

# Cone and Seed Insects of North American Conifers



Canadian Forestry Service, United States Forest Service,  
Secretaría de Agricultura y Recursos Hidráulicos, México.



# **CONE AND SEED INSECTS OF NORTH AMERICAN CONIFERS**

**Alan F. Hedlin, Harry O. Yates III,  
David Cibrián Tovar, Bernard H. Ebel,  
Thomas W. Koerber and Edward P. Merkel**



Cover: *Hylemya anthracina* on Engelmann spruce conelet.



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## PREFACE

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In 1974, the 10th meeting of the Study Group on Forest Insects and Diseases, North American Forestry Commission, FAO, held in Canada, approved the development of a publication on cone and seed insects of North America to include all insects which limit viable seed yields of North American conifers.

The publication was prepared by forest entomologists actively working in the field of cone and seed insect research. Alan F. Hedlin, coordinator of the writing team, is with the Pacific Forest Research

Centre, Canadian Forestry Service at Victoria, British Columbia; Harry O. Yates III, coordinator of the U.S. contributors, and Bernard H. Ebel, both of Athens, Georgia, and Edward P. Merkel at Olustee, Florida, all work for the Southeastern Forest Experiment Station of the United States Forest Service; Thomas W. Koerber is with the Pacific Southwest Forest Experiment Station, USFS, at Berkeley, California, and David Cibrián Tovar is at the Universidad Autonoma Chapingo, Chapingo, México.



The authors, Alan F. Hedlin, Edward P. Merkel, David Cibrián Tovar, Thomas W. Koerber, Harry O. Yates III, and Bernard H. Ebel (left to right) met for the first time as a committee in New Orleans, Louisiana, USA, March 1976.



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As coordinator, I have attempted to edit and organize all material without changing the intended meaning. I thank the authors for their cooperation, particularly Harry Yates for his tremendous interest and support, and his colleague Bernard Ebel for continued interest and much painstaking work.

Finally, acknowledgement is made for the support provided by Environment Canada, Canadian Forestry Service; the United States Department of Agriculture, Forest Service; and the Subsecretaría Forestal y de la Fauna, Secretaría de Agricultura y Recursos Hidráulicos, México.



## INTRODUCTION

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Over the past 30 to 40 years progressive development of seed orchards of important conifers has partly replaced natural stands as seed sources. Seed orchards provide a more reliable source of the large amounts of seed needed for extensive reforestation. More importantly, however, orchards provide a seed source of genetically superior stock of known geographic origin or adaptability. With the advent of orchards came emphasis on studies of seed loss, of which insect damage has proven to be a major factor. Such loss was anticipated by the early work of J.M. Miller (160) and associates in California and Oregon. These studies were more fully reported with pertinent additions in 1958 by Keen (111) in *Cone and Seed Insects of Western Forest Trees*. Over the past three decades studies of many aspects of the cone and seed insect problem have been conducted in the United States and Canada. More recently, similar studies were started in Mexico.

The present publication summarizes information on the recognition, biology and importance of cone- and seed-destroying insects of Canada, the United States and Mexico as a comprehensive guide for the seed orchard manager.

In presenting the material, we have discussed the four major commercial tree host genera — *Abies*, *Picea*, *Pinus* and *Pseudotsuga* — and have included keys to aid the reader in determining insects associated with particular hosts. Insect arrangement is alphabetical by order, family, genus and species. Numbers in parenth-

eses after the insect name or in the text indicate selected references. Host names which appear in bold face are major hosts. Common names of insects approved by the Entomological Society of America are also in bold face type; other common names used are not officially approved but we suggest them as being acceptable. Older scientific names of insects which have commonly appeared in cone and seed insect literature are also included in parentheses after the currently accepted names.

Illustrations consist of color photographs, life cycle diagrams and distribution maps. The photographs should aid the reader in making identifications; photo credits are as follows: CFS, Canadian Forestry Service; OSU, Oregon State University, Corvallis, Oregon; UACH, Universidad Autónoma, Chapingo, Mexico; USFS, United States Forest Service; WC, Weyerhaeuser Company; distribution maps are based on known insect distributions and also on host distributions to indicate potential areas over which insect species may occur.

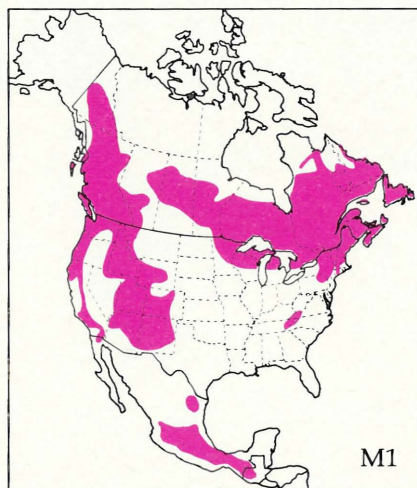
We have discussed only the broad aspect of control and suggest that workers looking for detailed specific information should contact the nearest forestry research establishment. We feel that because of continuing research on the use of chemicals and a variety of other control techniques, specific recommendations made here would soon become outdated.



# I CONIFER HOSTS

Insects probably cause seed losses in cones of most if not all species of the 16 genera of conifers native to North America. Insect-caused damage is of concern particularly where seed is being produced under controlled conditions such as in seed orchards and seed production areas. It is not usually a natural regeneration problem.

Of particular concern are the economic losses caused to seed of tree species in the four genera: *Abies*, *Picea*, *Pinus* and *Pseudotsuga*. The fruiting habits of these genera are discussed briefly. Keys are included to assist the reader in identifying insect pests of these conifers. Insects infesting other genera are listed in synoptic form (p. 9). A host list includes scientific and common names of all tree species mentioned in the publication.



## *Abies* - Fir (13 species) (M1)

North American firs include two eastern species: balsam and Fraser firs, and seven western species: bristlecone, California red, grand, noble, Pacific silver, subalpine and white firs. In Mexico, the best known species is sacred fir, but three other species occur (130).

Fruiting Habits — Both male and female flowers occur in the upper crown. Females occur singly or in small clusters on the upper side of the previous year's



Fig. 1 Fir cone. CFS.

twig growth (Fig. 1) and males occur in clusters on the underside of twigs, usually lower in the tree crown.

Mature cones range from 7 to 25 cm long, are cylindrical in shape and remain upright throughout their development. They mature in one season and disintegrate in the fall, when scales and seeds drop to the ground. The spike-like cone axes remain on the tree and may persist for many years.

