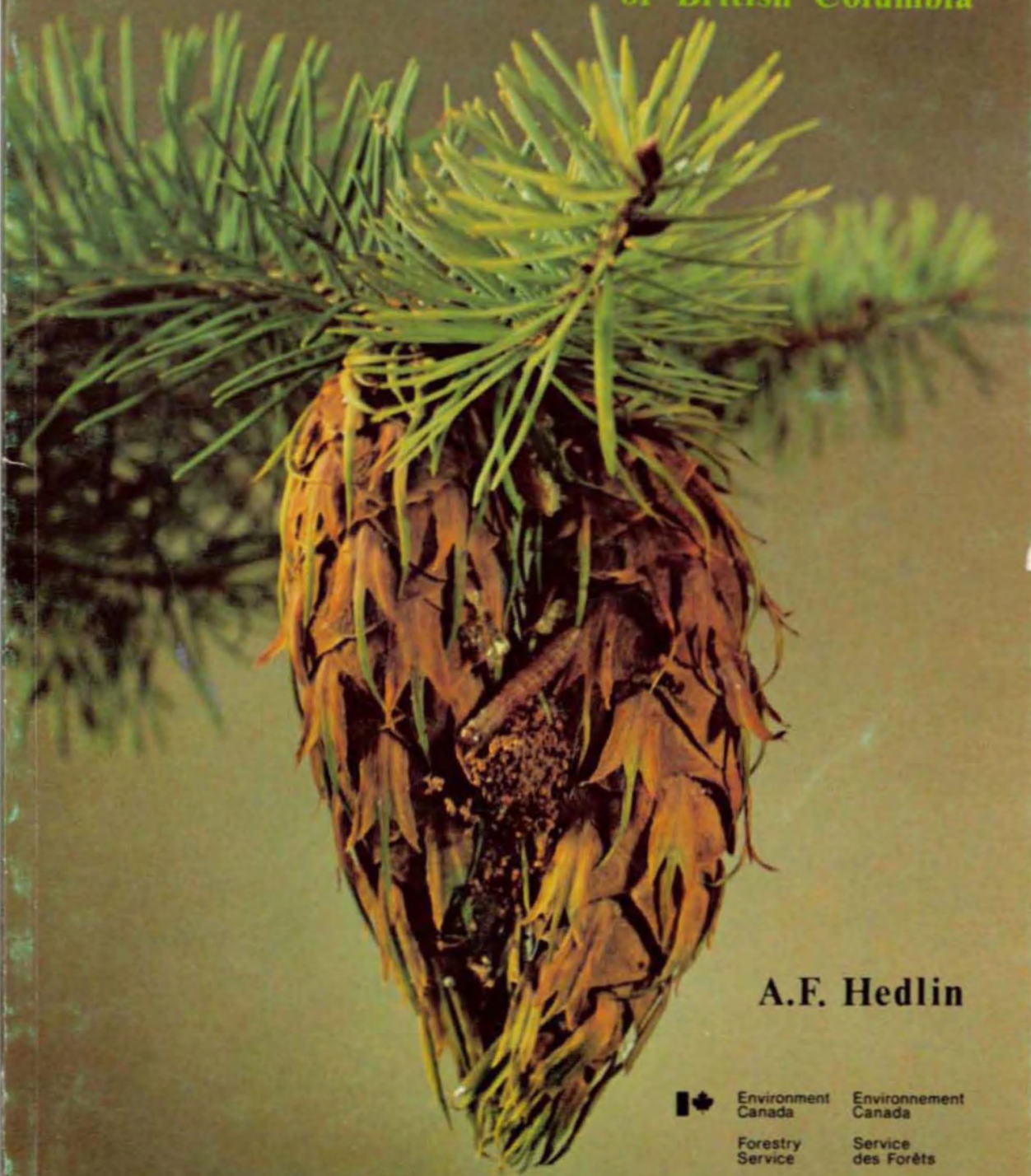


Canada  
PERC  
Insects rept.  
BC-X-90

FOREST CONE RESEARCH CENTER  
100 WEST BURNHAM ROAD

# Cone and Seed Insects

of British Columbia



A.F. Hedlin

 Environment Canada / Environnement Canada  
Forestry Service / Service des Forêts

# **Cone and Seed Insects of British Columbia**

by **A.F. Hedlin**



**Environment  
Canada**

**Environnement  
Canada**

**forestry  
Service**

**Service  
des Forêts**

**Pacific Forest Research Centre  
506 West Burnside Road  
Victoria, B.C.**

## ABSTRACT

This handbook, which includes the more important **cone** and seed insect pests on 15 species of trees in British Columbia, is intended as a guide to anyone interested in insect problems associated with production and collection of tree seed. Damage **keys** and illustrations are included to aid in insect identification. Practical methods for prevention and control are discussed.

## RÉSUMÉ

Ce livret, qui comprend les insectes nuisibles les plus importants des cônes et semences de 15 espèces d'arbres en Colombie britannique, est destiné à guider quiconque intéressé aux problèmes des insectes en ce qui a trait à la production et ramassage des semences d'arbres. Des clés des dommages et des illustrations **sont** inclus pour aider à l'identification des insectes. Des méthodes pratiques pour la prévention et le contrôle sont discutées.

# Contents

<b>INTRODUCTION</b> .....	7
<b>TRUE FIRS</b> .....	11
Amabilis Fir, <i>Abies amabilis</i> .....	11
<i>Megastigmus lasiocarpae</i> .....	11
<i>Earomyia abietum</i> .....	11
Grand Fir, <i>Abies grandis</i> .....	13
Key to Grand Fir Cone Insects .....	13
<i>Megastigmus pinus</i> .....	14
<i>Megastipus rafni</i> .....	14
<i>Earomyia abietum</i> .....	14
<i>Barbara</i> sp. <sup>1</sup> .....	15
<i>Dasineura abiesemia</i> .....	15
<i>Dasineura</i> sp. ....	15
<i>Resseliella</i> sp. ....	15
Alpine Fir, <i>Abies lasiocarpa</i> .....	17
Key to Alpine Fir Cone Insects .....	17
<i>Earomyia aquilonia</i> .....	17
<i>Megastigmus lasiocarpae</i> .....	17
<b>JUNIPER</b> .....	18
Rocky Mountain Juniper, <i>Juniperus scopulorum</i> .....	18
Key to Juniper Berry Insects .....	18
<i>Trisetacus quadrisetus</i> .....	18
<i>Eurytoma juniperiana</i> .....	18
<b>SPRUCES</b> .....	23
Key to Spruce Cone Insects .....	23
<i>Laspeyresia youngana</i> .....	26
<i>Hylemya anthracina</i> .....	26
<i>Dasineura rachiphaga</i> .....	27
<i>Dioryctria abietivorella</i> .....	48
<i>Mayetiola carpophaga</i> .....	28
<i>Megastipus piceae</i> .....	28
<i>Dasineura canadensis</i> .....	28
<b>PINES</b> .....	33
Lodgepole Pine, <i>Pinus contorta</i> .....	33
<i>Eucosma recissoriana</i> .....	33
Western White Pine, <i>Pinus monticola</i> .....	35
<i>Conophthorus monticolae</i> .....	35
Ponderosa Pine, <i>Pinus ponderosa</i> .....	37

---

<sup>1</sup>Identified as *Barbara colfaxiana siskiyouana* (Kft.) by Dr. D.R. Davis, USNM, Wash., D.C., since going to press.

Key to Ponderosa Pine Cone Insects .....	37
<i>Laspeyresia piperana</i> .....	37
<i>Laspeyresia miscitata</i> .....	37
<i>Dioryctria auranticella</i> .....	38
<i>Dioryctria abietivorella</i> .....	48
<i>Dioryctria rossi</i> .....	38
<i>Resseliella</i> sp. ....	39
<b>DOUGLAS-FIR</b> .....	42
Douglas-fir, <i>Pseudotsuga menziesii</i> .....	42
Key to Douglas-fir Cone Insects .....	42
<i>Barbara colfaxiana</i> .....	43
<i>Contarinia oregonensis</i> .....	45
<i>Megastipus spermotrophus</i> .....	45
<i>Dioryctria abietivorella</i> .....	48
<i>Choristoneura occidentalis</i> .....	49
<i>Contarinia washingtonensis</i> .....	49
<i>Camptomyia pseudotsuga</i> .....	51
<i>Pityophthorus orarius</i> .....	53
<i>Ernobius punctulatus</i> .....	53
<i>Earomyia barbara</i> .....	53
<i>Leptoglossus occidentalis</i> .....	54
<b>CEDAR</b> .....	57
Western Red Cedar, <i>Thuja plicata</i> .....	57
<i>Phytophaga thujae</i> .....	57
<b>HEMLOCK</b> .....	59
Western Hemlock, <i>Tsuga heterophylla</i> .....	59
<i>Megastigmus tsugae</i> .....	59
<b>PREVENTION AND CONTROL OF CONE AND SEED INSECTS</b>	60
<b>LITERATURE CITED</b> .....	62

# Introduction

The first compilation of **work** on cone and seed insects in North America was by Keen (1958). Recently a complete bibliography was published by Barcia and Merkel (1972).

This publication provides general information on the common **insects** that destroy tree seed in British Columbia. It is intended for practicing foresters, seed collectors, and others interested in problems associated with tree seed production. With emphasis on seed production in orchards, many insect species, even though not considered serious in natural stands, could constitute a problem where the host is more consistently available. Tree hosts are treated in alphabetical order by scientific name and the insect **pests** are discussed in descending order of importance for each species of host tree. Some insects are mentioned only by name because they are relatively unimportant in this region; they may be of greater importance elsewhere.

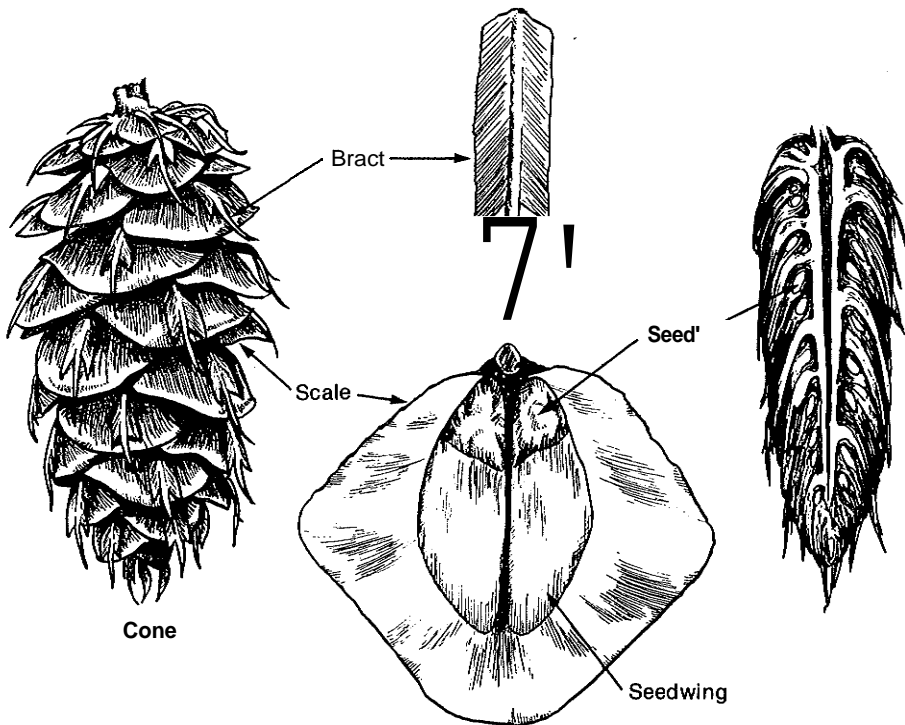


Fig. 1. Diagram of basic parts of Douglas-fir cone.

The keys are intended only as a guide for determination of insect species present in mature or nearly mature cones. In early summer, identification is often difficult as many **larvae** are immature.

Illustrations include a variety of figures intended to help the reader in identifying the different pests. Figure 1 illustrates basic parts of a cone which are referred to throughout the text. Early flower development, the period when most insect infestation occurs, has been described and illustrated for Douglas-fir by Allen and Owens (1972). Maps illustrating host distribution are based on Native Trees of Canada by R.C. Hosie (1969).

