cones are dwarfed and blighted by cone-beetle attack.

*Life history.*—Parent adult beetles attack small second-year cones in May or June and extend egg gallery into axis of cone, thus killing it before it matures. More than one cone may be attacked by a pair of beetles. Larvae develop in the cones during July and August. Pupae form during a short period in August, and then by the last of August and during September the new adults appear. These remain in the blighted cones over winter, feeding to some extent on the dead scales and seeds (fig. 7), and emerge the following spring. There is one generation a year.

***Conophthorus lambertianae* Hopk.**

**sugar-pine cone beetle**

*Description.*—A black, shining cylindrical beetle 2.85–3.95 mm. long, found in aborted cones. The larvae are small, white, wrinkled, legless grubs 3–4.55 mm. long when full grown.

*Hosts.*—Cones and twigs of *Pinus lambertiana* and *P. monticola*.

*Distribution.*—Throughout the range of sugar pine in southern Oregon and California. Type locality, Hilt, Calif. (37).

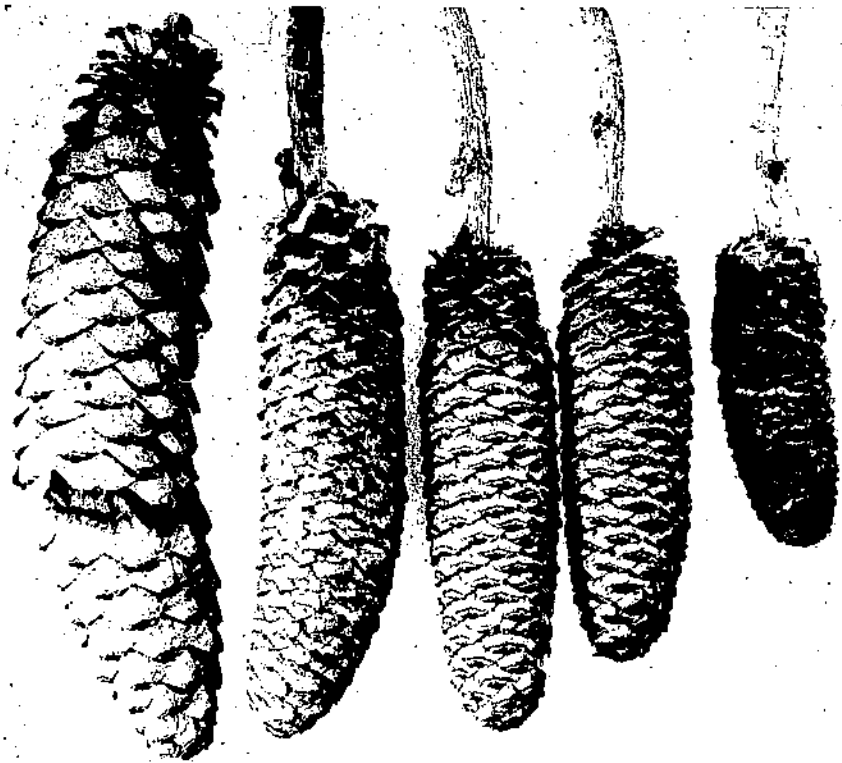


EPQ-7617

FIGURE 7.—A cone of limber pine sectioned to show work and adults (arrows) of the limber-pine cone beetle, *Conophthorus flexilis* Hopk.

*Damage.*—This is the most destructive species of cone beetle in the West. In many localities it has killed 90 percent or more of the cone crop in some years. Hall (28) reported 75 percent of sugar pine cones aborted by cone beetle in northern California in 1954. The damage, however, is variable from tree to tree, area to area, and year to year. A heavy build up of cone beetle in years of good crops apparently prevents one good crop from being followed by another (26). Second-year cones are attacked while they are immature and between 2½ and 8 inches long. Beetles bore into the stem of the cone and then extend an egg gallery through the axis, thus killing and blighting the cone (figs. 8 and 9). About 4 weeks after attack, the cones fall to the ground and in these the adult beetles overwinter. Struble (73) has also reported the sugar-pine cone beetle as causing heavy flagging of sugar pine twigs in years when the beetles were abundant. The beetles bore into twigs and down through the stem for 2 or 3 inches.

Damage by cone beetles is often confused with the work of squirrels because the damaged cones fall at about the same time



EPQ-11615A

FIGURE 8.—Young cones, attacked and dwarfed by the sugar-pine cone beetle, *Conophthorus lambertianae*.

that squirrels harvest cones. The work of these two destructive agents can be distinguished by the following characteristics:

*Cone beetle damage*

1. Cones fall with entire stalk attached.
2. Stalk shows small resinous entrance hole and pitch tube of cone beetle.
3. Cones lie on ground unmolested.
4. Cones less than 8 inches long, some not over 2½ inches; seeds blighted and hollow.

*Squirrel damage*

1. Cones fall with stalk cut close to cone, and part of stalk left on limb.
2. Wound on stalk shows rodent teeth marks.
3. Cones eaten or cached.
4. Cones 10 inches or more long; seeds full size and full.

*Life history.*—Parent adults overwinter in cones killed the previous season. They emerge during late April, May, and early June and attack immature second-year cones, which are then about 2-2½ inches long and attached to the limb by a stalk 2-3 inches long, just after the cones have started their second year's growth. Miller (59) reported:

"The parent adult beetle attacks the cone by boring into the stalk of the cone. The position of this initial entrance varies greatly: Usually it is just above the base of the cone, but it may



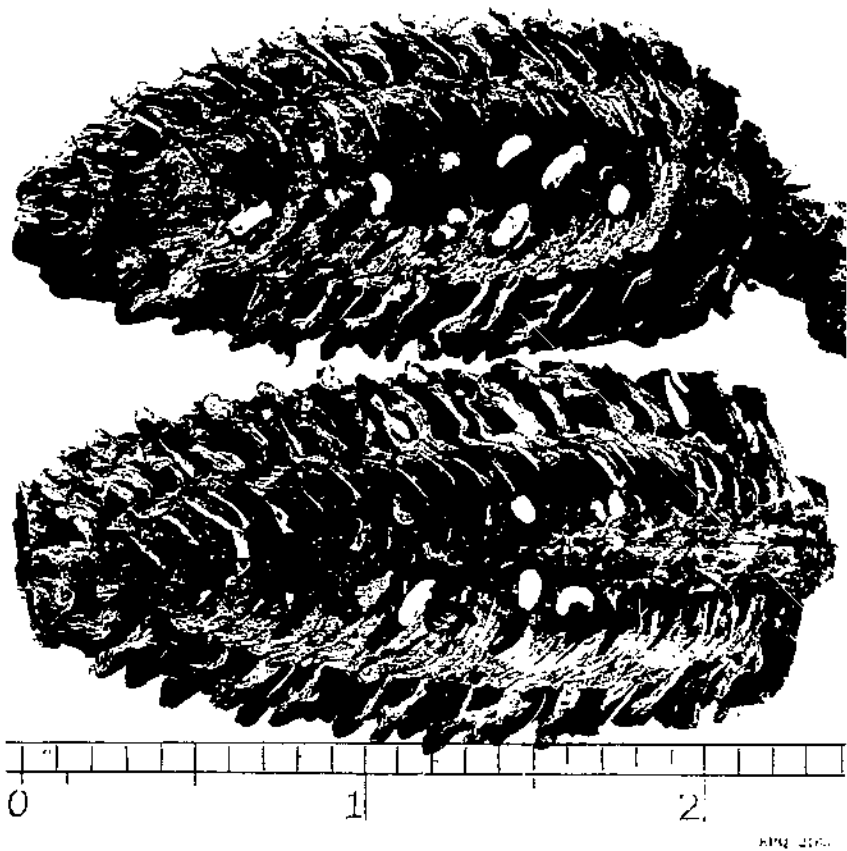


PLATE 216.

FIGURE 9.— Sugar pine cones opened to show infestation of the sugar-pine cone beetle, *Campithecus lambertianus*, larvae and pupae, and damage.

occur anywhere from the base of the cone to an inch or more above.

"The wound made by the beetle soon produces a flow of resin which gradually accumulates on the surface in the form of a small pitch tube. After boring into the center of the stalk the beetle turns toward the cone and continues to extend its tunnel straight outward through the axis of the cone. After it advances well into the heart of the cone the tunnel becomes the egg gallery, and single eggs are deposited at intervals in notches excavated along the sides of the burrow. The entire length of the egg gallery is packed with sawdust. Sawdust is also packed around the eggs in the egg notches."

(Egg galleries may be extended through the length of the small cones in a matter of 5-8 days, and eggs hatch in 1-10 days.)

"As a rule 1 pair of beetles (male and female) attack a single cone, but in some instances 3 pairs of beetles have been found advancing as many egg galleries in the same cone.

"The immediate effect of this attack on the cone is to check

all further growth. Eventually the infested cone withers, then becomes dry and hard, but for a period of time it hangs on the tree in a semimoist and souring condition. It is during this period that the eggs of the beetle incubate and the young larvae develop.

"The egg gallery is usually kept straight and close to the axis of the cone. During the early part of the season it has frequently been observed that in the small cones, from 2 to 4 inches long, the adults extend the egg gallery nearly to the outer end of the cone, depositing 4 or 5 eggs along its length, and then bore out through the scales and emerge. It has not been determined whether such emerging adults attack another cone or not, but it is reasonable to assume that this is the case. In the larger cones, from 6 to 8 inches long, which are attacked later in the season, from 15 to 30 eggs may be deposited; and as this probably represents the minimum number of eggs deposited by a pair of beetles, it is evident that very short cones do not afford sufficient length of egg gallery for the deposition of this number. Consequently a pair of parent adults may extend the egg gallery through several of the smaller cones before the egg-gallery capacity of the cone is exhausted.

"As the attack continues through the latter part of June, the size of the attacked cones keeps increasing until the larger ones are from 6 to 8 inches long. The parent adults seldom emerge from these larger cones and later in the season will be found dead in the end of the egg gallery. By the first of July the new attack is complete. At this stage the infested cones are from 2 to 8 inches long, while the normal unattacked ones are from 10 to 18 inches long. The blighted cones are brown and stand out conspicuously on the trees. The seeds seldom form when the smaller cones are attacked, whereas the seeds of the larger cones that are attacked may reach two-thirds normal size and the outer shell may harden, but they never fill or mature.

"Immediately after hatching the young larvae begin to feed upon the scales and tissues of the now withering cone. They feed in such a manner as to leave no distinct lateral larval galleries. If the cones are opened during the larval period the small white grubs may be found in any part of the cone, the axis, scales, and often in the tender milky seeds. The development of the larvae is very rapid. Pupae may be found in the cones within 4 weeks after the first attack. By the last of June the cones which contain pupae are dry, withered and reddish-brown in color. At about this stage the dry withered stalks begin to break from the limbs and the blighted cones fall to the ground. All sugar-pine cones which are attacked fall from the trees before the close of the season and the broods complete their development in these fallen cones. The pupae transform to new adults, which begin to appear by July 10, and this transformation continues throughout the summer, until by the middle of August the majority of the broods have reached the stage of new adults. Practically all of the infested cones have fallen by this time and the brood remains in these cones through the remainder of the summer and the long overwintering period.

"The new adults are not entirely dormant during this period

but feed to some extent on the dead tissue of the cone, as is apparent from the sawdust borings. The number of overwintering beetles which have been counted in a single cone varies from 1 to 36. The average, however, is from 6 to 10.

"A considerable percentage of these blighted cones will always be found in which the beetles have made the attack and completed the egg gallery, but the larvae have failed to develop. This failure of the broods is found more often in the very small and in the largest cones which have been attacked. The most successful attacks are found in the intermediate-sized cones from 4 to 6 inches in length. Some of the larger cones appear to resist the beetles by drowning them out, as some trees are capable of resisting barkbeetles. In every attack, however, the cone is killed.

"All evidence points to the existence of but one generation of this species annually. The broods develop successfully only in the immature cones between  $2\frac{1}{2}$  and 8 inches in length. The period during which the cones may be found in this stage is so short that it allows for the development of one generation only."

In some years, emergence of beetles in August and September has been noted. Just what becomes of these beetles has not been determined, except in the instance noted by Struble (73) in which they made attack upon terminal twigs.

*Parasites and predators.*—No parasites or predators have been definitely determined as preying upon this cone beetle. The repeated emergence of one species of braconid, *Eubadizon* sp., from cones infested with the sugar-pine and ponderosa-pine cone beetles suggests that this braconid may be parasitic on the cone beetle or on the powder-post beetle, *Ernobius pallitarsis*, which frequently is associated with these cone beetles in dry hard cones. In two cases a chalcid *Spathius* sp. has also been reared from cones infested with the cone beetle. Occasionally a clerid larva is found.

Miller (59) reported that one of the most important enemies of the sugar-pine cone beetle is an entomophagous fungus. He said: "In many of the cones the brood reaches the stage of full-grown larvae, pupae, or even new adults, and then dies. On an area near Sisson, Calif., in 1913, over 50 percent of the cones contained these dead broods. On one area near Coleston, Oreg., in 1914, the brood developed in only 57 percent of the attacked cones. The mortality of the developed broods amounted to 62 percent, so the broods were finally successful in but 21.6 percent of the cones attacked. While the cause appeared to be an entomophagous fungus it has not yet been reported definitely."

*Control.*—The method of control suggested by Miller (59) did not appear to be feasible and hence was never attempted. A more promising method of control became available with the development of such residual protective sprays as DDT. Aerial spraying of trees and cones with such a residual spray during the attack period in late May and June seemed to offer some promise of success.

Some experimental work along this line was undertaken in June 1953 by the Berkeley Forest Insect Laboratory in cooperation with the California Forest and Range Experiment Station and the

Stanislaus National Forest. An 80-acre tract was sprayed by helicopter with DDT at the rate of 2 pounds of DDT in 2 gallons of diesel oil per acre. The results, while not conclusive, appeared to be very favorable in protecting the cone crop.

***Conophthorus monophyllae* Hopk.**      singleleaf pinyon cone beetle

*Description.*—A black, shining cylindrical beetle 2.5–3.0 mm. long. Larvae similar to other cone beetles.

*Host.*—Cones of *Pinus monophylla*.

*Distribution.*—Ventura County, Calif. (type locality) (37), San Bernardino Mountains; probably through the range of the host tree in California, Nevada, Arizona, Utah, and Idaho.

*Notes.*—Several collections of this species have been made from cones of singleleaf pinyon in southern California, but the notes are not extensive enough for conclusions as to habits. Many adult beetles were found in March; larvae were found in January and October. It probably has a life history like that of other members of the genus. Damage to cones appears to be considerable in some years.

***Conophthorus monticolae* Hopk.**      mountain-pine cone beetle

*Host.*—Cones of *Pinus monticola*.

*Distribution.*—Idaho (type locality, Priest River), Canada (type locality, Cowitche Lake), and Washington (37).

*Notes.*—Only a few collections of this species have been made. These indicate that the character of cone damage and the beetle's life history is in every way similar to that of the sugar-pine cone beetle. For fieldmen, it is difficult to tell these species apart, and they may merely be races of the same species.

***Conophthorus ponderosae* Hopk.**      ponderosa-pine cone beetle

*Description.*—A dark brown, cylindrical beetle 3.5–4.00 mm. long; with pronotum dark and elytra reddish brown. The larvae are small, white curled, legless grubs from 3.5 to 4.5 mm. in length when full grown. They are found within the dry withered cones.

*Host.*—Cone of *Pinus ponderosa*, commonly, and rarely in *Pinus jeffreyi* cones.

*Distribution.*—Pacific Coast range of ponderosa pine. Reared locally from many localities in Oregon (type locality, Ashland) and California (37). Found in Jeffrey pine only at Waldo, Oreg.

*Damage.*—These beetles attack small immature cones in their second year of growth, bore into the axis and kill the cones, then riddle the interior. Beetle-killed cones are from 1 to 4 inches long and remain attached to the tree (figs. 10 and 11), where the reddish brown color readily distinguishes them against the green foliage. Damage is extensive but varies greatly from tree to tree and from season to season. Counts made in 1914 of 2 trees standing close together showed 8.5 percent beetle-killed cones on one tree and 46.5 percent on the other. Complete kill of cones has been noted on trees. In general, this beetle causes less damage than the sugar-pine cone beetle.

*Life history.*—Adult beetles overwinter in killed cones on the



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FIGURE 10.—Normal ponderosa-pine cones and cones dwarfed by the ponderosa-pine cone beetle, *Conophthorus ponderosae*.

tree, since only a few cones fall, and emerge from late April through May. From 1 to 20 beetles may be found in each cone, an average of 5-8 attacking second-year cones through May and early June, at a time when the cones are 1-1½ inches long. According to Miller (59). "The adults enter a cone by penetrating the scales very close to the base of the cone. Sawdust boring may be seen on the surface of the scales and quite often a tiny pitch tube collects around the entrance of the burrow. The adult does not turn directly outward through the central axis of the cone, but bores completely around the axis, forming a short spiral tunnel. This spiral twist of the tunnel before the beginning of the egg gallery is not noticeable in sugar pine, but it is characteristic of attack in yellow pine. Its result is completely to cut off the nourishment and insure the deadening of the cone, which produces the condition necessary for the development of the larvae. After completing this girdle at the base of the cone the adult extends the egg gallery out through the central axis."

Eggs deposited in notches along this gallery hatch in from 4 to 10 days and the larvae feed and develop in the dying, withering cones without making any distinct larval tunnels. Pupae form between June 1 and July 15, and new adults appear from the last of June through July. These remain in the cones overwinter, feeding to some extent on dead cone tissue, and emerge the following spring.

*Habits.*—A few attacks have been observed on small first-year



EPQ-2149

FIGURE 11.—Cones of ponderosa pine infested with the ponderosa-pine cone beetle, *Conophthorus ponderosae*, opened to show larvae, pupae, and damage,  $\times 1.5$ .

cones, but this seems to be a rare habit. Eggs are not deposited and broods cannot develop in these small cones.

Second-year cones attacked by beetles can first be noted by their turning brown and withering about the first of June. These second-year cones do not fall from the trees but turn reddish-brown and may adhere for several years after the beetles have abandoned them. Occasionally, a new brood fails to develop even though the cone is killed.

No parasites or predators have been recorded.

***Conophthorus radiatae* Hopk.**

**Monterey-pine cone beetle**

*Description*.—A small black, shining beetle 2.4–3.6 mm. long.

*Host*.—Cones of *Pinus radiata*.

*Distribution.*—Monterey peninsula, Calif. (type locality, Pacific Grove) (37).

*Damage.*—Not important; blighted cones are hard to find.

*Notes.*—Very little is known about this species because only the type collection made by J. M. Miller in November 1913 is recorded. He found only one cone containing live adults (about 18). Some cones were killed while quite small, and, Miller noted that many of the small first-year cones seemed to be killed by the feeding of this beetle.

#### *Conophthorus scopulorum* Hopk.

*Description.*—Superficially indistinguishable from its close relative *C. ponderosae*. Pronotum dark, elytra reddish brown, 3.2 to 3.5 mm. long (37).

*Host.*—Cones of *Pinus ponderosa* var. *scopulorum*.

*Distribution.*—Through the range of the variety of ponderosa pine in Arizona, New Mexico, and Colorado.

*Damage.*—The damage to ponderosa pine cones by this species is in every way similar to that of *C. ponderosae*. Collections of the 1915 cone crop in Colorado showed 33 to 75 percent of the cones infested. One record showed this beetle working in twigs like a twig beetle.

*Life history.*—Collections and rearing records show this species following the same life cycle as *C. ponderosae*. Overwintering adults emerge from killed cones in April and May, attack the small second-year cones, and develop new adults by July and August. One collection made by D. DeLeon near Evergreen, Colo., showed only parent adults and eggs present on July 5 in 25 percent of the cones. On July 11, half- to full-grown larvae were found in cones collected July 5, and the contents were practically completely mined out and brown. When collected, the cones were soft and white inside with only a single egg gallery. Seven larvae were counted in one cone. *Conophthorus* adults were found hibernating in the bark of a green tree in November, by D. DeLeon and C. L. Massey.

#### *Conophthorus* spp.

#### other cone beetles

Several cone beetles not identified as to species have been collected from pines. These include:

*Conophthorus* sp. From bristlecone pine, Hermit Peak, Santa Fe National Forest, N. Mex.

*Conophthorus* sp. From knobcone pine, Gasquet and Monumental Pass, Calif. Two collections of cone beetle have been made from this tree.

*Conophthorus* sp. From foxtail pine, Bishop Creek, Inyo National Forest, Calif. Two collections made from this tree.

*Conophthorus* sp. From Washoe pine, Mt. Rose, Nev. This is probably *C. ponderosae*, since Washoe pine is a close relative of Jeffrey pine.

## ORDER DIPTERA FLIES

## FAMILY CHAMAEMYIIDAE

*Leucopia* sp.

Four adult flies emerged in October from ponderosa pine cones collected in September near Larkspur, Colo. Nothing is known of their habits. (Hopkins U. S. No. 12569e.)

## FAMILY CHLOROPIDAE

*Elachiptera costata* (Loew.)

These small black flies were found in ponderosa pine cones from Ashland, Oreg., in December. Others emerged from old cones during July. Nothing was determined concerning their habits. They probably feed on the decaying parts of old cones.

*Oscinella conicola* (Greene) (= *Madiza conicola* Greene)

smaller cone maggot

*Description*.—The adults are very small shiny black flies about 1 mm. long (27); larvae small, nearly colorless maggots, 2 mm. long, abundant in wet cones, both from trees and on the ground.

*Hosts*.—Cones of *Abies concolor*, *A. magnifica* var. *shastensis*, *Pinus ponderosa*, and *P. jeffreyi*. Insects thought to be this species were collected from *P. lambertiana*, *P. edulis*, and *Picea sitchensis*. Probably found in other *Abies* cones.

*Distribution*.—California and southern Oregon. Probably more widely distributed.

*Damage*.—The larvae often riddle fir cones from end to end so that all seeds are destroyed and the cone contains nothing but a mass of larval castings. This small maggot is exceedingly destructive to cones that remain on the trees or on the ground after the first of October. Cones examined near Ashland, Oreg., in 1914 showed an almost complete destruction of the seeds in October, but no damage in September.

*Life history*.—Larvae were found in the fall (October), in the winter (December), and spring (March). They feed through the scales and seeds, completely destroying the interior of the cones. They pupate in April and adult flies emerge from the last of April to the middle of July. Maximum emergence occurred from May 13 to June 22. Empty puparia and dead adults were found on October 2, in an isolated cone put away in July. Therefore, this fly probably was two brooded, the first brood maturing during July and emerging in August, and the second brood remaining overwinter as larvae, pupating about the middle of April, and emerging principally during May and June.

## FAMILY CHYROMYIDAE

*Chyromya* sp.

Small light-yellow flies, 1.5 mm. long, were reared from Sitka spruce cones collected at Crescent City, Calif., in June 1916. The next June 15 adults emerged. The larval habits are unknown. (Hopkins U. S. No. 14266e.)



## FAMILY ITONIDIDAE

The cones and seeds of western forest trees are commonly infested with various species of resin or gall midges of the Family Itonididae (Cecidomyiidae). The small pink or red larvae of these midges emerge by the millions from mature cones put out to dry in the fall. Sometimes in the fall, but mostly in the spring, the small pink midges emerge in large quantities. On the basis of larval habits and host attacked, some 30 or more species were assumed to be represented. Of these about 15 were reared through to the adult form. Until 1955 only three species had been named by Felt from cones or berries of western conifers. In 1955, Tripp (77) reviewed species of gall midges found in white spruce cones in Canada and named two new species. Some of these may extend into the western United States. Recently the group has been studied by R. H. Foote (24), who named seven new species. There are undoubtedly other species not recognized as yet, because the adults have not been successfully reared.

In the following section, the named species are discussed in alphabetical order.

*Contarinia oregonensis* Foote

Foote (24) has named this new species from specimens reared from Douglas-fir cones from Mistletoe, Oreg., collected by P. D. Sergeant and J. E. Patterson on August 25, 1916. Larvae were found at the base of cone scales in February 1917. The notes do not show exactly what the larval habits were, but it is assumed that this is the species causing galls to form at the base of the cone scales. Emergence occurred from May 25 to June 6, 1917, and again in 1918 from April 8 to May 8.

*Dasyneura abiesemia* Foote

## fir-seed gall midge

*Description.*—Adults are large dark midges, with the third vein (R<sub>3</sub>) simple at base and straight, meeting the costa before the apex of the wing, fifth vein forked (24). Larvae are pink with a Y-shaped sclerite or breastplate, which is very prominent, and with two rounded lobes on the last anal segment. They crawl over the ground by a sort of flowing motion, thus differing from the larvae found loose on the cone scales, which travel by snapping.

*Hosts.*—Cones of *Abies concolor*, *A. grandis*, *A. magnifica*, and *A. magnifica shastensis*. Larvae probably of this species also are found in cones of *A. procera*.

*Distribution.*—Throughout the Pacific Coast range of the host trees. Reared from cones from southern Oregon south to Sequoia National Park, Calif.

*Damage.*—The larvae (fig. 12) cause galls to form in the seeds, usually near the point of attachment, and on the outside of seeds or cone scales. Galled seed may show a normal appearance but are a little lighter in color and more brittle than normal seeds. The seed galls destroy from one-half to 1 percent of the seed crop in some localities. Galls on the cone scales or seed may attach the seed to the scales and prevent the seed from falling.

*Life history.*—Not completely known. Probably similar to *Dasy-*

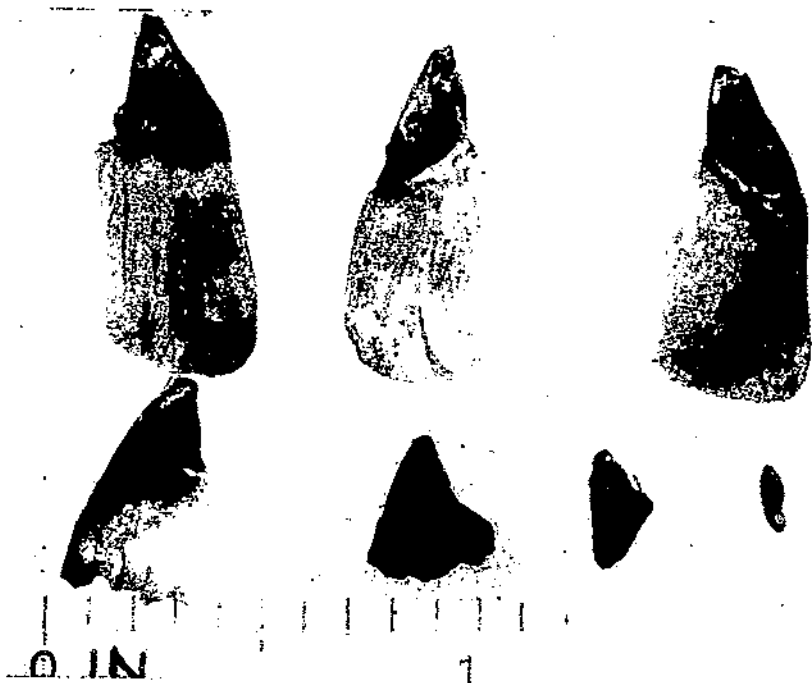


FIGURE 12.—Fir-seed gall midge larvae, *Dasynoura abiesana*, in seeds of grand fir.  $\times 225$ .

*neura canadensis*. Larvae are to be found in gall pockets on the outside of seeds and on cone scales (fig. 13) from July through October. Probably most larvae remain overwinter in their galls, while some may drop to the ground to hibernate. Pupae form in the spring, and adults emerge from April until June.

*Parasites*.—About 2 percent of the larvae are parasitized by a small chalcid *Platygaster* sp. This parasite can be found in the midge galls inside the larval skins of the midge, which turns quite brown and resembles a flaxseed.

*Dasynoura canadensis* Felt

spruce bract midge

This species was described by Felt in 1907 from white spruce cones near Ottawa, Canada. According to Tripp (77) it attacks the cone scales of white spruce (*Picea glauca*) so may be found in the western United States, Canada, and Alaska.

*Description*.—Small dark midges about 2 mm. long, the antennae usually with 15 segments; third vein of wing (R) nearly straight and meeting costa at the apex. Larvae light to dark orange color about 3 mm. long, without a breastplate, found in small galls on cone scales.

*Host*.—Cones of *Picea glauca*. Probably other species of spruce.

*Distribution*.—Not fully known. Probably throughout the range of white spruce.



FIGURE 13.—Larvae of the fir-seed gall midge in pockets on grand fir cone scales,  $\times 2$ . EPG-1956

*Damage.*—Although Tripp found this species the most prevalent gall midge in white spruce cones, the fact that it primarily infests the cone scales rather than the seed would indicate that it is not of much economic importance.

*Life history.*—The seasonal history, worked out by Tripp (77) is of interest in that it illustrates characteristics of this genus: "The eggs are deposited in lots of 2 to 3 on the scales when the cones are open for the acceptance of pollen, which usually occurs about mid-May. The stickiness of the scales at this time holds the eggs firmly in place. In 1951, a sample of 10 cones averaged 137 eggs per cone. Although nearly all eggs hatch, only a few larvae survive.

"Newly hatched larvae are inconspicuous and often difficult to locate. They burrow through the seed wings and in a few weeks small swellings appear on the inner surface of the scales. Each swelling indicates the presence of a single cecidomyiid larva. As the larva increases in size, the gall pocket is enlarged and the surrounding tissue becomes hard. By July, the gall is plainly visible from both sides of the scale. It is oblong in shape with its long axis directed along the long axis of the scale. About mid-July, the larva makes a small exit hole at the upper end of the gall. After sealing this opening with silk, it spins a tightly woven cocoon and passes the winter in this condition. Pupation occurs in late

April or early May and about mid-May the adult emerges through the exit hole made the previous autumn. The pupal skin generally remains in the cocoon but is sometimes found protruding from the exit hole.

"In common with most other white spruce cone insects, *Dasyneura canadensis* was observed to undergo diapause. Several larvae from 1950 cones failed to pupate until 1952."