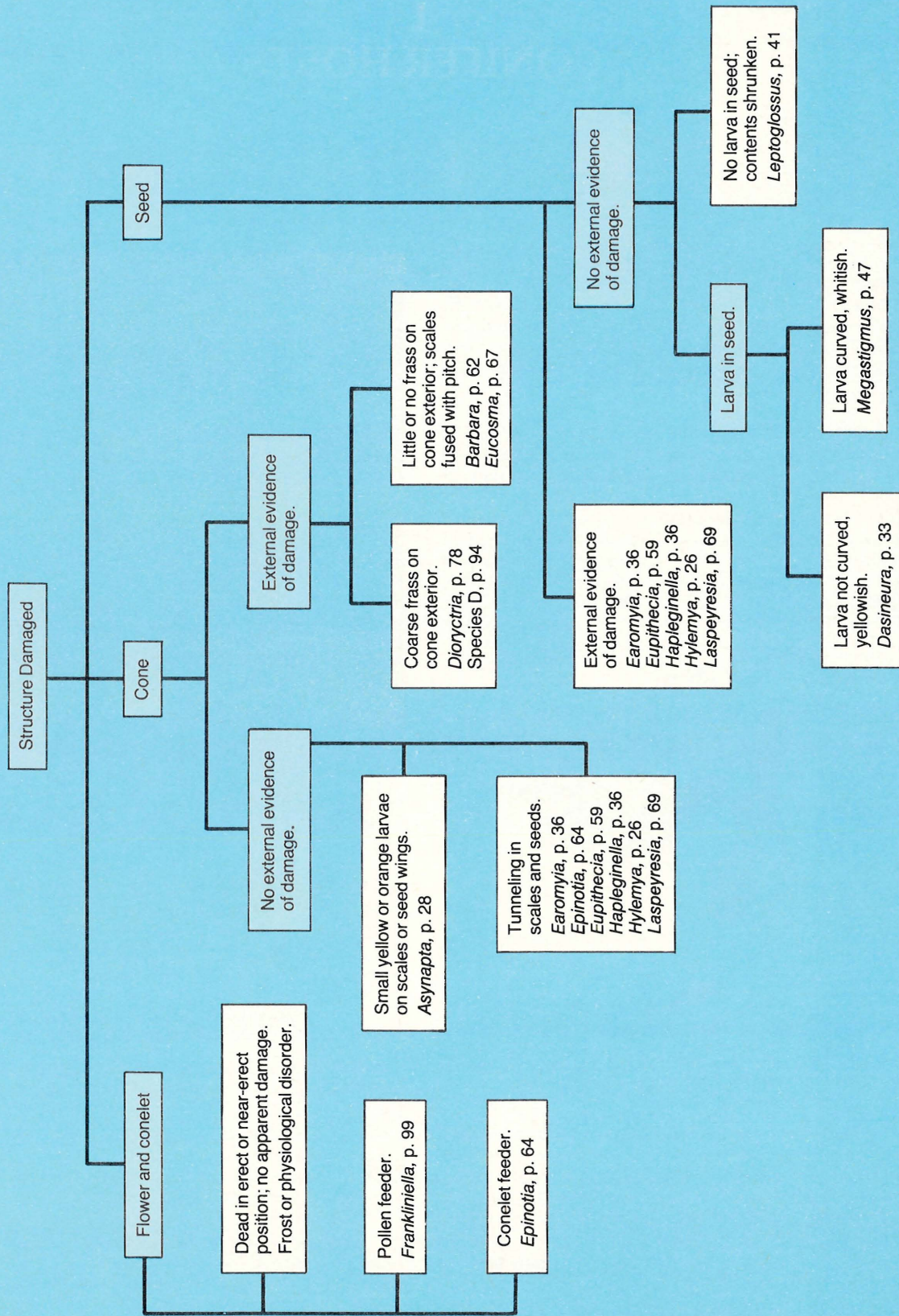
## *Picea* - Spruce (7 species) (M2)

Spruce is an important lumber species in North America with transcontinental range in Canada extending into the United States along the eastern and western mountain ranges. Species include red in the east and blue, Brewer, Engelmann and Sitka spruces in the west. Black and white spruces occur across Canada and the northeastern United States (129).

Fruiting Habits — Female flowers develop near the ends of shoots in the upper part of the crown. They are erect during pollination, but later the scales close and the cones become pendent (Fig. 2). Cones mature

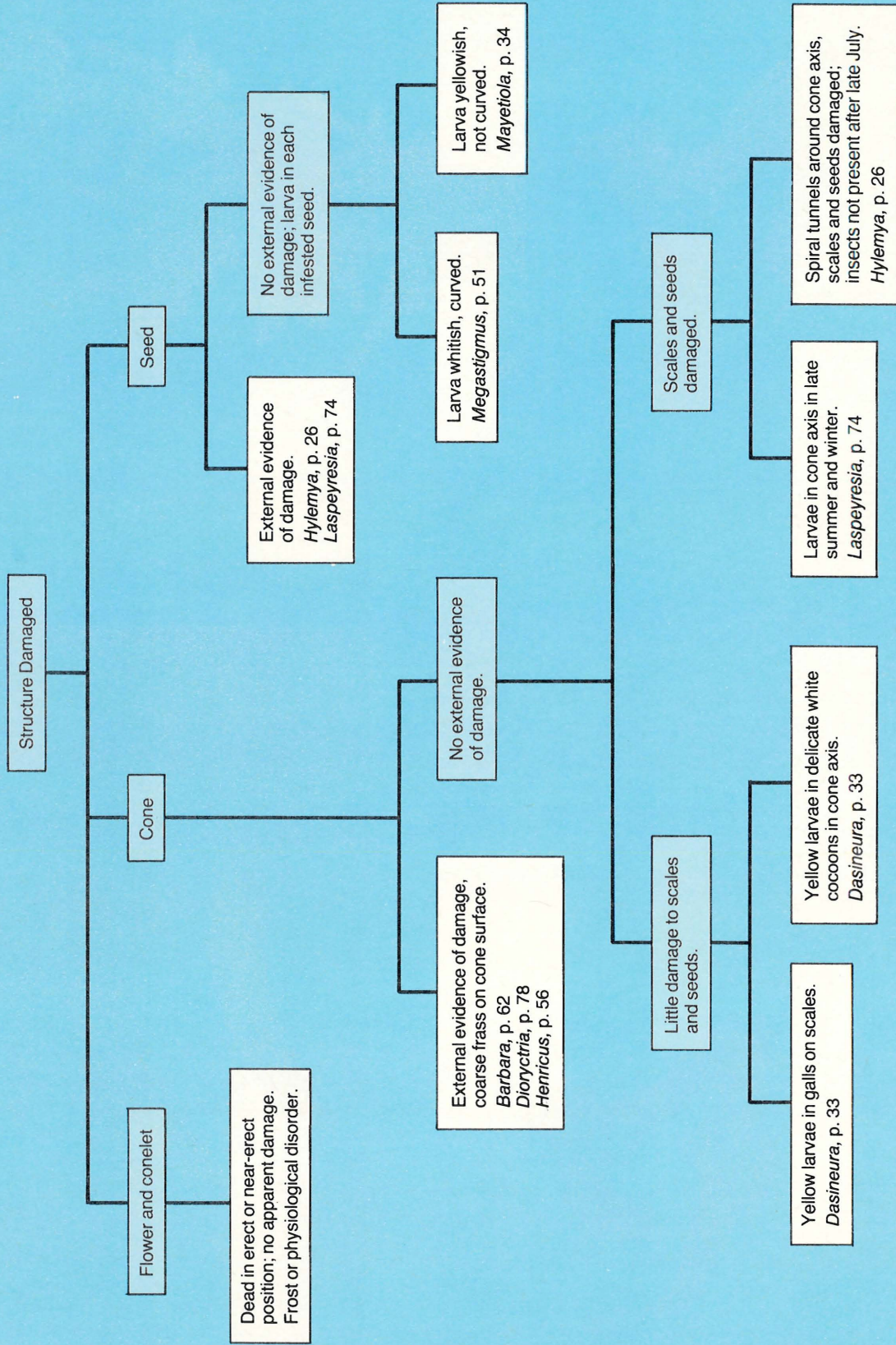


# KEY TO CONE AND SEED INSECTS OF FIR





# KEY TO CONE AND SEED INSECTS OF SPRUCE





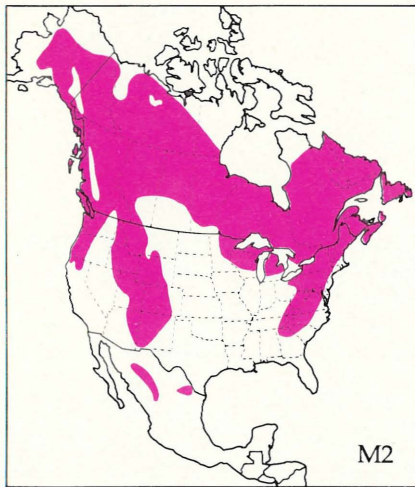


Fig. 2 Spruce cones. CFS.

in one season and, with the exception of black spruce, open in fall and shed their seeds. Cones of black spruce are semi-serotinous, gradually releasing seed over a period of several years.