Some host species are frequently attacked by more than one insect species. As cones reach maturity in autumn, damage caused by lesser insect species tends to be obscured by the more dominant feeders. Although specific insect collection points are indicated on host distribution maps, insects may occur anywhere within the range of the host.

I am indebted to my colleagues at the Pacific Forest Research Centre, namely, A.R. Craigmyle, E.J. Chatelle and J.C. Wiens for photographic and illustrative assistance, and others for advice and editorial comments. I am particularly grateful to D.S. Ruth for his technical assistance and for willingly and ably assuming responsibility for organization, in the final stages of manuscript preparation, during my absence. N.E. Johnson of Weyerhaeuser Company made helpful comments and kindly gave permission to use photographs for Figures 26 d, 30 a, b.

# AMABILIS FIR



Fig. 2. Amabilis fir distribution showing locations where insects have been collected.



# True Firs

## Amabilis Fir, *Abies amabilis*

Amabilis fir (Figures 2, 3) may suffer seed loss to two species of insects which also attack other true firs. *Megastigmus lasiocarpae* is a common pest of alpine fir and *Earomyia abietum* of grand fir. Both species are discussed under the other hosts.



Fig. 3. Cones of amabilis fir.

# GRAND FIR



Fig. 4. Grand fir distribution showing locations where insects have been collected.

## Grand Fir, *Abies grandis*

Grand fir (Figure 4) is a fairly good seed producer but a large portion of the seed crop may be destroyed by a number of different insect species. Figure 5 illustrates diagrammatically the **typical** feeding sites of insects that feed on the cone scale or in seeds.

### Key to Grand Fir Cone Insects

1. Damage to scales and seeds; larvae feed freely throughout the cone,
  - (a) whitish larva **with** dark head; feed in cone during summer; pitch-coated cocoon near axis in late summer.  
*Barbara* sp.<sup>1</sup> p. 15
  - (b) whitish larva with whitish head, usually feed in seeds during **summer**.  
*Earomyia abietum* p. 14
2. Damage restricted to specific scales or seeds; larvae do not move from one part **of** cone to another.
  - (a) whitish curved larva in seed.  
*Megastigmus pinus* p. 14  
*Megastigmus rafni* p. 14
  - (b) yellow larva in seed.  
*Dasineura abiesemia* p. 15
  - (c) yellow larva in swollen gall in scale.  
*Dasineura* sp. (gall midge) p. 15
  - (d) yellow larva exposed on cone scale.  
*Resseliella* sp. (scale midge) p. 15

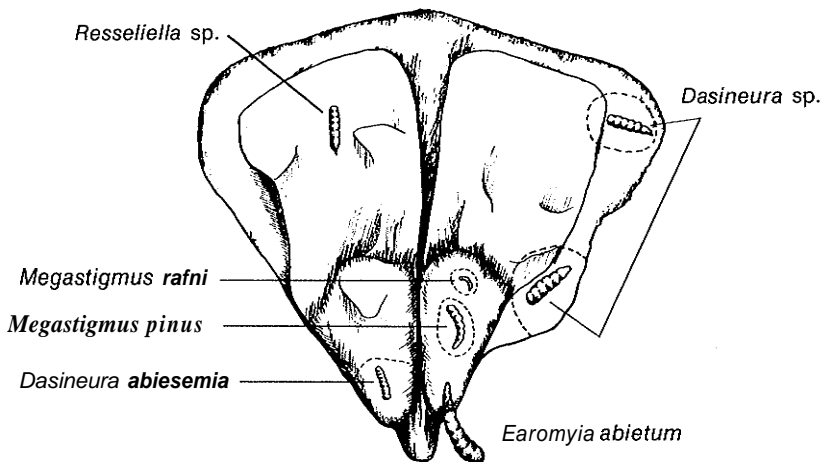


Fig. 5. Diagrammatic illustration of typical feeding sites of insects attacking grand fir cone scale and seeds.

<sup>1</sup>*Barbara colfaxiana siskiyouana*

## GRAND FIR

### **A fir-seed chalcid, *Megastipus pinus* Parfitt**

**Host:** Grand fir, amabilis fir, alpine fir and species of *Abies* introduced to British Columbia.

**Damage:** Each larva spends its entire period of development in a single seed devouring the contents. This insect is important as a seed destroyer, particularly in grand fir. Hedlin (1967a) showed that these two chalcids were responsible for 50% of the seed loss caused by insects in cones of this host; 25 seeds were destroyed per cone. There is no external evidence of damage until the adult emerges leaving a small hole in the seed.

**Description:** The adult wasp is black and yellow. The larva is greyish white and, when fully developed, almost fills the seed.

**Life History:** The adult emerges sometime during mid-May to mid-June. The female lays an egg in the seed near the cone axis. The young larva feeds throughout the summer and overwinters in the seed in the forest litter. When the mature larva is disturbed, it is extremely active in contrast to the sluggish *M. rafni* larva. The larva pupates in the spring within the seed.

**Reference;** Hedlin 1967a.

### **A fir-seed chalcid, *Megastigmus rafni* Hoffmeyer**

**Host:** Grand fir and introduced species of *Abies*.

**Damage:** Although this insect is probably not an important destroyer of grand fir seed, it is more destructive than is apparent. Damage is masked by competition with *Megastipus pinus*. When larvae of both occur in the same seed, *M. rafni* is killed and therefore the damage is attributed to the survivor, *M. pinus*. In the absence of *M. pinus* damage would be caused by and credited to *M. rafni*. There is no external evidence of damage to the seed until the adult emerges.

**Description:** The adult wasp is yellow-amber. The mature larva is whitish and fills most of the hollowed seed.

**Life History:** The adult emerges during June. The egg is laid in the seed adjacent to the seed wing. Early larval feeding occurs in this portion of the seed.

**References:** Hedlin 1967a; Keen 1958.

### **A fir-cone maggot, *Earomyia abietum* McAlpine**

**Host:** Grand and amabilis fir.

**Damage:** The larva is basically a seed feeder, moving from one seed to another in the growing cone. However, it is also predacious and other insects, such as *Megastipus*, that are present in the seeds may be devoured.

**Description:** The adult is a small black fly. The larva is whitish with distinct black mouth hooks.

**Life History:** The adult emerges and lays its eggs between scales of the young cone in May. Watching occurs during May and June. The larva moves to the central portion of the cone to feed on seeds. In late summer, the mature larva drops to the ground to enter the litter and overwinter in a dark-brown puparium.

**Reference:** Hedlin 1967a.

**A fir-cone moth, *Barbara* sp.<sup>1</sup>****Host:** Grand fir.**Damage:** The larva feeds on scales and seeds, causing extensive damage. Excessive pitch flow causes scales **to fuse** so cones usually do not disintegrate as early in autumn as uninfested cones. A single larva in a cone may destroy up to 25% of the seed; two will destroy 50% or more.**Description:** The adult is a small dark grey moth (Figure 9a). The whitish larva has a dark head capsule.**Life History:** This insect has not been studied in detail. The adult probably lays its eggs on the cone bracts in spring. When the larva has completed feeding in July, it spins a cocoon in the cone in which to pupate. When the cone disintegrates in late summer, the cocoon falls to the ground and remains in the litter over winter.**A fir-cone seed midge, *Dasineura abiesemia* Foote****Host:** Grand fir and other species of *Abies* introduced into British Columbia.**Damage:** The larva feeds in the seed of the host, one insect in each infested seed. It is not a serious pest of fir seed.**Description:** The adult is a small dark midge. The mature larva is yellow.**Life History:** The larva remains in a seed throughout the summer and drops to the ground to overwinter in the seed after the cone disintegrates.

The following spring it pupates and the adult emerges.

**References:** Hedlin 1967a; Keen 1958.**A fir-cone gall midge, *Dasineura* sp.****Host:** Grand fir.**Damage:** The larva forms a gall or swelling in the cone scale, usually adjacent to a seed. The seed is destroyed or fused **to** the cone scale. Damage is usually light.**Description:** The adult is a small dark midge. The mature larva is orange-yellow.**Life History:** The larva remains in the gall throughout the summer and in autumn drops to the ground when the cone disintegrates, **It** overwinters in the litter to pupate and emerge in spring.**Reference:** Hedlin 1967a.**A cone-scale midge, *Resseliella* sp.****Host:** Grand fir and probably other conifers.**Damage:** Larvae feed, either singly or in clusters, on the inner surface of the cone scale, often between the seed wing and the scale. Larval feeding causes the scale to darken and sometimes turn brown prematurely. Although insects may be plentiful, damage is usually not severe because insects do **not** feed directly on seeds.**Life History:** The larva remains in the cone until late summer and drops to the ground when the cone matures. It overwinters in the litter as a larva and the adult emerges the following spring.**Reference:** Hedlin 1967a.

---

<sup>1</sup>*Barbara colfaxiana siskiyouana*

# ALPINE FIR



Fig. 6. Alpine fir distribution showing locations where insects have been collected.

## Alpine Fir, *Abies lasiocarpa*

### Key to Alpine Fir Cone Insects

1. Damage to scales and seeds throughout the cone.
  - (a) whitish larva, usually feeding in seeds.
 

*Earomyia aquilonia* p.17
2. Internal damage to seeds only; larvae do not move from one seed to another.
  - (a) whitish curved larva in seed.
 

*Megastigmus lasiocarpae* p.17

#### A fir cone maggot, *Earomyia aquilonia* McAlpine

**Host:** Alpine fir (Figures 6, 7).

**Damage:** The larva feeds on seeds, moving freely from one to another within the cone. There may be 4 or 5 larvae per cone, which together destroy most of the seeds.

**Description:** The adult is a small velvety black fly. The larva is whitish with distinct black mouth hooks.

**Life History:** The adult lays its eggs between scales of young cones in early summer. The larva feeds during summer, mainly on seeds. In autumn, it drops to the ground to pupate and overwinter in the litter.

**Reference:** Keen 1958.

#### An alpine-fir seed chalcid, *Megastigmus lasiocarpae* Crosby

**Host:** Alpine fir and amabilis fir.

**Damage:** Each larva feeds in one seed, devouring the contents. The insect does not usually occur in large numbers so is not a serious pest.

**Description:** The adult female wasp is black. The long ovipositor curves up and forward over the abdomen. The male is black, except the lower portions of the head which are yellow.

**Life History:** The larva develops in the seed of the host, similar to *Megastigmus pinus* (p.14 )

**Reference:** Keen 1958.

Fig. 7. Cones of alpine fir.



# Juniper

## Rocky Mountain Juniper, *Juniperus scopulorum*

### Key to Juniper Berry Insects

1. Berries apparently normal, larva in berry in early summer; round emergence hole in berry in late summer.  
*Eurytoma juniperiana* p.18
2. Berries noticeably shrunken, many mites in each berry.  
*Trisetacus quadrisetus* p.18

#### A juniper berry mite, *Trisetacus quadrisetus* Thomas

**Host:** Rocky Mountain juniper.

**Damage:** The mite attacks berries of juniper and prevents normal development (Figure 8). Hundreds of mites feed in each berry, causing it to develop in a shrivelled form instead of a smooth, round berry. Almost 100% of the berries on infested trees are destroyed each year. This pest is not considered to be important because of little demand for juniper seed.

**Reference:** Morgan and Hedlin 1960.

#### A juniper seed chalcid, *Eurytoma juniperiana* Marcovitch

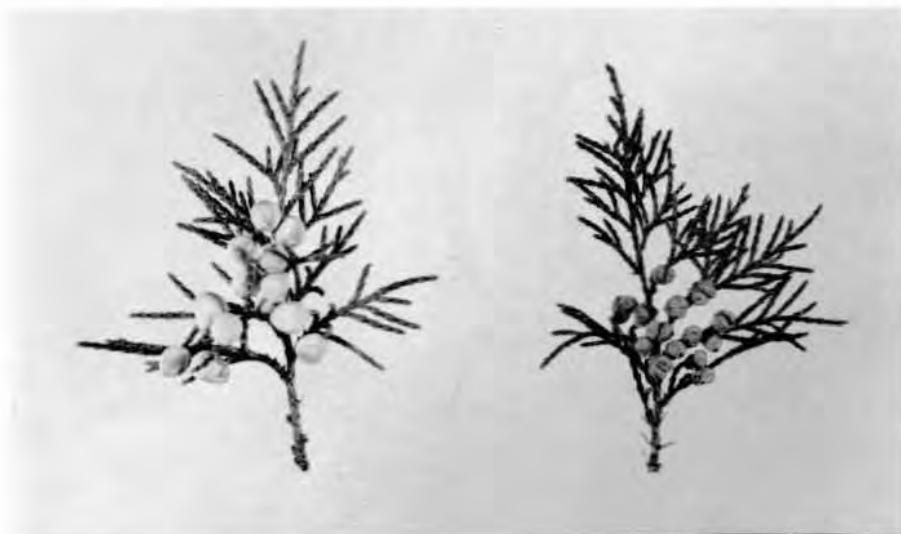
**Host:** Rocky Mountain juniper.