***Dasyneura rachiphaga* Tripp** spruce cone-axis midge

This species, which makes small gall pockets in the rachis of white spruce cones, was described by Tripp (77) in 1955.

*Description*.—Small dark midges about 2.20 mm. long; antennae normally with about 17 segments, stemmed in the males and sessile in the females; third vein of wing ( $R_3$ ) nearly straight, meeting costa slightly before the apex. Larvae yellowish orange about 3 mm. long when full grown and without breastplate, similar to *Dasyneura canadensis*, but found in the axis of cones where they form a white papery cocoon before pupating (fig. 14).

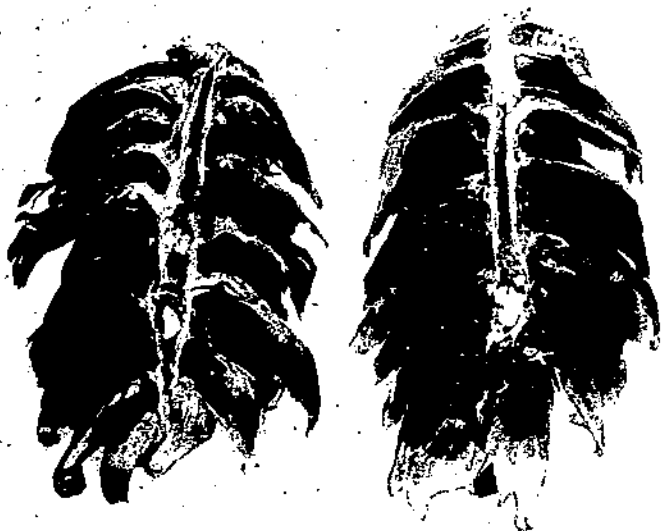


FIGURE 14.—Spruce gall midges, probably *Dasyneura rachiphaga*, in papery cocoons in pith of Engelmann spruce cones.

*Hosts*.—*Picea glauca*. A species of exactly similar larval habit is found in the axis of cones of *P. engelmanni* and *P. sitchensis*.

*Distribution*.—From eastern Canada westward through the range of white spruce into western United States, Canada, and Alaska. The species of similar habit in Engelmann spruce and Sitka spruce cones is found in Colorado, Montana, Washington, Oregon, and California.

*Damage*.—No appreciable damage to seeds was noted.

*Life history*.—According to Tripp the life cycle of this species is similar to *Dasyneura canadensis* but there is a difference in

larval habit. Eggs are assumed to be deposited at the extreme bases of the cone scales, near or on the rachis. "On hatching, each larva makes its way into the tissue at the extreme base of a scale where a small cavity is formed. As it approaches maturity it makes a small hole at the base of the scale just beneath the corresponding bract. A thin layer of silk covers the hole through which the adult eventually emerges. During the latter part of July, the larva makes a silk-lined passage into the rachis. Here it constructs a cocoon by simply sealing itself off in the blind end of the silken tube. Such cocoons are readily identified even when removed from their habitat.

"The winter is passed in the larval stage and pupation occurs in April. Adults emerge in mid-May, slightly in advance of *D. canadensis*, leaving the pupal case in the cavity or partly protruding from the exit hole."

*Parasites*.—A small, black chalcid *Platygaster* sp. was reared from spruce cones and is probably parasitic on this midge.

Collections represented by Hopkins U.S. Nos. 10849a, 10850h, 10859c, 12408c, 12509e, 12557d, 12570b, 13242a, 14284c, 14226a.

#### *Holoneurus strobilophilus* Foote

This species, recently described by Foote (24), has been reared from cones of white fir and red fir. Probably it will be found in cones of other firs. The adults emerged between April 12 and May 25 from cones maturing the previous fall. They were not definitely associated with the larvae, but these were thought to be pink larvae found loose between cone scales, where they feed upon small patches of pitch exudation.

#### *Janetiella siskiyou* Felt

#### Port-Orford-cedar seed midge

This species was described by Felt (22) from seeds of Port-Orford-cedar collected by H. E. Hoefner along the south fork of the Coquille River on the Siskiyou National Forest, Oregon, in September 1916.

*Description*.—Females with dark-reddish abdomen; length 2.5 mm.; antennae extending to base of the abdomen; sparsely haired, 17 or 18 cylindrical segments. Larvae are moderately stout pink, or pale yellowish; length 1.5 mm.; breastbone reddish brown, strongly chitinized, bidentate, the posterior extremity somewhat obsolescent; terminal segment of larvae slightly bilobed, the lobes broadly rounded.

*Host*.—*Chamaecyparis lawsoniana* cones.

*Distribution*.—Southwestern Oregon and northwestern California through the range of the host tree.

*Damage*.—Cones of Port-Orford-cedar were collected by the writer from a tree at Waldo, Oreg., in August 1914. The Hopkins No. 12544a states: "A large number of cones were examined with only a very small percentage of infestation. A pink cecidomyiid larvae with a very short, blunt Y-shaped sclerite and without anal tubercles was responsible for the entire damage. It was found in small pockets between two seeds closely fastening the seeds together and ruining both of them."

*Life history.*—Very little is recorded concerning the biology of this species. Apparently larvae develop in the fall of the year as the seeds mature. Emergence of adults takes place the following spring, in April or May.

*Parasites.*—A black chalcid parasite *Platygaster* sp. was found in the gall pockets parasitizing the midge larvae. A species of *Tetrastichus* emerged in large numbers from cedar cones placed in rearing, but its host was not specifically determined.

#### ***Lestodiplosis taxiconis* Foote**

This species of midge (24) was reared from cones of Douglas-fir collected near Ashland, Oreg., in 1914 and 1915. Emergence of adults occurred from April 20 to June 28 in the year following maturity of the cones. Larvae and adults were not definitely associated but it was thought that the larvae live loose among the cone scales and are possibly predaceous.

#### ***Mycodiplosis conicola* Foote**

Adults of this species of midge (24) were reared from white fir and red fir cones from northern California and southern Oregon. Adults emerged from April 12 to May 25 the year after cone maturity. They were small red midges with short abdomens; third vein ( $R_3$ ) of wing simple at base, widely separated from costa, nearly straight, meeting and terminating costa at the wing tip. The larvae and adults were not definitely associated.

#### ***Mycodiplosis coryloides* Foote**

This species of midge (24) was reared from cones of white fir, red fir, and Douglas-fir in northern California and southern Oregon. Adult emergence occurred from January through the spring of the year following maturity of the cones. The larvae were not recognized, but they probably occur loose in cones where they feed on fungus.

#### ***Phytophaga carpophaga* Tripp**

This species, which attacks the seeds of white spruce in Canada, was named in 1955 (77).

*Description.*—Small midges with body length about 2.4 mm.; antennae with 16 or 17 segments; tarsal claw simple; third vein of wing ( $R_3$ ) slightly curving at posterior and meeting costa slightly before the apex. Pink larvae about 3 mm. long; breastplate absent.

*Hosts.*—Cones of *Picea glauca*. Same species identified by R. H. Foote as occurring in *Picea sitchensis* and *P. engelmanni*, who states "it seems to be widespread on *Picea* spp."

*Distribution.*—Apparently following the range of white spruce in Canada, and on other spruces in Colorado, Montana, Oregon, and California.

*Damage.*—Injurious to spruce seeds, but degree of damage not estimated.

*Life history.*—According to Tripp, "Its life-cycle is similar to that of the *Dasyneura* species in the (spruce) cone. Eggs are deposited in late May, larvae spin cocoons in July, pupate in April,

and adults emerge in early May. Some larvae remain in diapause over the second summer.

"\* \* \* eggs \* \* \*" may be identified by their position near the ovule micropyles. Upon hatching the larvae work their way through the micropyles into the ovules. In a few weeks these ovules exhibit an abnormal swelling and are pale green while normal ovules are streaked with red at this stage. Gradually, as the larvae mature, the infested ovules become shiny brown, brittle, and misshapen. As they are somewhat larger than normal seeds, they are held more firmly by the scale and thus do not drop to the ground during normal seedfall. The cocoons of this species, when removed from the seed, may be distinguished from those of the other species in the cone by their larger size."

### *Rübsaamenia keeni* Foote

### cone resin midge

This resin midge (24) is common in the cones of many species of western coniferous trees, where it feeds on small patches of resin between the cone scales.

*Description.*—Adults are small light-pink midges, third wing vein ( $R_3$ ) forked at base, curved, meeting costa at or slightly before the wing tip; vein  $Cu_1$  present to base of wing; male with 12–24 pedicellate antennal joints, female with 10–26 joints. Larvae are bright red or brilliant pink, 3 mm. long when full grown; faint I-shaped breastplate and two chitinized anal appendages.

*Hosts.*—Cones of *Abies concolor*, *A. grandis*, *A. magnifica*, *A. magnifica* var. *shastensis*, *Picea engelmanni*, *Pseudotsuga menziesii*, *Pinus ponderosa*, *P. contorta*, *P. lambertiana*, and probably other trees. Larvae thought to be this species were also noted in cones of *Abies lasiocarpa*, *Picea glauca*, *P. sitchensis*, *Pinus coulteri*, *P. jeffreyi*, and *Tsuga mertensiana*.

*Distribution.*—Probably throughout the western coniferous forests.

*Damage.*—Although these resin midges are very plentiful in the cones they do little apparent damage. They may cause a small amount of resin to be formed and feed upon this, or possibly abort cones. Where they are abundant they inflict some damage by preventing the seeds from falling to the ground.

*Life history.*—Not completely known. Larvae are plentiful in cones during June, July, and August. In September when mature cones are placed on sheets to dry, the larvae fall from the cones by the millions. The larvae travel by coiling and then snapping. Normally they leave the cones about this time to go into the ground to pupate. Pupae have been found only in April of the year after the maturing of the cones, but it is evident that some of the larvae pupate in the fall because some emergence has been noted at that time.

In firs, adults emerge from maturing cones from the latter part of August to the last of October and again the next spring from March and April until the latter part of August.

In pines, larvae are found in cones during August, September, and October. Adults emerge during August and September of the first year and then again in March, April, May, and June of the

next spring. Thus there appears to be one complete annual generation and a partial second one.

#### *Walshomyia juniperina* Felt

*Description*.—Adults are 1.5–2.0 mm. long with dark reddish-brown abdomens; 16–19 antennal segments; 1 papal segment and simple tarsal claws; third vein of wing ( $R_3$ ) meeting costa a little before the apex. This is the only known species in this genus.

*Note*.—This unique species was described by Felt in 1908 (19); he stated "Bred June 19, 1884, from fruit of *Juniperus californica* taken at New Indria (sic) (probably New Idria) Calif." In 1916 (20) in redescribing this species he stated "Both sexes of this species were reared June 19, 1884 from the fruit of *Juniperus californica* taken at New Indria, Calif. The gall from which this species was reared is nearly 1 cm. in length, 0.5 cm. in diameter, purplish brown, hollow, the free end with 3 or 4 conspicuous diverging lobes."

In Key to American Insect Galls (21) Felt lists this species in his key as "Reared from slightly enlarged fruit of *Juniperus californica*, *J. monospernum*, and also from a conical, purplish, apical bud gall, with 3 or 4 diverging lobes when mature, length 1 cm., diameter 3 mm. Itonid. Juniper berry midge, *Walshomyia juniperana* Felt."

This gall midge has recently been reared by the writer from purplish-brown, globose, 'urn-shaped', thick walled, hollow galls, 1 cm. long and nearly 0.8 cm. wide, with 3 or 4 diverging lobes at the free end when mature, collected from *Juniperus californica* near Idria, California in March 1956. The species was identified by Dr. Richard H. Foote of the United States National Museum. These galls are common on juniper and might have been mistaken for the fruit. It is unlikely that the midge makes this gall and also deforms juniper berries. I strongly suspect that it does not attack the fruit as first reported by Felt.

A number of Itonididae larvae were found in various cones, but either the adults were not reared or not definitely associated with the larvae. Some of these are worthy of mention.

### Gall Midges in Fir Cones

#### *Species A-3*

Long cigar-shaped pink larvae without a breastplate were often found abundantly in wet cones of various firs. These may have been larvae of a fungus gnat rather than a gall midge. Adults were not associated with the larvae.

### Gall Midges in Incense-Cedar Cones

Several species of Itonididae were found galling the foliage of incense-cedar and one species infesting the pistillate buds.

#### *Species L-1*

*Description*.—Larvae are light straw-yellow with an I-shaped breastplate. Last abdominal segment rounded with a pair of nipple projections; other segments also with a pair of nipple projections. Adults were not noted.



*Damage.*—Larvae galled the center of pistillate buds, with 1-6 larvae in each gall. Infestations as high as 15 percent of pistillate buds were found.

*Life history.*—Not determined, as rearing of adults was unsuccessful.

Collections represented by Hopkins U. S. Nos. 12596a, 13207a, 13210a.

### Gall Midges in Pinyon Cones

According to Little (50) "Destruction of (pinyon) pine cones of first year is caused principally by larvae of unidentified gall midges (Itonididae). The cones are attacked after pollination and killed when less than one-half inch long. Eggs were found in a cone early in July. The white larvae, less than one-eighth inch long, are active in July and August but were found as late as September. They feed on the young seeds and soft tissues at the base of the cone scales. The infested cones usually die in August, shrivel slightly as they dry, and fall off when touched. When examined they are usually hollow and show no evidence of insects.

"A less common type of insect damage is that of abnormally swollen cones caused also by larvae of gall midges (Itonididae). In August or the last of July a few cone scales begin to grow more rapidly than the others and produce an asymmetrical cone with the larger scales protruding one-sixteenth to one-eighth inch. A whitish larva about one-sixteenth inch long develops at the base of the enlarged scale and feeds upon the seed and scale."

### Gall Midges in Douglas-fir Cones

Besides the common resin midge found loose between cone scales, pink gall-forming larvae were found in small galls at the base of cone scales.

#### *Species D-2*

*Description.*—Adults are small red midges, with third vein ( $R_3$ ) of wing simple at base, widely separated from margin and meeting the costa at apex, not curved; fifth vein forked. Larvae are small, red maggots found in galls at base of cone scales. This species may be one of the new species described by Foote (24).

*Host.*—*Pseudotsuga menziesii*.

*Distribution.*—Probably throughout the range of the host tree. Reared from Ashland, Oreg., and vicinity.

*Damage.*—These midges form large galls on the cone scales (fig. 15) and often include the seeds in their work. Practically every time the cone scale is so galled, the seeds do not mature. The galls contain many little cells, each with a midge larva.

*Life history.*—Not completely known. Galls were formed during the growing season of the new cones. Adults emerged during April, May, and June from cones maturing the previous year.

*Parasites.*—These midges were parasitized by probably two species of chalcids. One chalcid, *Tetrastichus* sp., was reared in quantities from these galls. A species of *Platygaster* also appeared to be parasitic.



FIGURE 15.—Gall midge larvae in pockets of aborted cone scales of Douglas-fir. EPQ-3751

#### Gall Midges in Western Redcedar Cones

Two collections of cones from western redcedar from Wind River, Wash., and Tillamook, Oreg., showed larvae of Itonididae "in papery cocoons in cone scales," and between the scales where the seeds normally form (fig. 16). These larvae were credited with having destroyed about 90 percent of the seed. Several parasitic Hymenoptera were reared from these cones, but no adult midges emerged; therefore, the species was not determinable.



FIGURE 16.—Gall midges in cones of western redcedar. EPQ-3753

#### FAMILY LARVAEORIDAE (TACHINIDAE)

Members of the Family Larvaeoridae are for the most part parasitic on other insects. Quite a few of these beneficial flies

were reared from cones, but the host was seldom determined. Many of the species have not been determined and probably quite a few are still undescribed.

***Exorista* sp. (probably a species of *Zenillia*)**

Two adults emerged in September from ponderosa pine cones of the current year's crop which were collected in August. Nothing is known of the habits, but since these cones were infested with *Dioryctria* and *Laspeyresia* it was assumed that the species was parasitic on one or both of these moths. (Hopkins U.S. No. 13251f-2.)

***Goliathocera setigera* (Thom.)**

The adults are small black flies 3.5 mm. long.

One adult emerged in May from a lot of mountain hemlock cones which matured and were collected 2 years previously from Mt. Ashland, Oreg. Seven adults emerged from white fir cones from the middle of June to the Middle of August of the year after cones reached maturity. As these cones were infested with cone moths, it is assumed that this species of *Goliathocera* was parasitic on the lepidopterans. One fly was reared from a vial containing a pupa of *Dioryctria abietella*, so is probably parasitic on this moth.

***Hypostena* sp.**

One adult emerged from Sitka spruce cones collected at Crescent City, Calif. Nothing is known concerning its habits. (Hopkins U.S. No. 12557k.)

***Myiophasia atra* (R.D.)**

This fly, about the size and general appearance of a housefly, was reared in quantities from the acorns of California black oak collected at Ashland, Oreg., in August 1916. The flies emerged the next year between June 23 and July 25. They are known to be parasites of the acorn weevils. In this case, the acorns were infested with *Curculio uniformis* Lec. and these flies were undoubtedly parasitic on this species. (Hopkins U.S. No. 14279j.)

***Lydeellohoughia* sp.**

(Incorrectly identified by C. T. Greene as *Tachinophyto floridensis* (Tns.).)

Adults of this species, about 5 mm. long, are similar to small houseflies. They emerged in June, July, and August from cones of white fir and Douglas-fir. The host on which they were parasitic was not determined, but is probably one of the cone moths. (Hopkins U.S. Nos. 14201j, 12535d-2.)

**Other Larvaevoridae**

Several other species of Larvaevoridae were reared from cones but their host and identification were not learned. (Hopkins U.S. Nos. 12529b, 13274g, 13295g, etc.)

## FAMILY LAUXANIIDAE

*Minettia flaveola* (Coq.)

*Description*.—The adults are peculiar light-yellow flies about 4 mm. long, with large mesothorax covered with sparse long black hairs, small abdomens, and wings longer than the body.

*Hosts*.—Cones of *Abies concolor*.

*Notes*.—Not very much was learned concerning the habits of this species. The larvae apparently feed on decaying plant material, and were found in cones feeding on decaying scales and bracts.

*Sapromyza* spp.

These are light-yellow flies with long clear wings. The larvae apparently feed on decaying cones, eating the scales and bracts. Adults emerged during May and June from ponderosa pine cones which had lain overwinter on the ground under the snow. Nothing else was learned of their habits.

## FAMILY LONCHAEIDAE

The adults of the Family Lonchaeidae are small shiny black flies, the auxiliary vein entire and the tibia without preapical bristles. The larvae live in plants and decaying vegetation and some may be predaceous.

*Euromyia* spp.fir seed maggots<sup>7</sup>

The maggots of this group of flies are one of the most abundant and important fir seed destroyers.

*Description*.—Adults (fig. 17) are rather small metallic shiny black flies; bodies 4 mm. long, wings much longer than abdomen, 5 mm. long; auxiliary vein of wings distinct, basal cells present; front rather narrow, with single orbital bristle.

The larvae (fig. 18) are white, footless maggots about 8 mm. long and 1 mm. wide when full grown; body composed of 12 distinctly constricted segments, all roughened by very small bristles, tapering to head; anterior spiracles fan-shaped with 12 lobes on tip; head with two large black hooks or mandibles attached to cephalopharyngeal skeleton, which is also black, and plainly visible through the skin; posterior end without prominent apical spines, but with two prominent chitinized blunt anal tubercles.

Puparia are dark red and coarctate, 5.5 mm. by 1.75 mm.; finely annulated; anterior end with two projections, remnants of the anterior spiracles; posterior end more or less rounded with two prominent blunt projections, remnants of the anal tubercles. These puparia differ from those of the large dipteran by their small size and by having the two prominent anal projections; also by the fact that they are always found in the soil.

<sup>7</sup> In the early rearings at Ashland, Oreg., from *Abies* cones from California, Oregon, Washington, and Colorado, it was thought that only one species of *Lonchaea* was represented. This species was variously misidentified as *Lonchaea viridana* Meig., *L. rufitarsis* Macq., *L. albitarsis* Zett., and *L. polita* Say. Recently McAlpine (52) has reviewed this group, placed them in the genus *Euromyia* Zett., and described five new species. Since these species were not recognized earlier, the notes refer to a composite of this group, and the individual habits cannot now be separated.



FIGURE 17.—Adults of fir seed maggots, *Eucomyia* spp.,  $\times$  5. EPQ-2077



FIGURE 18.—Larvae and pupae of fir seed maggots, commonly destructive to cones and seeds of white fir,  $\times$  2.5. EPQ-2214

Eggs are white, long (1.5 mm.), narrow, gourd-shaped, with one end smaller than the other.

*Character of damage.*—Upon breaking open a white fir cone in August and September, one may see the white, footless maggots wriggling out of the seed near the point of attachment. They seem to feed entirely within the seed and bore through the cone scales

only to reach the seeds. Seeds mined by these species are flat and limp, generally almost black in color and show the exit hole of the emerging larva.

Damage by these species differs by locality and year. The maggots often destroy from 1 to 2 percent of fir seeds where they are present and may destroy up to 25 percent of the seeds in single cones.

*Hosts.*—Cones of *Abies concolor*, *A. grandis*, *A. magnifica*, *A. magnifica* var. *shastensis*, and *A. lasiocarpa*.

*Distribution.*—California, Oregon, Washington, British Columbia, Alberta, and Colorado; probably throughout the range of western true firs.

*Seasonal history and habits.*—Females ovipositing on white fir cones were first observed by the writer on June 18, 1915. With their heads toward the tip of the cone, they felt around until they found a suitable place, usually at the juncture of two cone scales; then they backed over the place and inserted the spear-shaped ovipositor under the edge of the cone scale. Several jabs were made with the ovipositor apparently laying an egg with each jab. From 1 to 4 eggs were found in a group. The female then removed her ovipositor and wiped it off with her two hind tarsi and moved to another spot. One female was noticed to spend more than an hour on one cone, laying eggs on every part of it. Oviposition continued until July 23.

Eggs may be found under the cone scales, with the tips of the eggs protruding, from early June to the end of July.

The small maggots (fig. 19) hatch from the eggs within a few days and then enter the cone and search out the seeds. First larvae were observed on June 24. On July 18, small 1-mm.-maggots were found completely within the seeds. During the summer they bore in the seeds, rarely destroying more than two seeds per larva. By the middle of September most of the larvae reach full growth, leave the cones, and drop to the ground to pupate.

Puparia are formed in the ground from the middle of September until cold weather; the maximum pupation occurs about the first of October. Some larvae may still be found in the cones in December.

A few adults emerge the next spring in March, April, May, and June; most of the brood remain in the soil as puparia and emerge the second spring. A few may emerge after the third winter season. The maximum emergence occurs about the first of April; thus, there appears to be one biennial generation and a partial annual generation of this fly, an adaptation to the variable cone crop and food supply.

*Parasites.*—No parasites have been reared from this species.

The new species set up by McAlpine (52) consist of the following five.

#### *Earomyia abietum* McAlpine

This species "has yellow tarsi, dark calyptral fringes, a cluster of stigmatal bristles, and a hairy sternopleuron. It can be separated from most species in the group by its hairy eyes and its wide cheeks" (52).

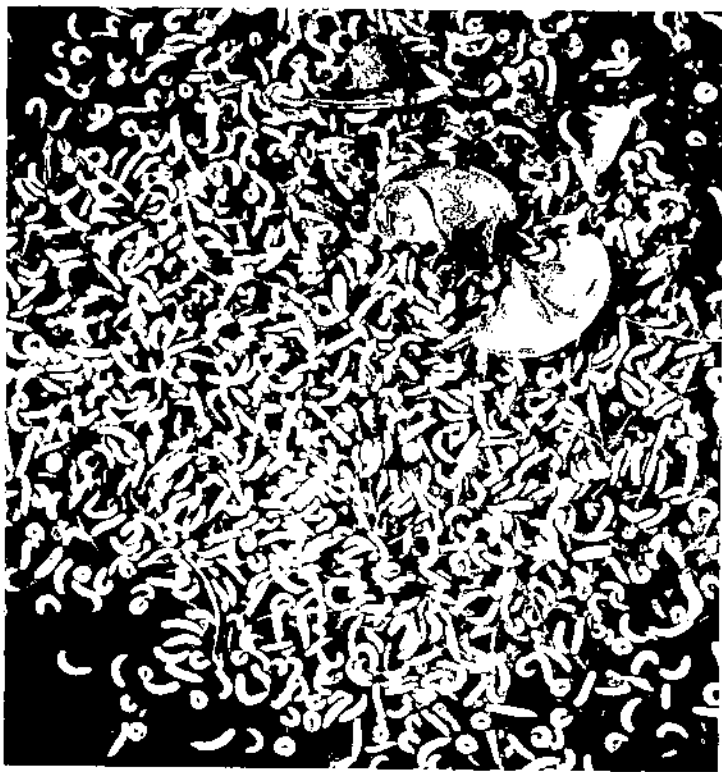


FIGURE 19.—Maggots of *Eucomyia* spp. which emerged in large quantities from white fir cones.

*Hosts.*—Western *Abies* including *A. amabilis*, *A. concolor*, *A. grandis*, and *A. magnifica*.

*Distribution.*—California, Oregon, Washington, British Columbia, and Colorado.

*Life history and habits.*—McAlpine reported: "The rearing records for *abietum* suggests that the species usually passes two winters in the pupal stage. However, as evidenced by three specimens reared from cones of *Abies amabilis* in British Columbia, the series reared from *Abies grandis* in British Columbia by W. G. Mathers and the majority of the specimens reared from *Abies concolor*, Hopkins U. S. No. 11130a, in California, it sometimes emerges after spending only one winter in the puparia.

"According to the rearing records a few larchaetids emerged from lots bearing Hopkins U. S. Nos. 12538j and 12561c after the third winter season. Specimens of *abietum* were reared from both these lots and some may have remained 3 years in the pupal stage.

"Whether these irregularities occur in the field is not known. Rearing techniques may have adversely affected the natural train of events connected with diapause and emergence; but it is not impossible that a fraction of each generation emerges annually

over a period of 3 years. This would ensure the continuation of the species through years that few or no cones are produced."

#### *Earomyia barbara* McAlpine

McAlpine stated: "The species has the following combination of characters: Tarsi yellowish, calyptrae dark, eyes bare, one to several stigmatal bristles, sternopleuron haired on the disc, and notopleuron bare except for the usual two bristles. It is the smallest species discussed in this paper and, in the larval stage, the most general (apparently not the most abundant) pest of cones."

*Hosts.*—*Abies concolor*, *A. magnifica*, *Picea engelmanni*, *P. glauca*, *Pinus ponderosa*, *Pseudotsuga menziesii*, and *Tsuga mertensiana*.

*Distribution.*—California, Oregon, British Columbia, Alberta, and Colorado.

*Life history and habits.*—According to McAlpine: "All of the type material reared from cones of Douglas-fir emerged the spring following collection. This seems to indicate that on this host in British Columbia and Oregon the species completes its life cycle in 1 year. The same is true of specimens reared from cones of ponderosa pine (Hopkins U. S. No. 13251j) in Oregon. But, in view of the limitations of the data concerning Hopkins U. S. material from cones of *Abies concolor*, *A. magnifica*, *Picea engelmanni* and *Tsuga mertensiana*, and because a number of species are involved in each of these experiments, nothing very definite can be deduced about the length of the life cycle of these specimens. However, since some specimens in these lots emerged over a period of 3 years, the possibility remains that sometimes *barbara* may spend more than one winter in the puparia."

#### *Earomyia brevistylata* McAlpine

McAlpine stated that this species "has yellow tarsi, dark calyptral fringes and several stigmatal bristles. Characters that distinguish it from other similar species are: Bare eyes, narrow cheeks, and hairy sternopleuron."

*Hosts.*—Mainly from cones of *Abies concolor* and, in limited numbers, from cones of *Abies magnifica*.

*Distribution.*—California, Oregon, and Colorado.

*Life history and habits.*—According to McAlpine: "Rearing records of *brevistylata* indicate that the species usually remains in the pupal stage for two winters. However, under laboratory conditions a few adult specimens emerged after only one winter from Hopkins U. S. lots 11430a, 12538j, 12560e, 13228d, 13298d, and 14200f. Because of this and the limitations of the Hopkins rearing records there is no way of being certain that some of these specimens are not *brevistylata* adults. In one case, Hopkins U. S. lot 12564e, emergence occurred after the puparia passed three winters \* \* \* It seems probable that each generation of the species emerges over a period of several years—the majority appearing after the second winter."

#### *Earomyia longistylata* McAlpine

McAlpine stated: "*Longistylata* is a large, hairy, anthomyid-like



species with orange-yellow metatarsi, dark-brown calyptrae and fringes, hairy eyes, numerous stigmatal hairs and elongated abdomen. It is so named because of its very long ovipositor."

*Hosts.*—"The preferred host seems to be the cones of *Abies magnifica*; it has also been reared from cones of *Abies grandis*, and *Abies concolor*."

*Distribution.*—California and Oregon.

*Life history and habits.*—"Information from the Hopkins records indicate that *longistylata* usually completes its life cycle in 1 year, i. e., adults emerge each spring after passing 1 winter, only, in the pupal stage. It should be noted, however, that the rearing experiments from which specimens of *longistylata* were reared, yielded adults over a 2-year period. In spite of the fact that most of the flies which emerged the second spring can be traced to other species, some of them may be *longistylata*" (52).

#### *Earomyia aquilonia* McAlpine

This species was not included in any of the rearings from cones taken in the United States and appears to be restricted to Canada. McAlpine reported: "*E. aquilonia* is an entirely dark species, apparently with a northwestern distribution. The following characters distinguish it from all other *Earomyia* species known to me: Tarsi entirely dark brown to black, calyptrae and fringes blackish, wings brownish-fumose, eyes pubescent, several or more stigmatal bristles; disc of sternopleuron with numerous stiff hairs; body velvety black, especially in the male."