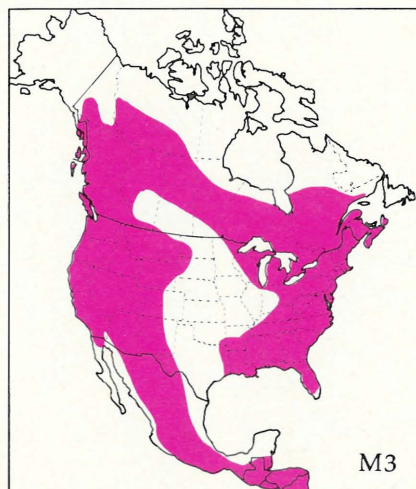
### *Pinus* - Pine (56 species)(M3)

This genus is the largest and most widely distributed — Alaska to Nicaragua — of the conifers in North America. Because of the large number, individual species are not listed here (34).

**Fruiting Habits** — Male and female flowers develop in the spring from flower buds formed the previous year. Cone and seed development usually take place during two successive growing seasons. Pollination occurs in spring or early summer of the first year. Fertilization occurs early in the second summer, after which cones grow rapidly and mature later in the sum-

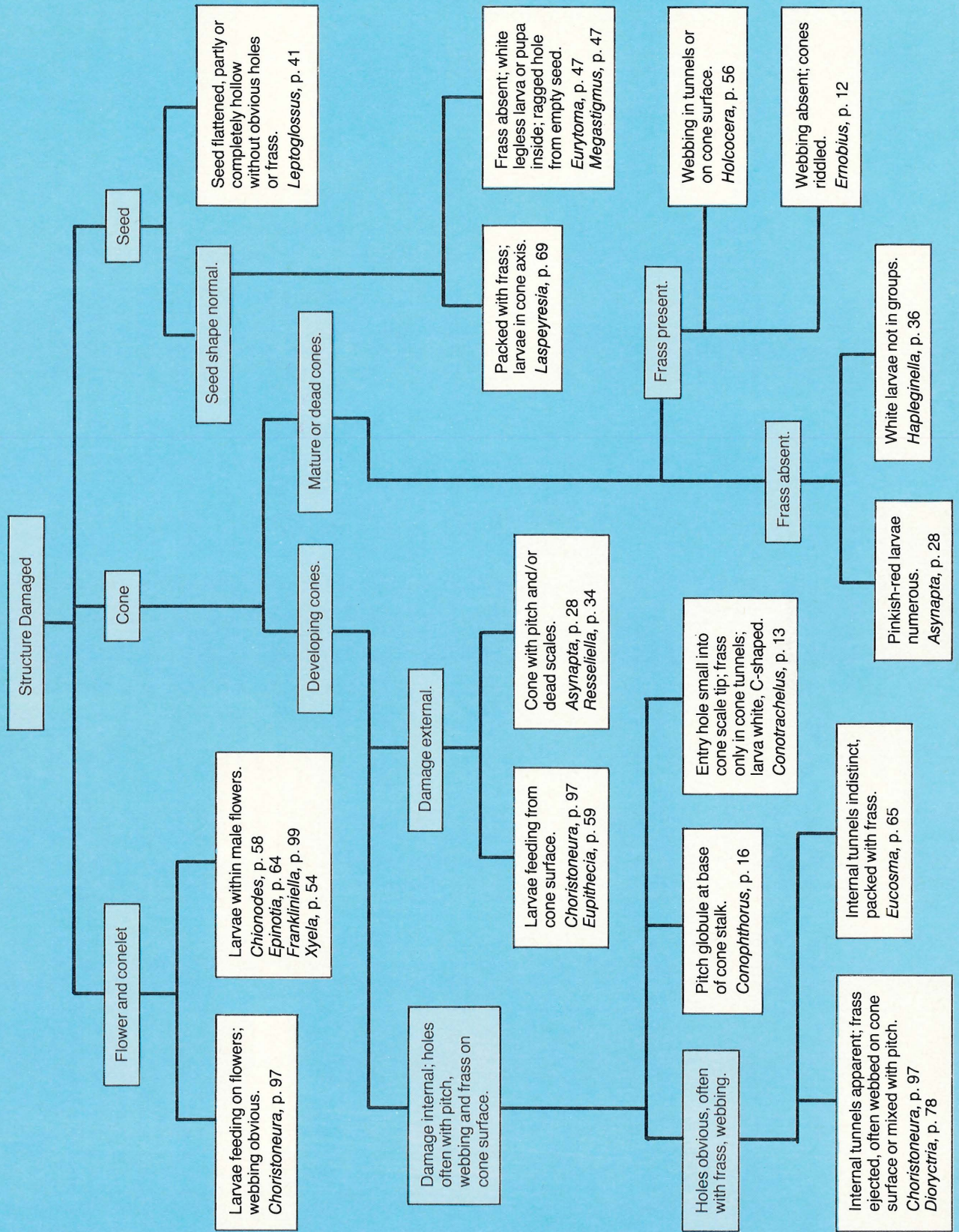


Fig. 3 Pine cones. CFS.