**Damage:** The larva feeds in a second-year berry and destroys a single seed, similar to members of the related genus *Megastigmus*. Damage is apparent only after the adult has emerged through an exit hole bored in the seed.

**Life History:** The adult emerges during July or early August. Possibly eggs are laid during late summer in first-year berries and the insect overwinters as an egg or young larva. Larval development and pupation occur in second-year berries.

**Reference:** Keen 1958.

Fig. 8. Juniper berries; left, normal and right, infested with juniper berry mite.





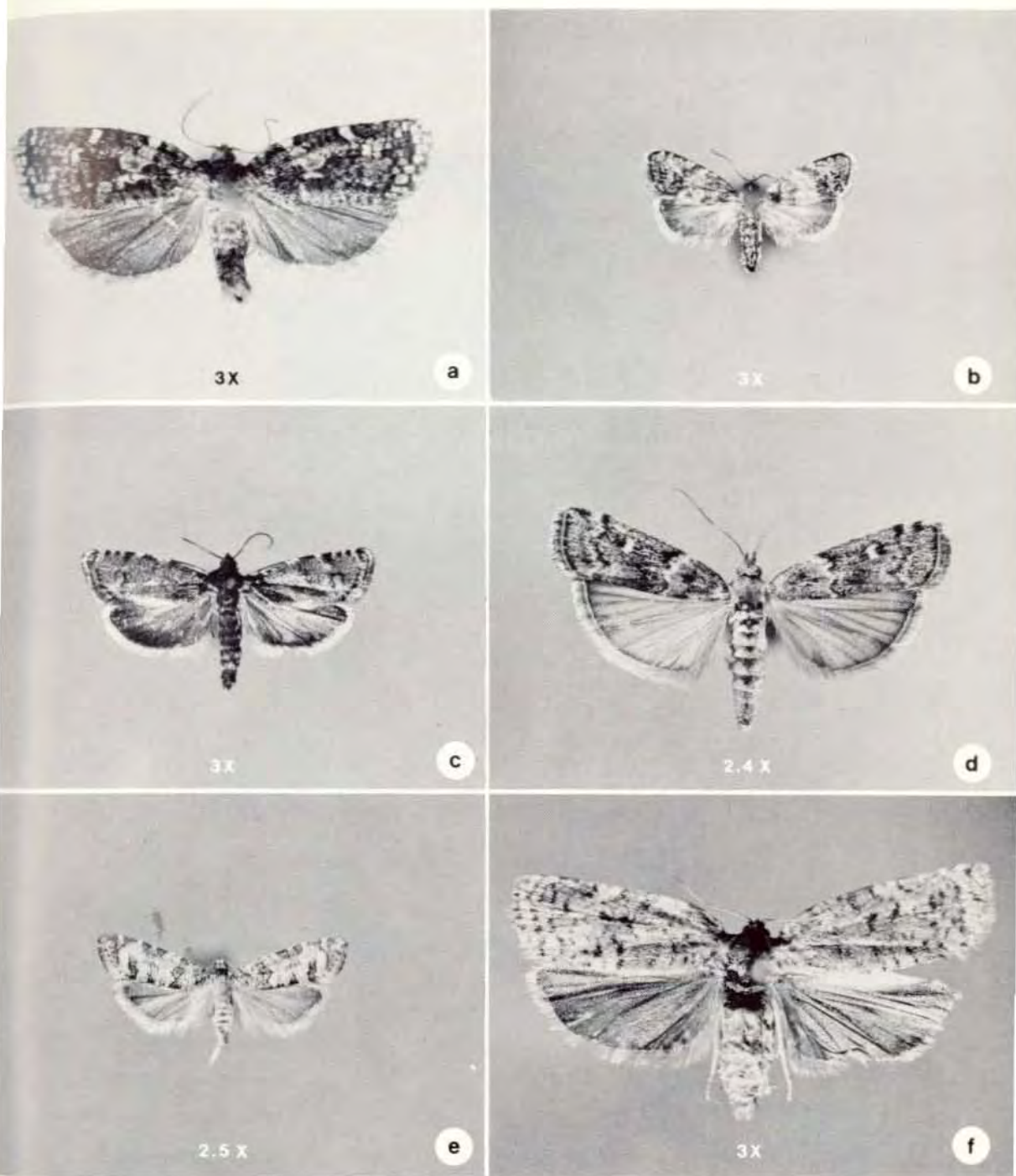


Fig. 9. Adults; (a) *Barbara* sp. (grand fir), (b) *Laspeyresia youngana* (spruce), (c) *Laspeyresia piperana* (ponderosa pine), (d) *Dioryctria abietivorella* (Douglas-fir, spruce, ponderosa pine), (e) *Barbara colfaxiana* (Douglas-fir), (f) *Choristoneura occidentalis* (Douglas-fir).

WHITE SPRUCE / ENGELMANN SPRUCE



Fig. 10. White and Engelmann spruce distribution showing locations where insects have been collected.



Fig. 11. Sitka spruce distribution showing locations where insects have been collected.

# BLACK SPRUCE



Fig. 12. Black spruce distribution showing locations where insects have been collected.

# Spruces

Spruce cone insects are not specific to a single host and most occur in all species, i.e. *Picea glauca*, white; *P. engelmannii*, Engelmann; *P. sitchensis*, Sitka; and *P. mariana*, black spruce (Figures 10, 11, 12).

## Key to Spruce Cone Insects

1. Damage to scales and seeds; larvae move freely throughout the cone.
  - (a) damage severe with quantities of coarse frass on cone exterior; large reddish larva.

*Diorcytria abietivorella* p.48  
*Diorcytria reniculelloides* p.49
  - (b) damage often not apparent on cone exterior; larval damage mostly to seeds during summer; larva white with black head, in cone axis in late summer and winter.

*Laspeyresia youngana* p.26

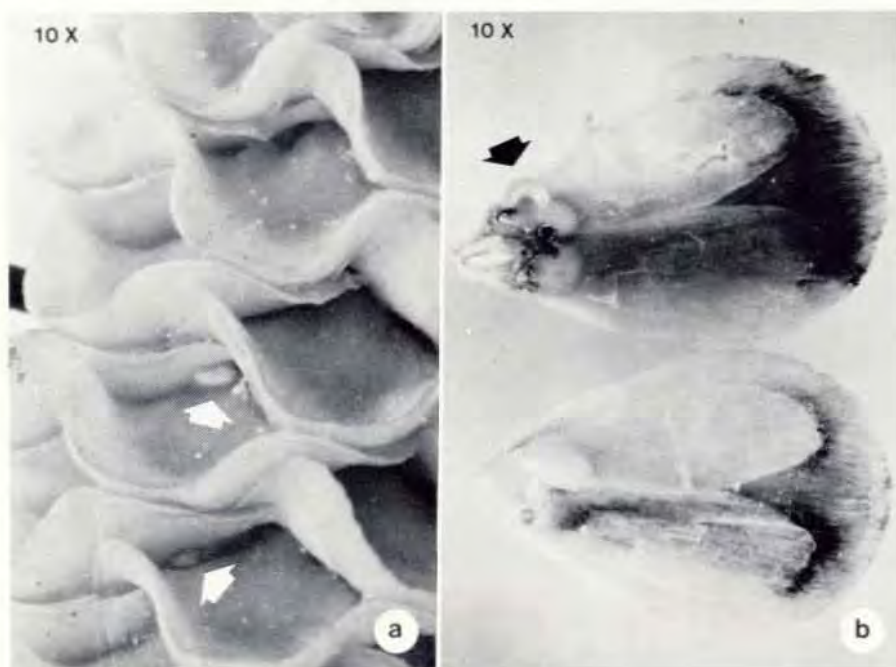


Fig. 13. *Laspeyresia youngana*; (a) eggs in conelet, (b) young larva feeding in seed (arrow).

## SPRUCES

- (c) damage often not apparent on cone exterior; larval feeding tunnel spirals around cone axis through seeds; larva, white with no obvious head, leaves cone in late July; damage may be confused with that of *Laspeyresia*.  
*Hylemya anthracina* p.26
2. Damage restricted to specific portion or portions of the cone; larvae do not move from one part of cone to another.
- (a) whitish larva in seed.  
*Megastigmus piceae* p.28
- (b) yellow larva in seed.  
*Mayetiola carpophaga* p.28
- (c) yellow larva in small gall in cone scale.  
*Dasineura canadensis* p.28
- (d) yellow larva, feeds in scale, and in late summer spins a delicate white silken cocoon in cone axis.  
*Dasineura rachiphaga* p.27



Fig. 14. Mature larva of *Laspeyresia youngana* in cone axis. (above)

Fig. 15. White spruce cone sliced longitudinally to show typical damage of *Hylemya anthracina* larva. Arrow (A) indicates one of points where seed has been destroyed by the insect as it moves around the cone axis; (B) normal seeds. (right)



### **A spruce seedworm, *Laspeyresia youngana* (Kearfott)**

**Host:** White, Engelmann, Sitka and black spruce.

**Damage:** The newly hatched larva goes directly to a young seed to commence feeding. From June to September it feeds almost entirely on seeds, moving from one to another as each is destroyed. The young larva enters each seed to devour the contents (Figure 13b). As it gets larger it bores a hole through the seed coat and feeds from outside the seed. Damaged seeds are usually left filled with excrement. The mature larva enters the cone axis (Figure 14) and continues to feed on seeds from the axis tunnel for some time before going into hibernation. One larva may destroy from 10 to 20 seeds. There is no external evidence of damage.

**Description:** The adult is a small dark-grey moth (Figure 9b). The pale orange, oval egg is less than 1 mm in diameter. The mature whitish larva with a dark head is up to 10 mm long. The pupa is tawny in color, between 5 and 6 mm long.

**Life History:** The adult moth emerges in June to lay its eggs between cone scales of spruce flowers (Figure 13a) which are open for pollination. The egg hatches during the latter half of June, and the larva spends the summer feeding on seeds. It enters the cone axis in late August or early September to overwinter. If several larvae are present in one cone they separate themselves in the axis with plugs of frass. They pupate in May of the following year.

**References:** Hedlin 1973; Tripp 1954; Tripp and Hedlin 1956.

### **A spiral spruce-cone borer, *Hylemya anthracina* Czerny**

**Host:** White, Engelmann, Sitka and black spruce.

**Damage:** The larva feeds in the cone from mid-June until the latter half of July. As it feeds, it moves spirally around the cone axis damaging scales and destroying seeds (Figures 15, 17b). There is no visible external evidence of damage until the larva bores an exit tunnel to the surface of the cone, usually late in July. Several larvae may feed in one cone, in which case up to 100% of the seeds are destroyed. Usually only a single larva completes development in each infested cone and may destroy up to 50% of the seeds.

**Description:** The adult is a small black fly about 6 mm long. The white elongate egg (Figure 17a) is between 1 and 2 mm long, and the fully grown whitish maggot is about 6 mm; it has a pair of distinct black mouth hooks.

**Life History:** The adult emerges in May or June to lay eggs singly between cone scales. The egg hatches in about a week and the larva feeds in the area around the cone axis. By mid-July, the larva is fully grown and bores an exit tunnel to the surface of the cone (Figure 17c). During damp or wet weather in late July or early August, it vacates the cone and drops to the litter. It pupates in late summer or autumn and overwinters in this stage in a smooth brown puparium in the litter.

**Reference:** Hedlin 1973.





Fig. 16. *Dasineura rachiphaga* cocoons in white spruce cone axis.