*Hosts.*—*Abies lasiocarpa*, *Pseudotsuga menziesii*, and *Larix laricina*.

*Distribution.*—British Columbia and Alberta.

*Life history and habits.*—McAlpine, quoting R. W. Reid, Forest Zoology Laboratory, Calgary, Alberta, stated: "\* \* \* it seems rather certain that the species has a 1-year life cycle.

"Frequently 4 or 5 larvae were found burrowing throughout the cone, feeding on cone tissue and seeds. When removed from the cone and placed on a flat plane, they often curled up, locking the anterior and posterior segments together. Release was sudden, and spring-like, moving the larva 1 or 2 inches."

### FAMILY LYCORIIDAE

#### *Bradysia coprophila* (Lint.)

The tiny, black midges were reared from the acorns of California white oak and the seeds of Oregon ash in California and southern Oregon. No information was obtained on the larval habits, but most of this family are fungus feeders. (Hopkins U.S. Nos. 32246, 32317.)

#### *Bradysia pauciseta* (Felt)

Adults were reared from Douglas-fir cones in interior British Columbia, according to a note from D. A. Ross of the Forest Biology Laboratory, Vernon, British Columbia.

#### *Bradysia* spp. (= *Sciara* spp.)

Other undetermined species of this genus were reared from

cones of white fir at Ashland, Oreg. Emergence occurred from April 12 to June 8 from cones of the previous season. (Hopkins U. S. No. 12560y.)

### FAMILY MUSCIDAE

#### *Hylemya (Pegohylemyia) abietis* Huckett

#### larger white-fir cone maggot

*Description.*—The adults (fig. 20) are large, shiny black or brownish-black flies, 8–9 mm. long, partly dusted with gray and covered with scattered long, black bristles; wings 7 mm. long, clear, light brown, grading to yellow at the base; halteres yellow; cells of wing widely open at apex (38).

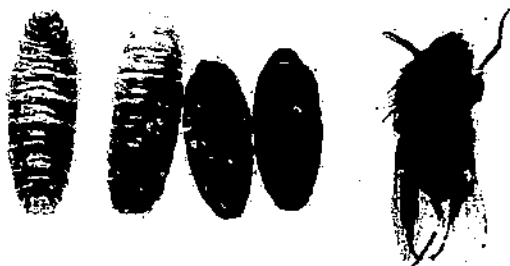


FIG. 20

FIGURE 20.—Larvae, pupae, and adult of the larger white-fir cone maggot, *Hylemya abietis*,  $\times 3.5$ .

Eggs are long (about 1.7 mm.), narrow, and pearly white, gourd-shaped with one end smaller than the other.

The larval body is white, composed of 13 segments, 8 mm. long, to 2.5 mm. wide tapering to the head, which has 2 great hooks; anterior spiracles with 18 lobes.

The puparia are dull yellowish-red to brown coarctate; 6.5 mm. by 2.5 mm. Old anterior spiracles remaining as two large anterior projections; posterior end more or less blunt with numerous small projections representing the larval apical spines; body slightly annulated. This puparium is often found within the cone, embedded in resin in its gallery. It differs from puparium of *Earomyia* by its large size and duller color, and by the absence of the two prominent anal tubercles possessed by the *Earomyia*.

*Character of damage.*—The large white maggots of this species bore through the scales and seeds in the heart of white and red fir cones leaving a mass of pulverized material in their wake. The damage is often considerable but varies from year to year and also by localities. It may run as high as 30 percent of the seed. Other times cones may be bored, but less than 2 percent of the seeds damaged. Galleries are distinguishable from those of the cone moths by their very ragged margins, caused by the tearing action of the two great hooks carried by the larvae.

*Hosts.*—Cones of *Abies concolor*. Similar larvae found in cones

of *Abies magnifica* var. *shastensis*. Probably occurs in other fir cones in its range.

*Distribution.*—Southern Oregon and California south to Quincy; probably occurs over the wider range of the host trees.

*Seasonal history and habits.*—Oviposition of this species was first observed in the field near Ashland, Oreg., by the writer on June 22, 1915. The female performed in much the same manner as *Earomyia*. With head pointed toward the tip of the cone, she backed up and inserted the tip of the ovipositor under a cone scale, remaining in this position from 30 seconds to 2 minutes. Several eggs were laid in each cone. On July 17 oviposition was at a maximum and was observed until July 23, 1915.

Eggs were found under cone scales from June 22 to July 23.

First larvae were observed hatching July 17 (fig. 21). The small larvae follow along the surface of the cone scale feeding superficially. On reaching the center of the cones they feed upon seeds (fig. 22), and as they develop they bore through the scales from one seed to another, forming tortuous burrows throughout the cone. It is common to find 4 or 5 of these larvae in an infested cone. Some cones were killed as early as June 25, and on July 23 contained full-grown larvae. Prepupal larvae in pupal cells in the cones were observed as early as August 12.

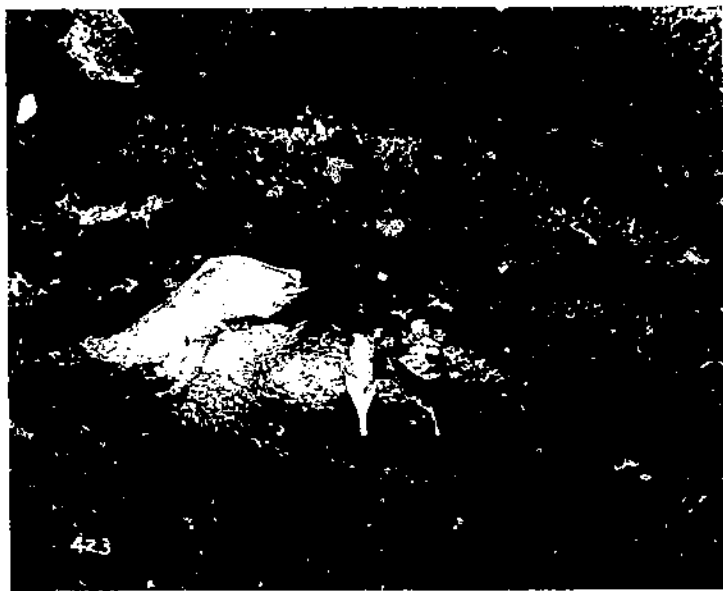


FIGURE 21.—Hatching eggs of the larger white-fir cone maggot, under bracts of white fir cone,  $\times 8$ . EPQ-7561

The first puparia were found October 7, and during this month and November most of the larvae pupated. Most of the larvae formed their puparium inside the cones embedded in pitch in their galleries; many of them left the cones and formed the puparium in the soil.

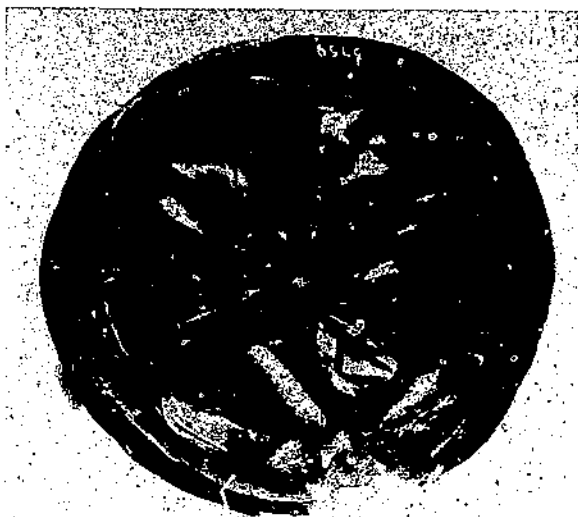


FIGURE 22.—Larva of larger white-fir cone maggot in its gallery in a white fir cone. SPQ-5739

Some adult flies emerge from puparia from April 25 to June 7 in the year after their attack on cones, but an even larger number appear to remain as puparia for another year and emerge in the second spring. By this retardation, the species is protected from extermination by a cone-crop failure.

*Parasites*.—None specifically recorded.

***Hylemya (Pegohylemyia) anthracina* (Czerny)**

**hemlock cone maggot**

Another species of *Hylemya* very similar to *H. abietis* but considerably smaller was reared from mountain hemlock cones. Adults emerged from cones of the 1914 crop between April 6 and 28, 1915. Larvae were not observed. The habits of this species are similar to the above as reported by Kangas and Leskinen in 1943 (41).

Flies identified as near this species were reared from cones of Sitka spruce from Crescent City, Calif. Adults emerged between April 28 and May 14 from cones of the previous year's crop. (Hopkins U.S. No. 14266c.) Tripp (75) reported a species close to this working in cones of white spruce in southern Ontario. "Eggs are deposited between the cone scales about mid-May, usually during the pollination period when the scales are open. They hatch in 4 to 5 days. The maggots tunnel spirally about the radius, eating through the bases of the scales and destroying the seeds. In June, after about 3 weeks feeding, they tunnel their way out of the cone and drop to the ground. They overwinter as pupae and emerge in early May." Tripp found that this species had only 2 larval instars, as contrasted with a normal of 3 for most anthomyiid species.

**FAMILY PALLOPTERIDAE**

*Palloptera* sp.

This small, light yellow fly, 3 mm. in length, with long wings emerged in May from white fir cones of the previous year's crop at Ashland, Oreg. Nothing is known of its habits. (Hopkins U. S. No. 13228v.)

**FAMILY PIOPHILIDAE**

*Mycetaulus* sp. (near *costalis* Mel.)

The adults are small flies, 2.5 mm. long, with light yellow thorax and dark abdomen. The larvae are long, slim, and white with black line markings on anterior body. The larvae were found March 19 feeding on the scales and seed bracts of wet sugar pine cones which had been killed by cone beetles the previous fall, and which had lain on the ground over winter. Emergence of 18 adults occurred in June. (Hopkins U. S. No. 14285B.)

**FAMILY SPHAEROCERIDAE**

*Leptocera* spp.

These are small black flies, 1.5 mm. long, with prominent body bristles and clubbed antenna with prominent arista. Adults emerged during late April and through May from cones of white fir and ponderosa pine, and seeds of bigleaf maple. The habits were not determined. (Hopkins U. S. Nos. 14203c, 13228p, 14423c.)

**ORDER HEMIPTERA      BUGS**

**FAMILY ANTHOCORIDAE**

*Anthocorus* sp.

pirate bugs

The adults are small, 3-4 mm. long, flat, clear-winged bugs with sharp pointed heads, and light-brown wings. One or more species were reared from the cones of Sitka spruce, the adults being found between the cone scales from August through October. They were probably predaceous on aphids or scales not noted in the collections.

*Triphleps tristicolor* White

The adults are small, 1.5-2 mm. black pirate bugs which are found commonly in the western States feeding on scales, aphids, and mites. Adults emerged from one lot of Oregon ash seeds in October. The host was not determined.

**FAMILY PENTATOMIDAE**

*Elasmostethus cruciatus* (Say)

One large stink bug of this species with yellowish-green thorax and wings emerged from one lot of sugar pine cones in February. It was probably a stray.

**ORDER HYMENOPTERA WASPS**

More than 100 species of Hymenoptera were reared from cone and seed insects at the Ashland Laboratory. Most of these were parasitic on destructive cone and seed pests, a few were phytophagous, and some were hyperparasites and inquilines. Of the seed-feeding groups, the most important are the seed chalcids of the genus *Megastigmus*. Other destructive forms are included in the families Cynipidae, Diprionidae, and Eurytomidae. A large number of the parasitic species discussed here were named from series reared in connection with the Ashland cone- and seed-insect rearings. Notes as to biology, host, and distribution are not uniform, but go only so far as the material at hand justifies.

The nomenclature is that established by Muesebeck et al. in their comprehensive synoptic catalog of the Hymenoptera of North America (62). The reader is referred to this catalog for citations of original descriptions and synonyms. Some additional references to economic literature are given in the following notes. These notes are arranged in systematic order by Superfamilies, but alphabetically by family, genus, and species under each Superfamily.

*Superfamily Megalodontoidea***FAMILY XYELIDAE***Xyela* spp.

Small yellowish-white larvae of this genus have been collected many times in great abundance as they drop from staminate cones of ponderosa pine to enter the soil to pupate. Repeated efforts to rear the larvae through to adults have invariably ended in failure, so that adult and larval forms have not been definitely associated.

The larvae have subcylindrical bodies, with short, conic, functionless thoracic feet and no abdominal feet. The color is yellowish waxy white, with transparent skins. Head small, rounded, same color as body except faintly brownish around mouth and with very small black eyes. Length about 8 mm.

The larvae feed in the pine catkins in early spring and reach maturity at the time the catkins mature, about the middle of May (15). The larvae then drop to the ground to pupate, where they probably remain until adults emerge the next spring. One generation a year is assumed.

The species apparently does very little damage to the catkins, for even infested ones produce pollen in abundance. Collected from California and Oregon. (Collection: Hopkins U. S. No. 33746a and others.)

This or another species about three sixteenths inch long has been reported by Little (50) as abundant in the staminate cones of pinyon just before maturity.

*Superfamily Tenthredinoidea***FAMILY DIPRIONIDAE**

*Augomonoctenus libocedrii* Rohwer incense-cedar cone sawfly

Adult sawflies are thick-set, shining blue-black, with the abdo-

men brick-red or orange, except for the last three tergites. Length 5-9 mm.

The sawfly larvae, with seven pairs of prolegs, were found feeding in cones and on twiglets of incense-cedar near Siskiyou, Oreg., September 18, 1915, by P. D. Sargent. Cocoons were formed in November 1915, attached to the walls of a cage in which the collected material was confined and beneath the soil on the bottom of the cage. The larvae remained in cocoons until they emerged, from June 28 to July 2, 1917. The species was named from this one collection. No further biological information has been obtained.

### Superfamily Ichneumonoides

#### FAMILY BRACONIDAE

##### *Agathis acrobasilis* (Cushm.)

The adult has a black thorax and large golden yellow abdomen. It was reared from California black oak acorns at Ashland, Oreg., emerging June 3 from acorns matured the previous fall. Its insect host was not determined.

##### *Agathis nucicola* (Mues.)

This is reported by Dohanian (14) as an important parasite of *Melissopus latiferreanus* in acorns and *Andricus* galls in California and Oregon.

##### *Allorhogas* n. sp.

These small dark brown braconids with amber legs, 2 mm. long, emerged from ponderosa pine cones which had been killed, but were no longer infested by cone beetles. Various species of insects, including *Ernobius* species, emerged from these cones. The host insect was not determined. A few adults emerged in December 1913, and 61 adults emerged from June 2 to July 17, 1914, from cones of the 1912 crop. Collections represented by Hopkins U. S. Nos. 10832ba and 10887g.

##### *Apanteles californicus* Mues.

This species, which was originally described as a parasite of the lodgepole needle miner in California, was reared from the cocoons of *Eucosma bobana* in cones of Jeffrey pine in southern California. Adults emerged in August.

##### *Apanteles laspeyresiae* Vier.

The adults are very dark brown braconids. Length 3.5 mm. They are important primary parasites of the larvae of the pine cone moths *Laspeyresia piperana*, *L. miscitata*, and *Hedulia injectiva* in ponderosa and Jeffrey pine cones in California, Oregon, and Idaho. When mature, the larvae spin a thin, membranous, silky cocoon in the galleries of the host. Pupation occurs in the spring from April 15 to June 15, and emergence occurs from April 15 to June 23 in the year after cones mature. There appears to be one annual generation.

##### *Apanteles* spp.

Other species of *Apanteles* emerged from cones of white fir

(Hopkins U. S. Nos. 12560w, ww and 12571a), limber pine (13249d), Douglas-fir (13295d), and acorns of California black oak (14279f). In each case, only 1 to 4 adults emerged.

***Aphidius bifasciatus* Ashm.**

This species was reared from a lot of Douglas-fir cones from Ashland, Oreg. Five adults emerged between April 22 and May 5. The genus is normally parasitic on aphids (*Cinara* spp.), but in this case the host was not determined (Hopkins U. S. No. 14234j).

***Blacus* spp.**

Three adults of this genus emerged in May from Shasta red fir cones of the previous year's crops, near Ashland, Oreg. (Hopkins U. S. No. 14200h). Five adults of this genus emerged between March 15 and June 26, 1915, from Douglas-fir cones of the 1914 crop near Ashland. No information was obtained as to insect hosts.

***Bracon erucarum* (Cushm.)**

These small braconids emerged from one lot of Douglas-fir cones collected at Ashland, Oreg., in November 1913, which were infested with *Barbara colfaxiana*. Eight adults emerged between February 17 and June 12, 1914. The host was not specifically determined. Muesebeck et al. (62) records it as distributed in Colorado, Utah, Arizona, Idaho, and Oregon.

***Bracon rhyacioniae* (Mues.)**

The adults are small brown braconids with nearly black heads and thorax, bright yellow abdomens marked with brown dorsally, and with smoky brown wings. Length about 4 mm. The species was described from adults found parasitizing *Rhyacionia* sp. on ponderosa pine in Nebraska. It has also been reared from cones of white fir, from cones of Douglas-fir infested with *Barbara colfaxiana* and *Dioryctria abietella*, from Engelmann spruce cones infested only with *Laspeyresia youngana*, and from twigs of Coulter pine infested with *Dioryctria* sp. In these cases the host was not specifically determined. Emergence occurred from April 27 to July 6, but mostly in May from cones of the previous season. Probably found throughout the West, as it was reared from California, Oregon, Colorado, and Montana, and recorded by Muesebeck (62) from Idaho, South Dakota, and Nebraska.

***Bracon xanthonotus* Ashm.**

Syn. (*Bracon* (*Habrobracon*) *hopkinsi* Vier.)

These are small, dark-brown wasps 2.5-3 mm. long, with cloudy iridescent wings, black thorax, and light-colored abdomens. They have been found to be parasitic on a number of lepidopterous hosts from California, Oregon, and Washington east to Colorado and New Mexico (57). They were reared from Douglas-fir and ponderosa pine cones from Ashland, Oreg., but the specific hosts were not determined.

***Chelonus* sp.**

Two small black braconids of this genus were reared from berries of western juniper from Hilt, Calif. The host was not



determined, but is presumed to be some lepidopteran. (Hopkins U. S. No. 12513a-4.)

***Coeloides scolyti* Cushm.**

These parasitic wasps are variable in size, from 3 mm. long for the males to 7 mm. long for the females. The heads and abdomens are orange yellow, the thorax dark brown, and the wings dark smoky brown. This species is commonly parasitic on *Scolytus* from California, Oregon, and Washington east to Colorado (72). It emerged in May from singleleaf pinyon cones in southern California which were infested the previous year with *Conophthorus monophyllae* and *Ernobius montanus*. It was presumed to be parasitic on the *Conophthorus*.

***Doryctes pacificus* (Prov.)**

This species was reared from old persistent cones of knobcone pine from McCloud, Calif. The cones were infested with the cone borer *Paratima conicola*. On March 31, a *D. pacificus* pupa was found in the pupal cell of the host, and the adult emerged June 21. It is distributed from northern California through Oregon, Washington, and British Columbia.

***Eubadizon* new species**

Several new species of *Eubadizon* (*Brachistes*) were reared from cones, the most important of which was one from cones of ponderosa and sugar pines.<sup>8</sup>

*Species A.*—These are small black-bodied braconid wasps, 4 mm. long, which were reared in considerable numbers from ponderosa and sugar pine cones, from California and Oregon. Emergence occurred from January to July, but mostly in April and May from cones of the previous year's crop. Some adults emerged the second spring. The wasps were presumed to be parasitic on either *Conophthorus* or *Ernobius*, as species of these beetles were common to practically all lots from which this parasite was reared. Collections: *Pinus ponderosa*, Hopkins U. S. Nos. 10832g, 10875b-6, 10870f, 10876j, 11472d, 12539L, 13205i, 13302c, 14224g. *Pinus lambertiana*, Hopkins, U. S. Nos. 10833d, 10871d, 10872d, 10878b, 10890e.

*Species B.*—Two collections of a *Eubadizon* were made from singleleaf pinyon cones in southern California. Both collections were infested with *Ernobius* sp., and one with *Conophthorus* sp.

*Species D.*—One adult emerged in April from cleaned seeds of red fir from the Tahoe National Forest, Calif., collected 2 years before. This may have been a stray. The only other insects present were *Megastigmus* spp.

*Species E.*—Eight adults emerged August 26 to October 1, 1915, from the 1914 crop of cones of Sitka spruce from Crescent City, Calif. These adults were solid amber yellow in color; female 5 mm. long with 6 mm. long ovipositor. The cones were infested

<sup>8</sup> Two of these new species have been named and described by C. F. W. Muesebeck in FOUR NEW SPECIES OF EUBADIZON NEES FROM WESTERN UNITED STATES (HYMENOPTERA-BRACONIDAE). Brooklyn Ent. Soc. Bul. 52 (2):51-56. 1957.

with several different insects, including *Laspeyresia* sp. and *Henricus* sp. The host of this parasite was not determined. (Hopkins U. S. No. 12557f.)

*Species Y.*—A large dark braconid, with clear wings, red legs, and a light streak on the lateral portions of the abdomen, was reared from several lots of Douglas-fir cones, from the coast of Oregon to Elliston, Mont. Adults emerged in May and June from cones of the previous year's crop and from 2 years previously. The host was not determined. (Hopkins U. S. Nos. 12502e, 14211d, 13260d.)

*Species Z.*—One adult of *Eubadizon* emerged June 23, 1917, from acorns of California black oak of the 1916 crop at Ashland, Oreg. The host was not determined. (Hopkins U. S. No. 14279h.)

#### ***Macrocentrus aegeriae* Rohwer**

This small, black braconid has rufous legs and iridescent wings, length 8 mm., ovipositor 8.75 mm. It is parasitic on a large number of lepidopterous hosts and is found throughout the United States except in the southern tier of States. It was reared from cones of white fir and Shasta red fir, in which it was presumed to be a parasite of *Barbara colfaxiana siskiyouana*. Pupae were found in cocoons on cone scales in April, and emergence occurred from April 19 to May 22 in the year following cone maturity. It is also reported as a parasite of *Laspeyresia cupressana*.

#### ***Macrocentrus ancylivorus* Rohwer**

This species of braconid, which is found throughout the United States, was reported by Dohanian (14) as parasitic on *Melissopus latiferreanus* in Oregon and California. It was reared from California black oak acorns at Ashland, Oreg., which were infested with this and other species. Adults emerged June 28 to July 2 the year after acorns matured.

#### ***Meteorus indagator* (Riley)**

These medium-sized yellow braconids were found to be parasites of *Dioryctria auranticella* in cones of knobcone pine at Patricks Creek, Calif. Larvae and pupae were found in the pupal cells of the host on July 1. Emergence occurred from July 16 to 20. The species is recorded from the Atlantic to the Pacific, parasitizing a wide variety of lepidopterous hosts.

#### ***Microtypus dioryctriae* Rohwer**

This yellow braconid, length 5.5 mm., was found to be parasitic on *Dioryctria auranticella* in cones of knobcone pine from Patricks Creek, Calif. Larvae and pupae were found in pupal cells of the host on July 1. Emergence occurred between July 8 and 20, 1916. This was the type material from which the species was described.

#### ***Orgilus dioryctriae* Gahan**

This large dark braconid was found to be parasitic on *Dioryctria auranticella* in cones of knobcone pine from Patricks Creek, Calif. Larvae and pupae were found in the pupal cells of the host on July 1. Emergence occurred between July 8 and 29, 1916. The species was described from this material.

***Phanerotoma erythrocephala* Rohwer**

Adults of this wasp have orange-colored heads and basal parts of abdomens. Thorax and tip of abdomens are dark brown. Length 5 mm. The type series was reared from ponderosa pine cones, Glenwood Springs, Colo., which were infested with ponderosa pine cone moths *Laspeyresia piperana* (erroneously called *L. toreuta*). Others were reared from Jeffrey pine cones from California, infested with the same species or its near relative *Hedulia injectiva*. Both times the cones were infested only with these pine cone moths; so it can be reasonably presumed that this wasp is parasitic on these species. Emergence occurred during June in the year following the attack on the cones.

***Phanerotoma fasciata* Prov.**

This species, which is widely distributed through the United States and Canada, was bred at Ashland, Oreg., from acorns of California black oak. Adults emerged from May to mid-July from acorns of the previous year's crop. Muesebeck (62) reported it is parasitic on *Melissopus latiferreanus*.

***Phanerotoma laspeyresiae* Rohwer**

The adults are black with clear wings and orange-yellow legs. Length 5 mm. They were found to be parasitic on the pine cone moths *Laspeyresia piperana*, *L. miscitata*, and *Hedulia injectiva* in ponderosa and Jeffrey pine cones from California and Oregon. Pupae were found in the pupal cell of the host on April 11. Adults emerged from April 19 to July 1 in the year after moth attack on the cones, and some emerged during the same period in the second year, indicating a 2-year diapause. According to a note by S. A. Rohwer of April 21, 1914, "This belongs to a group where the egg of the parasite is laid in the egg of the host, although the parasite kills the larva after the cocoon is spun."

***Phanerotoma tibialis* (Hald.)**

This species was reported by Dohanian (14) as a parasite of the filbert worm *Melissopus latiferreanus* in Oregon and Washington. The species has been reared from other lepidopterous hosts from the Atlantic to the Pacific.

***Spathius californicus* Ashm.**

These small, light-brown braconid wasps, 3 mm. in length, emerged from one lot of sugar pine cones of the 1913 crop collected at Ashland, Oreg., February 14, 1914. Emergence of nine adults occurred the same year from April 9 to June 19. The insect host was not determined. The species was described from the Santa Cruz Mountains of California.

**FAMILY ICHNEUMONIDAE*****Calliephialtes comstockii* (Cress.) (=Ephialtes)**

*Description.*—This is a very common species of ichneumon. The adults have black heads and shiny black bodies with reddish-to-yellow legs; wings clear with iridescent green and red splotches; stigma consisting of black triangular splotch on anterior margin

of forewing. Males with bodies about 9 mm. long; abdomen with 10 segments; underside of second to seventh segments white with a black longitudinal mark on the side; antennae with 28 cylindrical sessile joints; labial palpi 5-jointed, rather short, white; maxillary palpi 5-jointed, white, shorter than the labial palpi. Females similar to males with bodies 10 mm. long, and ovipositors 12 mm. long; maxillary palpi black. Larvae white, 6 mm. long, 2 mm. wide, tapering to both ends; body composed of head and 13 segments. Antennae consisting of two small bristles.

*Hosts.*—Larval parasite of *Barbara colfaxiana* varieties *colfaxiana*, *taxifoliella*, and *siskiyouana* common; also *Laspeyresia piperana*, *L. miscitata*, and *Hedula injectiva*; *Dioryetria auranti-cella*, *Holocera* sp., and probably other cone moths. Also reared from material containing *Laspeyresia cupressana* and *L. youngana*. Reported in the literature from other species of Lepidoptera and from *Pissodes*.

*Notes.*—Adults emerged in September and October from cones of the current year's crop and again in March, April, and May of the next spring. Maximum emergence occurred from the middle of April to the middle of May. In general males emerged about 2 weeks ahead of the females. Apparently there are two generations annually. About 25 percent of the Douglas-fir cone moth broods were parasitized by this species.

#### *Calliephialtes nucicola* Cushman.

This species was reported by Dohanian (14) as an important parasite of *Melissopus latiferranus* on fiberts in Oregon, California, and Washington. It was reared in April at Ashland from the previous year's crop of bigleaf maple seeds infested with *Proleoteras aesculana*.

#### *Calliephialtes* spp.

A species of this genus was reared from the cones of Engelmann spruce from Manitou, Colo. The pupae were found in April in the galleries with the remains of *Laspeyresia youngana* larvae. Adults emerged May 16-19 from cones of the previous year. (Hopkins U. S. No. 12408bx.)

Another species was reared from Sitka spruce cones from Crescent City, Calif. It emerged in May from the previous year's cones. (Hopkins U. S. No. 13231e.)

Another species was reared from mountain hemlock cones at Ashland, Oreg. Two adults emerged in May 1916 from cones of the 1914 crop. (Hopkins U. S. No. 12559h.)

#### *Campoplex argyresthiae* (Rohwer)

The adults are small, black-bodied wasps with the ventral portion of the abdomen and legs light yellow. Length 4.5 mm.

This species was reared from the cocoons of *Argyresthia libocedrella* infesting the cones of incense-cedar, at Ashland, Oreg. Adults emerged from April 12 to May 28 in the spring following maturity of the cones, from May 8 to 31 in the second year and from May 30 to June 4 of the third year. The type was described from this collection.

***Campoplex conocola* (Rohwer)**

The adults are jet black ichneumons with red legs; length 7.5 mm. The species was described from adults reared from isolated pupae of *Dioryctria cambiicola* (Dyar), found infesting twigs and buds of Coulter pine at Julian, Calif. Other adults were reared from larvae and pupae in cells of *Dioryctria auranticella* in cones of knobcone pine and from cones of white fir and Douglas-fir infested with *Dioryctria abietella* and other cone moths. The species appears to be primarily a parasite of *Dioryctria* spp. in California, Oregon, and British Columbia. Emergence occurred in September and October from cones of the current year and in April to July of the next year, thus synchronizing with the two annual generations of *Dioryctria* spp.

***Campoplex laspeyresiae* (Rohwer)**

*Description.*—The adults are of medium size, with black thorax, dorsal portion of abdomen black, ventral portion white to light yellow, and legs yellow to orange. Length 7.5 mm. with short ovipositors (2 mm.).

*Hosts.*—Probable parasites of *Laspeyresia piperana*, *L. miscitata*, and *Hedulia infectiva*, in cones of ponderosa pine.

*Distribution.*—California, Oregon, and Colorado.

Adults emerged in May and June from cones infested by cone moths the previous year. Some held over and emerged in the second year.

***Campoplex milleri* (Rohwer)**

This small ichneumon, length 4.5 mm., was reared from sugar pine cones of the 1913 crop at Ashland, Oreg., between March 4 and May 9, 1914. The cones were infested with *Dioryctria abietella*, and this moth was assumed to be the host. (Type collection: Hopkins U. S. No. 10833d-3.)