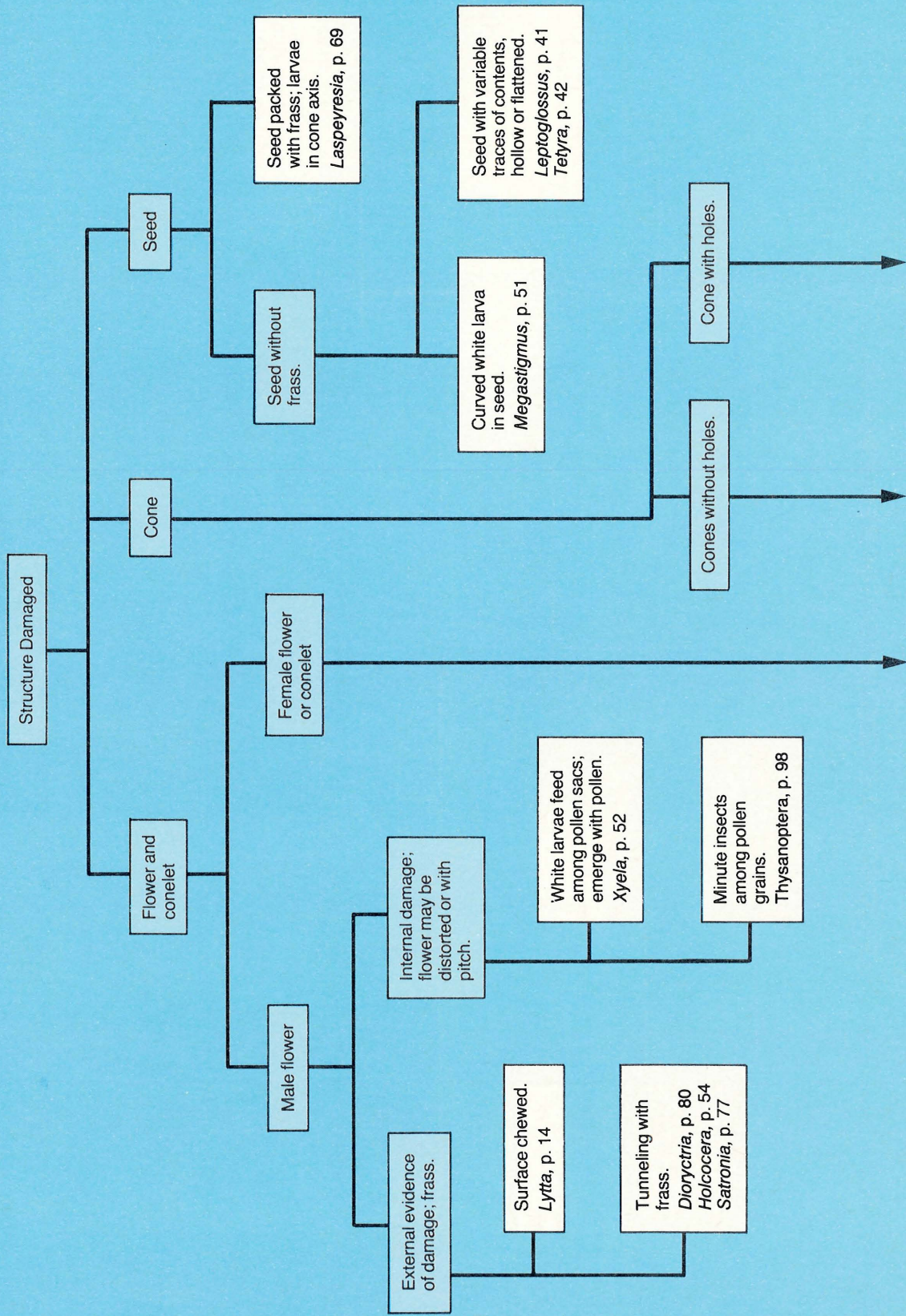


# KEY TO CONE AND SEED INSECTS OF WESTERN PINES

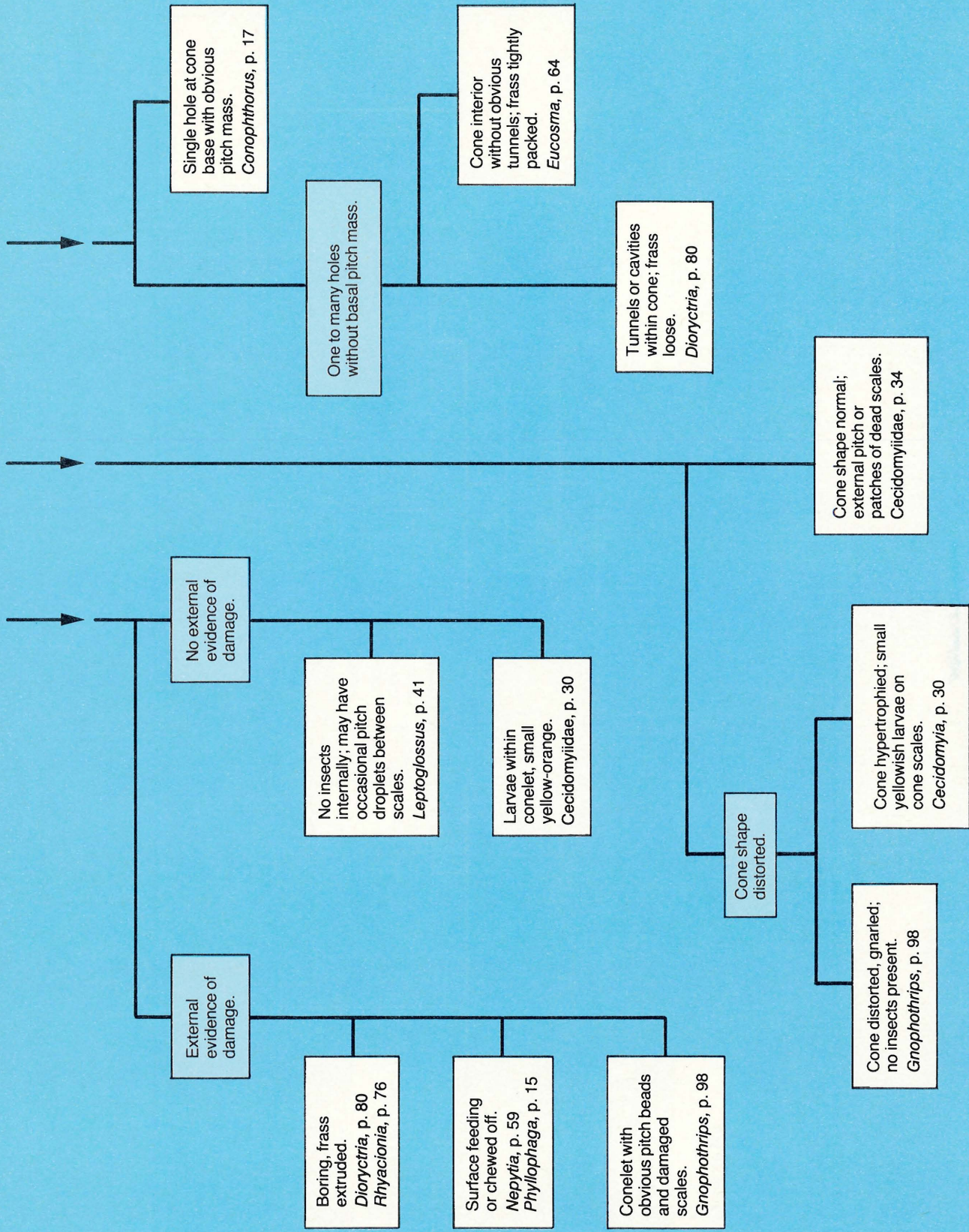




# KEY TO CONE AND SEED INSECTS OF EASTERN PINES

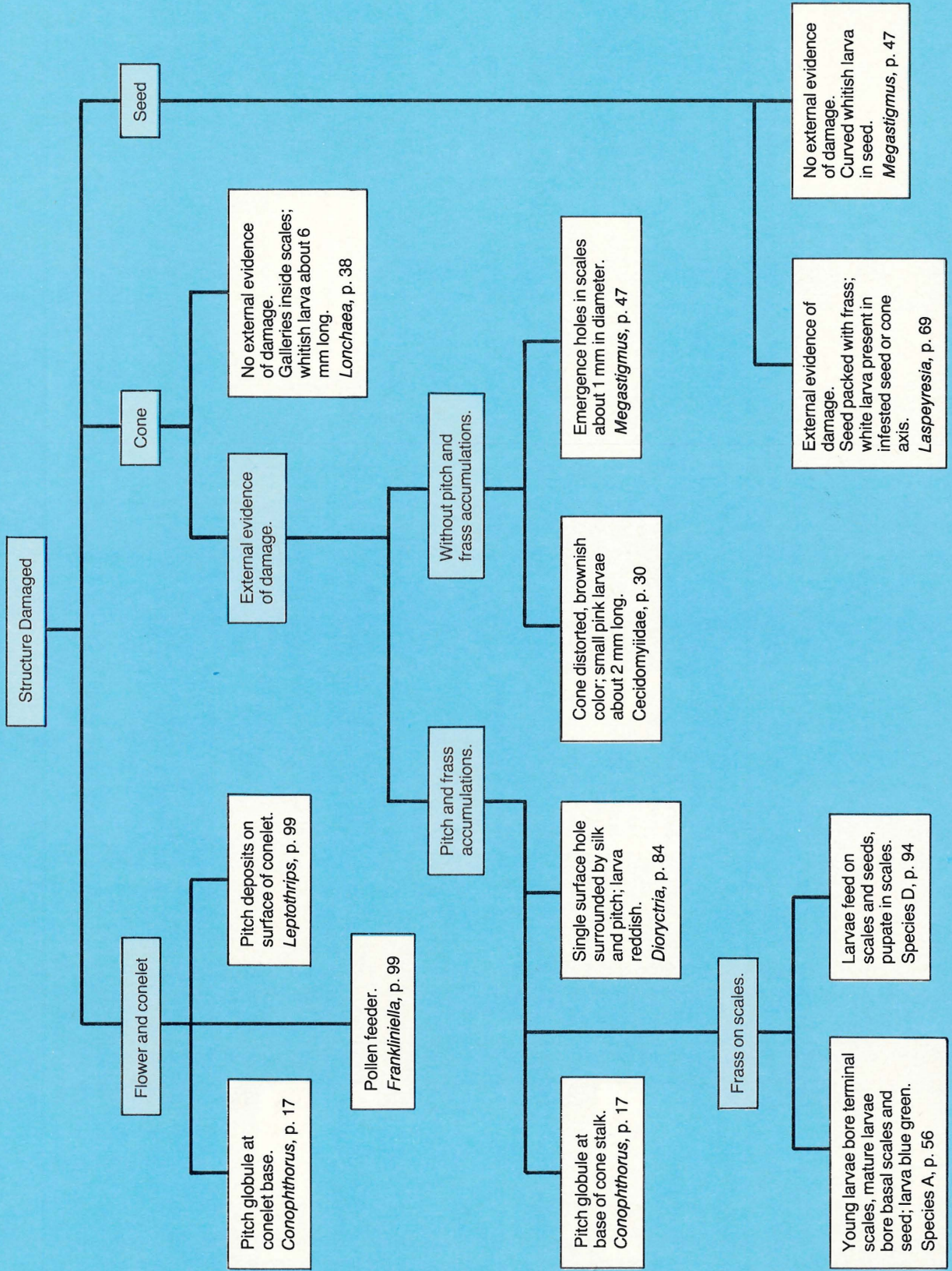




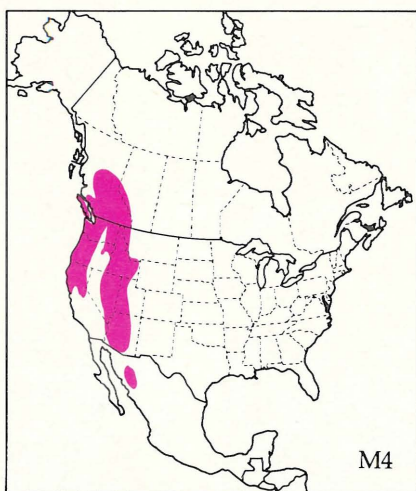




# KEY TO CONE AND SEED INSECTS OF MEXICAN PINES







### *Pseudotsuga* - Douglas-fir (2 species)(M4)

Two species of *Pseudotsuga* are native to western North America: Douglas-fir and bigcone Douglas-fir (129). Only Douglas-fir is of major importance.

**Fruiting Habits** — Flowering occurs during early spring. After pollination, the conelets become pendent. They mature in 1 year and are easily recognized because of the 3-lobed protruding bracts characteristic of the genus. They mature in late summer, and seeds are gradually released during fall and winter. Most cones persist on the tree until the following summer (Fig. 4).

### Other Conifers

Very little information exists on cone and seed insects of conifers other than Douglas-fir, fir, pine and spruce. The following synopsis directs the reader to species included in this report and indicates the current paucity of information available.

#### *Chamaecyparis* - False cypress

chamaecyparis: *Laspeyresia cupressana*, p. 72  
Port-Orford-cedar: *Argyresthia libocedrella*, p. 97

#### *Cryptomeria* - Japanese cedar

Japanese cedar: *Laspeyresia cupressana*, p. 72.

#### *Cupressus* - Cypress

Gowen cypress: *Laspeyresia cupressana*, p. 72.  
Monterey cypress: *Ernobius cupressi*, p. 13;  
*Henricus macrocarpana*, p. 56; *Laspeyresia cupressana*, p. 72.  
white cypress: Species B, p. 57.

#### *Juniperus* - Juniper

alligator juniper: *Periploca atrata*, p. 58; Species C, p. 58.  
California juniper: *Periploca atrata*, p. 58.  
eastern redcedar: *Eurytoma juniperina*, p. 47.

Utah juniper: *Eurytoma juniperina*, p. 47.  
western juniper: *Eurytoma juniperina*, p. 47.

#### *Larix* - Larch

tamarack: *Adelges lariciatus*, p. 44; *Choristoneura fumiferana*, p. 96; *Earomyia aquilonia*, p. 37; *Megastigmus laricis*, p. 51.  
western larch: *Dioryctria abietivorella*, p. 78; *Henricus fuscodorsana*, p. 56.

#### *Libocedrus* - Libocedrus

incense-cedar: *Argyresthia libocedrella*, p. 97; *Augomonotenus libocedrii*, p. 46; *Leptoglossus occidentalis*, p. 41.

#### *Sequoia* - Redwood

redwood: *Henricus fuscodorsana*, p. 56.