**A spruce-cone axis midge, *Dasineura rachiphaga* Tripp**

**Host:** White, Engelmann, Sitka and black spruce.

**Damage:** This is one of the most common insects in spruce cones in British Columbia. In spite of large numbers, it is less destructive than some other species. Infested cones are not usually attacked by more than one larva per scale. The insect feeds in the scale during early summer, gradually moving into the cone axis. A severely infested cone may have 15 to 20 larvae in the axis, visible only when the cone is opened. There is no external evidence of damage, except in black spruce where the base of the infested scale becomes distinctly swollen.

**Description:** The adult is a small dark midge between 2 and 3 mm long. The fully developed larva is yellow and occurs in a delicate silken cocoon in the cone axis (Figure 16).

**Life History:** The adult emerges from the cocoon in the cone axis in late May or June to lay its eggs near ovules of spruce flowers which are open for pollination. The young larva enters scale tissue near an ovule and gradually tunnels towards the cone axis. In late July, the fully grown larva spins a delicate, white silken cocoon in the cone axis, in which to overwinter. It pupates in the cone in early May.

**References:** Hedlin 1973; Tripp 1955.

## SPRUCES

### A Spruce seed midge, *Mayetiola carpophaga* (Tripp)

Host: White and possibly other spruces.

**Damage:** Each larva feeds in and destroys a single seed. Although it may occur in large numbers in some localities it is not generally common so overall losses are slight.

**Description:** The adult is a delicate midge. The larva is yellow and lives within a seed.

**Life History:** The adult lays its eggs in June in the openings of the ovules. Pollen grains are also plentiful in this location at the time of insect egg laying. The larva lives in the seed where it completes its development and remains to overwinter. It pupates in the seed in May and the adult emerges several weeks later.

**References:** Hedlin 1973; Tripp 1955.

### A spruce seed chalcid, *Megastigmus piceae* Rohwer

Host: White, Engelmann and probably other spruces.

**Damage:** Each larva feeds inside a seed devouring the seed contents. The insect is not a common pest of spruce in British Columbia.

**Description:** The adult of this very small chalcid is almost black with some brown and yellow markings.

**Life History:** The female adult lays its eggs in the seeds of young cones, one egg per infested seed, in late June. The larva feeds in the seed until late summer when it is fully grown. By this time the seed contents are completely devoured. The larva remains in the seed until spring, to pupate during May. The adult emerges during June.

**References:** Keen 1958; Werner 1964.

### A spruce-cone gall midge, *Dasineura canadensis* Felt

Host: White and probably other spruces.

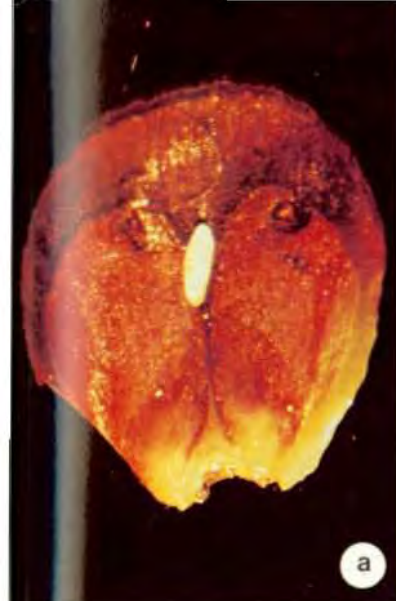
**Damage:** The larva forms a gall in the cone scale usually not adjacent to a seed. It occurs in small numbers and probably has little effect on seed production.

**Description:** Similar to the cone axis midge (p. 27), except that the yellow larva feeds in a gall in the cone scale.

**Life History:** The adult lays its eggs in June on the inner surface of the scales of young cones which are open for pollination. When the egg hatches, the larva enters the scale tissue to form a gall. When fully developed in late summer, it spins a delicate cocoon within the gall to overwinter. It pupates the following spring and the adult emerges in late May, or June.

**References:** Hedlin 1973; Tripp 1955.

Fig. 17. a, b, c. *Hylemya anthracina* in black spruce; (a) egg on cone scale, (b) cone sliced longitudinally to show larval feeding damage, (c) larval emergence hole in cone, (d) *Resseliella* larvae on white spruce cone scale, (e) Douglas-fir twig "flagged" by *Pityophthorus* tunneling, (f, g, h) *Barbara colfaxiana* in Douglas-fir, (f) eggs in flower, (g) cone sliced longitudinally to show larval damage, (h) pupal cocoon in mature cone.





■ *Eucozma recissoriana*

Fig. 18. Lodgepole pine distribution showing locations where insects have been collected.



Fig. 19. Lodgepole pine cone damaged by *Eucosma recissoriana*.

# Pines

## Lodgepole Pine, *Pinus contorta*

**A lodgepole pine cone moth, *Eucosma recissoriana* Heinrich**

**Host:** Lodgepole pine (Figures 18, 20).

**Damage:** The larva tunnels in second-year cones, feeding on scales and seeds (Figure 19). Larval-burrow openings on the surface of the cone are surrounded by brown frass. The insect does not occur consistently through the lodgepole pine areas of British Columbia but, when present, may cause significant seed loss.

**Life History:** The larva feeds in the cone until late summer when it leaves to pupate and overwinter in a silken cocoon. The adult emerges the following spring.

**Reference:** Keen 1958.



Fig. 20. Cones of lodgepole pine.

# WESTERN WHITE PINE



▲ *Conophthorus monticolae*

Fig. 21. Western white pine distribution showing locations where insects have been collected.

## Western White Pine, *Pinus monticola*

**A pine cone beetle, *Conophthorus monticolae* Hopkins**

**Host:** Western white pine (Figure 21).

**Damage:** The beetle bores into the stalk of the cone and tunnels into the axis. The female lays its eggs in the tunnel, which now becomes an egg gallery. The attack kills the cone and destroys all its potential seeds. Damaged cones drop to the ground in early summer.

**Description:** The adult is a small shiny black beetle.

**Life History:** The adult emerges in spring from a cone killed the previous summer. It bores into an immature second-year cone. Each attacked cone is usually inhabited by one pair of beetles, but sometimes there are two pairs, which excavate separate galleries. At completion of oviposition, the female vacates the cone, usually through the entrance hole, which she then plugs with frass. Larvae are present from mid-June to mid-July (Figure 22) and pupate during July and early August. After about one week in the pupal stage they transform to adults, which remain in the cone until the following spring.

**Reference:** Williamson *et al.* 1966.



Fig. 22. Larvae of *Conophthorus monticolae* feeding in a white pine cone.



# PONDEROSA PINE



Fig. 23. Ponderosa pine distribution showing locations where insects have been collected.

## Ponderosa Pine, *Pinus ponderosa*

Ponderosa pine suffers considerable loss of seed to *Laspeyresia piperana* and several species of *Dioryctria*. The fact that the species is a good seed producer reduces the effect of the losses.

### Key to Ponderosa Pine Cone Insects

1. Damage to scales and seeds; larvae move throughout much of the cone.
  - (a) large dark reddish larva in cone in summer, large red pupa in feeding cavity in late summer.  
*Dioryctria auranticella* p. 38
  - (b) brown striped larva in cone.  
*Dioryctria rossi* p. 38
  - (c) dark reddish larva smaller than *D. auranticella* causing similar damage.  
*Dioryctria abietivorella* p. 48
  - (d) larva feeds almost entirely on seeds, moving from one to another as each is devoured; in cone axis in late summer and winter.  
*Laspeyresia piperana* p. 37
2. Damage restricted to specific portions of the cone; insects do not move from one part of cone to another, many larvae, often in clusters causing surface damage to scales.  
*Resseliella* sp. p. 39

#### A ponderosa pine cone moth, *Laspeyresia piperana* (Kearfott)

**Host:** Ponderosa pine (Figure 23).

**Damage:** The larva feeds from June to September, almost entirely on seeds. It moves from one seed of each pair to another completely devouring the contents and constructs a silken tunnel between them so the two seeds become fused (Figure 24a). The larva leaves each seed filled with frass. The mature larva moves into the cone axis (Figure 24b) where it constructs extensive mines, but continues to feed on seeds for some time through short tunnels out to the seeds. In one study, an average of 14 larvae per cone destroyed 47% of the total seed produced. There is no external evidence of damage to the cones.

A related species, *L. miscitata*, causes similar damage in some ponderosa pine regions but is apparently not common in British Columbia.

**Description:** The adult is a small dark-brown moth (Figure 9c). The inconspicuous egg is usually reddish, but sometimes whitish, in color. The fully developed larva is creamy white with a brown head. The early pupa is white, turning almost black before emergence of the adult.

**Life History:** The adult emerges in May and the female lays its eggs, often in small clusters, on scales of second-year cones, usually near the base. The egg hatches in June and the young larva moves between cones scales to commence feeding in a young seed. In late July, it enters the cone axis; in late

summer or fall, it spins a delicate cocoon in which it overwinters. It pupates the following April.

**References:** Hedlin 1967b; Keen 1958.

**A pine coneworm, *Dioryctria auranticella* (Grote)**

**Host:** Ponderosa pine.

**Damage:** The larva tunnels extensively in the second-year cone (Figure 25a) to destroy seeds and scales in the area of tunneling. When plentiful, the insects destroy a considerable amount of seed.

Two other species, *D. abietivorella* and *D. rossi*, occasionally cause extensive

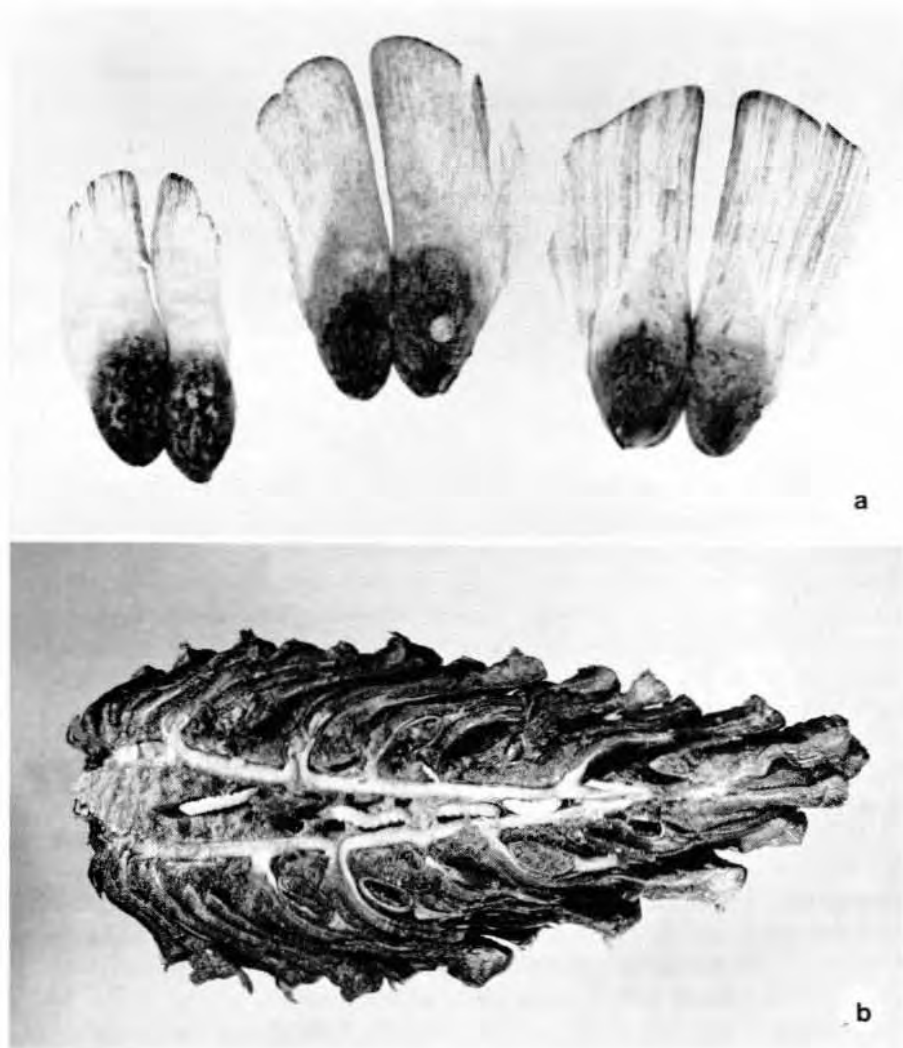


Fig. 24. *Laspeyresia piperana*; (a) seed pairs fused by larval silken feeding tunnels, (b) cone sliced longitudinally to expose larvae and feeding tunnels.

damage of a similar nature.