***Campoplex* spp.**

Other members of this genus, or possibly one of the named species, were reared from ponderosa pine cones from Glenwood Springs, Colo., and from Jeffrey pine cones from central California. Adults emerged in May and June from cones of the previous year's crop. They were presumed to be parasitic on *Laspeyresia* spp. (Collections: *Pinus ponderosa* Hopkins U. S. No. 10857e; *Pinus jeffreyi* Hopkins U. S. Nos. 10831ca, 11477bb.)

***Coelichneumon brunneri* (Rohwer)**

*Description.*—Adults are large, slender, black ichneumons with black legs; head and front tibia marked with white. Length 9–12 mm.

*Host.*—*Dioryctria auranticella* in ponderosa pine cones.

*Distribution.*—Rocky Mountain region, Idaho, Montana, Colorado, and Utah.

*Notes.*—Adults emerged in November from the pupae of a *Dioryctria* infested in August. Most emergence occurred in May from pupae parasitized the previous year. Several adults emerged

from one lot of cones in which the only recorded moth was *Laspeyresia miscitata*, but it was not ascertained whether this was the host species.

*Dicaelotus pacificus* (Ashm.)

One of these ichneumon adults emerged in December from ponderosa pine cones collected at Ashland, Oreg., the previous July. No information was obtained as to its insect host, and it may have been hibernating in the cone. (Hopkins U. S. No. 12532f-2.)

*Dicaelotus* prob. n. sp.

A few adults were reared from Douglas-fir cones at Ashland, Oreg. Habits unknown. (Hopkins U. S. Nos. 13209bd-3, 6, 7.)

*Exochus evetriae* Rohwer

These small ichneumons, length 6 mm., were reared from the pupae of *Barbara colfaxiana siskiyouana* in the cones of white fir and from *Barbara colfaxiana colfaxiana* in the cones of Douglas-fir in southern Oregon. Larvae were found in the pupae of the host in September and emerged the next year as adults in March, April, and May. These rearings represented the type material.

*Celis tenellus* (Say)

This widely distributed species was reared from one lot of ponderosa pine cones collected at Ashland, Oreg. It emerged in March from cones of the previous year's crop. Nothing was determined concerning its biology.

*Glypta evetriae* Cushman.

*Description.*—This was a very common parasite collected from white fir and Douglas-fir cones. The adults (fig. 23) are black with ventral surface of abdomen white and with orange-red legs, and wings without an aerolet. Length 8 mm., antennae 6 mm., ovipositor 6 mm.



FIGURE 23.—Pupae and adults of *Glypta evetriae*, a common parasite of the Douglas-fir cone moth.

EPG-7708

*Hosts.*—*Barbara colfaxiana*, probably all varieties; also *Holococera* sp.

*Distribution.*—California, Oregon, Washington, Montana, and Colorado.

*Notes.*—Larvae were found in the pupae of the host as early as July and a few adults emerged in August. These represented the fall portion of the brood. Others overwintered in the pupal cases of the host, pupated in March, and emerged in late March, April, and May. There appears to be one and a partial second generation each year.

#### *Glypta rufiscutellaris* Cress.

This species was reared from *Melissopus latiferreanus* larvae by Dohanian (14) from hazelnuts in California, Oregon, and Washington.

#### *Horogenes* spp.

Several species of this genus were reared from cones, mostly as single individuals.

From white fir cones at Ashland, Oreg., one adult emerged April 3, 1915, from 1914 cones. (Hopkins U. S. No. 12560x.)

Also at Ashland, one small ichneumon of this genus was found among ponderosa pine cone scales in December (Hopkins U. S. No. 12532i), and one emerged in May 1914 from sugar pine cones collected in September 1913.

One adult emerged in June from acorns of California black oak collected at Ashland the previous fall (Hopkins U. S. No. 13294f).

From mountain hemlock cones collected at Mt. Ashland, Oreg., one adult was reared from the pupa of *Eupithecia spermaphaga* Dyar, emerging July 12, 1916, from cones of the 1914 crop. (Hopkins U. S. No. 12559ix.)

#### *Itopectis evetriae* Vier. (= *Itopectis plesia* Rohwer)

*Description.*—The adults are small black ichneumons with short ovipositors, yellow legs, with tibia and tarsi on hind legs banded with white and black. Length 6 mm. Ovipositor 2 mm.

*Hosts.*—*Barbara colfaxiana* varieties in Douglas-fir and white fir cones. Reported from *Rhyacionia* and *Dioryctria* spp. Also reared from Oregon ash seeds.

*Distribution.*—California, Oregon, Washington, Montana, and Alaska.

*Notes.*—Larvae and pupae of this species were found in the cocoons of *Barbara colfaxiana*. Adults were found in cocoons in December, but emergence occurred mostly in April and May in the spring following infestations of these fir-cone moths. There appeared to be one generation a year.

#### *Itopectis* sp.

Two adults of this genus emerged from Monterey cypress cones collected at Pacific Grove, Calif., in October 1914. The host was not determined. (Hopkins U. S. No. 12579k.)

***Mesostenus gracilis* Cress.**

The adults are pale yellowish-rufous, with head, antennae, and mesothorax black varied with white. Length 7 mm. Widely distributed through United States. One adult emerged July 8, 1916, from a pupal cell of *Dioryetria auranticella* in the 1916 cones of knobcone pine collected at Patricks Creek, Calif. (Hopkins U. S. No. 14265hx.)

***Neoxorides borealis* (Cress.)**

*Description.*—The adults of this species of ichneumon have long legs, the forelegs and femora yellowish-red, the hind tarsi and tibia black. They hold their abdomens at an upward angle. Length 10–12 mm. Antennae 8 mm.

*Hosts.*—Commonly found in cerambycid and buprestid larvae.

Adults emerged in May from Jeffrey pine cones of the previous year's crop at Kyburz, Calif., containing *Hedulia injectiva* ("*Laspeyresia toreuta*"), but whether the ichneumon was parasitic on these cone moths was not determined.

***Phaeogenes* sp.**

Adults of this genus have been reared from Douglas-fir cones in southern Oregon. They emerged in May and June from cones of the previous year's crop. The host was not determined. (Hopkins U. S. Nos. 12510bb and 12535ta.)

**Phaeogenini Genus? Species?**

One adult of an unknown genus of this tribe was reared from the pupa of *Laspeyresia cypressana* infesting Monterey cypress cones at Point Lobos, Calif. It emerged in December from cones collected the previous August. (Hopkins U. S. No. 13264fx.)

***Pimplopterus conocola* (Rohwer)**

*Description.*—The adults are black with reddish legs, the posterior tibia and tarsi dusky, wings hyaline with venation dark brown. Length about 7 mm.

*Host.*—*Barbara colfaxiana* in cones of true firs and Douglas-fir.

*Distribution.*—California and Oregon.

*Notes.*—Larvae were found in the pupal cells of the host insect in the fall of the year, and the adult parasites emerged from March 27 to May 15 the next year. Maximum emergence occurred about April 10.

***Pimplopterus dakrumae* (Ashm.) (= *Lissonota dioryctriae* Rohwer)**

The adults are dark ichneumons, with a red spot on the dorsal thorax, and with red legs. Length 5 mm.

J. M. Miller and J. E. Patterson found this species parasitizing *Dioryetria auranticella* in cones of knobcone pine at Patricks Creek, Calif, June 9, 1916. Larvae and pupae were found in the pupal cells of the host insect on July 1; emergence occurred between July 8 and 10, 1916. This species was also found parasitizing *Melissopus latiferreamus* in acorns of California black oak. Pupae were found in February, and adults emerged in April.



***Pimplopterus evetriae* (Rohwer)**

The adults are black, except for white patches on legs, with posterior tibiae and tarsi reddish; wings hyaline iridescent with dark brown venation. Length 5 to 6.5 mm.

This species was reared from Douglas-fir cones, all from Cheyenne Mountain, Colo. In four lots of material it was found parasitizing the larvae of a cone moth, *Holcocera* sp. Larvae were found in parchmentlike cocoons within the host cocoons of *Holcocera* sp. in December and January. Adults emerged early the next summer from May 16 to June 20. Unfortunately, the material sent to Rohwer for naming was labelled a parasite of "*Evetria taxifoliella*." A search of the original records failed to indicate any instance where it was actually reared from this host, that is, *Barbara colfaxiana taxifoliella*, although it may be a parasite of this species. All lots of material showed *P. evetriae* to be parasitic on *Holcocera* sp.

***Pimplopterus inconstans* (Cushm.)**

This species has been reported by Dohanian (14) as a parasite of *Melissopus latiferreanus* in filbert nuts in Oregon and California. It probably will also be found parasitizing this moth in oak acorns.

***Pimplopterus* spp.**

Several unidentified species of this genus were reared from fir cones. The host was not determined. (Collections: Hopkins U. S. Nos. 12538n2, p2, 13297c from *Abies concolor*; 13296e from *Abies magnifica shastensis*.)

One new species of this genus was reared from the moth *Eucosma recissoriana* from lodgepole pine cones.

***Poemenia americana* (Cress.)**

The adults are black, anterior coxae and legs white, their femora yellowish behind, posterior legs honey-yellow, abdomen with venter whitish, ovipositor shorter than abdomen. Length 9.4 mm.

This species of ichneumon, identified by S. A. Rohwer in 1916, was reared from cells of *Paratimia conicola* in knobcone pine cones and from galleries of *Laspeyresia piperana* and *Hedulia injectiva* in cones of Jeffrey pine. In Jeffrey pine this species may not have been actually parasitic on the cone moths. Pupae were found in November, and emergence occurred the next spring from March 24 to May 18.

This species is listed by Muesebeck (62) as distributed only in the East, and the present species may be a closely related western form.

***Scambus ephialtoides* Cushm.**

The adults are small, black ichneumons 7 mm. long, with yellow legs, antennae 5 mm., and ovipositor 9 mm.

This species was reared from cones of white fir, Sitka spruce, Englemann spruce, and blue spruce, from California, Oregon, Colorado, and Montana. In the fir cones it was found parasitizing

the larvae of *Barbara colfaxiana siskiyouana*. Larvae were found in the cocoons of the moth in November from which adults emerged the following spring. The species was reared from spruce cones infested with *Laspeyresia youngana* and was presumed to be parasitizing this species. Adults emerged from April 1 to May 20 the year after infestation by the cone moths.

***Scambus pterophori* (Ashm.)**

This species is reported by Muesebeck (62) as transcontinental in distribution, parasitizing many species of Lepidoptera including *Proteoteras aesculana*. From one lot of bigleaf maple seeds infested with *Proteoteras aesculana* which were collected at Ashland, Oreg., in October 1916, a species of *Scambus* emerged in June 1917. No other information was obtained concerning it. (Hopkins U. S. No. 14296c.)

***Scambus* sp.**

Another species of this genus emerged in July 1919 from mountain hemlock cones of the 1917 crop collected at Yosemite National Park, Calif. (Hopkins U. S. No. 13344c.)

***Syrphoctonus* spp.**

Single adults of this genus emerged from cones of white fir and Shasta red fir in April and May following maturity of the cones. The host was not determined, but the genus is known to parasitize Diptera. (Collections: *Abies concolor*, Hopkins U. S. No. 12577k; *Abies magnifica* var. *shastensis*, Hopkins U. S. No. 14200h.)

## Superfamily Chalcidoidea

### FAMILY ENCYRTIDAE

***Copilosoma* sp.**

The adults are tiny black wasps, 1.5–2 mm. long, with iridescent green and blue prothorax; antenna with 9 joints; abdomen sharp-pointed. Larvae are small white footless grubs, 2 mm. long; body composed of 14 segments, tapering toward both ends.

Many colonies of these small chalcid wasps were often found parasitizing completely the larvae and pupae of *Diorctria*, *Barbara*, and *Eupithecia* cone moths (fig. 24.) As many as 936 adults emerged from 9 larvae. Emergence occurred from March 22 to May 25 in the year after their parasitizing of the larvae, from cones of white fir, Shasta red fir, and mountain hemlock. (Collections: *Abies concolor*, Hopkins U. S. Nos. 12538kx, 12560kk, 13290ix, 13298ii; *Abies magnifica shastensis*, 14200m; *Tsuga mertensiana*, 13344d.)

***Pentacnemus* sp. (close to *bucculatricus* Howard)**

Adults of this genus emerged from larvae in cocoons of *Argyresthia libocedrella* from cones of incense-cedar, from March 4 to May 6 in the year after maturity of the cones. Cones collected at Julian, Calif. (Hopkins U. S. No. 13280fx); and at Ashland, Oreg. (Hopkins U. S. No. 12565g, gg).



FIGURE 24.—Larvae of a parasite, *Copidosoma* sp., filling the larval skin of *Dioryctria abietella* larvae.

### FAMILY EULOPHIDAE

#### *Elachertus glacialis* Ashm.

These tiny wasps, 1.5 mm., were reared from cones of white fir, acorns of California black oak, and seeds of bigleaf maple from southern Oregon and eastern Colorado, where it parasitized various lepidopterous caterpillars. In white fir, large numbers of pupae were found in the cocoons of *Barbara colfaxiana siskiyouana* in September. Adults emerged from these cocoons from March 29 to May 1 the next year. In oak acorns, adults were reared from the pupal cells of *Melissopus latiferreanus*, emerging from March 4 to June 3. Apparently, the species is widely distributed in the West from Colorado to Oregon and Alaska.

#### *Elachertus* spp.

Other species of this genus were reared from cones of white spruce, knobcone pine, lodgepole pine, Coulter pine, and Douglas-fir. In the lodgepole cones, collected at Yosemite National Park, Calif., black pupae were found in the pupal cells of *Eucosma recisoviana*, and with the remains of the host larvae in March. Seven naked parasitic pupae were taken from one pupal cell of the host. This parasite is evidently an external feeder, as the host larval skin was intact and parasitic pupae were lying adjacent in the pupal cell. This species was mixed with *Euderus* sp. in the rearings. (Hopkins U. S. No. 13375bx.)

From Coulter pine cones collected at Julian, Calif., in September, three adults emerged the next July. The host was not determined. (Hopkins U. S. No. 13278h.)

#### *Entedon* sp.

Two adults emerged in November from recently matured Jeffrey pine cones collected at Pine Valley, Calif., in August. The host was not determined, but this may be parasitic on *Ernobius* sp. (Hopkins U. S. No. 13276h.)

***Euderus* sp.**

Six adults emerged in May or June from lodgepole pine cones collected at Yosemite National Park, Calif., the previous fall, along with many *Elachertus* sp. These may be parasitic on *Eucosma recissoriana*. (Hopkins U. S. No. 13375bx.)

***Hyssopus evetriae* (Girault)**

These are very minute chalcid flies which were reared from a vial containing a pupa of the cone moth *Barbara colfaxiana* from near Ashland, Oreg. Emergence occurred in December 1915 from Douglas-fir cones of the 1914 crop collected near Colestin, Oreg., on June 30, 1914. They were assumed to be parasitic on the cone moth.

Dohanian (14) reported the species as parasitic on *Melissopus latiferreanus*. H. J. Rust, at the Coeur d'Alene, Idaho, Forest Insect Laboratory, reared the species in quantity from the ponderosa pine cone moth *Laspeyresia miscitata*. Except for the emergence record, nothing was determined concerning its biology.

***Hyssopus* sp.**

Adults emerged March to June 1916 from the 1915 crop of acorns of California black oak at Ashland, Oreg., from the pupal cells of *Melissopus latiferreanus*. (Hopkins U. S. No. 14218cx.)

***Hyssopus thymus* Girault**

Adults are very minute dark chalcid flies. A colony of pupae were found July 1, 1916, in the pupal cell of, and with the larval remains of *Dioryctria auranticella* in green cones of knobcone pine collected at Patricks Creek, Calif., June 9, 1916, by J. M. Miller and J. E. Patterson. Fourteen adult flies emerged between July 8 and 20, 1916. This species is also parasitic on *Rhyacionia* in Nebraska, Virginia, and Connecticut.

***Paracrias* sp.**

Two males emerged in October 1916 from seed of the 1916 crop of Oregon ash at Ashland, Oreg., and many more emerged in June of the next year. The host was not determined. (Hopkins U. S. No. 14295c.)

***Tetrastichus chrysopae* (Crawf.)**

Black pupae of these tiny parasites were found in November in the galleries of *Melissopus latiferreanus* in acorns of California black oak at Ashland, Oreg. Adults emerged from May 29 to June 3 the following year. They were presumed to be parasitic on the acorn moth. The species is widely distributed from the Atlantic to the Pacific.

***Tetrastichus strobilus* Burks**

Adults are minute, metallic blue-black flies with sharp-pointed abdomens, and clear wings except for a stigma below the anterior margin of the forewing. Length 1.5-2.2 mm.

The type series of this species was reared from Douglas-fir cones of the 1938 crop collected at Jenny Creek, Oreg., by J. E. Patterson, November 26, 1938. The cones were infested with fir

cone moth *Barbara colfaxiana*. Thirty adults emerged from December 23, 1938, to May 3, 1939. They were assumed to be parasitic on the cone moth.

### *Tetrastichus* spp.

Hundreds of small adults of *Tetrastichus* spp. were reared from various lots of cones, but only a few host insects were determined. Most of these *Tetrastichus* have not been specifically identified, or named if they were new.

One species was found parasitizing a gall-forming Itonididae midge, *Janetiella siskiyou*, in seeds of Lawson cypress. One hundred and two adults emerged in September from cones maturing that month. (Hopkins U. S. No. 12544bx.)

A few to many small black adults emerged from two lots of cones of Monterey cypress collected at Cypress Point, Calif., by J. M. Miller. Emergence occurred in May and June from cones that matured the previous fall. The host was not determined. (Hopkins U. S. Nos. 10864L, 13313i.)

Several collections of ponderosa pine cones near Placerville, Calif., were found to have a species of *Tetrastichus*, apparently parasitizing the seed chalcid *Megastigmus albifrons*. Larvae and adults were found in March in hollow seeds which had been infested with the larvae of *Megastigmus*. Larvae, pupae, and new adults were found in seeds in April and May; by the middle of May nearly all were adults. One seed was found to contain as many as 35 adult parasites. (Hopkins U. S. Nos. 14216dx, 11462ax, 11468b.)

One species of *Tetrastichus* was reared from cones of bigcone Douglas-fir from Figuero Mountain, Calif. (Hopkins U. S. No. 31974b.)

A species of *Tetrastichus* was reared very abundantly from cones of Douglas-fir collected from California, Oregon, Montana, and Colorado. This species was parasitic on the fir cone moth *Barbara colfaxiana taxifoliella*. Larvae were found in the pupal cells of the host and emergence occurred both in the spring, from April through June, and in the fall. As many as 83 adults emerged from 2 host cocoons. (This species is represented by a large number of collections from Douglas-fir, including Hopkins U. S. Nos. 10848c, 10899b, 11475c, 12535r, 12538cx, 13202k, 14211e, and 14292d.)

Other species of *Tetrastichus* were reared from cones of western redcedar (Hopkins U. S. Nos. 13256b and 31664) and from mountain hemlock cones (Hopkins U. S. No. 13344e).

Another similar species of *Tetrastichus* was reared from the white-fir cone moth *Barbara colfaxiana siskiyouana* from cones of white fir (fig. 25). (Hopkins U. S. Nos. 12529d2, 12538c2, 13228m.)

## FAMILY EUPELMIDAE

### *Eupelmus* sp. (near *limneriae* Howard)

These are very small metallic green wasps about 3 mm. long. They emerged July 1-3, 1914, from ponderosa pine cones of the



FIGURE 25.—Larva of a parasite, *Tetrastichus* sp., of the white-fir cone moth, *Barbara colfaxiana siskiyouana*, in a larval gallery of an infested white fir cone. 679-3755

1912 crop collected December 14, 1913, which were infested with the ponderosa-pine seed moth *Laspeyresia piperana*. (Hopkins U. S. No. 10870e.)

Other species of this genus emerged from white fir cones (Hopkins U. S. No. 12564o); and from cones of Douglas-fir collected at Quincy, Calif. (Hopkins U. S. No. 14292g).

Many adults of this genus emerged in April, May, and June from seeds of Oregon ash which matured the previous fall. These seeds were collected at Ashland, Oreg., and were infested with a weevil and chalcid larvae. (Hopkins U. S. No. 14202f.)

#### FAMILY EURYTOMIDAE

Some members of this family are phytophagous, feeding in seeds and plant galls. Others appear to be parasitic.

##### *Eurytoma* sp. near *juniperina* Marc.

The adults are shiny jet-black tiny wasps with pointed abdomens and clear wings except for small brown stigma in forewing. Length about 2 mm.

The larvae of this species infest juniper berries, forming cells in the seed. Berries of the 1914 crop of western juniper were collected by P. D. Sargent at Hilt, Calif., May 20, 1914, when

larvae and pupae of this species were found in cells in the seed. Thirty-nine adults emerged between May 30 and June 13, 1914. About 25 percent of the 1913 crop was infested by this species. (Hopkins U. S. Nos. 12518a<sup>2</sup>, 10840c.)

### *Eurytoma* spp.

Many other species of *Eurytoma* were reared from cones, and a few of these appeared to be definitely phytophagous. The most important of these was a species reared from the seeds of Douglas-fir. The larvae were found feeding, developing, and pupating in the seeds, in every way similar to the behavior of seed chalcids. Adults emerge in April, May, June, and July of the year after cone maturity, but an even larger number were found emerging late in the spring of the second year. (Collections: Hopkins U. S. Nos. 10808h, 10874g, 11475b, 12535m, 13202m, 14292f.)

Another seed-feeding species was reared from the seeds of Oregon ash at Ashland, Oreg. Nine hundred and eighty-six adults emerged from March to July 26 from one lot of seed that matured the previous fall, and 509 adults emerged in October from seeds of that year's crop. It was estimated that 15 per cent of the seeds were infested. (Hopkins U. S. Nos. 14202e, 14295f.)

A few adults of *Eurytoma* were reared from cones of white fir (Hopkins U. S. No. 12503b), ponderosa pine (Hopkins U. S. No. 10875b<sub>1</sub>), and western redcedar (Hopkins U. S. No. 13256c). Nothing was learned concerning their habits.

## FAMILY PTEROMALIDAE

### *Acerocephala atrovioleacea* (Crawf.)

The adults are small black wasps, smooth polished, with long flat heads and strong mandibles; abdomen with a purple luster, the thorax above with bluish and greenish luster; nine antennal joints, smoky wings with stigmal club close to margin. Length 3 mm.

The type of this species was reared from pinyon cones at Las Vegas, N. Mex. The cones were infested with *Conophthorus edulis*. It was also reared from pinyon cones from El Paso County, Colo. Each time this species was assumed to be parasitic on the cone beetle. The species has also been reared from limber pine cones from Colorado, where pupae were found in the pupal cells of *Conophthorus flexilis* on January 27, and in San Diego County, Calif., from Coulter pine branches infested with *Magdalis*, *Pityophthorus*, and *Cylindrocopturus*. Pupae were found in January in the pupal cells of the host insect, and adults emerged from the middle of June to July 5 from cones of the previous season.

### *Amblymerus verditer* (Norton)

Adults are small wasps with head and prothorax green, thorax and base of abdomen blue-green; apex of abdomen purple-bronze; antennae 13-jointed, with 4 basal joints yellow; coxae green, remainder of legs yellow; apical tarsal joints blackish; males with yellow band about middle of abdomen. Length 0.12-0.13 inches (3.0-3.3 mm.). This species was reported by Muesebeck (62) as

a parasite of *Barbara colfaxiana colfaxiana*. It was also reared by H. J. Rust from the ponderosa-pine seed moth *Laspeyresia miscitata* at Coeur d'Alene, Idaho, in 1935 and 1936. The species was not identified from the numerous *Amblymerus* spp. reared at the Ashland Laboratory.

#### *Amblymerus* spp.

These small chalcids are often metallic green with bronze reflections, yellow legs, and red eyes; 1 to 3 mm. long; sharp-pointed abdomens; and clear wings with a single stigmal club. A large number were reared from fir and spruce cones, and may have been parasitic on *Megastigmus* spp.

From white fir cones, adults emerged from October to mid-November in the year of cone maturity, and again the next spring from mid-April to mid-June. The host was not determined. California and Oregon. (Hopkins U. S. Nos. 12538s-2, 13228g, and 14201k.)

From red fir cones, larvae were found attached to the larval skin of *Megastigmus pinus* in January. One adult emerged in June, California. (Hopkins U. S. No. 14209hx.)

From Shasta red fir cones of the 1915 crop, 89 adults emerged from April 21 to June 16, 1916. Oregon. (Hopkins U. S. No. 14200g.)

From Douglas-fir cones, many small chalcids of this genus emerged from March 23 to June 3 in the spring following cone maturity. They had metallic-green bodies with bronze reflections; yellow legs and red eyes. The host was not determined. Oregon and Colorado. (Collections: Hopkins U. S. Nos. 10834g, 13295e, 14211b, 14234i.)

From Engelmann spruce cones from Colorado, adults emerged in June after cones reached maturity. (Hopkins U. S. No. 10849j.)

From Brewer spruce cones from Oregon, adults emerged in the laboratory from October 15 to February 16. The host was not determined. (Hopkins U. S. No. 18836B.)

From western redcedar cones from Oregon, three adults emerged. No host was noted. (Hopkins U. S. No. 31664c.)

#### *Caenacis* sp.

Adults are metallic green or bronze, with yellow legs and large, clublike stigma in their forewings. Length 2 mm. One adult was collected from ponderosa pine cones at Ashland, Oreg., in December, and one emerged the following June. The host was not determined. (Hopkins U. S. Nos. 12532g, 13302d.)

#### *Habrocytus* spp.

Several of these small bronze or metallic green chalcids emerged from cones or seeds. Two adults emerged from one lot of extracted seeds of white fir from central California. They were presumed to be parasitic on the seed chalcids *Megastigmus* spp. (Hopkins U. S. No. 11418d.) Six adults emerged from extracted seeds of Shasta red fir from southern Oregon which were heavily infested with *Megastigmus pinus*. The *Habrocytus* appeared to be parasitic on the seed chalcids. (Hopkins U. S. No. 31666B.) About 150



adults emerged in October 1916 from the 1916 crop of Oregon ash seeds collected at Ashland, Oreg., and many more emerged the following June. The host was not determined. (Hopkins U. S. No. 14295e.)

#### *Hypopteromalus* spp.

Several species of this genus were reared from cones and seeds. One adult emerged from extracted seeds of white fir from the Sierra National Forest, Calif. (Hopkins U. S. No. 11418c.) One adult emerged July 31 from isolated seeds of Shasta red fir collected in southern Oregon the previous September. These seeds were infested only with the seed chalcid *Megastigmus pinus*. (Hopkins U. S. No. 14205hx.) Some 272 adults of this genus emerged from April 29 to July 26 from seeds of Oregon ash collected at Ashland, Oreg., in October of the previous year. These seeds were infested with the ash seed weevil *Thysanocnemis* sp. (Hopkins U. S. No. 14202c.)

#### *Psychophagus omnivorus* (Walker)

These small chalcids, which are commonly found parasitizing many species of Lepidoptera in the Eastern States, were reared from ponderosa pine cones from Palmer Park, Colo. They emerged in the fall from cones collected the previous fall. The insect host was not determined, but was probably *Diorctria auranticella*, which was infesting these cones, since this species of chalcid is a general parasite of Lepidoptera.

#### *Rhopalicus pulchripennis* (Crawd.)

These small (2-3 mm. long) bright, metallic green chalcids, with bronze abdomens and bright red eyes, are known to be parasites on various small bark beetles and weevils, such as *Cylindrocapturus*, *Pissodes*, *Dendroctonus*, *Polygraphus*, and *Scolytus*. In the cone rearing, they emerged from sugar pine cones from Coe-stin, Oreg., which had been killed by attacks of the cone beetle *Conophthorus lambertianae* and had fallen to the ground at an early date. Cones were collected on July 18, and two of these chalcids emerged July 30 and August 2. They may have been parasitizing the cone beetles. This species is widely distributed.

#### *Systasis* sp.

Two adults of this genus emerged in November from maturing cones of Coulter pine collected at Julian, Calif. (Hopkins U. S. No. 13279f, g.)

#### *Zacalochlora milleri* Crawd.

*Description*.—The adults are small, coppery-green wasps with sharp-pointed abdomens which are longer than head and thorax combined, legs reddish-honey-colored, eyes red, wings hyaline; antennae 13-jointed with ring joints, the third subquadrate, the last 3 forming a club which is slightly enlarged. Length 3 mm.

*Hosts*.—Cones of white fir, blue spruce, Coulter pine, Jeffrey pine, ponderosa pine, and Douglas-fir, where it was found parasitizing *Laspeyresia* spp.

*Distribution.*—California, Oregon, and Colorado.

*Notes.*—The species was described from Yreka, Calif., where J. M. Miller found it parasitizing the pupae of the Jeffrey-pine seed moth *Laspeyresia piperana* and *Hedulia injectiva*, or both. Several individuals were found in each parasitized pupae. Since this record, the species has been reared many times from *Laspeyresia* spp. in various cones, and may possibly be parasitic on other insects, but its parasitism on other hosts is very uncertain and needs further checking.

Some emergence has been noted in the fall of the year from cones of the current year's crop. Possibly this is the emergence of parent adults. Larvae have been found in larval chambers of *Laspeyresia* and with remains of the host larvae in November and December (fig. 26). Pupae have been found in the pupal cells of *Laspeyresia* from December through April, and emergence has followed from January 2 to July 3. Maximum emergence occurs during May and June. Many adults have been found hibernating among cone scales in December.



EPQ-7710

FIGURE 26.—Larvae of a parasite, *Zacalochlora milleri*, in larval galleries of the pine seed moth, *Laspeyresia piperana*, in the axis of a ponderosa pine cone.

This is one of the most common parasites emerging from cones infested with *Laspeyresia* spp.