#### *Taxodium* - Baldcypress

baldcypress: *Dioryctria amatella*, p. 81; *D. pygmaeella*, p. 90; *Taxodiomyia cupressi*, p. 36.  
pondcypress: *Dioryctria amatella*, p. 81; *D. ebeli*, p. 86; *D. pygmaeella*, p. 90.

#### *Thuja* - Arbor-vitae

western redcedar: *Mayetiola thujae*, p. 34.

#### *Tsuga* - Hemlock

eastern hemlock: *Choristoneura fumiferana*, p. 96; *Eucosma tocullionana*, p. 68.  
mountain hemlock: *Asynapta hopkinsi*, p. 28; *Dioryctria reniculelloides*, p. 90; *Earomyia barbara*, p. 37; *Eupithecia albicapitata*, p. 59; *E. spermaphaga*, p. 59; *Hylemya (Lasiomma) anthracina*, p. 26.  
western hemlock: *Eupithecia columbrata*, p. 59; *Megastigmus tsugae*, p. 52.



Fig. 4 Douglas-fir cones. CFS.







## II INSECTS

Members of seven insect orders damage cones and seeds of conifers. The order Lepidoptera contains the largest number of major pests and is by far the most important. The other orders are represented by fewer species of serious pests.

Most of these insects feed specifically on cones and seeds, but some also feed on foliage, cambium, etc. Since cone crops tend to be cyclical, there are often years when the food supply is low, or perhaps non-existent in some localities. Many species of cone- and seed-feeding insects undergo an extended diapause when part of their population remains in the overwintering stage for 1 or more years (Fig. 5). This situation is strikingly apparent in years when cone crops are poor. The phenomenon is important to the survival of

these insects and, at the same time, influences their damage potential because the population of insects available to attack a new crop may consist not only of insects produced in the previous year's infested cones, but also of adults emerging from a pool of insects in diapause produced during previous years. In the event of a crop failure the previous year, there may be significant numbers of diapausing insects available to infest cones.

Each insect of economic importance is discussed under the following headings: host, description, damage, life history and habits, and importance. Some species of lesser importance, and others about which little is known at present, are treated more briefly.

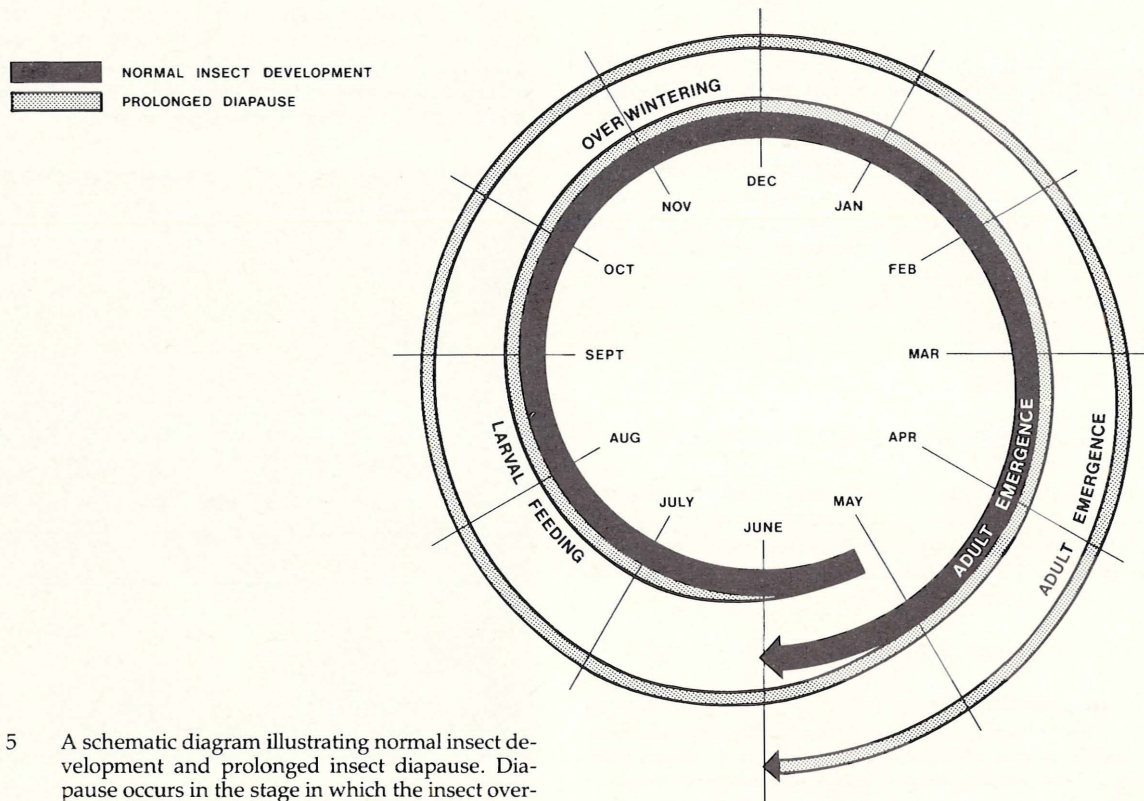


Fig. 5 A schematic diagram illustrating normal insect development and prolonged insect diapause. Diapause occurs in the stage in which the insect overwinters.