**Description:** The adult is a medium-sized grey moth. The larva is large, dark in color and very active.

**Life History:** The larva lives in the cone throughout the summer. In late summer, it pupates (Figures 25b) in the cone and remains there over winter to emerge as a moth the following spring.

**Reference:** Keen 1958.

**A cone scale midge, *Resseliella* sp.** (Figures 17d, 26) (See *Resseliella* under Grand fir) p. 15

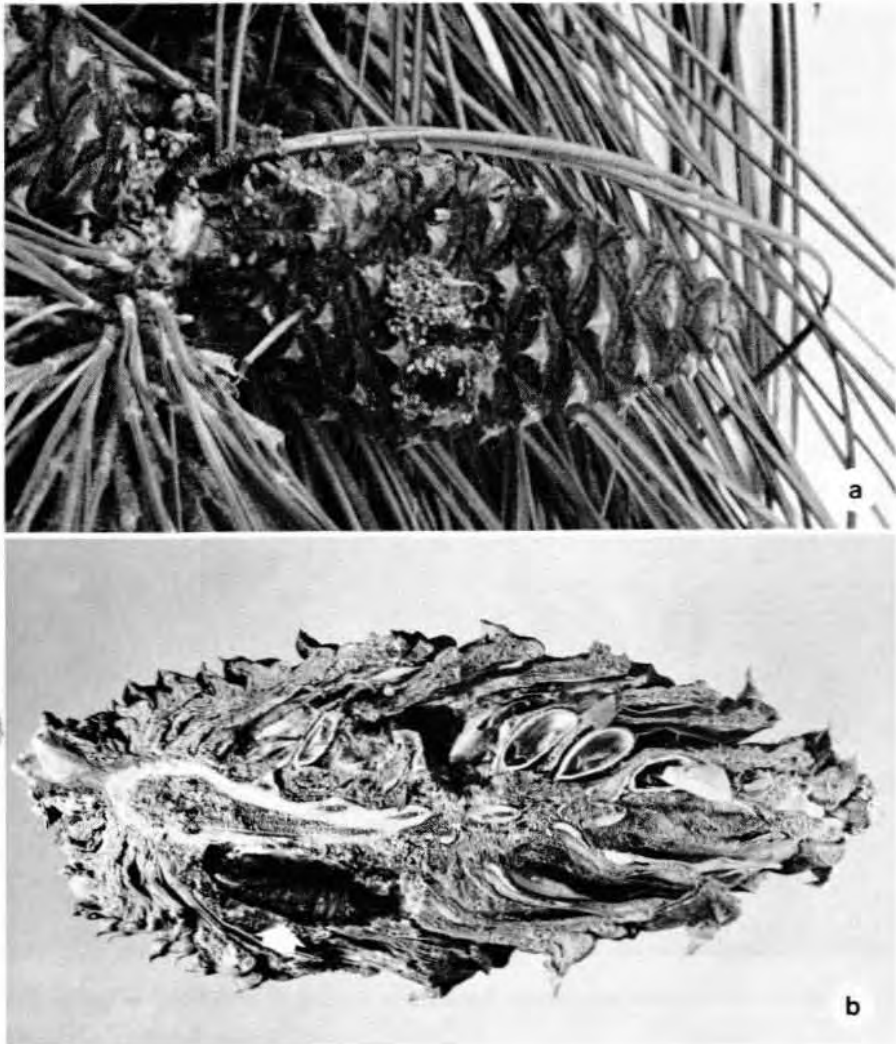


Fig. 25. *Dioryctria auranticella*; (a) frass and larval burrow on surface of ponderosa pine cone, (b) pupa in damaged cone.



Fig. 26. Larvae of the cone scale midge, *Resseliella* sp. feeding on scales in a ponderosa pine cone.



Fig. 27. Douglas-fir distribution showing locations where insects have been collected.

# Douglas-Fir

## Douglas-fir, *Pseudotsuga menziesii*

Douglas-fir suffers considerable seed loss to a number of insect species. Figure 28 illustrates diagrammatically the feeding sites of the more common ones. Frequent severe damage and a general high demand for seed combine to make the problem particularly important.

### Key to Douglas-fir Cone Insects

1. Damage to scales and seeds; larvae move freely throughout much of the cone.
  - (a) large active reddish larva present in cone in summer; much coarse frass in region of larval feeding.  
*Dioryctria abietivorella* p. 48
  - (b) dark larva with distinct light-colored spots; feeds on cone surface as well as in tunnels.  
*Choristoneura occidentalis* p. 49
  - (c) whitish larva with dark head feeding in cone until mid-July; reddish pupa in pitch-coated cocoon near cone axis in late summer.  
*Barbara colfaxiana* p. 43
  - (d) whitish active larva tunneling through seeds and scales; head not dark.  
*Earomyia barbara* p. 53
  - (e) beetles and/or larvae feeding only in mature cones, on tree or in storage; never in growing cones.  
*Ernobius punctulatus* p. 53
2. Damage restricted to specific portion or portions of the cone; larvae do not move from one part of cone to another.
  - (a) whitish curved larva occurring in seed only.  
*Megastipus spermotrophus* p. 45
  - (b) scales with swollen galls usually near the seeds; U-shaped orange larva in gall.  
*Contarinia oregonensis* p. 45
  - (c) scales mined, orange larva in tunnel between conductive tissue in scale during summer.  
*Contarinia washingtonensis* p. 49  
*Camptomyia pseudotsuga* p. 51

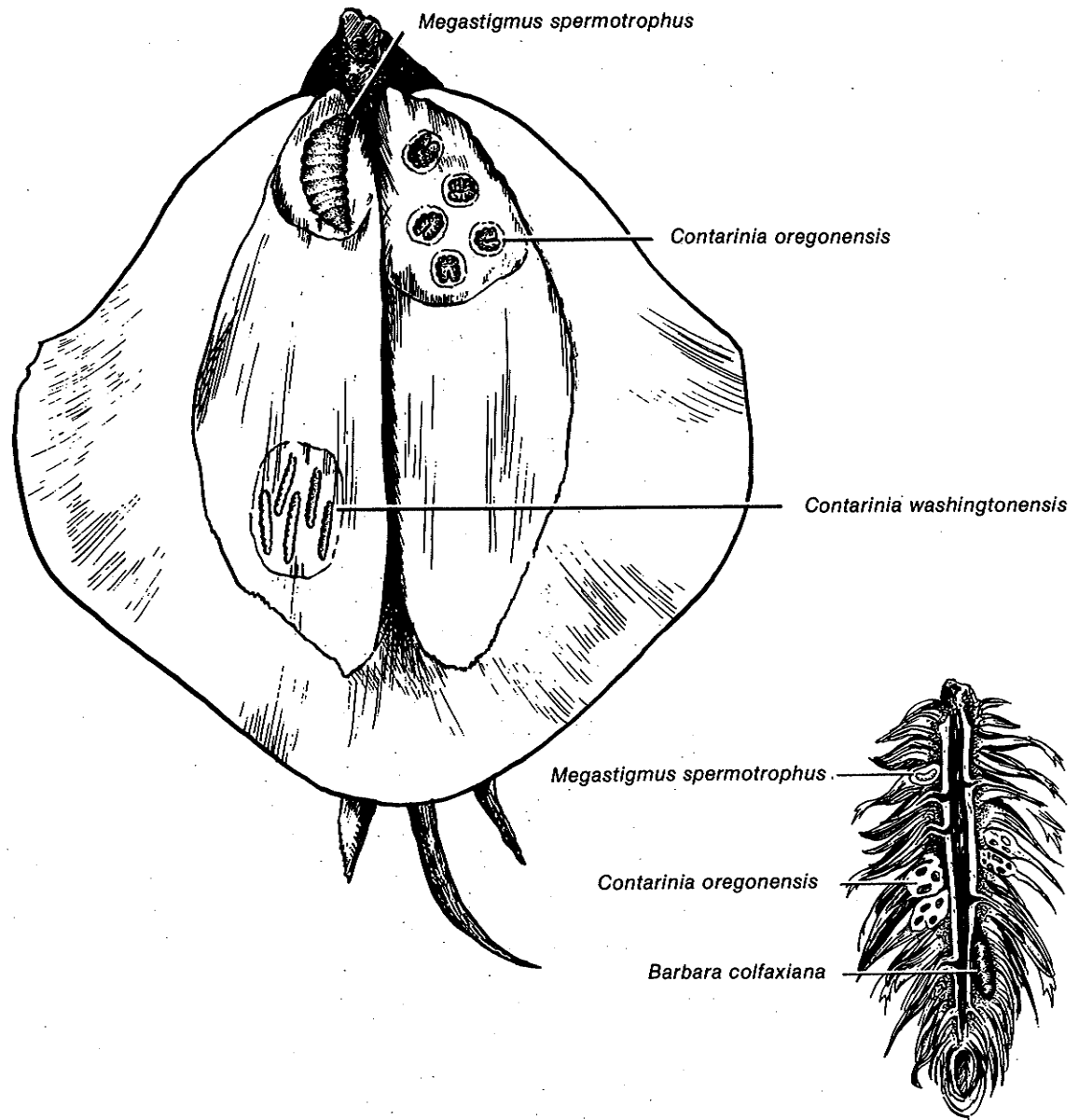


Fig. 28. Diagram of typical feeding sites of the more important Douglas-fir cone insects.

3. Damage to cone-bearing and potential cone-bearing twigs and shoots. Young shoots become flaccid in June, turn red during July.

*Pityophthorus orarius* p. 53

**The Douglas-fir cone moth, *Barbara colfaxiana* (Kearfott)**

**Host:** Douglas-fir (Figure 27).

**Damage:** Damage is caused by the larva feeding, in the early stages largely on scale tissue, and in the latter stages mainly on seeds (Figure 17g). The larva is an active feeder, often leaving clusters of excrement (Figure 29b) on the cone as external evidence of its presence. When cones are large, as they often





Fig. 29. *Barbara colfaxiana*: (a) pupa in sectioned Douglas-fir cone, (b) comparison of frass of *B. colfaxiana* (right) and *Dioryctria abietivorella* (left).

are in coastal areas, there may be no external evidence of damage; in interior drier areas, cones are usually smaller and surface frass is common. It is a common belief that large amounts of pitch on the surface of growing cones indicate the presence of insects; however, Douglas-fir cones often exude pitch freely, even when not infested. Although infested cones are often attacked only by a single larva, multiple infestations are common. It is one of the most serious pests of Douglas-fir cones. A single larva will destroy about 65% of the seed in a cone and three or more will destroy 100%.

This insect probably occurs throughout the range of the host. In British Columbia, it occurs consistently and is a more serious pest in the drier interior regions than in coastal areas.

**Description:** The adult is a small greyish brown moth (Figure 9e). The round egg is pearl color when laid, has an uneven surface and is about 0.8 mm in diameter. As the embryo develops, the egg changes in color through orange to almost black. The larva is yellowish white with a black head in early stages which later turns brown.

**Life History:** The moth emerges when Douglas-fir flowers are open for pollination, usually during the latter half of April or early May. It flies only during the evening and is particularly active when weather is warm. The female lays its eggs, usually singly, on the outer surface of cone bracts (Figure 17f). When the egg hatches, the young larva tunnels into a cone scale and feeds there for some time, gradually moving towards the cone axis. It pupates in a tough pitch-coated cocoon (Figures 17h, 29a) during the last half of July. It overwinters in the cone, which usually remains on the tree until the following summer.

**References:** Clark *et al.* 1963; Hedlin 1960a; Hedlin 1960b.

#### **A Douglas-fir cone gall midge, *Contarinia oregonensis* Foote**

**Host:** Douglas-fir.

**Damage:** The larva of this insect causes seed loss by forming a gall on the cone scale which fuses the developing ovule to the scale. Up to 30 larvae may form a single gall, which will destroy both seeds on the scale (Figure 30a). Severe infestations will destroy all seeds in the cone (Figure 30b). Under severe conditions cone scales will die prematurely and turn a reddish color in late July or August, providing the only external evidence of damage by this insect (Figure 30c).

This insect is one of the most serious pests in Douglas-fir cones. It probably occurs throughout the range of the host but is generally more serious in wetter coastal areas than in the drier Interior.