### FAMILY TORYMIDAE

#### Genus *Megastigmus*

#### seed chalcids

The larvae of this genus are for the most part phytophagous, living and feeding within the seeds of various plants (69). Several species are seriously destructive to the seeds of conifers, particularly Douglas-fir, true firs, and spruces. Only one named species is found in pine (*M. albifrons* in ponderosa pine). Recently another species, as yet undetermined, was reared from *Pinus montezumae* var. *rudis* from near Mexico City.

The adults are small, antlike, subglobose wasps with clear wings, except for a dark, well-defined, clubbed stigma below middle anterior margin of forewing; the females with a long, curved ovipositor about as long as, or longer than the body, which varies from 2.5 mm. to 6.5 mm. in different species. Colors vary from black to brown or lemon yellow.

The eggs, described by Crosby (10), are "white, smooth, and spindle-shaped, with a very long pedicel at the anterior end and the vestige of one at the opposite end."

The larvae are small, up to 6 mm. long, yellow-white, footless grubs, with strongly arched bodies tapering towards each end, with small rigid head capsule, and the body with 14 distinct segments; mouth parts slightly differentiated with chitinized mandibles with three sharp teeth in the inner surface of each. The larvae are always completely enclosed in normal-appearing seeds, and there is no danger of infestation spreading from seed to seed in storage.

*Biology.*—The life history and habits of the coniferous seed-infesting species are very similar. Eggs are deposited directly into the soft, embryonic seeds by the female inserting her ovipositor through the cone scales and into the seeds at a time when the young cone is small and soft (60). Although several eggs may be deposited in a single seed, only one larva develops inside each infested seed. The larva absorbs the inner part of the seed and leaves the outer coat intact. Growth of larvae keeps pace with growth of the seeds, and the larvae reach maturity at the time in the fall, about September, when the seeds normally reach maturity. Pupae of most species form in the seeds during the next year, in February, March, and April. Pupae of *M. albifrons* form in October and November and the new adults emerge in April, May, and June in time to infest the new crop of cones. On emerging, they leave a neat, round hole in the seed coat. A safeguard against extinction of the species in years of cone-crop failure is that a certain percentage of the brood is retarded and carries over a second or even a third season before emerging.

*Parasites.*—Parasites of *Megastigmus* were very scarce. Several records indicated that a species of *Tetrastichus* was parasitic on *Megastigmus* spp. Other suspected parasites included *Amblymerus* sp., *Hypopteromalus* sp., *Habrocytus* sp., and *Torymus* sp.

*Control.*—Control of seed chalcids under forest conditions has not been successfully developed as yet. At its Clemons Tree Farm in Washington, the Weyerhaeuser Timber Co. carried out some experimental spraying in 1954, using a 2½-percent DDT water emulsion applied to small trees with ground equipment. The results looked promising (71).

Hussey (39) has suggested that in seed orchards "it might prove feasible to spray the forest floor with a residual insecticide such as DDT during the fortnight in which the *Megastigmus* adults emerge from the seed." However, if an effective spray is found, it might be better applied by airplane to the tops of trees and young cones at the time of chalcid mating and before oviposition, to protect the young cones from infestation.

*Chronology of the more important references on Megastigmus.*—

1906, MacDougall (53).	1929, Hoffmeyer (33).
1909, Crosby (10).	1930, Hoffmeyer (34).
1913, Crosby (11).	1931, Laidlaw (48).
1913, Rohwer (69).	1949, Milliron (61). <sup>9</sup>
1914, Miller (58).	1952, Hanson (29).
1916, Miller (60).	1954, Hussey (39).

*Megastigmus albifrons* Walker

pine seed chalcid

*Description.*—Adults are dull yellowish to yellowish-brown and black wasps, 6.0–6.5 mm. long. Female with ovipositor sheath 4.7 mm.

*Hosts.*—Seed of *Pinus ponderosa*.

*Distribution.*—Found only locally in the Sierra Nevada of California, from Eldorado County south to Fresno County.

*Damage.*—Heaviest damage was noted at Placerville, Calif., in 1912; 25 percent or more of the seed were infested. Owing to a seed crop failure in this locality in 1913, the chalcid almost disappeared. It recovered slightly in 1914 and to a considerable extent in 1915.

*Seasonal history.*—It was not determined when eggs are deposited, but they probably are laid in the young, soft, first-year cones in March or April as soon as the cone buds open, and do not complete their development until the second fall when the pine cones mature. On May 16, 1947, cones were bagged on the Eldorado National Forest by F. I. Righter, of the Institute of Forest Genetics, to control pollination. When these cones were collected on October 25, 1948, 118 chalcid-infested seed were found, indicating that oviposition must have occurred before the cones were bagged. It is also logical to assume that these seed chalcids with short delicate ovipositors would be unable to penetrate second-year cones but could penetrate the soft immature

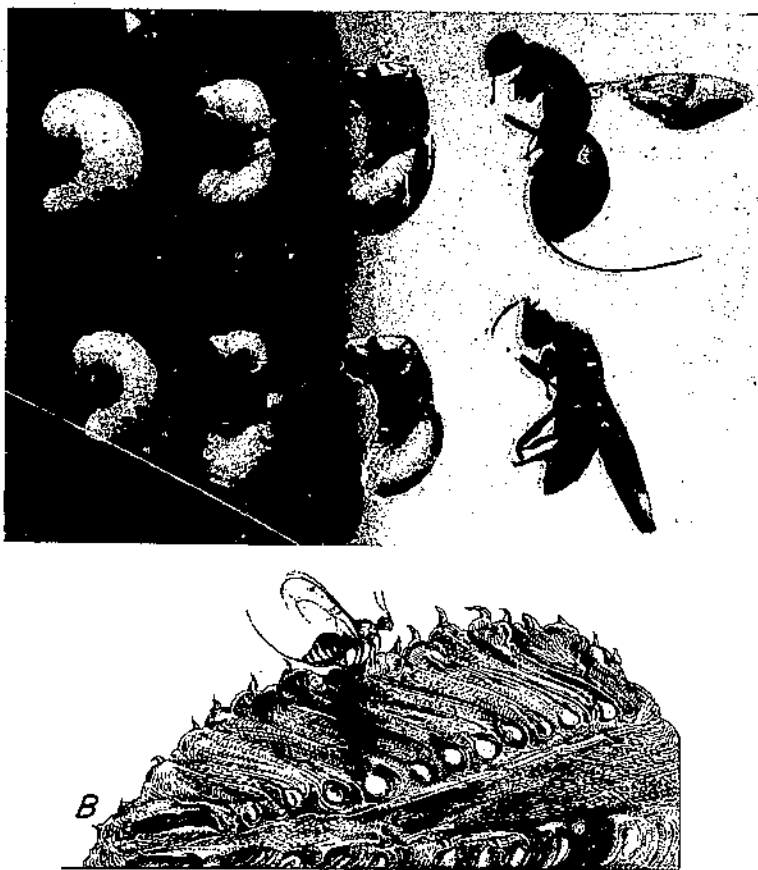
<sup>9</sup> In this publication Milliron reviews the genus, redescribes the species, and gives a comprehensive account of their biology. Anyone who wishes to go further into the character and habits of this genus than is possible in this publication should consult Milliron's monograph. The monograph also contains a more extensive list of references.

first-year cones. Full-grown larvae are commonly found in the fall of the year in fully mature seeds (figs. 27 and 28).



FIGURE 27.—Larvae and pupae of the pine seed chalcid, *Megastigmus albifrons*, in sectioned cone of ponderosa pine.

Pupae form in October and November in the seed, and adults emerge from February through April, mostly in March. A small percentage of the brood, probably less than 1 percent, are retarded and emerge the second spring.



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FIGURE 28.—A, Larvae, pupae, and adults of the pine seed chalcid, *Megastigmus albifrons*, X 5; B, drawing showing method of oviposition in seed of ponderosa pine (drawing by Edmonston).

*Parasites.*—A species of *Tetrastichus* has been found several times in seeds formerly infested with the pine seed chalcid and is presumed to be parasitic.

***Megastigmus lasiocarpa* Crosby**                      **alpine-fir seed chalcid**

*Description.*—The adults are jet black and yellow, length 3.7 mm. in the female with ovipositor sheath 3.1 mm., male 2.3 mm.

*Hosts.*—*Abies lasiocarpa* and *A. amabilis*.

*Distribution.*—Colorado, Washington, and British Columbia. Probably will be found through the range of its host trees.

*Notes.*—This is a relatively uncommon species which was not reared at the Ashland Laboratory. It probably has a 1-year life cycle synchronized with the development of the seed of its host trees.

**Megastigmus milleri** Milliron**Millers seed chalcid**

*Description.*—This species is jet black with greenish to golden-yellow markings. Female 4.2 mm. with ovipositor sheath 3.8 mm. Male 3.3 mm.

*Host.*—Reared from *Abies grandis* at Crescent City, Calif., and on Vancouver Island, B. C. Milliron records it as occurring in *Abies magnifica* var. *shastensis*.

*Notes.*—This species is very similar to *M. pinus* and has been confused with it. The type series were reared from the 1914 crop of grand fir cones collected by J. M. Miller at Crescent City, Calif., on August 18, 1914. Less than 10 percent of the seed were infested, but 750 adults were reared from the cones. These emerged from April 1 to May 6, 1915, the males coming out about a week in advance of the females. The heaviest emergence of males occurred on April 19 and the maximum emergence of females on April 26.

**Megastigmus piceae** Rohwer**spruce seed chalcid**

*Description.*—This is one of the smallest species of seed chalcids. The adults are mostly black with a few brownish and yellow markings. Female, length 2.7 mm. with ovipositor sheath 2.3 mm.; male, 2.4 mm. (34).

*Hosts.*—Seeds of *Picea sitchensis*, *Picea engelmanni*, and *Picea pungens*.

*Distribution.*—Reared from Crescent City, Calif., and several points in Colorado and Alaska. Probably will be found throughout the range of host trees.

*Damage.*—Heaviest damage was found in Engelmann spruce seed from Beulah, Colo., in 1913, when about 8 percent of the seed were infested. In blue spruce the heaviest damage was about 3 percent; in Sitka spruce damage was very light.

*Seasonal history.*—Larvae develop in the seed during the summer and fall. One record indicates that they overwinter as larvae and pupate in the spring. Adults emerge in April, May, and June of the following year. Records indicate that about 30 percent of the brood in Engelmann spruce seed and about 5 percent of the brood in blue spruce are retarded and emerge the second spring.

*Parasites.*—None found.

**Megastigmus piceae** var. **montana** Milliron

*Description.*—This variety is similar to *M. piceae*. However, the dorsum of the pronotum is black except for two large, triangular, bright-yellow spots on the posterior margin, side of the pronotum nearly entirely yellow. Females, length 2.4 mm., ovipositor sheath 2.0 mm.; males, length 1.9 mm.

*Host.*—*Picea engelmanni* seeds.

*Distribution.*—Recognized only from Montana.

*Note.*—This variety was not recognized in the Ashland rearings.

**Megastigmus pinus** Parfitt**fir seed chalcid**

*Description.*—Adults of this species are variable, but generally jet-black with orange and yellow markings, the pronotum with

a rectangular reddish-orange spot on the dorsal surface. Females (fig. 29), length 5.1 mm., ovipositor sheath 5.6 mm.; males, 4.4 mm. in length. Eggs are pearly white, long, slim, unsculptured, spindle-shaped, pointed at both ends and at one end have a long, taillike process; length 2 mm. The larvae are yellowish-white, footless, up to 6 mm. long when full grown, tapering to both ends, surface smooth with hairs very sparse and microscopic in size; brown mouth parts, the inner margin of the mandibles with three sharp teeth. Pupae are yellowish-white, female with ovipositor curved over back reaching to about the middle of the thorax; length 3-4 mm.



FIGURE 29.—Seeds of red fir damaged by the fir seed chalcid, *Megastigmus pinus*: larva, male, and female of this species. EPQ-6799

*Hosts*.—Seeds of *Abies* spp. Reared at Ashland from *Abies concolor*, *A. magnifica*, *A. magnifica* var. *shastensis*, and *A. procera*. Reported by Milliron (61) also from *A. grandis* and *A. lasiocarpa*; by Crosby (11) from *A. amabilis*, and by Essig (17) from *Abies bracteata*.<sup>10</sup>

*Damage*.—The seed infested by this species and its associate *Megastigmus rafni* in white fir cones varies from 1 to 60 percent of the seed crop, but usually averages about 8-10 percent. The heaviest damage was found near Colestin, Oreg. (in the Siskiyou Mountains), where the 1914 crop of white fir seeds was 60 percent destroyed by seed chalcids.

*Distribution*.—California (type), Oregon, Washington, British Columbia, Idaho, Nevada, and Colorado.

*Habits and seasonal history*.—The oviposition of this chalcid as it normally occurs in nature was observed for the first time on June 18, 1915 by the writer from a vantage point in the top of a 125-foot white fir tree near Ashland, Oreg. The young cones were about 60 mm. long and 17 mm. in diameter. Upon alighting

<sup>10</sup> The type material was probably from *Abies bracteata*. Parfitt (64) records it as *Picea bracteata*, but refers to "pine cones." This tree was first recorded as *Pinus bracteata* D. Don; synonyms = *Pinus venusta* Dougl. = *Abies venusta* (Dougl.) K. Koch = *Abies bracteata* (D. Don) Nutt. There is no other native conifer in California (the type locality) except this to which the name *Picea bracteata* might conceivably apply.



on a cone, the female first wandered over it feeling about with her antennae for a suitable place. After several minutes a favorable spot was selected. Then the head was pointed down toward the stem end of the cone, the abdomen was lifted, and at the same time the tip of the abdomen was doubled under so that the sheath and its enclosed ovipositor was brought forward between the legs until the tip rested on the surface of the cone scale directly beneath the head, and at the juncture of two cone scales. The sheath was then removed and assumed its normal position, the ovipositor was sunk slowly into the cone, and the abdomen lowered until it was on a level with the rest of the body. Almost the entire ovipositor was sunk into the cone. In this position the female rested for a minute; then the ovipositor was withdrawn and returned to its sheath. Cones on which the female was killed while in the act of ovipositing were sectioned. The course of the ovipositor was traced through the cone scales to its tip, sunk into a newly formed seed. Thus, the female lays her eggs directly in the seed, and the larvae on hatching are bountifully surrounded with food.

Eggs were dissected from the center of seeds. By July 18, very small larvae, 1 mm. in length, were found in sectioned seed. These develop with the seed and consume the seed contents about as fast as formed. However, the seed coat of infested seeds continues to grow to full size. These seeds cannot be distinguished superficially from fertile seeds. Larvae develop within the seeds during July, August, and September, and overwinter in this position.

Pupation occurs the following March and April. This period lasts about 30 days.

Adults then emerge in April and May. A round exit hole is bored in the seed. The males are first to emerge. They come out from April 1 to June 1. The females appear about April 11, and both sexes reach a maximum emergence about the first of May. Not all the seed chalcids emerge in the first spring: from 25 to 50 percent are retarded as larvae within the seed until the second or even the third year. Thus, the species is adapted to the irregularity of good cone crops, and is not made extinct by a cone failure.

*Parasites.*—These appear to be very scarce. One record indicated that *Zacalochlora milleri* was parasitic on this host.

### *Megastigmus rafui* Hoffmeyer

### fir yellow seed chalcid

*Description.*—The adults are light to brownish (or greenish) yellow with brown or black markings. Females, 4.2 mm. long, with ovipositor sheath 4.7 mm. Males 3.0 mm. long (33). The adults are very similar to *M. spermotrophus* and were confused with it in the Ashland rearings. The females are easily separated by the ovipositors being much longer than the body in *M. rafui*; their color is also brighter yellow to brown or greenish and more shining.

*Hosts.*—Seeds of *Abies* (fig. 30). Reared at Ashland from *Abies concolor*, *A. grandis*, *A. magnifica*, and *A. magnifica shastensis*.

*Distribution.*—California, Oregon, Washington, British Columbia, Colorado, Arizona, and New Mexico. Probably throughout the range of the host trees. Also introduced into Scotland (48).



EPQ-2091

FIGURE 30.—Larvae of the fir yellow seed chalcid, *Megastigmus rafni*, in seeds of white fir.

*Damage.*—In combination with *M. pinus* up to 60 percent of seed destroyed in some areas and some years. Damage not separated between these two species.

*Seasonal history.*—The seasonal history for this species is very similar to that of *M. pinus* and *M. spermotrophus*. Emergence occurs slightly later than for *M. pinus*, from April 18 to July, with the maximum from May to June 16. One lot of material from Beulah, Colo., continued emergence through July and August to September 24. As in *M. pinus*, the males come out about a week before the females.

On December 13, 1916, J. M. Miller wrote to Dr. A. D. Hopkins for the attention of S. A. Rohwer, the following note concerning the biology of this species:

"In *Abies concolor*, the emergence of *Megastigmus spermotrophus (rafni)* always seems to follow that of *M. pinus*. The habit of emergence of *M. spermotrophus (rafni)* from white fir differs from that of the species from Douglas-fir on the Pacific Coast, the maximum occurring about a month later in *Abies concolor* than in *Pseudotsuga* under the same conditions. The lots of Douglas-fir from Colorado are an exception to this as emergence in lots from this locality occurs nearly as late as from *A. concolor*.

"In the Pacific Coast region I do not believe that the adults which emerge from *A. concolor* attack the Douglas-fir cones for the reason that by the time emergence is completed the Douglas-fir cones have hardened beyond the condition suitable for attack, while the white fir cones at that time are quite immature and suitable for oviposition. This difference applies between other species of *Abies* from which we have reared *M. spermotrophus (rafni)* and Douglas-fir." (Mr. Miller was correct in recognizing that the *Abies*-infesting species was biologically distinct from *M. spermotrophus*.)

This species also retards, and emergence occurs in the second and third years.

*Parasites*.—None reared.

***Megastigmus spermotrophus* Wachtl**      **Douglas-fir seed chalcid**

*Description*.—The females of this species are brownish yellow or orange, 2.8–4.3 mm. long with ovipositor sheaths 2.5–4.6 mm. long. Males are lemon yellow with some black on the head; length 2.7–3.7 mm.

*Host*.—Seeds of *Pseudotsuga menziesii*.

*Distribution*.—California, Oregon, Washington, British Columbia, Idaho, Colorado, and New Mexico. Probably throughout the range of Douglas-fir. Introduced by seed into Great Britain, New Zealand, Germany, and western Europe (29, 48, 53).

*Damage*.—Destruction of Douglas-fir seed by seed chalcids varies by localities and years, and often ranges between 2 and 10 percent of the seed crop. Heaviest damage recorded was 50 percent of the 1913 seed crop near Ashland, Oreg. The most serious damage occurs in years when the seed crop is normally light (35). In some areas of Great Britain and in some seasons infestation of sound seed has reached 100 percent (39).

*Seasonal history*.—Mating is reported by Hussey (39) as taking place on the needles, after which "the females cease to hover around the apices of the flushing shoots and remain settled for long periods on the cones." He states that the female can lay fertile eggs without fertilization but that all the adults from such parthenogenic eggs are males.

Miller (60) recorded in detail the act of oviposition, both in cages and in the field. This was essentially the same as just described for *M. pinus*. Again the female rested on a cone scale with its head pointed toward the base of the cone, drove her ovipositor down through the cone scales, and laid an egg in a young seed. Since Douglas-fir cones are pendent, this placed the female in an upright position. The time required for oviposition varied from 2 to 5 minutes.

Oviposition occurs late in April and throughout May in immature cones from 2 to 3 weeks old. Probably most of the oviposition in the field occurs in May (at elevations around 3,000 feet) and at the higher elevations in June. Hussey (39) reported that susceptible cones are from 1½ to 3 inches long, with exposed parts of bracts from one-half to three-quarters inch long and held tightly against the surface of the cone. Younger or older cones are safe from attack.

Eggs are smooth, white, and minute, with an oval body and taillike process or pedicel. The body of the egg is about 0.3 mm. in length and with its stalk about 1.5 mm. in overall length. According to Hussey (39), "normally only one egg is laid in each seed, but where the insects are numerous, and where there is considerable competition between the laying females for suitable seed, as many as 7 eggs have been found in 1 seed. When several eggs are laid within the same seed, only one larva develops to



***Torymus (Callimome) spp.***

The adults are bright-metallic blue, green, or bronze chalcids, the females with long ovipositors. They have been reared from Douglas-fir, spruce, and western redcedar cones, and oak acorns. Milliron (61) reports a species of this genus as parasitic on *Megastigmus*. Other species are known to be parasitic on gall wasps.

In the seeds of Brewer spruce collected in Oregon, chalcidlike larvae were found, and it was presumed that these were a species of *Megastigmus*. When adults emerged in October, they proved to be a new species of *Torymus*. It was not determined whether these were phytophagous or parasitic on a *Megastigmus* seed chalcid. (Hopkins U. S. No. 18836a.)

Adults of another species of *Torymus* emerged in May 1916 from the 1914 crop of Engelmann spruce cones collected in Colorado. (Hopkins U. S. No. 12570d.) Other species of *Torymus* emerged from white spruce and Sitka spruce cones.

Many *Torymus* sp. adults emerged during April and May from Douglas-fir cones of the previous year's crop. From one lot of cones collected in California and Oregon, 355 emerged. Their habits were not determined. (Hopkins U. S. Nos. 10852h-6, 11475e, 13202k.)

*Torymus* sp. near *coloradensis* Huber were reared from cones of western redcedar collected in Oregon. (Hopkins U. S. Nos. 13262b, 31664b.)

Some 66 adults of *Torymus* sp. emerged in September and October from the current crop of California black oak acorns, at Ashland, Oreg. They were suspected of being parasitic on cynipid gall wasps infesting these acorns. (Hopkins U. S. No. 12561e.)

**FAMILY TRICHOGRAMMATIDAE*****Trichogramma evanescens* Westwood and *Trichogramma minutum* Riley**

These minute yellow parasites, about 0.3 mm. long, which are commonly found parasitizing eggs of many species of insects throughout the United States and Canada, were reported by Thompson (74) as egg parasites of *Melissopus latiferreanus* (14). They were not reared from eggs of other cone and seed insects at the Ashland Laboratory.

**Superfamily Cynipoidea****FAMILY CYNIPIDAE GALL WASPS*****Eumayria eldoradensis* (Beut.) (*Andricus*)**

*Description.*—The adults are brown, rounded-bodied cynipid wasps about 2-5 mm. long. The larvae form hard cells in the kernel and on the inner shell of oak acorns, sometimes completely filling the interior.

*Hosts.*—*Quercus agrifolia*, *Q. kelloggii*, *Q. wislizenii*, and probably other oaks in Oregon and California.

*Notes.*—Larvae were found in hard gall pockets in the kernel of acorns and on the inner shell, during November; 4-8 larvae were in each infested acorn. Adults emerged in September and October from newly matured acorns, and in March of the second year, none coming out in the first year after acorns matured. Sometimes only a few acorns were found infested by this cynipid, but other times 60 percent or more of the acorns were infested. Acorns often are dwarfed or stunted, but sometimes they do not appear to be seriously injured by the galls. A green chalcid, *Torymus* sp., issued abundantly from the infested acorns and was evidently parasitic on the cynipid larvae. Parasitic larvae were also found in the galls.

#### FAMILY FIGITIDAE

The Family Figitidae include mostly secondary parasites.

##### *Sarothrus* spp.

Six adults of this genus emerged July 17, 1919, from mountain-hemlock cones of the 1917 crop collected in Yosemite National Park, Calif. Their habits were not determined. (Hopkins U. S. No. 13344b.)

Another species of this genus emerged from cones of Sitka spruce collected at Crescent City, Calif. Two black adults emerged on May 1, 1916, from cones of the 1915 crop. L. H. Weld stated in a letter that these are dipterous parasites. (Hopkins U. S. No. 13231d.)

#### *Superfamily Proctotrupeidea*

#### FAMILY GASTERUPTIIDAE

##### *Aulacostethus californicus* Townes

The adults are large, black, ichneumonlike wasps with black heads and thorax; brownish-red abdomens and fore and middle legs; hind legs brown; forewings with dark spot below the stigma. Length about 10 mm. The species was described from adults which were found parasitizing the roundheaded cone borer *Paratimia conicola* in knobcone pine cones collected at Patricks Creek, Calif., September 14, 1916, by J. E. Patterson. Larvae were found in the pupal cells of *Paratimia* on September 20 and pupae were found in pupal cells on November 29. Emergence occurred on March 24 and April 24.

##### *Aulacostethus editus* (Cress.)

*Description.*—The adults are large, ichneumonlike wasps with black heads and thorax and red abdomens and legs; forewings without spots. Length about 10 mm. This is a rather common parasite of a number of cerambycid and buprestid beetles. It has been reared from *Melanophila drummondi* under the bark of fir, Douglas-fir, and hemlock; from *Buprestis aurulenta* in lodgepole pine; from *Poecilوناتa fraseri* in willow; and from *Paratimia conicola* in knobcone pine cones.

*Distribution.*—California, Pacific Northwest, and British Columbia.

*Notes.*—Pupae have been found in the pupal cells of the host on various dates from January through May and again in August and September. Adults emerge in June and July and again in September. Apparently there are two generations a year, and the species overwinters as larvae or pupae in parchmentlike cocoons in the galleries of the host insect.

### FAMILY PLATYGASTERIDAE

Members of this family are tiny wasps which, for the most part, are parasitic on Diptera. Many of those reared from cones and seeds were parasitic on Itonididae gall midges.

#### *Platygaster gahani* Fouts

Adults are tiny, shiny black wasps (fig. 31), 1.5–2.0 mm. long, with clear wings, 11-jointed antennae with the second joint much longer than others, and sharp-pointed abdomens with short ovipositors. This species was named from specimens reared from one lot of white fir cones of the 1915 crop collected at Quincy, Calif., by F. P. Keen, September 20, 1915. Sixteen adults emerged 2 years later, from April 26 to May 5, 1917. Usually adults emerge from the middle of April to the first of June in the year after the cones mature. The species has also been reared from grand fir cones from Crescent City, Calif., where it was found parasitizing a gall midge (Itonididae) in a gall pocket of the cone scales. Adults were found in August in the larval skins of the midge.

#### *Platygaster lucida* Fouts

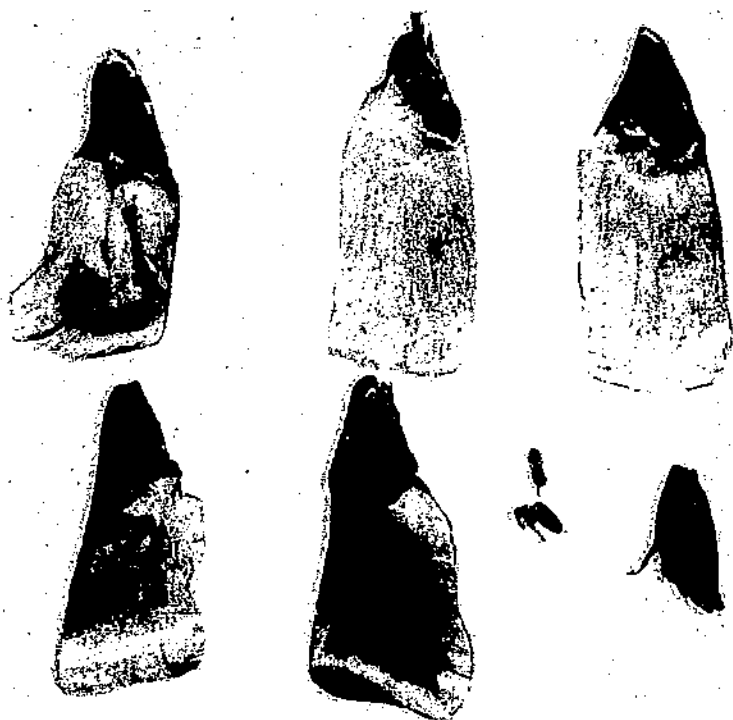
This small black wasp, 2 mm. long, was named from a collection of Engelmann spruce cones of the 1916 crop collected by J. H. Pollock at Mt. View, Colo., September 5, 1916. Eight adults emerged June 23, 1917. They were probably parasitic on the gall midges (Itonididae) infesting these cones, the adults of which emerged at the same time. It has also been reared from cone gall midge larvae from Sitka spruce at Crescent City, Calif., emerging in late April and early May from cones of the previous year.

#### *Platygaster rohveri* Fouts

This species, 1.3 mm. long, similar to *P. lucida*, was reared from sugar pine and white fir cones from northern California and southern Oregon. They were parasitic on gall midges Itonididae, and emerged from infested cones from May 9 to June 10 in the year following maturity of the cones.

#### *Platygaster shastensis* Fouts

These small black wasps, 2.5 mm. long, similar to the preceding species, were reared from Shasta red fir cones of the 1915 crop. The cones were collected from Palmerlee's Ranch, Oreg., by J. E. Patterson, September 8, 1915. Most of the adults, 123, emerged from June 1 to 5, 1916. Three more emerged the next year, June 9,



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FIGURE 31.—A gall midge parasite, *Platygaster gahani*; puparia and adults in gall midge pockets in seeds of grand fir,  $\times 2.25$ .

1917. The host was not definitely determined, but was presumed to be Itonididae midges.

***Platygaster* spp.**

Many species of *Platygaster* were reared from cones of fir, pine, and spruce. When the host was determined, it proved to be gall midges (Itonididae). The species were not always determined. Some may have been the species listed here or other, as yet undescribed, species. The seasonal histories for all were much the same.

**Superfamily Scolioidea**

**FAMILY FORMICIDAE ANTS**

***Camponotus* sp.**

**carpenter ants**

In November 1913, P. D. Sargent found a colony of carpenter ants making their abode in the center of a hard, dry knobcone pine cone near Mount Shasta City, Calif. (Hopkins U. S. No. 10868e.)



**Superfamily Sphecoidea**

**FAMILY SPHECIDAE**

***Passaloecus melanognathus* Rohwer**

This species of thread-waisted wasp is solid black, about 12 mm. long.

Pupae and adults were found in the pupal cells of *Paratimnia conicola* in knobcone pine cones during October and January. One adult emerged in May from a lot of Douglas-fir cones.