## COLEOPTERA - Beetles

In general, beetles are characterized by hard or leathery fore wings, called elytra. The membranous hind wings, used for flight, are folded under the elytra when not in use. Metamorphosis is complete. Larval body form varies from elongate to stocky, with the head capsule usually distinct and thoracic legs usually present (Fig. 6). Both adult and larva have chewing mouthparts. The resting pupal stage resembles the adult.

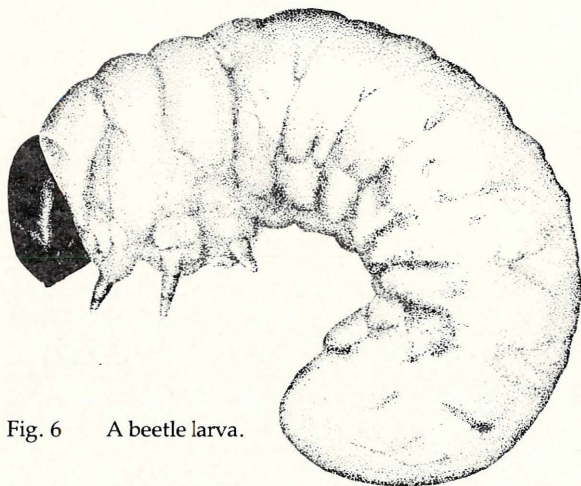


Fig. 6 A beetle larva.

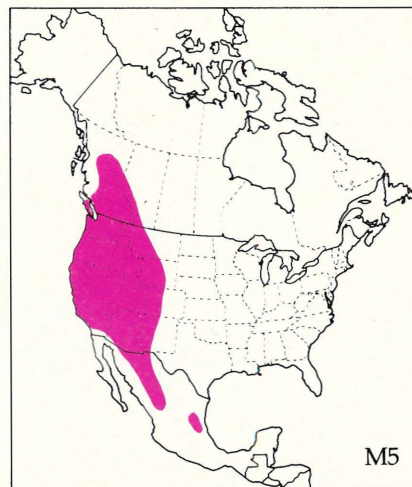
Species of relatively few beetle families and genera directly destroy seed crops of North American conifers. The family Scolytidae, however, is represented by one genus, *Conophthorus*, which is of widespread major importance. Other beetle families of less significance include Anobiidae, Buprestidae, Curculionidae, Meloidae, Nemomychidae and Scarabaeidae. Members of the family Cerambycidae have been implicated in destruction of persistent cones, and Chrysomelidae in incidental feeding on succulent flowers or conelets. The overall damage by members of these two families is too insignificant to warrant further discussion.

### Family Anobiidae - deathwatch beetles

Adult anobiids are relatively small but robust. Larvae are grub-like, with well-defined legs which distinguish them from members of Curculionidae and Scolytidae. Cone-inhabiting members of this family are all of the genus *Ernobius*.

Genus *Ernobius* (2, 45, 61, 66, 91, 111, 192, 197)

In general, members of the genus *Ernobius* are secondary insects, feeding in dead conelets and cones; exceptions to this have been reported for *E. melanoventris* Ruckes which feeds in green Jeffrey pine cones, *E. pinicola* Ruckes in green Jeffrey and ponderosa pine



cones (197), and *E. conicola* Fisher in both green and dead Monterey cypress cones (61).

### *Ernobius punctulatus* (LeConte) (91, 111)

*Hosts:* Douglas-fir; knobcone, Monterey and ponderosa pines. (M5)

*Description:* Adult shiny reddish brown, 2.5 to 4.5 mm long; larva curved, white with yellowish brown head.

*Damage:* Larvae and adults feed in mature or dead cones, damaging scales and seeds (Fig. 7). Damage may occur while cones are still on the tree, on the ground, or in storage. Usually when a cone becomes infested, the insects feed on it until it is completely destroyed. They do not attack living cones.



Fig. 7 *Ernobius punctulatus* larvae in mature Douglas-fir cone. CFS.



**Life History and Habits:** Eggs are laid from mid-April to mid-June in cones of the previous year's crop and in aborted cones of the current year. The larvae are able to feed on hard, dry cone tissues and eventually reduce even the very hard cones of knobcone pine to a fine brown powder. Mature larvae pupate in late summer and become adults a few weeks later. In the fall, these adults lay eggs in mature cones as the cones open to release seeds. Under mild conditions, this generation of beetles will go through the larval stage during the winter, becoming adults in the spring. They may repeatedly reinfest cones of trees, such as Monterey and knobcone pines, which have large persistent cones. Infestations may also persist in cones and debris in storage and seed-processing areas, producing beetles which may again infest the new crop of cones when they are brought in.

**Importance:** Reports of these insects killing cones are believed to be in error. Their normal role is that of scavenger in cones killed by other causes and in mature cones; however, they may destroy seeds in cones in storage prior to extraction. Such damage can be avoided by prompt processing.

Several other species of *Ernobius* beetles occur in dead conelets and cones: *E. cupressi* Van Dyke feeds in dead cones of Monterey cypress in California; *E. mollis* Le Conte has been recorded in cones of black spruce in Nova Scotia and Ontario; *E. montanus* Fall is found in southern California, where it is reported in cones of Coulter, Jeffrey, pinyon, singleleaf pinyon and ponderosa pines, and *E. pallitarsis* Fall has been reported feeding in dead cones and twigs of ponderosa and sugar pines in California, Oregon and Montana. Other species include *E. conicola* Fisher on Monterey cypress in California and Oregon; *E. conicola*, *E. granulatus* Le Conte on longleaf pine in the southeastern United States, and *E. nigrans* Fall on black spruce in British Columbia.

#### Family Buprestidae - flatheaded borers

Buprestid adults are metallic coppery-green, blue or black hard-bodied beetles. They attack weakened, dead or recently felled trees, where the larvae produce frass-filled galleries. One species, *Chrysobothris cupressicona* Barr & Wescott, has been reared from cypress cones from California (7, 186).

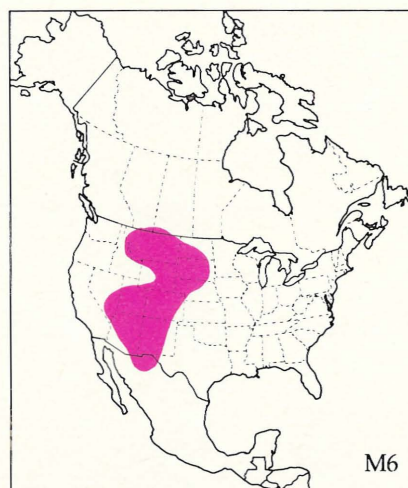
#### Family Curculionidae - weevils

The weevils are characterized by elongated snouts bearing the mouthparts apically. Larvae are legless.