**Description:** The adult is a mosquito-like insect about 3 to 4 mm long with an orange abdomen. The female has a long retractile ovipositor. The smooth, shiny, white elongate egg is so small it can hardly be seen. The mature larva is orange.

**Life History:** The adult emerges from the cocoon in the litter during April when Douglas-fir flower buds are bursting. The female deposits eggs near the base of the cone scale in the newly opened flower. When the egg hatches, the larva tunnels into the young cone scale and forms a gall or swollen area near an ovule. Once established the U-shaped larva (Figure 30d) remains in the same location until it completes its development, then drops to the ground during wet weather in autumn. Johnson (1960) observed that larvae often select old male cones on the ground in which to overwinter. Pupation occurs in February or March.

**References:** Foote 1956; Hedlin 1961; Johnson 1960; Johnson and Heikkinen 1958; Keen 1958.

#### **A Douglas-fir seed chalcid, *Megastipus spermotrophus* Wachtl**

**Host:** Douglas-fir.

**Damage:** The larva of this species feeds only on seed contents, each one feeding within and destroying a single seed (Figure 31a). After devouring the contents it remains within the seed coat. There is no external evidence of damage until the adult emerges, after which a clearly defined emergence hole is evident (Figure 31b). Prior to adult emergence, insect damage can be detected only by seed dissection or X-rays (Figure 31c). This insect causes

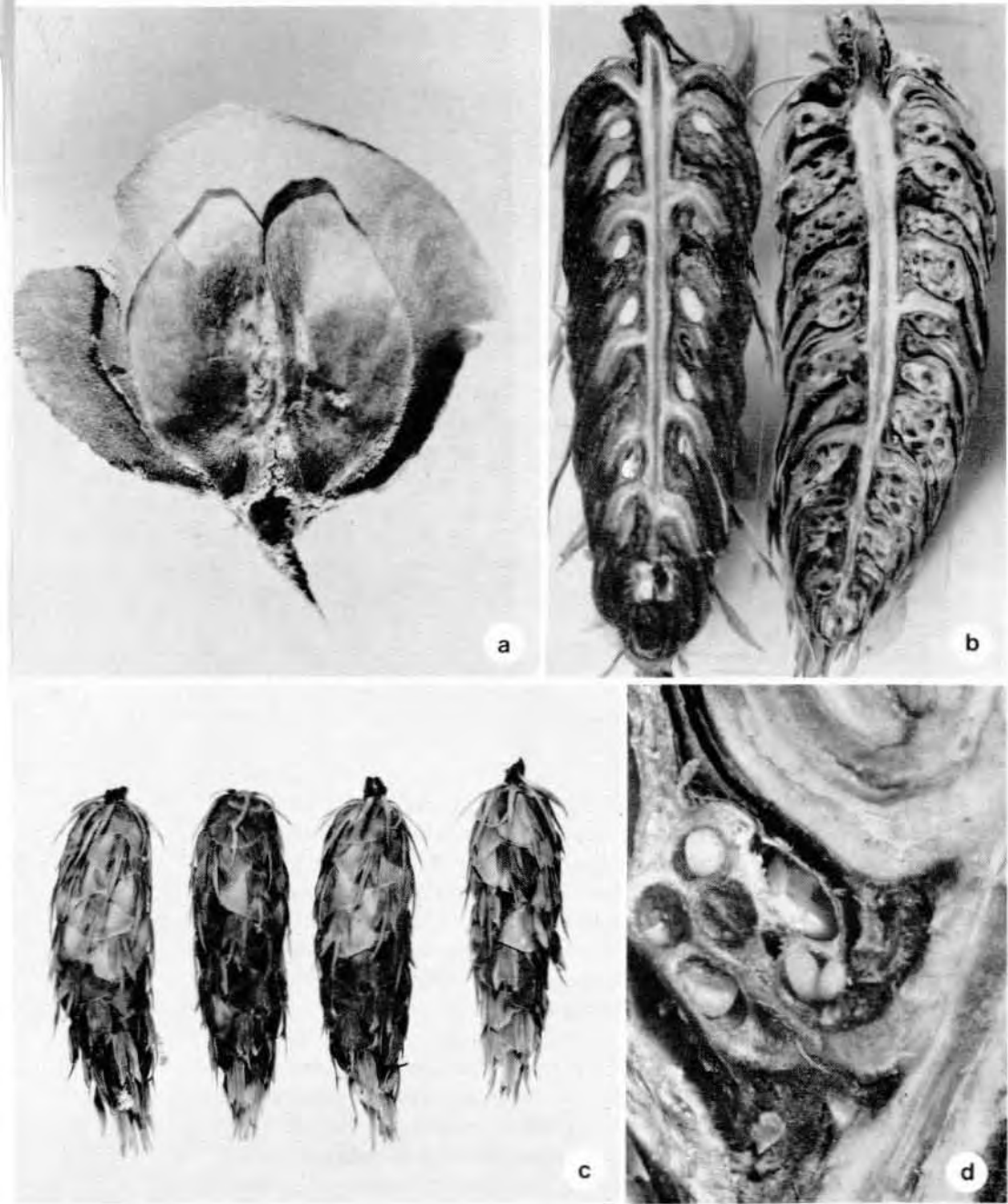


Fig. 30. *Contarinia oregonensis*; (a) Douglas-fir galled cone scale, (b) cones sliced longitudinally to show severe damage (right) and good seeds (left), (c) Douglas-fir cone scales killed (dark) by severe infestation, (d) exposed gall section showing typical U-shape larvae.

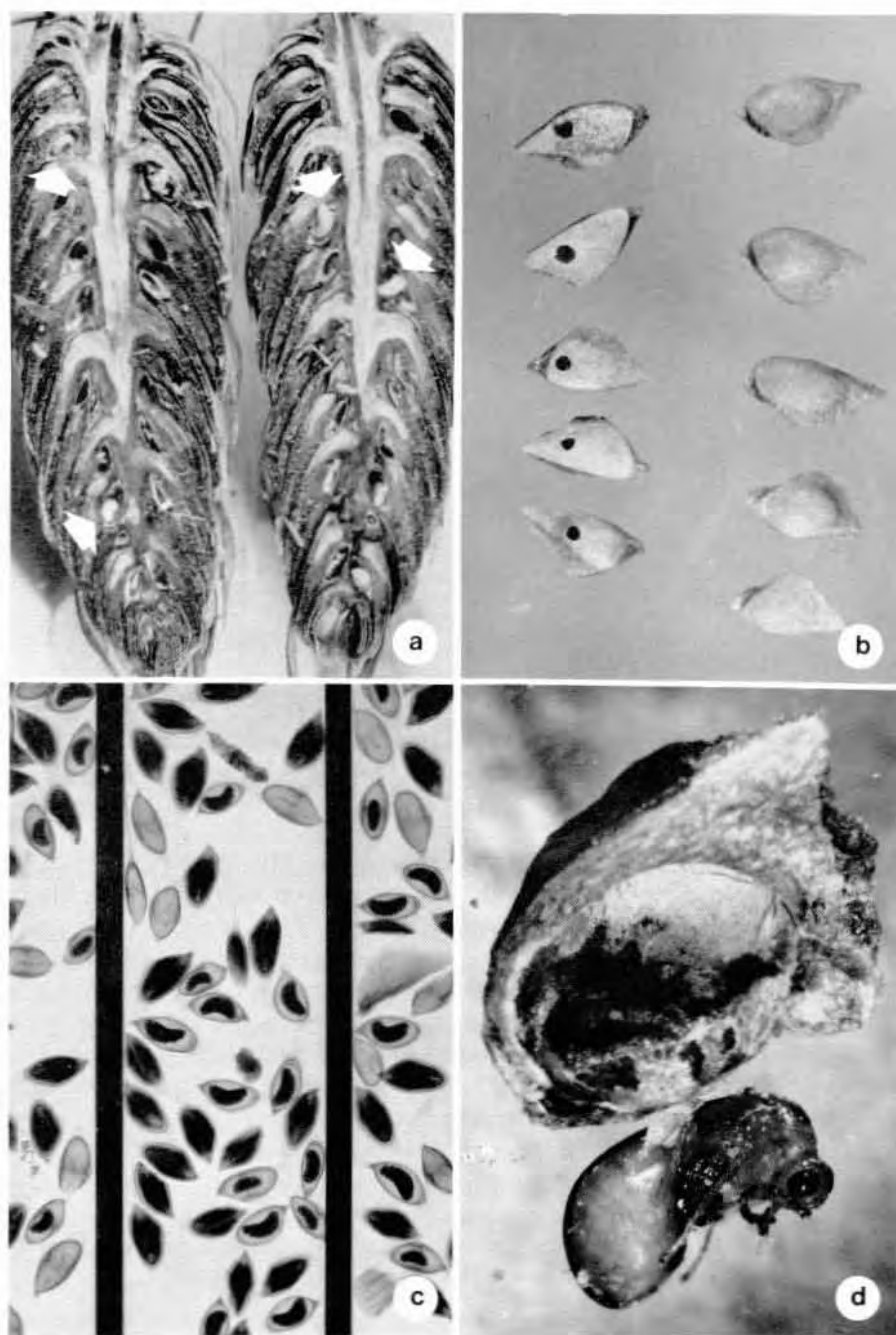


Fig. 31. *Megastigmus spermotrophus*: (a) Douglas-fir cone slice showing larvae (arrows), (b) adult emergence holes in seeds, (c) X-ray showing larvae in infested seeds, (d) pupa (female) removed from seed.

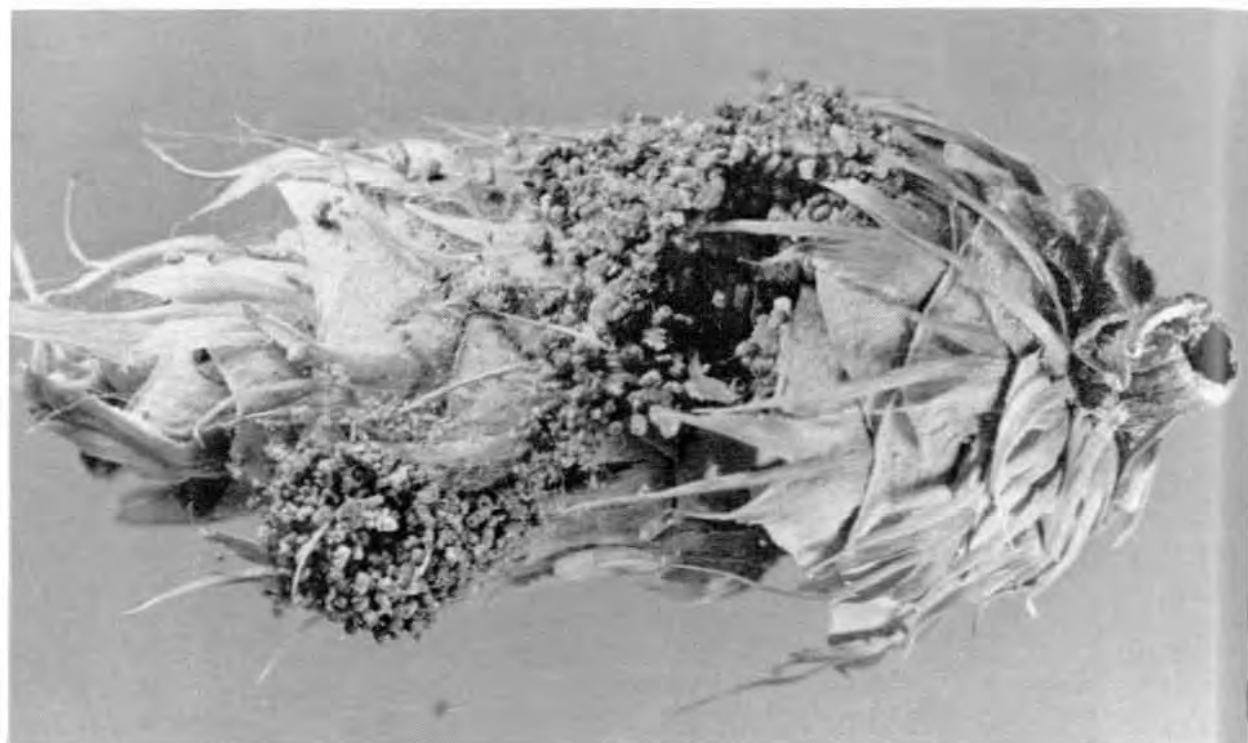


Fig. 32. Douglas-fir cone damaged by *Dioryctria abietivorella*.

damage fairly consistently, probably throughout the range of the host, including regions where Douglas-fir has been introduced. Although losses are general, they are not usually severe.