These predatory wasps were undoubtedly only using the cones as a convenient nesting place and cannot be considered as cone-infesting insects.

***Spilomena alboclypeata* Bradley.**

One specimen of this species was reared from Douglas-fir cones at Ashland, Oreg. Nothing was determined concerning its biology.

**Superfamily Apoidea**

**FAMILY MEGACHILIDAE**

***Osmia* sp.**

A species of these leaf-cutting bees was found making a nest in the galleries of *Paratimnia conicola* in cones of knobcone pines at Monumental Pass, Calif. (Hopkins U. S. No. 10856b.)

***Osmia coloradensis* Cress.**

Ruckes (70) reports finding a three-cell gallery of this bee in the pith of a Jeffrey pine cone in Los Angeles County, Calif., in October 1955.

**ORDER LEPIDOPTERA MOTHS**

The caterpillars of several species of moths are among the most destructive insects found in cones and seeds of western trees. They usually feed on scales, bracts, and seeds of tender growing cones. Besides dwarfing and deforming the cones, they kill a large percentage of seed. Their work is characterized by larval tunnels within the cones and an opening at the surface through which larval castings, and sometimes resin, exude.

Control of cone moths has not been attempted, but might be possible through aerial application of DDT before egg laying begins or before the small larvae hatch.

Moths affecting cones and seeds of western trees are discussed in alphabetical order by families, genera, and species in the following section. Owing to the lack of a comprehensive catalogue for Lepidoptera, references to original descriptions are usually given.

**FAMILY BLASTOBASIDAE**

Larvae of the family Blastobasidae have variable habits. Some bore in cones, nuts, and seeds. Others are scavengers following other primary insects. Some prey on scale insects.

***Holcocera augusti* Heinrich**

*Description.*—The adult moths are pale, dull-golden yellow, the forewings shading slightly darker near apex but without markings; hindwings and cilia a trifle darker than forewings, shading to pale fuscous. Alar expanse 17–19 mm. (30, p. 70). The eggs are pearly white, cylindrical oblong  $\frac{3}{8}$  by  $\frac{5}{8}$  mm., surface very rugose; not securely attached to outer and inner surface of cone bracts and under edge of scales; turning pink toward maturity and to deep crimson. The larvae are pink to deep red or reddish-brown in color, 12 mm. long, with dark-brown heads, and without anal shield.

*Host.*—*Pseudotsuga menziesii*.

*Distribution.*—Southern Oregon, northern California, and British Columbia.

*Notes.*—The larvae feed in cones of the current year's crop during the summer and fall, and adults emerge during April, May, and June of the next year. It was not specifically determined whether this species actually is primary in feeding on cone and seed tissues, is secondary to *Barbara* and other cone moths in acting as a scavenger, or is actually predaceous. It was found a couple of times feeding on the pupae of *Barbara* and appeared to be predaceous, but may have been acting as a scavenger because the pupae may have previously died.

***Holcocera* spp.**

Several undetermined species of *Holcocera* were reared from cones. The description of their work varied.

In Douglas-fir cones (fig. 32), larvae were described as pinkish, reddish, or brownish, 11 mm. long, feeding between the scales in the fall of the year, entering cocoons in late September, pupating the next spring, and emerging in May and June.

Material collected from Colorado was described as having larval habits very similar to *Dioryctria abietella* and causing heavy damage to cones and seeds. In the fall of the year these entered flattened, circular cocoons covered with dry frass or pebbles, on the surface of the cones or in the ground. In these cocoons, the prepupal larvae overwintered. Pupation occurred in May of the following year and emergence in June. The adults of this species are the same size as *H. augusti* but are gray in color.

During June, moths of this species were liberated in a cage containing fresh green cones of Douglas-fir. Eggs were laid on July 6, attached to both sides of cone bracts and on cone scales. Fresh eggs were pearly white, cylindrical oblong,  $\frac{3}{8}$  by  $\frac{5}{8}$  mm. in size. Eggs turned deep crimson as they approached incubation, within 10 days. One first instar larva  $3\frac{1}{2}$  mm. long was found on a scale. It was pinkish in color and very active. (Collections: Hopkins U. S. Nos. 13263d, 13270a, 13283a, 13295a.)

*Parasites.*—Ichneumonidae: *Pimplopterus evotriæ* (Roh.). In white fir cones collected from Mt. Manitou, Colo., the writer noted "grayish-brown larvae found in galleries of *Dioryctria abietella* and one in a pupa case of *Barbara colfaxiana siskiyouana*. They are predaceous on these moths." Actually they may have been



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FIGURE 32.—Damage by larvae of *Holcocera* sp. to cones of Douglas-fir.

scavengers feeding on dead larvae or pupae of these cone moths. (Collection: Hopkins U. S. Nos. 11459b, 14212d.)

#### Other *Holcocera* spp.

Other species of *Holcocera* were reared from cones of Monterey cypress (Hopkins U. S. Nos. 13264d, 13313j), Jeffrey pine (Hopkins U. S. No. 13276j), and bigleaf maple (Hopkins U. S. No. 12548c). Further investigations are needed on the habits of these species.

#### *Valentinia glandulella* (Riley)

acorn moth

*Description.*—The adults are light, smoky brown moths with narrow wings, more or less powdery and mottled. Hind wings much yellower, olive gray. Alar expanse 15 to 25 mm. (63, p. 216). The larvae are grayish-white or yellowish with blackish dorsal marks, and the cervical and anal shields are brownish.

*Host.*—Oak acorns, but also chestnuts and hickory nuts (25, p. 310). Reared from *Quercus kelloggii* in southern Oregon.

*Distribution.*—From the Atlantic to the Pacific.

*Character of Damage.*—The larvae feed on the oak acorn kernels which have previously been attacked by the acorn weevil *Cureulio*. Its activity appears to be dependent upon that of the weevil. However, Craighead (9) reports that Carl Heinrich found it in 1915 attacking perfectly healthy acorns.

*Seasonal history.*—Eggs probably are deposited by the females on the acorns or in the exit holes made by the acorn weevil. The larvae feed on the remaining portion of the kernel during the late summer, mature in September and October, and then enter

the ground to pupate. Some pupate in the fallen acorns. Adults emerge in June and July of the following year. There appears to be only one brood annually.

*Parasites*.—None reared from this host.

### FAMILY COSMOPTERYGIDAE

#### *Ithome* sp.

*Description*.—The adults are dark bronze moths with a wing expanse of 8–10 mm. The larvae feed through the seed coat of juniper berries and penetrate the seeds, which they completely hollow out, leaving only the larval castings in the seed. Exit holes were noted in the field on old berries.

*Host*.—*Juniperus californica*.

*Distribution*.—Collected at Jacumba, Calif. Probably more widely distributed through the range of juniper.

*Life cycle*.—Larvae feed in berries during the summer. Pupa-tion occurs in white silky cases attached to the leaves in late August and September. Adults emerge from September 1 to December 9. (Hopkins U. S. No. 14219g.)

### FAMILY GELECHIIDAE

#### *Chionodes periculella* (Busck) (= *Gelechia*)

*Description*.—Adults are small brownish black moths; face iridescent fuscous; forewings with a purple sheen and scattered white scales, a zigzag white line at the apical fourth; hind wings dark fuscous; abdomen yellow tipped; alar expanse 16–22 mm.

*Hosts*.—Cones of *Pinus ponderosa*, *P. edulis*, and *Pseudotsuga menziesii*. Probably in other cones.

*Distribution*.—California, Oregon, and Colorado. Probably more widely distributed.

*Note*.—The active, rose-colored larvae appear to be secondary, in that they feed on the trash left from the work of other cone-infesting insects and on decaying cones that have dropped from the trees. Adult moths emerge in June, July, and early August from cones which matured the previous year. Thus there appears to be an annual life cycle.

#### *Chionodes* sp.

Larvae similar to *C. periculella* were found doing similar work in cones of knobcone and sugar pines. Adults were not reared and hence identification was not complete.

#### *Gelechia* or *Stomopteryx* sp.

Full-grown larvae of an unidentified species of Gelechidae were found on April 27, 1916, by P. D. Sergeant at Wagner Springs, Oreg., feeding in the axis of ponderosa pine catkins. The larvae abort and twist the catkins, but do not seem to cause any damage to the pollen. On May 4 the larvae were found leaving the catkins, and on May 30 prepupal larvae were found in pebble-covered cocoons in the earth and on the floor of the cage. Adults emerged in July. The species has not been identified. (Hopkins U. S. No. 14255a.)

## FAMILY GEOMETRIDAE

***Eupithecia albicapitata* Packard**

*Description.*—Moths with brown and gray markings; reddish-brown crossbands on forewings; alar expanse 15–18 mm. (55, p. 658). Larvae are reddish-tinged, with six vague longitudinal stripes on upper portions of body.

*Host.*—Cones of *Picea engelmanni*, *P. glauca*, and *Pseudotsuga menziesii*; one record from *Adelges* gall on *Picea glauca*.

*Distribution.*—British Columbia and Yukon Territory, and across Canada following the spruce belt.

*Note.*—Rearing records were furnished by Dr. D. A. Ross of the Forest Biology Laboratory, Canadian Department of Agriculture, Vernon, British Columbia.

***Eupithecia columbrata* McDunnough**

The larvae of these moths, as reported by McDunnough (54, p. 40) have been found feeding in the cones of Pacific silver fir in British Columbia and Washington (55, p. 660).

***Eupithecia spermaphaga* (Dyar)**

fir cone looper

*Description.*—Adults are moths with body reddish-brown; forewings gray, marked with irregular reddish-brown band near base and tip of wings, bordered near costa with narrow black line; hind wings gray speckled with brown and bordered with broken black terminal line. Alar expanse 20–25 mm. (16, p. 68; 54, p. 40; 55, p. 660). Larvae are pale greenish, gray, or brown; typical geometrid larvae with 2 pair of prolegs at the rear end; 20 mm. long when full grown. Pupae are reddish in oblong silky cocoons on surface of cones or on ground.

*Hosts.*—Cones of *Abies concolor*, *A. magnifica*, *A. magnifica* var. *shastensis*, *Pinus ponderosa*, *P. monticola*, *Pseudotsuga menziesii*, *Tsuga mertensiana*; and from cones of *Abies amabilis* in British Columbia.

*Distribution.*—California, Oregon, British Columbia, Arizona, and Colorado; probably throughout range of western firs and Douglas-fir.

*Character of damage.*—The larvae bore large galleries through cones, destroying seeds and scales. About 20 percent of the fir cones are infested with this species, and 10 percent of the seed is destroyed in infested cones.

*Life history.*—Larvae develop in cones during June, July, August, and September. Pupae form during October and November, and the species hibernate in this stage in silky cocoons either on the cones or in the ground. Adults emerge in May, June, and July in time to lay eggs on new cones. There is one brood annually.

*Parasites.*—Encyrtidae: *Copidosoma* sp.; Eulophidae: *Elacherus glacialis* Ashm.; Ichneumonidae: *Horogenes* sp.

## FAMILY HYPONOMEUTIDAE

***Argyresthia libocedrella* Busck**

incense-cedar tip moth

*Description.*—The adults are silky, light-golden moths with two dark narrow bands across the forewing. Alar expanse 8 mm.

(4, p. 153). Larvae are small green caterpillars with red dorsal bands.

*Host.*—*Libocedrus decurrens*. Also reported (12) from *Chamaecyparis lawsoniana*.

*Distribution.*—California and Oregon; probably through range of incense-cedar.

*Character of damage.*—The larvae of this species mine the tender, green cones, seeds, and leaflets (fig. 33). Infestation frequently destroys 10 percent of the cone crop; all seeds in infested cones are eaten by the larvae. Sometimes practically all of the cone crop is destroyed.



FIGURE 33.—Caterpillars of the incense-cedar tip moth, *Argyresthia libocedrella*, feeding in cones of incense-cedar. A parasitic larva in cone to the right,  $\times 3$ .

*Seasonal history.*—The larvae feed and develop in cones during July, August, and September. Pupae form during October, November, and December. These hibernate in papery cocoons in the soil. Adult moths emerge from the middle of March through May. There is one generation annually, and delayed emergence in the second and third years.

*Parasites.*—The species is parasitized by an ichneumon, *Campoplex argyresthiae* (Roh.), a braconid, *Bracon* n.sp. near *laemosacci* Mues., and a species of Encyrtidae, *Pentacnemus* sp. (close to *bucculatricus* Howard).

#### FAMILY OLETHREUTIDAE

##### Genus *Barbara*

##### fir cone moths

This genus as established by Heinrich (31) includes five varieties or forms of a single species, *B. colfaxiana* (Kearfott), which,

as larvae, feed in the cones of Douglas-fir and true firs. Another species found in Engelmann spruce cones, was named in 1941 (see page 135). The five forms include the following:

***Barbara colfaxiana colfaxiana* (Kearf.) (43)**

*Host.*—*Pseudotsuga menziesii*.

*Distribution.*—California, Oregon, Washington, and British Columbia.

*Type locality.*—Colfax, Placer County, Calif.

***Barbara colfaxiana taxifoliella* (Busck)**

*Host.*—*Pseudotsuga menziesii*.

*Distribution.*—Montana, Washington, and British Columbia.

*Type locality.*—Missoula, Mont.

***Barbara colfaxiana coloradensis* (Heinrich) (30)**

*Hosts.*—*Pseudotsuga menziesii* and *Abies concolor*.

*Distribution.*—Colorado.

*Type locality.*—Mount Manitou, Colo.

***Barbara colfaxiana siskiyouana* (Kearf.) (44)**

*Hosts.*—*Abies concolor*, *A. magnifica*, and *A. magnifica* var. *shastensis*.

*Distribution.*—California and Oregon.

*Type locality.*—Siskiyou County, Calif.

***Barbara ulteriorana* (Heinrich) (30)**

Probably an aberrant form of *B. colfaxiana*.

*Host.*—*Pseudotsuga menziesii*.

*Distribution.*—Oregon.

*Type locality.*—Waldo, Oreg.

Heinrich's key to the species of *Barbara* (31) is as follows:

- |  |                             |
|--|-----------------------------|
| 1. Hindwing very dark brown, almost black, concolorous with dark areas of forewing; pale markings on forewing iridescent lead-gray.  | <i>ulteriorana</i>          |
| Hindwing pale or dark smoky fuscous, not blackish; paler than dark areas of forewing; pale markings on forewing gray, suffused with whitish, ocherous or pale greenish scales. | 2                           |
| 2. Head ferruginous ocherous.  | 3                           |
| Head blackish or fuscous, more or less dusted with white.  | 4                           |
| 3. White geminations on outer half of costa repeated on underside of forewing as short, very thin dashes.  | <i>colfaxiana</i> (typical) |
| White costal geminations repeated on underside of forewing as spots about as broad as long.  | <i>coloradensis</i> (part)  |
| 4. Pale areas of forewing partially suffused with ocherous.  | <i>taxifoliella</i>         |
| Pale areas of forewing tinted with pale greenish.  | 5                           |
| 5. Cilia of hindwing whitish; hindwing very pale ocherous fuscous  | <i>coloradensis</i> (part)  |
| Cilia of hindwing dark smoky fuscous; hindwing dark-brown fuscous  | <i>siskiyouana</i>          |

In the biological work at Ashland only two species were recognized: The form in Douglas-fir and the form in white fir and other true firs. Accordingly, the following notes will be so divided.

*Barbara* sp. (Douglas-fir form)

Douglas-fir cone moth<sup>11</sup>

Mostly *Barbara colfaxiana* vars.

*Description*.—Adults are grayish-brown moths with wings transversely marked with irregular bands of gray, silver, and brown, and with fringed margins (fig. 34). The variety which infests Douglas-fir cones from Montana, Washington, Oregon, and northern California is smaller and of darker coloration; alar expanse 15–21 mm. The variety from Colorado is larger and lighter in color, with alar expanse of 19–22 mm. Except for color and size, the moths of all varieties are scarcely distinguishable.



FIGURE 34.—A, Adults of the Douglas-fir cone moth, *Barbara colfaxiana*, X 2; B, larvae, X 2.

The pupa is reddish brown in color, about 7 mm. long and 2 mm. in diameter. It is enclosed in a papery cocoon encased in a mass of resin within the host cone between scales near the axis.

The full-grown larva is approximately 14 mm. long, pinkish or yellowish in color (often with a brownish tinge); the color of the head is brown, mouth parts black, thoracic and anal shields black, true legs black, and body hairs brown. The dorsal part of the body is yellowish to brown shading to cream on the ventral parts. The spiracles are brown.

The egg is pearly white in color; oblong and flattened; 1½ by 1 mm. It is attached to the outer surface of a protruding cone bract by a narrow flange which extends entirely around the egg. As the embryo develops it imparts a creamy to pinkish color to the egg.

*Host*.—Cones of *Pseudotsuga menziesii*.

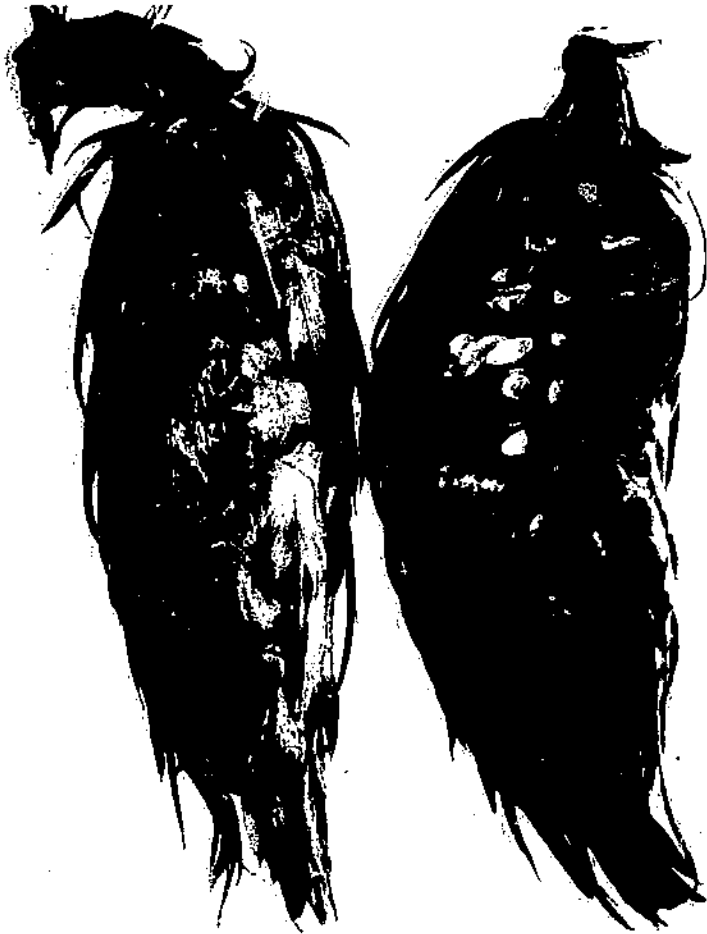
*Distribution*.—Throughout the range of Douglas-fir in the Pacific Coast States, British Columbia, and Rocky Mountains.

<sup>11</sup> Adapted from a manuscript report prepared by J. M. Miller and J. E. Patterson, June 1, 1916.

Although this species was not named by W. D. Kearfott until 1907 (49), it apparently was first discovered by R. A. Cooley in Montana in the spring of 1900. Cooley prepared a bulletin on "The Douglas spruce cone moth" (8) in 1908 from his studies on this species. In this bulletin the species was identified as *Cydia pseudotsugana* Kearf. (42). The writer is reasonably certain that the species was wrongly identified and that Cooley's bulletin is the first dealing with the Douglas-fir cone moth, *Barbara colfaxiana* vars. (See Keen, F. P., 1953, "Correction of the identity of the Douglas-fir cone moth" (47).)



*Character of damage.*—The damage done to the cones and seeds of the Douglas-fir by the Douglas-fir cone moth consists of tortuous food channels excavated by the larvae feeding within the cones (fig. 35). These food channels or burrows start at a point on the surface of the cone scales where the young larvae attack the cone. At the point of entrance they are almost indiscernible, but they gradually become larger as the larvae develop. Terminal parts of burrows excavated by full-grown larvae are about 2.5 mm. in diameter. Average length of feeding burrows is 45 mm. At the terminal end of the burrows, between two scales, near the axis of the cones, are found the pupal cells, which are usually



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FIGURE 35.—Cones of Douglas-fir damaged by the Douglas-fir cone moth, *Barbara colfaxiana colfaxiana*; cone on left shows pitch and larval castings on exterior of cone, and cone on right has been opened to show larva and its mines in the interior.

somewhat larger in diameter than the food burrows. The wound to the cone is heavier here than elsewhere, and it results in a large flow of resin which encases the larval cocoon in the pupal cell. The larvae do not seem to prefer one part of the cone over another, for they feed indiscriminately through scales, bracts, and seeds.

Cones containing only 1 or 2 larvae do not appear to be appreciably damaged, and unless attacked by other insects they develop and mature like normal ones. If the infestation is heavier, with three or more larvae in individual cones, the resultant damage is more noticeable: the cone is aborted and withers prematurely. Attacked cones, regardless of the degree of infestation, remain on the trees and fall with the normally developed ones. Immature cones infested with the larvae of the Douglas-fir cone moth are quite easily determined. The characteristic resin exudation, almost always present on the surface, denotes the active larvae within. Sometimes, frass thrown out by the larvae from the food burrows adheres to the surface of the cones and assists in identifying the infestation as that of *Barbara* sp. Damage follows, both as a direct and indirect result. Directly, larvae eat the seeds encountered in extending the food burrows spirally around the axis of the cones through the basal part of the scales; indirectly, the seeds fail to mature in heavily infested cones as a result of premature withering.

*Percentage of infestation and amount of damage.*—In 7 representative lots, 30 to 100 percent of the cones were infested; seeds destroyed ranged from 17 to 33 percent in 4 of these lots (table 1).

From extensive sampling in British Columbia, Radcliffe (65) reported "that a single caterpillar within an average-sized cone destroys approximately 45 percent of all the seed in a cone, 2 larvae account for about 75 percent of the seed, and 3 or more insects feeding within the cone will destroy the entire seed content." From 10 samples of cones on Vancouver Island, Radcliffe found the yield of cleaned seed to be 37.9 grams (0.08 pounds) per 100 cones, whereas insect-damaged samples yielded only 15.7 grams (0.03 pounds) of cleaned seed per 100 cones. The difference represented a loss of 58.5 percent.

Radcliffe (67) also found that cones damaged by the Douglas-fir cone moth "only produced 41.5 percent as much seed as sound ones" and that "germination tests showed a slightly poorer viability of seed from damaged cones when compared with seed from sound cones."

Isaac (40) reported that the Douglas-fir cone moth and seed chalcid "have destroyed up to 75 percent of the season's (seed) crop."

Hofmann and Willis (36) found that "insects are worse if the crop is small for the locality, for their attacks are then concentrated." They also found that "they are worse in the warmer places where the crop is normally large" and least troublesome in the higher and colder parts of the tree's range.

*Life history.*—The emergence and flight of cone moths occurs from about March 25–May 5 at elevations ranging from 2,000 to

TABLE 1.—Percentage of infestation and seed of Douglas-fir destroyed by the Douglas-fir cone moth<sup>1</sup>

Hopkins lot No. and locality collected	Cone crop	Date examined	Stage of insect	Cones		Cones		Insects found	Insects per cone	Insects per infested cone	Seed destroyed	Seed	
				examined	Seed	infested	Percent					destroyed per insect	crop destroyed
				Number	Number	Number	Percent	Number	Number	Number	Number	Number	Percent
Hopk. 12535 ; Coletin, Oreg.	1914	July 18, 1914	Larvae	40	1,700	19	47.5	37	0.92	1.95	555	15.0	32.65
Hopk. 12507 ; Ashland, Oreg.	1914	July 7, 1914	do	6	306	6	100.0	8	1.33	1.33	93	11.6	30.39
Hopk. 12584 ; Mistletoe, Oreg.	1914	Nov. 25, 1914	Pupae	50	2,250	25	50.0	35	.70	1.40	455	13.0	20.22
Hopk. 14220 ; Ashland, Oreg.	1915	Dec. 2, 1915	do	200	--	60	30.0	70	.35	1.17	--	--	--
Hopk. 12536 ; Ashland, Oreg.	1914	July 17, 1914	do	100	4,400	66	66.0	77	.77	1.17	770	10.0	17.50
Hopk. 10874 ; Emigrant Creek, Oreg.	1913	Dec. 29, 1913	do	50	--	50	100.0	99	1.98	1.98	--	--	--
Hopk. 10896 ; Missoula, Mont.	1913	Mar. 22, 1914	--	20	--	19	95.0	32	1.60	1.68	--	--	--

<sup>1</sup> Data obtained from cutting tests. Only the seeds actually eaten by the larvae were counted. The lots of cones were not especially selected; they represent the average infestation.

4,000 feet near Ashland, Oreg. From rearing material kept at elevations ranging from 4,000 feet to the limit of occurrence of the host tree, emergence has been recorded as late as the middle of July (fig. 36). Occasional stragglers come out earlier and continue later, but they in no way represent the main part of the broods. Emergence and flight also can be correlated very closely with the appearance of the pollen on Douglas-fir, sometimes preceding it by a few days. Emergence was found at its height just about the time the pollen was falling, and it preceded the appearance of the new cones on which the eggs were deposited by a few days or a week. The full bloom of the pollen on Douglas-fir seems a fairly reliable indication that the cone moth is flying in the locality.

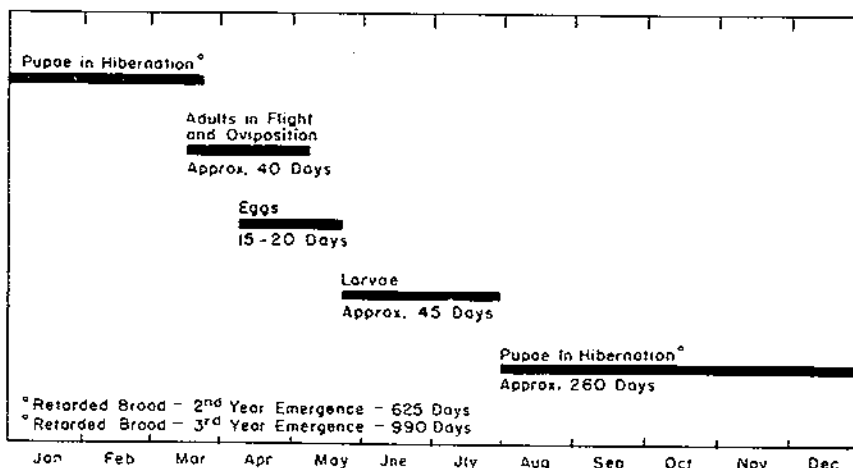


FIGURE 36.—Seasonal history of the Douglas-fir cone moth.

Data on copulation and oviposition were secured by collecting adult males and females which emerged between the dates of March 25 and 31 from insectary rearing cages, and by liberating them in specially constructed screened cages containing young living cones of the Douglas-fir. Strips of blotting paper saturated with sugar solution were placed in the cages and the moths were observed feeding on these at various times. Copulation occurred at intervals for a few days after the moths were liberated in the cages.

Oviposition was not observed, but must have occurred during the earlier hours of the evening, for eggs were found on the cones in the early morning before the moths became active. A single cone may bear several eggs, but only one egg is deposited on a cone bract. Oviposition in the field under natural conditions (fig. 37) has resulted in 3 and 4 and occasionally as high as 5 larvae in each infested cone. The number of eggs laid by a single female was not determined, but it is reasonable to suppose that each female deposits a large number because the caged cones were quite heavily infested.



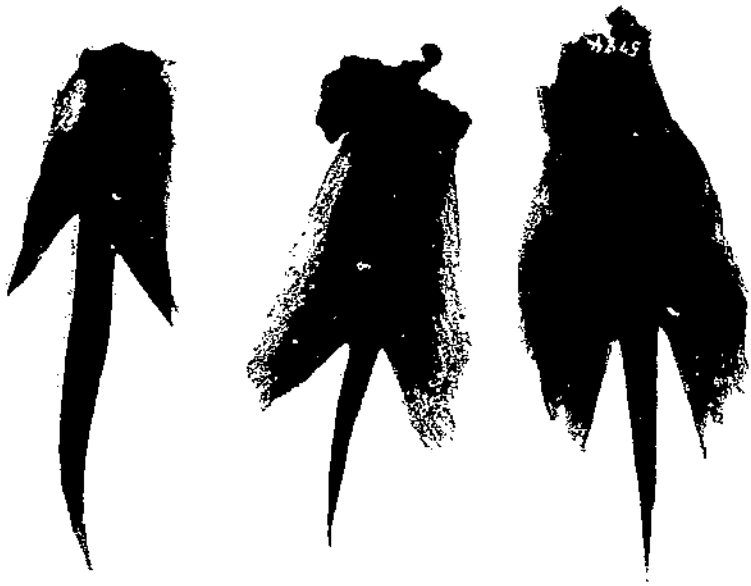
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FIGURE 37.—Adult of the Douglas-fir cone moth, *Barbara colfaxiana*, laying eggs on a young Douglas-fir cone.

In the field, eggs are deposited on the protruding cone bracts of young cones almost as soon as they appear.<sup>12</sup>

The egg stage (fig. 38) lasts between 15 to 20 days, and development within the egg progresses slowly. At the end of the fifth or sixth day the outline of the larva shows distinctly, and the egg at this stage assumes a pinkish tinge. Development continues gradually from this stage until hatching, when the color varies from yellow to brown. A few days before hatching, the larva within the egg may be seen distinctly, the black thoracic shield and the true legs being plainly visible. The embryo, which up to this time has been curled within the egg, now straightens out and bursts the eggshell. The following record of embryonic devel-

<sup>12</sup> The cones of Douglas-fir mature in one year. At the lowest elevations and in the warmer localities within its range, the first cone buds open the latter part of March. Elsewhere buds open through April and May, depending on local climate. The cones develop rapidly, reaching full size in 6-8 weeks. They ripen early in August and by September begin to open and shed their seeds. Many of these matured cones fall from the trees during the fall and winter, but often a considerable percentage remains attached to the branchlets until the following spring and later.