***Conotrachelus neomexicanus*** Fall - pine cone weevil (17)

**Host:** ponderosa pine. (M6)

**Description:** Adult (Fig. 8a) gray-brown, about 6 mm long, with prominent down-curved snout about half



as long as body; body and legs thinly covered with flattened white and gray-brown scales; egg yellowish white, translucent, smooth, elongate-oval, averaging 0.5 by 0.8 mm; larvae curved, legless, 9 to 10 mm long when mature; head light-brown; body from pinkish white to yellowish white; pupa white when newly formed but rapidly changes to orange-brown as color of adult develops.

**Damage:** Larvae feed on scales and seeds. In cones attacked early in the season, scales and seeds are consumed indiscriminately. Later in the season, seed coats become too hard for the larvae to penetrate. As feeding progresses, the cone gradually turns brown as the interior is consumed (Figs. 8b, c).

**Life History and Habits:** In the spring, shortly before the flower buds of ponderosa pine open, adult weevils emerge from hibernation sites in the ground. In northern Colorado, this occurs in mid-May. They begin feeding on new shoots and developing male flowers. Mating occurs at this time. Oviposition commences on cones about the last week of May and continues until mid-July. Most of the attacked cones are between 30 and 60 mm long. The female beetle chews a hole in the tip of a cone scale, deposits from 1 to 6 eggs, then plugs the opening with frass. Most oviposition sites are on the underside of the cone. The number of eggs per cone ranges from 1 to 36, with an average of about 15. Eggs hatch in 4 to 7 days. The larvae begin feeding on the succulent green tissues at the outer end of the cone scales, mining inward, filling the tunnel behind them with fine frass. The larvae pass through 4 instars in 4 to 6 weeks, usually 5 to 8 maturing in a single cone. After being stimulated by rain, mature larvae chew irregular exit holes in the now dry outer shell of the cone and drop to the ground. They immediately burrow into the soil and form cells at depths ranging from 5 to 55 mm below the surface. Under moist conditions, larvae transform to the pupal stage within a few days; however, if the soil is dry, formation of cells and pupation is delayed. The insects remain in the pupal stage for 8 to 12 days. The new adults remain in the pupal cell for a



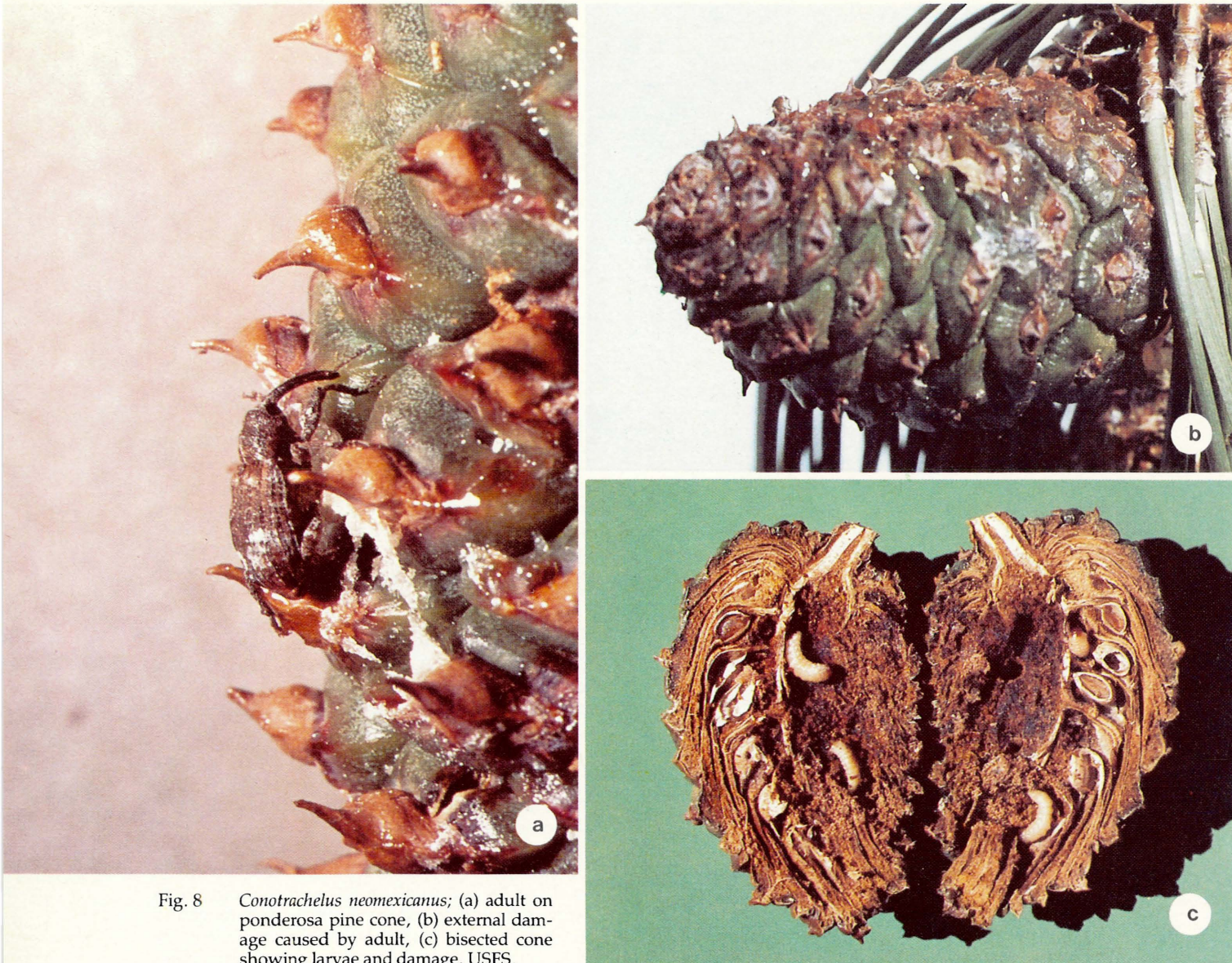


Fig. 8 *Conotrachelus neomexicanus*; (a) adult on ponderosa pine cone, (b) external damage caused by adult, (c) bisected cone showing larvae and damage. USFS.

few days while they darken and harden, before making their way to the soil surface. They feed on shoots for a short period and then enter the litter, where they overwinter.

*Importance:* In areas where this insect occurs, it may kill a large proportion of the ponderosa pine cone crop. Records of its occurrence are scarce, suggesting it has a limited distribution.

#### Family Meloidae - blister beetles

Blister beetles are soft bodied with leathery, rather soft fore wings, elongate form and are of moderate to

fairly large size.

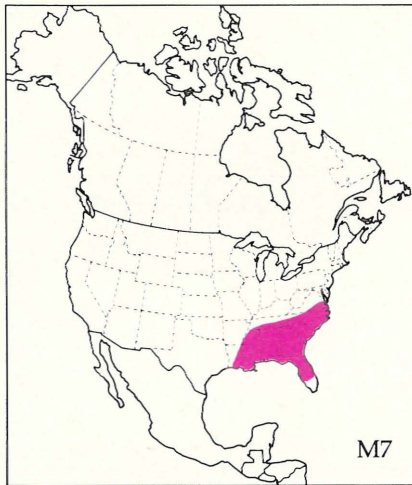
#### *Lytta polita* Say (2, 207)

*Hosts:* pond and shortleaf pines. (M7)

*Description:* Adult 13 to 22 mm long; head, thorax and under-surface of entire body shiny, greenish gold; elytra dull brassy; hind tibiae orange with black base and apex; fore and middle tibiae and tarsi black with green luster (Fig. 9).

*Damage:* Gregarious adults completely consume mature pollen sacs, leaving only the flower stalks or axes.





**Life History and Habits:** Adults have been collected from mid-December to June over their geographical range. Large swarms have been observed feeding on pond pine male flowers during the daytime in February in north Florida. Larvae of the genus *Lytta* feed on the provisions and immature forms of ground-nesting bees.

**Importance:** Serious outbreaks of this species are not known in southern pine seed orchards; however, male flowers on select parent trees in tree breeding experiments have been completely destroyed.