**Description:** The adult female is an amber-colored wasp-like insect about 4.0 mm long, with a long ovipositor which curves up over the abdomen (Figure 31d). The male is lighter in color, almost yellow, about 3.0 mm long.

**Life History:** Adults emerge from infested seeds in late May and June. The female inserts her ovipositor into young cones and deposits an egg into each seed selected. Multiple infestations may occur if different females deposit an egg in the same seed; when this occurs only one larva survives to maturity. A larva spends its entire life in one seed feeding on the seed contents during June, July and August. It remains over winter in the seed, either in the cone which may remain on the tree, or in the litter. It pupates in spring.

**References:** Hussey 1955; Keen 1958; Ruth and Hedlin 1974.

**A fir coneworm *Dioryctria abietivorella* (Grote)**

**Host:** Douglas-fir, spruce, ponderosa pine.

**Damage:** The larva of this species feeds voraciously, tunneling indiscriminately through scales and seeds. It leaves holes and considerable amounts of coarse frass on the surface of the cone (Figures 29b, 32). Infested cones of Douglas-fir and spruce are usually completely destroyed; ponderosa pine is

less severely damaged.

A related species, *D. reniculelloides*, although normally a foliage feeder, occasionally attacks cones causing a similar type of damage to that of *D. abietivorella*.

**Description:** The adult (Figure 9d) is a medium-sized greyish moth, with a wing span of about 28 mm. The fore wings are mottled dark brown and silver and the hind wings are grey. The mature larva is reddish with a brown head, about 20 mm long. It is extremely active when disturbed. The pupa is dark reddish brown in a tough round silken cocoon, usually covered with dirt or frass.

**Life History:** The life history is apparently variable. According to Keen, some larvae pupate in cocoons on the ground during July, August and September to emerge shortly afterwards, and lay eggs which overwinter. Others overwinter as prepupae in cocoons to pupate in March and April and emerge as moths in May and June. Moths emerging in the fall probably lay eggs which overwinter on foliage to hatch in spring. Larvae feed from June to September.

**References:** Keen 1958; Munro 1959.

#### **The western spruce budworm, *Choristoneura occidentalis* Freeman**

**Host:** Douglas-fir.

**Damage:** This insect normally feeds on foliage. Although not a common pest of cones in British Columbia, occasionally larvae cause severe damage by feeding on cone scales and seeds (Figure 33).

**Reference:** Dewey 1970.

#### **A Douglas-fir cone scale midge, *Contarinia washingtonensis* Johnson**

**Host:** Douglas-fir.

**Damage:** Larvae lie in clusters in longitudinal tunnels just below the scale surface under the seed wing (Figure 34a). Although feeding tunnels may extend below the seeds, they do not cause direct damage. They may, however, affect seed viability; but, if so, the extent is not known. There is usually no exterior evidence of damage on cones lightly or moderately infested. Severely infested cone scales may die prematurely (Figure 34b) and turn red in late July, or August.

These insects always lie fully extended in the feeding tunnel and never form a gall; thus they can easily be separated from gall midges which also feed in the scale but lie in a U-shape in a distinct gall.

When mature cones infested by this insect are picked, larvae vacate the cone. They are the yellow-orange insects which sometimes occur in very large numbers on the ground in cone-drying sheds.

**Description:** The adult is a mosquito-like insect, superficially indistinguishable from that of the Douglas-fir cone gall midge.

**Life History:** The adult emerges in June from its cocoon in which it has overwintered, in the litter. The female deposits its eggs between the scales of young cones. When the egg hatches, the larva crawls between cone scales to enter scale tissue. It remains there until late summer when it drops to the



Fig. 33. Larva of *Choristoneura occidentalis* feeding on Douglas-fir cone.

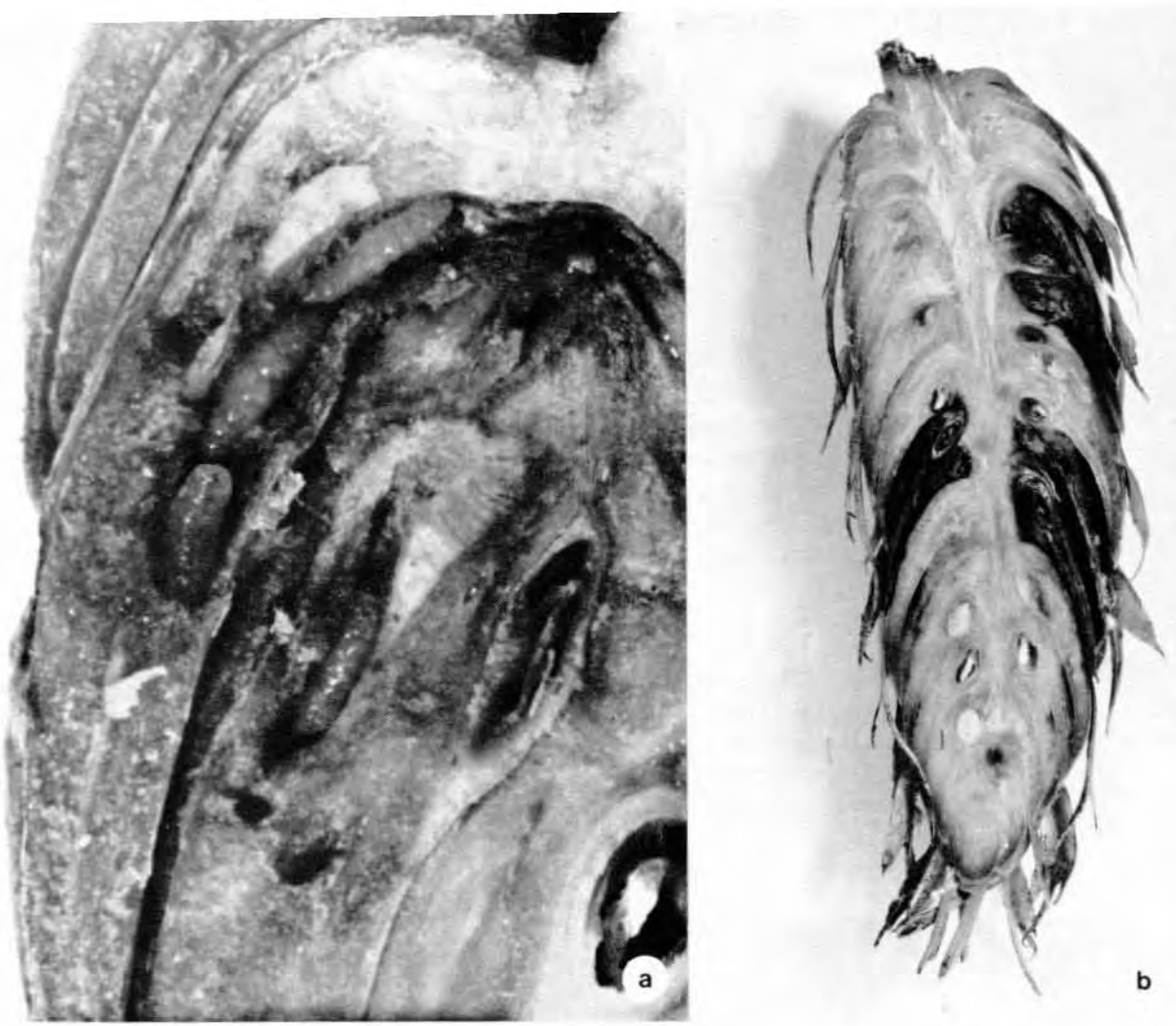


Fig. 34. *Contarinia washingtonensis*; (a) larvae in feeding tunnels in Douglas-fir cone scale, (b) cone sliced to show scales killed by larval feeding.

ground to enter the litter and form a cocoon prior to overwintering. Pupa-  
tion occurs the following May.

**References:** Hedlin and Johnson 1963; Johnson 1963.

**A Douglas-fir cone scale midge, *Camptomyia pseudotsugae* Hedlin and Johnson**

**Host:** Douglas-fir.

**Damage:** Larvae of this species occur only in cones infested by its cohabitant *C. washingtonensis*. The two species feed together in the same area causing the same type of damage.

**Description:** All stages of the insect are similar in appearance and size to those of the cohabitant. Two prominent anal hooks aid in distinguishing the larva from that of *C. washingtonensis*.

**Life History:** The life history is very similar to that of *C. washingtonensis*. The reason for the association between the two species is not known.

**Reference:** Hedlin and Johnson 1968.





20 X



**A Douglas-fir twig-mining beetle, *Pityophthorus orarius* Bright**

Host: Douglas-fir.

**Damage:** Beetles and larvae of this species cause damage, not by feeding in cones but by mining and killing young twigs (Figure 35a). The twigs turn brown or red during July (Figure 17e). This damage has an effect on the crop of the following year, because many of these twigs would normally bear cones the next year.

**Description:** The adult is a small black beetle 2 to 3 mm long (Figure 35b).

**Life History:** Adult beetles overwinter in tunnels in twigs of the host and emerge in May to tunnel into last year's twigs. The female lays 1 or 2 eggs at the base of a lateral twig during June. Larvae usually feed in last year's growth, but sometimes in new shoots, during June and July. Pupae are present from mid-July to mid-August and the young adults appear during this period.

**Reference:** Hedlin and Ruth 1970.

**A Douglas-fir cone beetle, *Ermobius punctulatus* (Leconte)**

Host: Douglas-fir, ponderosa and several other species of pine.

**Damage:** This insect feeds only in mature cones, which may be on the tree, the ground or in storage. When plentiful, it may destroy significant quantities of seed in cones held in storage prior to seed extraction. However, since it is not usually abundant, it is not a serious pest.

**Description:** The adult is a reddish brown beetle 3 to 4 mm long. The white larva is curled and has a brown head.

**Life History:** The eggs are laid in dead or mature cones, usually in the year of development. Larvae remain in the cones over winter until the following summer, when pupation occurs. They develop to the adult stage during June, July and August. Some larvae remain in the cone for an additional year before they pupate.

**References:** Hedlin and Stickland 1959; Keen 1958.

**A fir-cone maggot, *Earomyia barbara* McAlpine**

Host: Douglas-fir.

**Damage:** The larva feeds in Douglas-fir cones, damaging scales and seeds. It is also predacious, particularly on midge larvae. A single larva may move actively throughout a cone, invading mines and galls formed by midge larvae, destroying all the inhabitants. It does not occur in sufficient numbers to be considered important as a seed destroyer.

**Description:** The adult is a small black fly about 3 to 4 mm long. The larva is a whitish maggot about 6 mm long and has a pair of distinct black mouth hooks.

**Reference:** Keen 1958.

Fig. 35. *Pityophthorus orarius*; (a) Douglas-fir cones killed by larval and beetle twig mining (2 small cones), (b) pair of beetles in twig mine.

## DOUGUS-FIR

### **A cone bug, *Leptoglossus occidentalis* Heidemann**

**Hosts:** Douglas-fir and other conifers.

**Damage:** The adult and nymph of this insect insert their long proboscises into cones to suck juices from the seeds. They cause significant losses to Douglas-fir and pines in California but do not appear to be a serious pest in British Columbia.

**Description:** The adult is a large reddish brown bug about 18 mm long (Figure 36).

**Life History:** The adult overwinters to emerge in early summer and feed on juices of seeds in young cones. It lays eggs on foliage of the host tree. Nymphs and adults feed throughout the summer.

**References:** Koerber 1963; Krugman and Koerber 1969.

5.5 X



Fig. 36. Adult *Leptoglossus occidentalis*.

WESTERN RED CEDAR



■ *Phythopaga thujae*

Fig. 37. Western red cedar distribution showing locations where insects have been collected.