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FIGURE 38.—Eggs of the Douglas-fir cone moth on cone bracts,  $\times 2.5$ .

Development of the Douglas-fir cone moth was prepared from observations of eggs collected in the field and incubated in an insectary:

Date:		<i>Condition of embryo</i>
April	25.....	Eggs, fresh pearly white.
	26.....	Do.
	27.....	Eggs turning pinkish.
	28.....	Do.
	29.....	Eggs turning yellow.
	30.....	Do.
May	1.....	Outline of larvae showing.
	2.....	Do.
	3.....	Do.
	4.....	Larvae distinct, eggs turning brown.
	5.....	Do.
	6.....	Larvae developing, legs distinctly seen.
	7.....	Do.
	8.....	Development more complete.
	9.....	Do.
	10.....	Legs and thoracic shield plainly discernible.
	11.....	Do.
	12.....	Larvae fully grown, shield and legs fully formed.
	13.....	Do.
	14.....	Larvae straightening in eggs.
	15.....	Larvae leaving eggshells.

The newly hatched larva immediately bores through the supporting bract and enters the cone through the scale directly below the bract to which the egg was attached. The larva grows rapidly, increasing in length from about 2 mm.—4 mm. within the first 3 or 4 days. When newly hatched, the larva is wide, flattened

in front, constricted behind, with the true legs plainly discernible, and the thoracic shield sclerotized and black, covering the dorsal part of the first thoracic segment. The color of the young larva ranges from fawn to brown.

The first result of cone attack is a flow of resin from the wound that the entering larva makes in the scale. The resin flows unchecked as the larva continues to develop and bores deeper into the cone, the mass growing from a minute tear to a large globule that entirely covers the entrance and fills the food burrow through its length. This probably protects the larva from birds and parasitic enemies.

The larval stage lasts about 45 days; during this time the larva is never quiescent. It extends the food burrow through all parts of the infested cone, feeding on scales, tissues, and seeds. In the fall the larvae complete their development and form pupae which become embedded in resinous channels near the axis of the cones.

The moths remain dormant in the pupal stage for about 260 days, or from July to March or April of the following spring. Then adult moths emerge and flight begins just before the advent of the new cone crop.

It is a peculiarity of this insect that not all of the overwintered pupae transform and emerge as adults the first spring (table 2). Some of the brood continues in diapause through the spring, summer, and winter of the second year. The majority of these retarded pupae emerge at the normal time during the second spring. In one lot of breeding material some of these retarded pupae remained dormant during the third summer and winter and finally emerged the third spring, after a dormant period of  $2\frac{1}{2}$  years—nearly 3 years after the beginning of development.

TABLE 2.—*Emergence and retardation of broods of the Douglas-fir cone moth*<sup>1</sup>

Hopkins lot No. and locality collected	Date collected	Cone crop	First year emergence	Second year emergence	Third year emergence
Hopk. 10508; Ashland, Oreg.	Oct. 2, 1913	1913	Mar. 20-Apr. 15, 1914, 12 imagos.	Mar. 17-25, 1915, 3 imagos.	
Hopk. 10a31; Ashland, Ores.	Sept. 2, 1913	1913	Mar. 21-Apr. 15, 1914, 53 imagos.	Mar. 18-Apr. 2, 1915, 4 imagos.	
Hopk. 10882; Ashland, Oreg.	Jan. 24, 1914	1913	Mar. 20-June 24, 1914, 215 imagos.	Mar. 15-Apr. 7, 1915, 15 imagos.	
Hopk. 11454; Moffat Creek, Calif.	Feb. 4, 1913	1912	Feb. 13-Apr. 17, 1913, 23 imagos.	Mar. 19-Apr. 21, 1914, 9 imagos.	Mar. 20, 1915, 1 imago.
Hopk. 12502; Elkhon, Mont.	Apr. 10, 1914	1913	Apr. 12-15, 1914, 2 imagos.	Mar. 16-22, 1915, 2 imagos.	

<sup>1</sup> Based on 5 lots of cones. About 10 percent of the broods in these lots retarded as pupae. Table prepared from actual rearings; parasitism and other influences not considered.

Radeliff (66) found 6.8 percent of the 1950 brood in diapause, and more in wet sites (11.0 percent) than in dry sites (3.4 percent). He also found a higher percentage in diapause where pupae overwintered in cones on the ground (9.2) than where they overwintered in cones on the trees (4.1). Pupae overwintering in cones on the ground were not molested by mice or shrews.

No records were obtained of the longevity of the adult moths under normal outdoor conditions. Adults that emerged March 27 and were liberated in rearing cages lived for about 3 weeks, the last one dying April 17.

*Parasites.*—The natural enemies of the Douglas-fir cone moth are numerous and an important factor in the control of the species. In several lots of material, parasitism was determined to vary from 31 to 83 percent. The following primary hymenopterous parasites have been reared from larvae and pupae of this moth:

Braconidae

*Bracon erucarum* (Cushm.)

Eulophidae

*Hyssopus exetriæ* (Girault)

*Tetrastichus strobilus* Burks (Prob.)

*Tetrastichus* sp.

Ichneumonidae

*Calliophialtes comstocki* (Cress.)

*Campoplex conocola* (Roh.) (Prob.)

*Exochus exetriæ* Roh.

*Glypta exetriæ* Cush.

*Itoplectis exetriæ* Vier.

*Pimplopterus exetriæ* (Roh.)

Pteromalidae

*Amblymerus verditer* (Norton)

*Zacalochlora milleri* Crawford

*Control.*—Where intensive forestry methods are applicable, as in Douglas-fir seed orchards, the value of the seed crop may warrant special measures of protecting cones from damage. Aerial spraying with a residual DDT spray, at the time of moth flight and egg laying may prove to be effective as a control measure.

**Barbara sp. (true fir form)**

**white-fir cone moth**

Mostly *Barbara colfaxiana siskiyouana* (Kearf.).

*Description.*—Adult moths are gray with forewings speckled with black and tipped with brown (fig. 39). Alar expanse 21–24 mm. Body 6 mm. (44, p. 77) (31, p. 28).

Pupae are dark reddish-brown to black, 8 mm. long.

Larvae are yellow-white, 11 mm. long to 2½ mm. wide when full grown; head dark brown to black with chitinized plate extending back under first thoracic segment; body with 14–16 scattered short yellow bristles on each segment.

Eggs (fig. 40) are pearly white, oblong, flattened, about 1½ by 1 mm. in size, and are attached to upper surface of cone bracts, sometimes on very tip, by a flange which extends entirely around the egg.





FIGURE 39.—Larvae, pupae, and adult of the white-fir cone moth, *Barbara colfaxiana siskiyouana*, X 3.

*Hosts*.—Cones of *Abies* spp.; reared from *Abies concolor*, *A. grandis*, *A. magnifica*, and *A. magnifica* var. *shastensis*.

*Distribution*.—California, Oregon, and Washington, and Colorado (*B. colfaxiana coloradensis*). Probably throughout the range of western *Abies*.

*Character of damage*.—This is one of the most destructive pests found in white fir and red fir cones. The larvae attack the cone while it is quite young and either stop its development altogether, or, by boring tortuous channels through scales and seeds, cause one side of it to die. This causes an abortion of the cone and a general curved appearance. A considerable flow of resin sticks the scales together and prevents the cone from opening (fig. 41). From 1 to 12 larvae may be found boring through infested cones. Damage varies, in different years and localities, from 2 to 46 percent of the seed crop.

*Life history*.—The life cycle is completed in a single generation. From the first of April to the latter part of May, the adult moths deposit their eggs upon the young, tender cones. The cones then are only three-quarters of an inch to 1½ inches long, and the cone bracts are not yet covered by the growing scales. Upon hatching, the young larvae bore between the cone scales into the heart of the cone (fig. 42). Here they feed upon scales and seeds, making a torturous, resinous burrow. The larvae reach full growth by the middle of July, and in the center of the cone, among the resin-matted scales, they form a papery resin-coated cocoon in which



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FIGURE 40.—Egg of the white-fir cone moth, *Barbara colfaxiana siskiyouana*, on bracts of young white fir cone,  $\times 4$ .

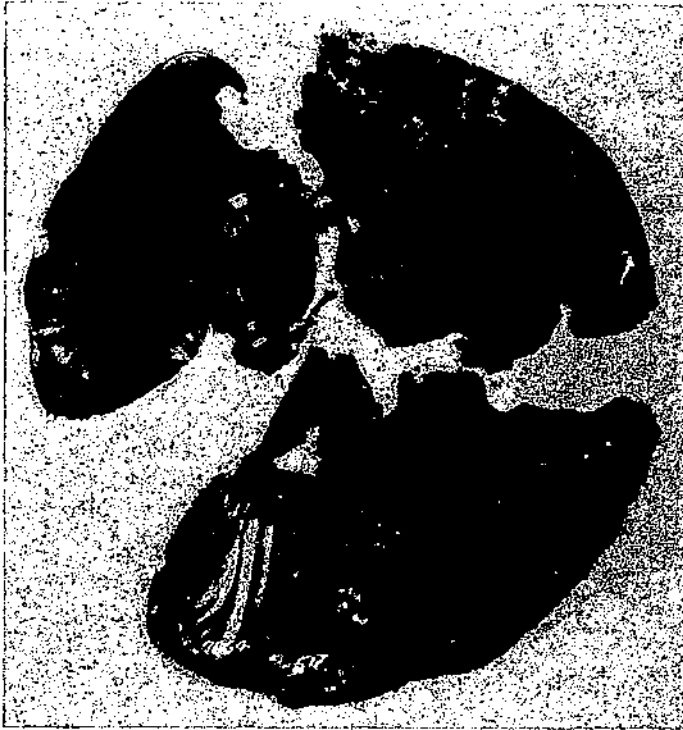


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FIGURE 41.—Cones infested with the white-fir cone moth show pitch exudations and deformity.



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FIGURE 42.—Larva of white-fir cone moth, *Barbara colfaxiana siskiyouana*, boring within a cone.



EPQ-7864  
FIGURE 43.—Pupae of *Barbara colfaxiana siskiyouana* in cocoons among resinous white fir cone scales.

they transform to pupae (fig. 43). In this condition they pass the winter, emerging as adult moths the following spring during March, April, and May. There is evidence that a small percentage of the brood is retarded, remains as pupae for another year, and emerges the second spring. Thus there is one complete generation annually, and a retardation which takes 2 years to complete a generation. There may even be some retardation until the third spring, as was noted for the Douglas-fir cone moth.

*Parasites and predators.*—This species probably has all the natural enemies recorded for the Douglas-fir cone moth. Those reared from this species include:

Parasites

Eudophidae

*Elachertus glacialis* Ashm.

*Tetrastichus* sp.

Ichneumonidae

*Calliephialtes comstockii* (Cress.)

*Campoplex conocola* (Roh.)

*Exochus evetriae* Roh.

*Glypta evetriae* Cush.

*Itoplectis evetriae* Vier.

*Pimplopterus conocola* (Roh.)

*Scambus ephialtoides* Cushman.

Predators

*Enoclerus humeralis* Schaff.

***Barbara mappana* Freeman**

This species of *Barbara* was named by Freeman in 1941. The forewings are gray above, reticulated with numerous black, wavy lines often narrowly bordered with light brown; wing expanse 15 mm. It was reared from cones of Engelmann spruce from Trinity Valley (near Vernon) British Columbia.

***Epinotia albangulana* Wislm.**

**alder catkin moth**

*Description.*—The adults are small reddish-brown moths; forewings with wavy reddish-brown band at base followed by lighter band, splashed with white near apex of wing; hind wing light brown with white scales. Alar expanse 14–16 mm. (31, p. 212).

*Host.*—*Alnus rubra* in pollen catkins and on foliage.

*Distribution.*—California, Oregon, Washington, Idaho, and British Columbia. Type locality Mendocino County, Calif.

*Parasites.*—An undetermined species of ichneumon.

*Notes.*—The larvae feed in the center of pollen catkins during the late winter and early spring months. By April they start spinning cocoons in the outer end of dry catkins and on other objects. Pupation occurs in cocoons during early May and adults emerge from the middle of May to the middle of June.

***Epinotia hopkinsana* (Kearf.)**

*Description.*—Adults are small moths with light tan bodies and forewings mottled with brown and green scales; hindwings uniformly light brown. Alar expanse 16–19 mm. (43, p. 36). Larvae are reddish with large thoracic shield.

*Hosts.*—*Picea sitchensis* and *Pinus radiata*.

*Distribution.*—California, Oregon, Washington, and British Columbia.

*Notes.*—This species was found feeding in the terminal shoots and foliage buds of Sitka spruce by J. E. Patterson. It caused a moderate amount of damage. Heinrich (31, p. 206) reports it as feeding in the cones on seeds of spruce and pine. Our one collection was from the foliage and not from cones. Emergence occurred early in July.

***Epinotia hopkinsana cupressi* Heinrich**

*Description.*—The adults of this variety are similar to *E. hopkinsana*, but according to Heinrich (31, p. 207) are "much darker green in color of thorax and primaries, which are a decided absinth rather than pale bluish or verdigris-green shade." The hindwing is dark smoky fuscous.

*Host.*—*Cupressus macrocarpa*.

*Distribution.*—Monterey County, Calif.

*Note.*—The pinkish larvae develop in cones during August, September, and October, feeding mostly on scales but destroying some seed. Pupation occurs in cells in the cones. Adults were found emerging in January, February, March, and April, and again in October and November, therefore the species may have two broods a year. The larvae also feed under the bark on limbs and branches.

***Eucosma bobana* Kearf.**

**pine cone moth**

*Description.*—The adults are tan moths with bands of rust-red markings on forewings, and pale portions yellow; hindwings light tan brown. Alar expanse 17–28 mm. (43, p. 26; 31, p. 103). The eggs are similar to those of *Barbara*. The larvae are pinkish, about 15 mm. long when full grown, and have a distinct dorsal shield on the first thoracic segment widely separated from the head.

*Hosts.*—*Pinus ponderosa*, *P. jeffreyi*, *P. monophylla*, and *P. attenuata*. Reported from *Pinus edulis* by Little (50, p. 248).

*Distribution.*—California, Oregon, Colorado, Montana, Utah, Arizona, and Texas.

*Character of damage.*—The larvae feed through young green cones in their second year, doing a moderate amount of damage to scales and seeds (fig. 44).

*Seasonal history.*—Eggs are deposited on the very tip of cone scales, well up against the spines, during June and July. Incubation period is about 15 days. Larvae attack the cones through the tip of the scales, mine out the scales, and feed and develop in the cones through the summer and fall. Pupation occurs in September and October in parchmentlike cocoons, either in the cones, or in trash on the ground. They hibernate as pupae. Emergence of moths occurs the next year during May, June, and July. At low elevations emergence may occur as early as March 27 and continue through April and May. There is one brood annually.

***Eucosma rescissoriana* Heinrich**

**lodgepole cone moth**

*Description.*—The adults of this moth are similar to *E. bobana* except for color markings. Heinrich (30, p. 58) stated: "Thorax dark rust-red on forward part, heavily dusted with silver-gray scales behind. Ground color of forewings rich, dark, brick-red,



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FIGURE 44.—Larvae of *Eucosma bobana* feeding in cone scales and on seeds of Jeffrey pine.

with a faint sprinkling of black scales; a narrow indistinct fascia of silver-gray scales near the base." Also two bands of orange-yellow scales bordered by a thin line of white and silver scales. Alar expanse 23 mm.

*Host.*—*Pinus contorta* var. *latifolia*.

*Distribution.*—Oregon and California.

*Notes.*—In late July and August, new green cones will show infestation by this species by an exudation of fine reddish-brown frass issuing from small holes in the cones. Small, dirty white, very active larvae with yellow heads, 13 mm. long by 2 mm. wide, feed through the cone scales and seeds. By late August, these leave the cones to pupate and form silken cocoons in which the dark brown pupae, 8 mm. long, occur. Adult moths emerge in April of the following year. The species is fairly destructive to lodgepole cones from Yosemite north through eastern Oregon.

*Parasites.*—Eulophidae, *Elachertus* sp. and *Euderus* sp.; Ichneumonidae, *Pimplopterus* sp.

*Laspeyresia bracteata* (Fern.) (= *L. pallidibasalis* Hein.) (30, p. 60) fir seed moth

*Description.*—Adults are small, metallic-brown moths, with face and palpi very pale ochreous; head and thorax pale grayish drab; forewings deep lustrous brown with a grayish-drab basal patch and band of white scales across the middle, with five white costal dashes. Hindwings dark, lustrous brown. Wing expanse 11–14 mm.

Larvae are variable in size, from 4 to 12 mm. when full grown; light-pink body with darker pink stripes on anterior dorsal half of segments; 13 segments back of head, with 3 pairs of true

legs on the thoracic segments and prop legs on the 3d to 6th and 10th abdominal segments; 16-18 long yellow bristles arranged on each segment; head with chitinized plate extending back under upper half of first thoracic segment. Very active when disturbed.

*Host.*—Cones of *Abies bracteata*, *A. concolor*, *A. magnifica*, and probably other *Abies*; *Pseudotsuga menziesii* (rare); and *Picea sitchensis*.<sup>13</sup>

*Distribution.*—California, Oregon. (One specimen from Douglas-fir in Colorado—Hopkins U. S. No. 13263i.) Probably throughout the range of *Abies* in the Western States, and British Columbia. (Type locality Jolon, Calif., from cones of bristlecone fir.)

*Character of damage.*—The active small pink caterpillars of this species seem to damage the cones both by boring through the scales and seeds and by feeding upon the seeds directly (fig. 45). They enter the cones by boring between the scales, then bore along the cone axis as they go. They also bore directly into the seeds, near the point of attachment, eat the contents, and then withdraw through the same hole, or sometimes bore out through the opposite end. They are nearly as destructive as the white-fir cone moth. Counts of seed damaged by *Laspeyresia* in 1914 and 1915 showed a range from 4 to 46 percent. Commonly, from 10 to 15 percent of white-fir seeds are destroyed by this species.

*Seasonal history.*—Eggs were not found but are probably laid on the young cone bracts in June and July soon after the moths emerge. The caterpillars feed and develop during July, August, and September. By the first of October they are fully grown and start preparing for the overwintering period. Some spin silky cocoons about themselves within the cones, generally between the seed wing and the cone scales; others leave the cones and form their cocoons in bark crevices or in the ground, where they remain until the following May. Pupae form late in May, and moths emerge from the first of June to the middle of July. Most of the brood emerges in the first year, but a few may retard and emerge in June of the second year.

*Parasites.*—Numerous parasites were reared from white fir cones; some probably preyed on this species, but none were specifically determined.

*Note.*—The original description of this species was by Fernald from three specimens reared from bristlecone fir cones from Jolon, Calif., which emerged in September 1880 (23, p. 265). It is strange that these moths should have emerged in the fall, for we have had no such emergence from many lots of rearing material.

Larvae of this species have been collected from bristlecone fir cones in the fall of the year a couple of times by entomologists of the Berkeley Forest Insect Laboratory. These larvae have overwintered in silky cocoons, as is typical of this species, but moths failed to develop.

<sup>13</sup> W. G. Mathers of the Forest Biology Laboratory, Vernon, British Columbia, reared specimens from *Picea sitchensis* cones from Queen Charlotte Islands, British Columbia. These were designated as a variety of *L. bracteata* by McDunnough (1937 and 1938). Heinrich agreed with McDunnough that the specimens "are best placed as *bracteata*."

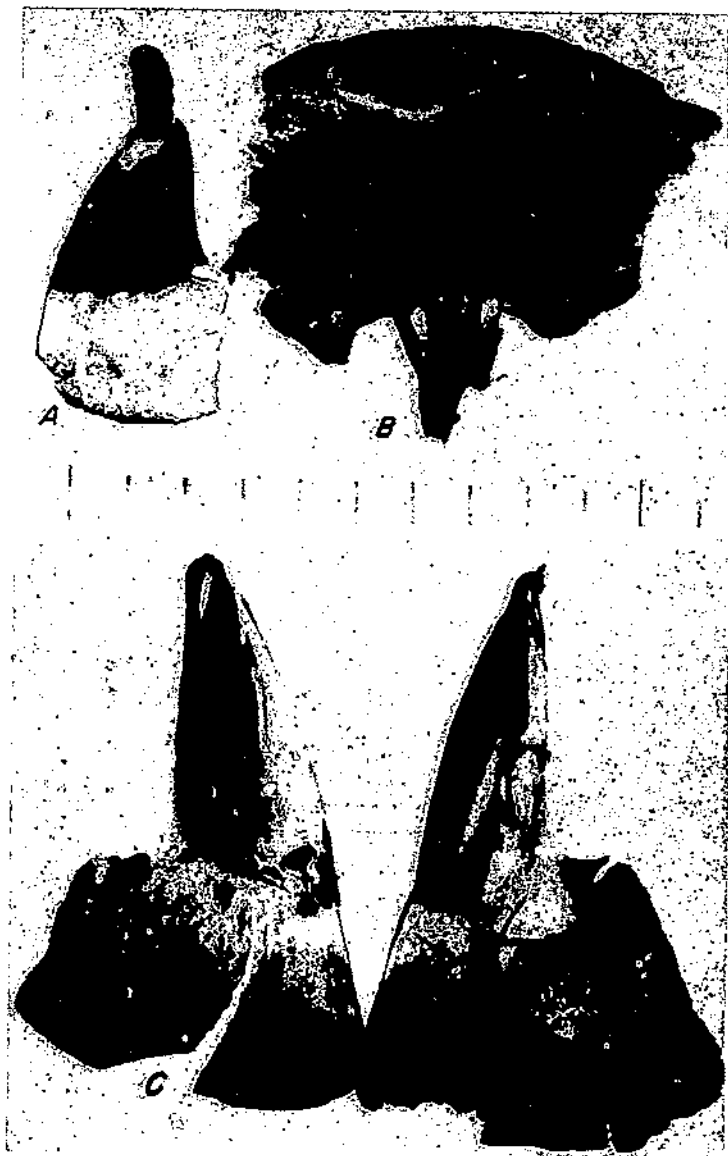


FIGURE 45.—Larvae of fir seed moth, *Laspeyresia bracteata*. A, Larva feeding in seed through point of attachment; B, prepupal larva forming cocoon on cone scale; C, larva feeding on seed;  $\times 3$ .

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*Laspeyresia cupressana* (Kearf.) cypress bark moth

*Description*.—Adults are small dark smoky brown moths (fig. 46), with antemedian bands on forewing grayish ochreous, only slightly paler than basal band and median areas, and bounded by narrow copper-metallic bands; hindwings uniformly dark brown. Wing spread 12–16 mm. (43, p. 54; 32, p. 56).





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FIGURE 46.—Pupae and adult of the cypress bark moth, *Laspeyresia cupressana*,  $\times 4$ .

Larvae are similar to other *Laspeyresia* larvae; slender, gray-white, and about 12 mm. long when full grown; first thoracic segment and tenth abdominal segment slightly chitinized dorsally. Eggs are oval, reddish, 1 mm.

*Hosts*.—*Cupressus macrocarpa* (type), *C. goveniana*, other species of *Cupressus*, *Chamaecyparis*, and *Cryptomeria* within its range.

*Distribution*.—Coastal California from San Diego County north to San Francisco and probably farther north. Mostly collected from Monterey peninsula in native groves of Monterey cypress.

*Character of damage*.—Larvae extend galleries through cones, destroying both seed and scales. Clusters of infested cones are often matted together by webbing material spun by larvae. The frass thrown out of infested cones by the larvae adheres to this web and forms a mass completely concealing the larvae within. Often about 50 percent of cones are infested, but the percentage of seeds destroyed is small. Probably 25 percent of attacked cones die before maturing (3, p. 368).

The caterpillars of this species also bore in the bark of branches and the main trunk, causing a rough, enlarged growth and a considerable flow of resin. The larvae apparently do not mine in the cambium, but wander through the phloem tissue, occasionally striking the cambium. They apparently cause sufficient injury so that a fungus can complete the destruction of the phloem and cambium. Successive broods of caterpillars work in the bark year after year, and often parts of the tree or the entire tree dies.

*Seasonal history*.—The seasonal history has not been accurately determined. Larvae overwinter in the cones or mined bark of trunk or branches. Sometimes moths may be found flying as early as February. Normally, pupation does not occur until mid-March, and emergence occurs from March to July. From eggs found in May, larvae and pupae developed by August and moths

emerged in September. Apparently at least two generations and considerable overlapping of broods occur each year, for almost every stage may be found from March to November.

*Parasites and predators.*—Ichneumons and a braconid reared from cones containing this moth were considered to be parasitic on it. These were—

Braconidae

*Macrocentrus aegeriae* Roh.

Ichneumonidae

*Calliephialtes comstockii* (Gress.)

Phaogenini—New genus (Hopkins U. S. No. 13264fx).

*Laspyresia piperana* (Kearf.)

pine seed moths

*Laspyresia miscitata* Heinrich

*Hedulia injectiva* Heinrich

Biologically these three species are indistinguishable and hence must be treated together since collections and rearings often included all three. In the early collections, these species were referred to as *Laspyresia toreuta* (Grote) which is an eastern species (32, p 62-66).

*Description.*—Adults are dark-brown moths, some with three rows of bronze scales across the forewings; hindwings solid dark brown. *Hedulia* is similar to *L. piperana* but darker, with white hindwing cilia and bicolored hindwings, and is distinguished by its having hairy vestiture of abdomen and legs. Alar expanse 16-20 mm. *L. miscitata* appears to be a hybrid between *L. piperana* and *Hedulia injectiva*, partaking of the characters of both.

Eggs (fig. 47) are whitish, oblong, nearly cylindrical 0.75 by 0.50 mm., opaque, smooth on surface though not glossy. They are attached rather insecurely to the surface of the cone scales.



KPQ-7867

FIGURE 47.—Eggs of a pine seed moth, *Laspyresia piperana*, on the surface of ponderosa pine cone scales, enlarged.

Larvae are found in axis of pine cones, or in seeds; head tan, partially retractable; prothoracic shield usually indistinct; body dirty-white or pale tan; small circular tan spiracles; ventral proleg crotchets in complete oval; body setae minute; length 9-14 mm. when full grown. Pupae are light yellow, 9 mm. long.



FIGURE 48.—Jeffrey pine cones infested with a pine seed moth, probably *Hedulia injectiva*. Larvae working through the pith into the seeds. Pupa in cell near tip of cone.

EPG-11545A

*Hosts*.—Cones of *Pinus ponderosa* and *P. jeffreyi*. *L. piperana* favors *P. ponderosa*. *L. miscitata* is found in both pines. *Hedulia injectiva* favors *P. jeffreyi*.

*Distribution*.—California, Oregon, British Columbia, and Colorado. Probably throughout the range of host trees.

*Character of damage*.—The larvae bore through seeds, cone scales and cone axis (fig. 48). They are the most destructive cone

insects of Jeffrey pine, destroying as much as 43 percent of the seed crop. In ponderosa pine from 12 to 100 percent of the cones are infested, and up to 50 percent of the seed destroyed by this species. On the average, about 25 to 30 percent of the seed is destroyed by this species.

*Seasonal history.*—On May 1, 1916, a pair of moths were observed copulating while settled on the walls of a screened cage. The tips of abdomens were connected and heads pointed in opposite directions. At 4:00 on the same day one female was observed ovipositing on a green ponderosa pine cone. The abdomen was extended about 3 mm. beyond the tip of the wings and reached to the bottom of the crevice formed by the juncture of two cone scales. The moth remained in this position about 3 minutes.

Eggs are laid soon after the cone starts its second year of growth and hatch in about 12 days. Larvae enter the cone by boring through the young scales to the seed, which they mine out, passing from seed to seed and feeding on the kernels until nearly full grown (fig. 49). Larvae develop during May, June, July, August, and September. When nearly full grown they enter the pith of the cone axis and excavate silken-lined pupal cells with emergence tubes, also silken lined, extending into the mined seeds.



FIGURE 49.—Characteristic damage to seeds of ponderosa pine by larvae of a pine seed moth, *Laspeyresia piperana*. EPQ-7698

Pupae form during September, October, November, and December in cells in the pith of cones and usually hibernate in this stage or as prepupal larvae. Pupae usually emerge part way from

cones to allow adult emergence. Adults emerge during February, March, April, May, and June. There is 1 annual generation, but about 35 percent of the brood retard as larvae and, with the exception of a small percentage, emerge the second year; this small percentage retard until the third year.

*Parasites.*—Several species of hymenopterous parasites have been reared from these species. These include—

**Braconidae**

- Apanteles laspeyresiae* Vier.  
*Phanerotoma erythrocephala* Roh.  
*Phanerotoma laspeyresiae* Roh.

**Eulophidae**

- Hyssopus evetriac* (Gir.)

**Ichneumonidae**

- Calliephialtes comstockii* (Cress.)  
*Campoplex laspeyresiae* (Roh.)  
*Poemenia americana* (Cress.)

**Pteromalidae**

- Amblymerus verditer* (Nort.)  
*Zacalochlora milleri* Crwfd.

***Laspeyresia youngana* (Kearf.) spruce seed moth**

*Description.*—The adults are small, dark-brown moths speckled with silvery scales; head smoky-black; forewings shiny bronze-brown, crossed at middle by a pair of shining bluish-white fasciae, and a similar pair in outer third of wing; hindwings smoky-brown. Alar expanse 8–11 mm. (44, p. 1; 9, p. 473; 76). Larvae are slender creamy-white, with brownish to black heads, partially retractable; found mostly in the axis of cones. Lengths up to 10 mm. Pupae are light-amber brown to nearly black; found in cells in pith of cone axis and extending into seeds; 7 mm. long.

*Hosts.*—Cones of spruce. Reared from *Picea engelmanni* and *P. sitchensis*. Reported from cones of *P. glauca*, *P. rubens*, and cones of other spruce in Canada and Eastern States (25, p. 393).