# Cedar

## Western Red Cedar, *Thuja plicata*

**A red cedar cone midge, *Phytophaga thujae* Hedlin**

**Host:** Western red cedar (Figure 37).

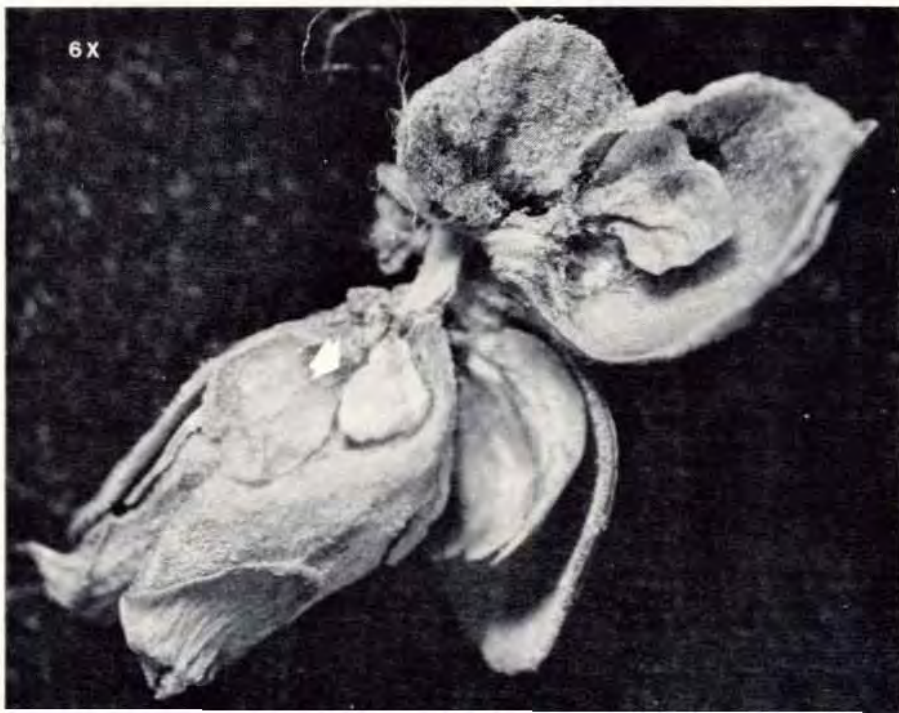
**Damage:** The larva feeds on the surface of scales and seeds in the central most fertile portion of the cone. Unlike most members of this group of insects, the larva moves around in the cone destroying more than one seed. Damage is visible externally after larvae have fed for a few weeks, because margins of scales split and turn brown. Mature infested cones are usually smaller than uninfested cones. Usually all seeds in infested cones are destroyed. However, since the host is normally a good seed producer these losses do not constitute a serious problem.

**Description:** The mature larva is orange. In late summer, it forms a delicate grey cocoon (Figure 38).

**Life History:** The adult emerges in March in coastal British Columbia, to lay eggs in small clusters in young red cedar cones which are being pollinated. The egg hatches in April and the larva feeds during the summer. It overwinters in a cocoon in the cone to pupate in February.

**Reference:** Hedlin 1964.

Fig. 38. Western red cedar cone partially dissected to show *Phytophaga thujae* cocoon (arrow).



# WESTERN HEMLOCK



▲ *Megastigmus tsugae*

Fig. 39. Western hemlock distribution showing locations where insects have been collected.

# Hemlock

## Western Hemlock, *Tsuga heterophylla*

A western hemlock seed chalcid, *Megastigmus tsugae* var. *heterophyllae* Milliron

**Host:** Western hemlock (Figures 39, 40).

**Damage:** The larva feeds in and destroys the seed of hemlock. It is not generally plentiful so is probably not an important factor in the production of seed.

**Life History:** Similar to other seed chalcids infesting seeds of trees.

**Reference:** Keen 1958.



Fig. 40. Cones of western hemlock.



# Prevention and Control of Cone and Seed Insects

Preventive measures against damage by cone and seed insects are possible and practical in limited areas such as seed orchards and seed production areas. It is not practical to consider control of cone insects in more extensive natural stands even though there is need for seed from these areas.

## Prevention

Most of the major seed-destroying insects lay their eggs in spring when flowers of the host are being pollinated. Trees that flower earlier or later than normal are less susceptible to attack. The technique of delaying the flowering time of trees in seed orchards by spraying with cold water to escape pollen from wild sources will also aid in evading attack by insects.

When possible, orchards should be established remote from, rather than adjacent to natural stands of the same species. In this way, they are less likely to be infested by insects that occur in natural stands.

Removal of all mature cones from orchard areas each year will ensure that most harmful insects are removed, and thus reduce the likelihood of severe attack the following year.

## Chemical Control

Seed losses to insects in seed orchards or seed production areas can be reduced with systemic insecticides if preventive measures do not prove satisfactory. The procedure has been outlined in some detail by Johnson and Hedlin (1967) for Douglas-fir and by Hedlin (1973) for white spruce. The following points are basic to the success of a control program:

1. Examine conelets at time of, or immediately after pollination to determine the insect egg density, and whether chemical control is necessary.
2. Spraying should be done after insect oviposition and before eggs have hatched. This is soon after pollination is completed and cone scales have closed, about mid-May for Douglas-fir, and late June to early July for spruce. Sprays applied too early will damage the flowers, and if applied too late, will not be effective.
3. For optimum results, sprays should be applied with a hydraulic-type sprayer to thoroughly wet cones and foliage throughout the cone-bearing portion of the tree. An insecticide concentration of 0.5% to 0.75% active ingredient of dimethoate by weight in water has proved adequate when properly applied. Heavier concentrations should be avoided as they may cause damage to cones and foliage. All protective precautions to operators must be exercised.

4. Before carrying out a control program, it is necessary to obtain permission from the Provincial authorities controlling use of pesticides.
5. It is advisable to contact someone familiar with the problem before carrying out a control program unless thoroughly acquainted with all aspects. In British Columbia, contact the Pacific Forest Research Centre in Victoria.

#### **Treatment of Infested Seed**

Larvae of the Douglas-fir seed chalcid, *Megastigmus spermotrophus*, can be killed by subjecting seed to a temperature of 45°C for 40 hours. If seed is more than 1 year old similar results can be obtained by treating at the same temperature for a shorter period (about 35 hours). The treatment has no harmful effect on germination of normal seed or seedling growth if seed is dry before treatment. The moisture content prior to treatment must not be more than 10% of dry weight.

# Literature Cited

- Allen, G.S. and J.N. Owens. 1972. The life history of Douglas-fir. Information Canada. Ottawa.
- Barcia, Dorothy, R. and Edward P. Merkel. 1972. Bibliography on insects destructive to flowers, cones and seeds of North American conifers. U.S. For. Serv. Res. Pap. SE-92.
- Clark, E.C., J.A. Schenk, and D.L. Williamson. 1963. The cone-infesting moth *Barbara colfaxiana* as a pest of Douglas-fir in northern Idaho. Ann. Entomol. Soc. **Am.** 56: 246-250.
- Dewey, Jerald E. 1970. Damage to Douglas-fir cones by *Choristoneura occidentalis*. J. Econ. Entomol. 63: 1804-6.
- Foote, R.H. 1956. Gall midges associated with cones of western forest trees. (Diptera: Cecidomyiidae). J. Wash. Acad. Sci. **46**: 48-57.
- Hedlin, A.F. 1960a. On the life history of the Douglas-fir cone moth, *Barbara colfaxiana* (Kft.) (Lepidoptera: Olethreutidae), and one of its parasites, *Glypta evetriae* Cush. (Hymenoptera: fchneumonidae). Can. Entomol. 92: 826-34.
- \_\_\_\_\_ . 1960b. Diapause in the Douglas-fir cone moth, *Barbara colfaxiana* (Kft.). Can. Dep. Agric., Bi-Mon. Prog. Rep. **16(6)**: 4.
- \_\_\_\_\_ . 1961. Some aspects of the cone and seed insect problem in the Pacific Northwest. For. Chron. **37**: 6-9.
- \_\_\_\_\_ . 1964. Life history and habits of a midge *Phytophaga thujae* Hedlin (Diptera: Cecidomyiidae) in western red cedar cones. Can. Entomol. 96: 950-7.
- \_\_\_\_\_ . 1967a. Cone insects of grand fir, *Abies grandis* (Douglas) Lindley, in British Columbia. J. Entomol. Soc. B.C. **64**: 40-44.
- \_\_\_\_\_ . 1967b. The pine seedworm, *Laspeyresia piperana* (Lepidoptera: Olethreutidae), in cones of ponderosa pine. Can. Entomol. 99: 264-7.
- \_\_\_\_\_ . 1973. Spruce cone insects in British Columbia and their control. Can. Entomol. **105**: 113-122.
- Hedlin, A.F. and N.E. Johnson. 1963. Life history and habits of a midge, *Contarinia washingtonensis* Johnson (Diptera: Cecidomyiidae), in Douglas-fir cones. Can. Entomol. **95**: 1168-75.
- \_\_\_\_\_ . 1968. A new species of *Camptomyia* (Diptera: Cecidomyiidae) from Douglas-fir cones. Can. Entomol. **100**: 532-5.
- Hedlin, A.F. and D.S. Ruth. 1970. A Douglas-fir twig mining beetle, *Pityophthorus orarius* (Coleoptera: Scolytidae). Can. Entomol. **102**: 105-108.
- Hedlin, A.F. and W.G. Stickland. 1959. An anobiid, *Ermobius punctulatus* Lec. in cones of Douglas-fir. Can. Dep. Agric., Bi-Mon. Frog. Rep. **15(5)**: 3.
- Hosie, R.C. 1969. Native trees of Canada. 7th ed. Queen's Printer, Ottawa.
- Hussey, N.W. 1955. The life-histories of *Megastipus spermotrophus* Wachtl (Hymenoptera: Chalcidoidea) and its principal parasite with descriptions of the developmental stages. Trans. R. Entomol. Soc. Lond. **106**: 133-151.
- Johnson, N.E. 1960. Distribution of Douglas-fir cone midges in the forest litter beneath young, open-grown Douglas-fir. Can. Entomol. **94**: 915-921.
- \_\_\_\_\_ . 1963. *Contarinia washingtonensis* (Diptera: Cecidomyiidae), new species infesting the cones of Douglas-fir. Ann. Entomol. Soc. Am. **56**: 94-103.

- Johnson, N.E. and H.J. Heikkinen. 1958. Damage to the seed of Douglas-fir by the Douglas-fir cone midge. *For. Sci.* **4**: 274-282.
- Johnson, N.E. and A.F. Hedlin. 1967. Douglas-fir cone insects and their control. Can. Dep. For. Rur. Dev. Publ. 1168.
- Keen, F.P. 1958. Cone and seed insects of western forest trees. USDA Tech. Bull. 1169.
- Koerber, T.W. 1963. *Leptoglossus occidentalis* (Hemiptera, Coreidae), a newly discovered pest of coniferous seed. *Ann. Entomol. Soc. Am.* **56**: 229-234.
- Krugman, S.L. and T.W. Koerber. 1969. Effect of cone feeding by *Leptoglossus occidentalis* on ponderosa pine seed development. *For. Sci.* **15**: 104-111.
- Morgan, C.V.G. and A.F. Hedlin. 1960. Notes on the juniper berry mite, *Trisetacus quadrisetus* (Thomas) (Acarina: Eriophyidae), in British Columbia. *Can. Entomol.* **92**: 608-610.
- Munro, E. 1959. Canadian species of *Dioryctria* Zeller (Lepidoptera: Pyralidae). *Can. Entomol.* **91**: 65-72.
- Ruth, D.S. and A.F. Hedlin. 1974. Temperature treatment of Douglas-fir seeds to control the seed chalcid, *Megastigmus spermotrophus* Wachtl. In preparation.
- Tripp, H.A. 1954. Description and habits of the spruce seedworm, *Laspeyresia youngana* (Kft.) (Lepidoptera: Olethreutidae). *Can. Entomol.* **86**: 385-402.
- \_\_\_\_\_. 1955. Descriptions and habits of Cecidomyiidae (Diptera) from white spruce cones. *Can. Entomol.* **87**: 253-263.
- Tripp, H.A. and A.F. Hedlin. 1956. An ecological study and damage appraisal of white spruce cone insects. *For. Chron.* **32**: 400-410.
- Werner, R.A. 1964. White spruce seed loss caused by insects in interior Alaska. *Can. Entomol.* **96**: 1462-1464.
- Williamson, D.L., J.A. Schenk, and W.F. Barr. 1966. The biology of *Conophthorus monticolae* in northern Idaho. *For. Sci.* **12**: 234-240.