*Distribution.*—Throughout the Northern States and Canada, Colorado, Montana, and on the Pacific Coast from California to Alaska, coinciding with the distribution of host trees.

*Character of damage.*—The larvae bore tortuous food burrows through cone scales near axis of cones, destroying both scales and seeds. Often the galleries run through the pith of the cone axis and out into the seeds through their point of attachment (fig. 50). A cone may have from 1 to 5 or more larvae. Heaviest damage was noted in cones collected near Corlett, Mont., in 1914, where about 60 percent of cones examined were infested and 20 percent of the seed in the infested cones was eaten by these larvae.

*Seasonal history.*—Eggs are laid between the cone scales in March, April, and May. They hatch in about 10 days, larvae work through the cone during the summer months and until September. In October and November, the full-grown larvae enter the axis of the cone and excavate pupal cells in the pith. Pupae form in silken-lined cells in the pith during winter months. Hibernation occurs as prepupal larvae and pupae. Adults emerge in March, April, and May. Approximately 40 percent of the brood retards, as prepupal larvae in cells in pith of cones, and emerges as adults

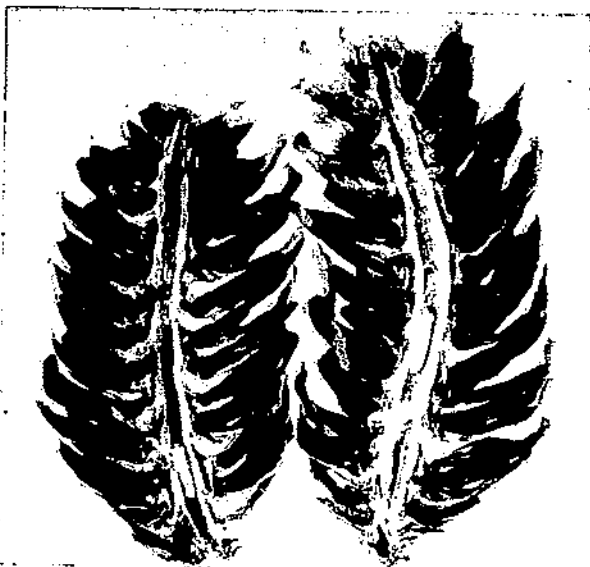


FIGURE 50.—Larvae of the spruce seed moth, *Laspeyresia youngana*, in the pith of Engelmann spruce cones. BPO-7689

the second spring. Thus the life cycle is typically 1 year and 2 years for those remaining in diapause.

Heinrich (32, p. 52) stated that there are two generations annually, adults appearing in April-May and in August-September. Rearings at the Ashland Laboratory do not confirm this.

*Parasites.*—Ichneumonidae: *Calliephialtes* sp.

***Melissopus latiferreanus* (Wlshn.)**

**filbertworm**

*Description.*—Adults are brown or reddish-brown moths with a median band of shining coppery or darker brown across the middle of the forewing and another near the tip; hindwings smoky-brown. Alar expanse 11–20 mm. The species is extremely variable with seven varieties recognized. The larvae are active white caterpillars with red heads and measure up to 15 mm.

*Hosts.*—Acorns and galls of *Quercus kelloggii*, *Q. garryana*, *Castanopsis chrysophylla*, and *Lithocarpus densiflorus*. Dohanian (13) reports it from *Corylus* both native and cultivated, *Juglans*, *Prunus*, *Castanea*, *Fagus*, and many other hosts.

*Distribution.*—General from Atlantic to Pacific.

*Damage.*—The greatest economic damage done by this species is to filberts in the Northwest. Oak acorns have been found from 8 to 80 percent infested by this species, which hollows out the kernel and leaves a mass of webbing. (fig. 51).

*Life cycle.*—Eggs are laid singly on the acorn cup bracts or on the acorn during June and July. These hatch within about 10 days and the larvae penetrate the young acorns and feed on the kernel for about 3 weeks, when they are ready for hibernation. Larvae are usually found on the acorns during August and Sep-

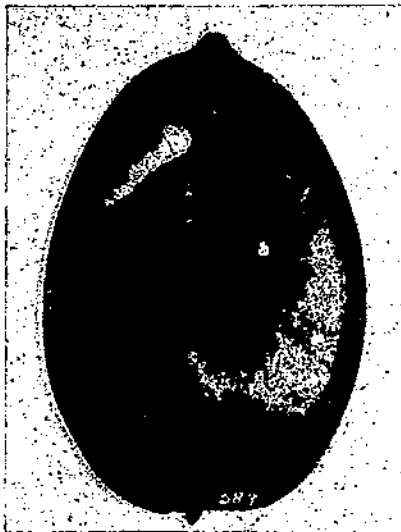


FIGURE 51.—Larvae of the filbert-worm, *Melissopus latiferreanus*, in a California black oak acorn.

tember. The larvae mostly leave the acorns in the fall and overwinter in papery cocoons in trash on the ground, under the soil, in crevices of bark, rolled leaves or in the acorn. Pupation occurs the following spring and adults emerge in June, July, and August. There appears to be one annual generation in the northern part of its range and a partial or full second generation in the southern part.

**Parasites.**—The following hymenopterous parasites are reported from this species, mostly by Dohanian (13, 14).

**Braconidae**

- Agathis nucicola* (Mues.)
- Macrocentrus ancylivorus* Roh.
- Phanerotoma fasciata* Prov.
- Phanerotoma tibialis* (Hald.)

**Eulophidae**

- Elachertus glacialis* Ashm.
- Hyssopus evetriae* (Girault)
- Tetrastichus chrysopae* (Crawf.)

**Ichneumonidae**

- Calliephialtes nucicola* Cush.
- Glypta rufiscutellaris* Cress.
- Pimplopterus dakrumae* (Ashm.)
- Pimplopterus evetriae* (Roh.)
- Pimplopterus inconstans* (Cushm.)

**Trichogrammatidae**

- Trichogramma evanescens* Westwood (Eggs)

**References.**—There are many references to this species in the literature, and further information can be had from the Index of American Economic Entomology.

***Polychrosis piceana* Freeman**

Adults are small brown-winged moths with silvery-gray and tan crossbands on the forewings; wing expanse 8–11 mm. The

species was originally described from moths reared from black spruce in Quebec. According to a note furnished by Dr. D. A. Ross of the Canadian Forest Biology Laboratory at Vernon, British Columbia, one adult was reared from cones of Engelmann spruce and one from Douglas-fir in British Columbia.

An insect tentatively identified as this species was reported by the Canadian forest insect survey of 1949 as having destroyed 17 to 88 percent of the Sitka spruce cones in one locality of Queen Charlotte Island, "greatly disturbing the commercial seed industry there."

***Polychrosis* sp.**

Adult moths are small bronze olethreutids, with a broad, tan band of scales across the middle of the forewing, and with a narrow band of dark-brown scales and a band of silver scales forward of this. Alar expanse about 14 mm. Larvae are white, about 12 mm., and very active. Larvae feed in the cones and seeds of incense-cedar in July, August, and September, usually 1 to 2 larvae per cone. Moths emerge from May 13 to June 21 in the following year. (Hopkins U. S. No. 12565i.)

***Proteoteras aesculana* Riley**

**maple seed moth**

*Description.*—Adults are small, olive-green moths, more or less mottled with yellow and gray and with some black marking. Alar expanse 11–18 mm.

*Host.*—*Acer macrophyllum*. Recorded from other species of maple and horse chestnut (68, p. 321; 63, p. 655; 80, p. 133).

*Distribution.*—Widely distributed through the Eastern, Middle West, and Pacific Coast States.

*Damage.*—Larvae bore in the seeds, seed stalks, and terminal twigs, causing them to wither and die. Bigleaf maple seeds have been found 7–50 percent infested.

*Notes.*—The larvae work in the seeds in September and October. They then abandon the seeds in the fall and hibernate in cocoons on the ground. Pupation occurs the following year and moths emerge in April and May.

*Parasites.*—Ichneumonidae: *Calliephialtes nucicola* Cush. and *Scambus pterophori* (Ashm.).

**FAMILY PHALONIDAE**

***Henricus fuscodorsana* (Kearf.) (= *Commophila*) (5)**

*Description.*—Adults are strikingly marked moths, with white faces; palpi and thorax white; forewings with basal quarter light reddish-brown and a reddish-brown band below the middle, the remainder of wings splotched with white. Alar expanse 16–18 mm. (42, p. 141). Larvae are reddish-green.

*Hosts.*—*Picea sitchensis*, *Picea pungens*, *Pseudotsuga menziesii*. (D. A. Ross of the Forest Biology Laboratory, Vernon, British Columbia, reports having reared this species from the cones of *Larix occidentalis* in British Columbia.)

*Distribution.*—California, Oregon, Colorado, British Columbia.

*Damage.*—The growing larvae feed by boring irregular channels through cones, destroying both scales and seeds. Examination



of a limited number of infested cones indicate considerable damage was caused by this species—an estimated 10 percent of the seed destroyed.

*Life history.*—Eggs were not noted but are probably laid on the young cones. Larvae develop during July and August (probably June also). Pupae form during the fall months, probably in October and November. Adults emerge the next spring from the first of May to early in July. There appears to be only one brood annually.

*Parasites.*—None reared from this host.

#### *Henricus macrocarpa* (Wlsh.)

*Description.*—Adults are showy light-brown moths splashed with white, especially along the margins and apex of the forewings; faces and palpi white, thorax gray, mottled with whitish. Alar expanse about 22 mm. (79, p. 499). Larvae are large (14 mm.), greenish, greenish-red, purplish, or reddish-brown caterpillars.

*Hosts.*—*Cupressus macrocarpa*, *C. goveniana*.

*Distribution.*—Locally from Monterey cypress groves in Monterey County, Calif., and central California.

*Character of damage.*—Infested cones are usually held together in clusters by weblike material spun by the larvae; the frass thrown out of the infested cones adheres to this web and with the cones forms a mass completely concealing the larvae within. The larvae feed on cones by extending galleries through scales and destroying some seeds. About 50 percent of the annual cone crop may be infested, but the percentage of seed destroyed is small. Probably 25 percent of infested cones die before maturing, and seeds do not mature.

*Life history.*—The life cycle has not been accurately determined. Larvae have been found working in cones from August through January. Pupae have been found from October through February. Adults have emerged in March, April, May, and June, but mostly between May 15 and June 22. A few moths have emerged in October and November, indicating that in central California this species may have two generations a year.

*Parasites.*—None specifically reared from this moth.

### FAMILY PHYCITIDAE

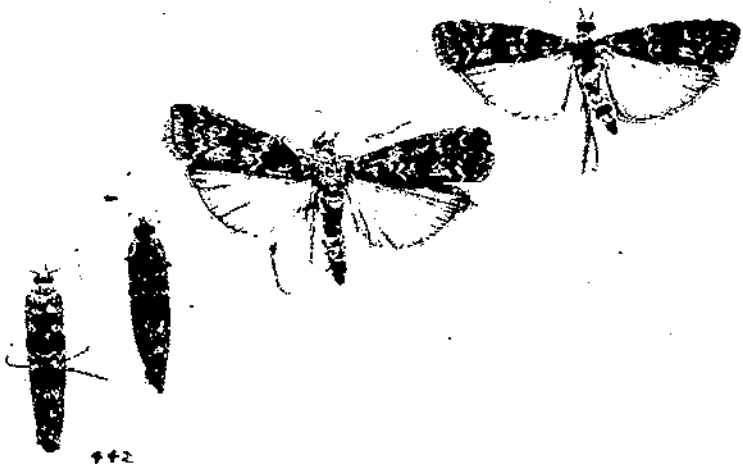
#### *Dioryctria abietella* (D. & S.)

fir coneworm

*Description.*—Adults (fig. 52) are bluish-gray moths, dusted with white, mottled with dark brown, with two narrow light-tan zigzag lines across the forewings alternating with dark brown wider bands. The hindwings are uniformly dusky white with a darker border near the margin. Alar expanse 20–30 mm., body 12 mm.

Pupae are dark reddish brown, 11 mm. long, terminal segments broadly rounded, bearing 6 thin spines; usually in silk-lined papery cocoons encrusted with dirt.

Larvae (fig. 53) are long, smooth, nearly naked caterpillars of variable coloring, 17–20 mm. long, to 2.5 mm. wide; upper



EPQ-1916

FIGURE 52.—Adults of the fir coneworm *Dioryctria abietella*.



EPQ-5763

FIGURE 53.—Larva, prepupal larva, pupae, and pebble-covered cocoons of *Dioryctria abietella* from Douglas-fir cones,  $\times 2.5$ .

half of body iridescent green and red to amber brown, with faint mid-dorsal and broader subdorsal stripes, venter flesh-colored; 18-20 long yellow bristles on each segment, more than 5 times as long as the diameter of the spiracles; head shiny brown with cervical shield paler; anal shield large and dull brown; 5 pairs of prolegs on 6th to 9th and 12th segments; very active.

Eggs (fig. 54) are oval, 1 by 0.65 mm., pink, with red spots on surface.



FIGURE 54.—Egg of  
*Dioryctria abietella* on  
Douglas-fir cone bract,  
× 3.

**Hosts.**—A wide variety of conifers, including *Abies*, *Pinus*, *Pseudotsuga*, and *Picea*. Reared from *Abies concolor*, *A. grandis*, *A. lasiocarpa*, *A. magnifica* var. *shastensis*, *Pinus attenuata*, *P. coulteri*, *P. flexilis*, *P. lambertiana*, *P. contorta* var. *latifolia*, *P. ponderosa*, and *Pseudotsuga menziesii*. Reported by D. A. Ross of the Forest Biology Laboratory, Vernon, British Columbia, as also having been reared from *Abies lasiocarpa* and *Picea engelmannii* cones and found boring in the bark of *Pinus monticola* and in *Cronartia* galls on *Pinus contorta*.

**Distribution.**—Pacific Coast and Rocky Mountain region, Eastern States, and in Europe. Appears to be distributed throughout the range of the genus *Pinus* in the Northern Hemisphere. Often confused with the spruce coneworm *D. reticulata* (Grote) (63, p. 854).

**Character of damage.**—According to Carl Heinrich (9, p. 451), "The larvae of *D. abietella* have a variety of habits. They are both primary and secondary. They bore into new and otherwise uninfested terminals and into terminals that have been attacked by *Rhyacionia buoliana* (Schiff.). They attack both healthy and

diseased cones of pine, spruce, and Douglas-fir. They bore into and feed in the cambium of smooth bark on the trunk and branches of all species of pine and Douglas-fir; and they also feed in galls on any part of the tree."

In discussing the comparative habits of *D. abietella* and *D. reniculella*, McKay (56) showed that *D. abietella* normally feeds in young green cones and occasionally on the foliage and buds of nearby twigs, and at the base of young white pines.

In the cone and seed work at Ashland, Oreg., *D. abietella* was found to be a commonly destructive species in fir cones. In white fir cones it was rated the third most destructive species. It was found less frequently in pine cones. Its other reported habits were not observed.

The larvae of this moth bore through the center of cones, making circular holes indiscriminately through scales and seeds. Its presence in the cones can generally be detected by the large holes (fig. 55). Its tunnels are round and clean cut and its castings usually free from pitch, in contrast to the work of *Barbara* which causes much flow of resin. Heaviest damage was noted near Ashland, Oreg., where 50 percent of the 1914 crop of Douglas-fir cones was infested, and 11 percent of the seed in infested cones destroyed. The extensive larval galleries often stop full development of cones and result in infertile seed.

*Seasonal history.*—The life cycle appears to be somewhat complicated and different in fir than in pine cones. In fir there seems to be one annual generation and a partial second. Larvae develop from June through September in the new growing cones. Pupation is two-staged. About 50 percent of the brood pupate in July,



FIGURE 55.—Damage by larvae of the fir coneworm, *Dioryctria abietella*, to cones of Douglas-fir.

August, and September in silky cocoons in the ground, and emerge in August and September. The remaining part hibernate as prepupal larvae in circular pebble-covered cocoons in the ground, pupate during March, and April, and emerge as adults during May and June. Eggs deposited in the fall probably overwinter in this state.

In pines, the larvae develop in 2-year-old cones during May, June, and July. They bore large open galleries through the cones and destroy both scales and seeds. Pupae form in sparsely lined pupal cells in and on the surface of cones during July and August. Adults emerge during July, August, and September. The species probably hibernates as eggs deposited on twigs, or as young larvae.

*Parasites*.—Encyrtidae, *Copidosoma* sp.; Eulophidae, *Hyssopus* sp.; Ichneumonidae sp.; Tachinidae sp.

#### *Dioryctria albovitella* (Hulst)

The moths have light tan forewings with scattered white scales and a narrow dark zigzag band of scales near the apex; body reddish-brown. Alar expanse 23–30 mm. Larvae of this species were found burrowing in the cones of singleleaf pinyon near Topaz Lake, Nev., in July 1939. Pupation took place in cells in the attacked cones. Adults emerged in August. Referring to this rearing from singleleaf pinyon cones, Carl Heinrich, of the United States National Museum, stated: "As far as I know this is the first rearing record for this species."

#### *Dioryctria auranticella* (Grote)

#### pine coneworm

*Description*.—Adults (fig. 56) are reddish-tan moths with darker reddish-brown bands across the forewing and one narrow light-tan band zigzag across wing near the tip; hindwings light silky tan. Alar expanse 27–33 mm. Pupae are reddish brown, 11–14 mm., and form in sparsely lined pupal cells in cones.

Large larvae are reddish green to dark brown, up to 25 mm. long, similar to *D. abietella*, head reddish brown to black, black prothoracic shield; suranal plate and circular spot on eighth abdominal segment pale tan with narrow black border; small, brown pinaculæ; hairs on body are short, weak, and rarely over twice the diameter of spiracle in length. The hooks on the prolegs are of one type and form a broad single-rowed oval. Eggs are creamy white, oblong, about 1 by 0.75 mm.

*Hosts*.—*Pinus attenuata*, *P. ponderosa*, *P. radiata*, and probably other pines.

*Distribution*.—California, Oregon, Washington, British Columbia, Arizona, New Mexico, Utah, Colorado, Idaho, Montana, and Nebraska. Probably throughout the range of ponderosa pine (7, p. 244).

*Character of damage*.—The larvae bore large, tortuous, circular food channels through the young cones and destroy both seed and scales (fig. 57). Heaviest damage was noted to the 1915 crop of knobcone pine cones near Gasquet, Calif. Here, about 50 percent of the crop was infested, and, as all the seed in infested cones was destroyed, the damage was severe. Also, heavy damage was



FIGURE 56.—A, Adults of the pine coneworm, *Dioryctria auranticella* × 2; B, full-grown larvae; × 1.3. EPQ-1980, 3775

noted to the 1913 crop of ponderosa pine cones near Missoula, Mont. Some cones contain 4-6 larvae of this species. The larvae also work in terminal twigs.

*Seasonal history.*—Larvae develop in cones during May and June. Pupae form during July in sparsely lined pupal cells in and on the surface of cones. Adults emerge during July and August and deposit eggs on the outer surface of cone scales. So far as is known, there is only one brood annually, but like *D. abietella*, this species may have a partial second brood.

*Parasites.*—Quite a few hymenopterous parasites were reared from this species, including the following:

**Braconidae**

*Meteorus indagator* (Riley)

*Microlytus dioryctriae* Roh.

*Oryctus dioryctriae* Gahan

*Rogas* sp.

**Eulophidae**

*Hyssopus thymus* Girault

**Ichneumonidae**

*Calliephialtes comstockii* (Cress.)

*Campoplex conocola* (Roh.)

*Exochus* (?) *atrocoalis* Cress.

*Coelichneumon bruneri* (Roh.)

*Mesostenus gracilis* Cress.

*Pimplopterus dakrumae* (Ash.)

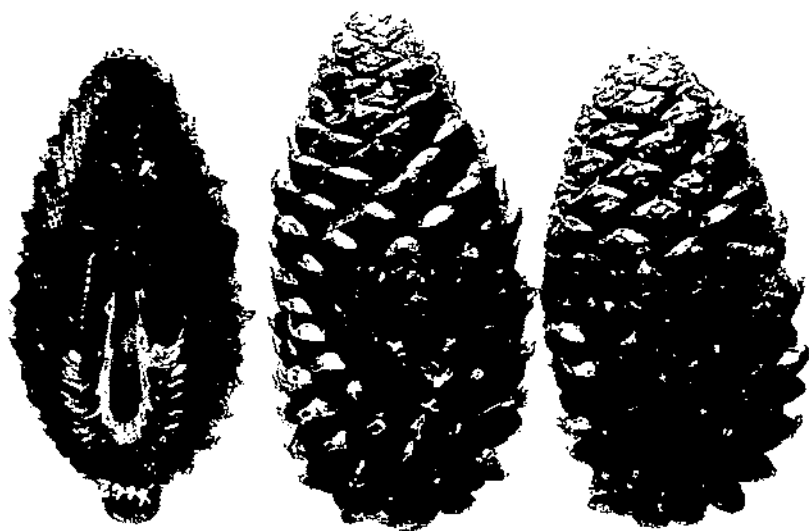


FIGURE 57. Young cones of ambrosia pine heavily attacked by larvae of the pine cone sawfly, *Dioryctria abietella*. Cone on left opened to show larval feeding.

*Dioryctria erythropusa* (Dyar)

*Description.* Adults are light reddish-brown moths, with a lighter band across the middle of the forewing and zigzag dark brown and tan lines across the forewing near its tip. Alar expanse 23-28 mm. Similar to *D. aberraticella*.

*Notes.* The brownish larvae of this species were found feeding on the cones of Chihuahuana pine near Redington, Ariz., by W. D. Edmonston, in December 1911. Moths emerged sometime during the following spring or summer, for they were collected dead from rearing tray on August 10, 1915. Nothing more is known of its habits.

*Dioryctria reniculella* (Grote)

spruce coneworm

*Description.* This species is very similar to *D. abietella* (D. & S.) and is often confused with it (9, p. 55). According to McKay (56), the wing color pattern of this species is more distinct than that of *D. abietella*; *D. reniculella* has a brown undertone, rather than a gray one. Adults have long and narrow forewings, brownish-gray ornamented with transverse zigzag white lines and white discal spot. Fringe dusky. Hindwings pale, tinged with fawn darkening toward fringe, which is pale. Legs dark-banded. Average expanse 25 mm. Full-grown larvae have reddish-brown heads and cervical shields; the body pale-yellow to light-amber-brown and each segment ornamented with piliferous warts. Length 17 mm.; 2.2 mm. wide.

*Hosts.* Principal food plant is *Picea*, including *Picea engelmannii*, *P. glauca*, *P. mariana*, *P. pungens*; has been reported from balsam fir, tamarack, and jack pine.

*Distribution.*—From northeastern United States and Canada through the Lake States, central Saskatchewan, southern Manitoba, and westward into Colorado, Montana, interior British Columbia (2), Washington, and California.

*Damage.*—The larvae of this species feeds primarily on the foliage of terminal shoots, on tender terminal growth, and also mines young cones. It is also reported as predaceous on the jack pine budworm (56).

*Seasonal history.*—It probably overwinters as young larvae because larvae are active in the spring, feeding on the new tender terminal growth and young cones. They cause the young cones to curl and cone scales to separate from the axis of the cone. Full grown larvae are found in late June and early July, and pupation occurs from June 6 to July 22. Moths emerge 6 to 10 days later. There is one generation a year. This seasonal history, reported by McKay (56), coincides with the seasonal history found at Ashland, Oreg., for the pine-feeding form of *D. abietella*.

#### *Ephesiodes gilvescentella* Rag.

Adult moths are light grayish-tan moths with irregular bands of brown scales across the middle of the forewings and near the apex. Alar expanse 12–16 mm. Three of these moths emerged from July 20 to August 5, 1916, from a lot of Shasta red fir cones collected near Ashland, Oreg., September 8, 1915. Nothing was determined as to the larval habits.

## ORDER NEUROPTERA      NERVE WINGS

### FAMILY RAPHIIDAE

The peculiarly long-necked insects called "rubber-necks," *Raphidia* sp., emerged from several lots of cones of ponderosa and sugar pine. They were presumed to be predaceous on cone insects, but their habits were not determined.

## CONTROL OF CONE AND SEED INSECTS

The ultimate objective of these studies of cone and seed insects was the development of methods of prevention or control. But we needed to know what insect species caused damage of economic importance and how they worked before we could expect to find clues to methods of suppression. The early work from 1913 to 1917 concentrated on studies of damage and of the biology of the more important species. Little thought was given to the development of control methods, since there seemed to be so little that could be done in vast areas of inaccessible forests.

### Natural Control

Nature provides checks and balances, so that no destructive species continues in epidemic numbers nor accelerates in destructiveness indefinitely. Sooner or later, natural control agencies bring it in check. Parasites, predators, and disease seem to be the more important agencies in bringing cone and seed insect damage under control. Of these, hymenopterous and dipterous



parasites and entomophagus fungi appear to be most prevalent.

Another limiting factor is the periodic failure of cone crops. When cone and seed crops fail, insect species that depend upon them for food would be exterminated were it not for diapause. Most insects dependent upon cones and seeds for sustenance do not completely emerge from winter hibernation. Some hold over and emerge the second year, and a few even hold over and emerge the third year. Thus the species survives.

Because of these natural enemies, cone and seed insects do not threaten extinction of tree species. Damaging insect populations fluctuate, and in some years trees will produce an abundant seed crop. It is unnecessary—probably futile—to attempt extermination of an insect species. Survival through diapause and wide distribution of the insect make extermination economically hopeless.

### Applied Control

What can be expected from applied control then? The answer is to so reduce destructive insect populations at a given time and place as to assure a reasonably satisfactory seed crop. How this can be done has been given some thought but very little experimentation.

Before powerful residual insecticides such as DDT were developed and aerial spraying worked out, there was little hope of economic applied control of cone and seed insects. The only proposal was to control sugar-pine and ponderosa-pine cone beetles by raking and burning cones where a seed crop was badly needed (59) but this method was never tried.

When residual insecticides became available, the idea was advanced (46) that these chemicals might be applied from the air to control cone and seed insects. One experimental project to control the sugar-pine cone beetle by applying DDT by helicopter was undertaken by the Forest Service in California in 1953 but was inconclusive (p. 54).

The first attempt to develop a control program for Douglas-fir cone and seed insects was an experiment undertaken by the Weyerhaeuser Timber Co. on its Clemons Tree Farm in Washington in 1954 (71). Four groups of 15- to 25-year-old Douglas-firs, with 10 trees per group, were sprayed with a 2½ percent DDT water emulsion. The spray was applied from the ground at the rate of 2 gallons per tree. The first group of 10 trees was sprayed 4 times: On May 7, May 21, June 18, and July 23. The first spray on May 7 was about 2 weeks after opening of the reproductive buds. The second group received 3 sprays, starting May 21; the third group received 2 sprays on June 18 and July 23; and the fourth group received 1 spray on July 23. Control appeared to be most effective on the first group of trees.

One of the problems of applied control for cone and seed insects is the lack of indicators of the degree of infestation before damage occurs. Since control needs to be applied before damage has started, the only solution is to develop a program under which seed orchards or cutover areas will be sprayed every year in which

a seed crop needs to be assured. Control therefore should be planned as a protective measure, and applied before the need is apparent.

Since the control of different groups of cone and seed insects presents special problems, it is advisable to consult the notes for different species and genera (pp. 47, 54, 103, and 131).

### Treatment of infested seeds

Most cone- and seed-infesting insects have completed their destructive work by the time cones are mature, so little can be gained by fumigating or treating cleaned seed. The damage is not likely to increase because cone and seed insects do not migrate from one seed to another while in storage. Also, the treatment is not likely to reduce insect infestations in the forest significantly.

When seeds are being shipped to foreign countries or to forest areas free of infestation, however, there may be reason to destroy the infestation.

Larvae in stored seeds may be killed by any of the common grain fumigants. These fumigants will not reduce germination, provided the moisture content of the seed is not over 12 percent and exposures are limited to 24 hours. Fumigation schedules are too variable to be given in detail here. Recommended dosages per 1,000 bushels of seed are 15 pounds of calcium cyanide, or 3 gallons of carbon disulfide, or 6 gallons of 3-to-1 mixture of ethylene dichloride and carbon tetrachloride. Methyl bromide also has been successfully used as a fumigant. Recommended dosage per 1,000 cubic feet is 1 pound of methyl bromide for an exposure of 24 hours at temperatures between 70° and 90° F., or 4 pounds for 2 hours at 70° F. under 27- to 29-inch vacuum. All of these fumigants are dangerous and must be handled with expert care.

Insects in seed may also be destroyed by heating at 140° F. for 10 minutes without reducing germination, unless the seed is of low vigor or its moisture content is high. Hussey (39) stated that "tests have shown that *Megastigmus* larvae can be killed by exposure to a temperature of 120° F. (49° C.) for more than 4 hours. If temperatures in the seed extraction kiln are adjusted therefore to this level, and the cones are heated for 5 to 6 hours to allow the temperature within the seeds in the cones to rise sufficiently, the larvae will be killed, without the viability of the uninfested seeds being impaired. The storage capacity of seed extracted at this temperature is not affected, but it should be noted that the actual treatment can only safely be done at the extraction time."

### SUGGESTED NEEDS FOR FURTHER STUDY

It must be realized that this report on cone and seed insects of western forest trees is not the definitive treatise on this subject. It is merely a digest of what is now known of these insects and the forestry problems they raise, as a starting point for further study.

Investigations are needed of the biology of the various destructive species as modified by latitude, longitude, elevation, and locality throughout the range of the host trees. More study is needed of phenology to define the relation between events in the life cycle of the insect, climate, and life events of the host tree or other plant indicators. This information is important in timing control to correspond exactly with emergence or attack of the damaging insect species.

The entire field of applied control is open for much needed study; practical, economic methods have not been developed. The possibility of controlling damage through modifying silvicultural practices should not be overlooked. We may be able to duplicate the best conditions for natural control to assure an ample seed source for future timber crops.

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