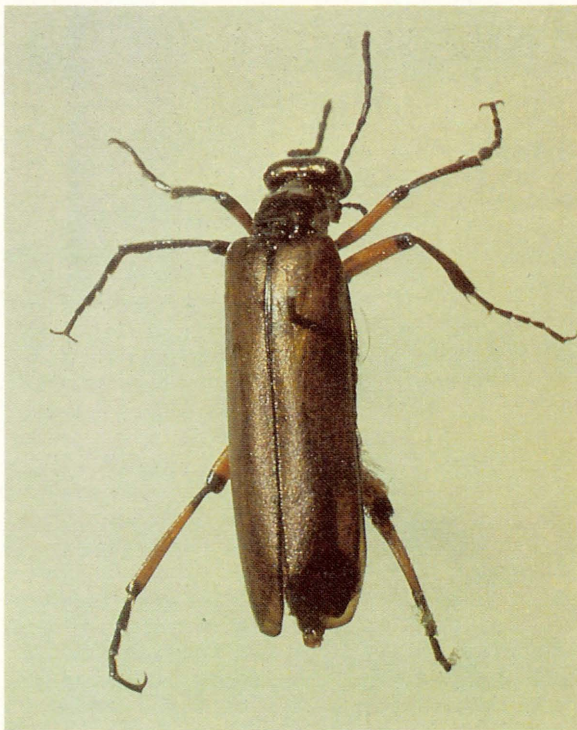


Fig. 9 *Lytta polita* adult. USFS.

### Family Nemonychidae - pine-flower weevils (4, 214)

In Ontario, *Cimberis elongatus* (LeConte) is regarded as a secondary borer in jack pine shoots damaged by *Conophthorus* sp. In the spring, emerging adults feed on male flowers of jack pine and lay their eggs in shoots damaged by *Conophthorus* sp., as well as in male flowers. *Cimberis pilosus* (LeConte) attacks Virginia pine. These are unimportant in seed production.

### Family Scarabaeidae - scarab beetles

Adult scarabs are generally very robust, with antennae terminating in plate-like segments. Larvae are robust, typical C-shaped, white grubs with obvious thoracic legs.

***Phyllophaga micans*** (Knoch) - a May beetle (131, 143)

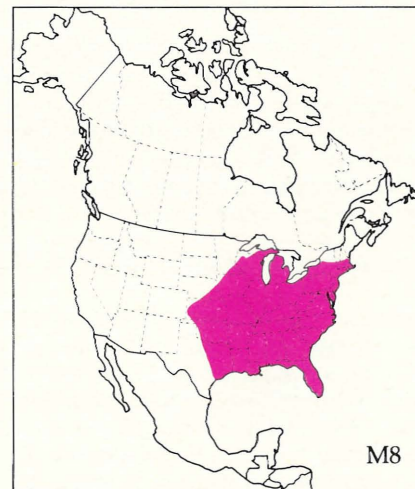
**Host:** loblolly pine (M8)

**Description:** Adult oblong and slightly broader at the posterior; brownish black with waxy coating giving a dull appearance (Fig. 10a); body length 15 to 17 mm; larva commonly called white grub, crescent-shaped, white with well-developed head and thoracic legs.

**Damage:** Adults prefer female flowers but also feed on needles. Feeding begins on the tips of flowers, but within a few hours only a mere stub may remain. Damage starts at the time flower buds burst and continues until about 2 weeks prior to peak pollination of the flowers.

**Life History and Habits:** Adults emerge from the soil in early March and cause flower injury and mortality for about a month. Feeding occurs at night. The eggs are laid in masses in the soil and the developing larvae feed on organic matter and the tender roots of plants. They pupate and overwinter in the soil.

**Importance:** Damage by members of this genus is apparently rare, with only one report from Louisiana





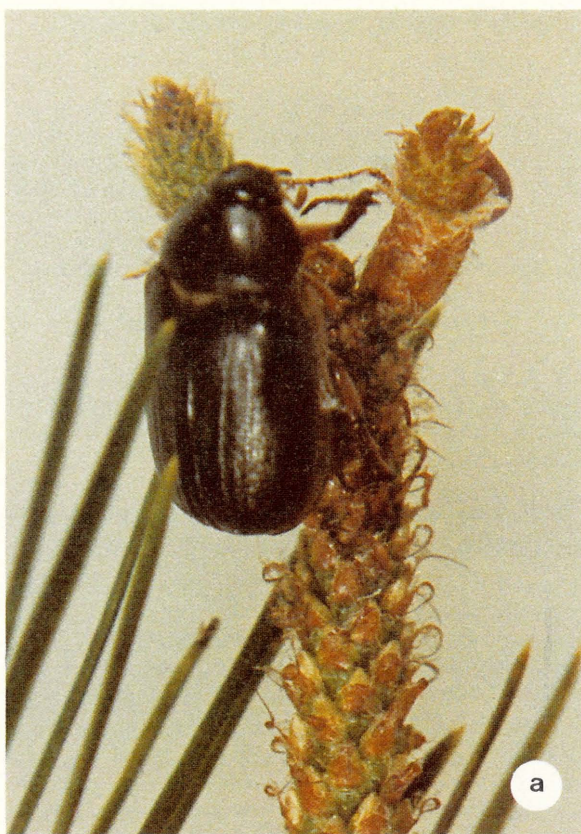


Fig. 10 Flower- and conelet-feeding beetles; (a) *Phyllophaga micans*, (b) *Dichelonyx backi*. USFS.

where 14 percent of sampled conelets were killed by May beetle feeding. Several other species of May beetles have been collected from seed orchards but have been observed only as foliage feeders.

Other scarabs:

*Dichelonyx backi* Kirby (Fig. 10b) has been recorded as a pest on ponderosa pine conelets in California (66).

#### Family Scolytidae - bark beetles

Bark beetle adults are small cylindrical beetles, from 1 to 10 mm long. Adults are usually reddish brown to dark brown or black. The body may be smooth and shiny or covered with minute hairs, bristles or scales, or it may be roughened. The head, which bears clubbed antennae, is usually entirely hidden by the prothorax when viewed from above.

Genus *Conophthorus* - cone beetles (165, 225, 226, 227)

This group of bark beetles infests cones of pines and ranks among the most destructive of North American cone and seed insects. Cone beetle species range from Mexico to Canada, but are surprisingly rare on the hard pines of southeastern United States. Twelve species are known in North America (225, 226), of which 11 attack pine cones. Since, in general, these

are similar in habits, they will be discussed as a group followed by an annotated list of the individual species. One species, *Conophthorus banksianae* McPherson, the **jack pine tip beetle**, does not feed in pine cones but attacks shoots of jack pine. This may indirectly cause cone losses.

*Description:* Adults of different species 2.4 to 4 mm long, shiny dark brown to black; bodies stout and clothed with moderately long erect hairs; heads may be concealed by the pronotum; eggs ovoid, pearly white, about 0.6 mm long by 1 mm wide; larvae C-shaped, white, legless, with amber to light-brown heads; pupae white when first formed then changing to brown and black.

*Damage:* Cones are attacked by adult female beetles. The conductive tissues of the cone stalk or base are severed, killing the cone regardless of whether or not brood is produced. Dead cones are noticeable as shriveled brown cones on the tree or as partly developed cones that fall to the ground. Pitch tubes usually mark the point of adult entry into a cone stalk or cone base.

*Life History and Habits:* The life histories of the various cone beetle species are basically similar, with only subtle differences. Adults of the various species bore into second-year cones in late spring or early summer. Entrance to the cone is made through the cone stalk or through the side of the cone near its base, where a small pitch tube is formed. Eggs are deposited in the gallery made in the cone. The infested cones may remain on the tree or drop to the ground. Larvae complete development in about a month, pupate and transform to teneral adults which gradually darken and harden over a period of several weeks. These new adults may then remain and overwinter in the dead brood cones or may leave and enter shoots or conelets, where they feed and then overwinter. In some species, adults may remain in diapause for an additional year. A single generation is produced each year. The life cycle of a cone beetle is shown in Fig. 11.



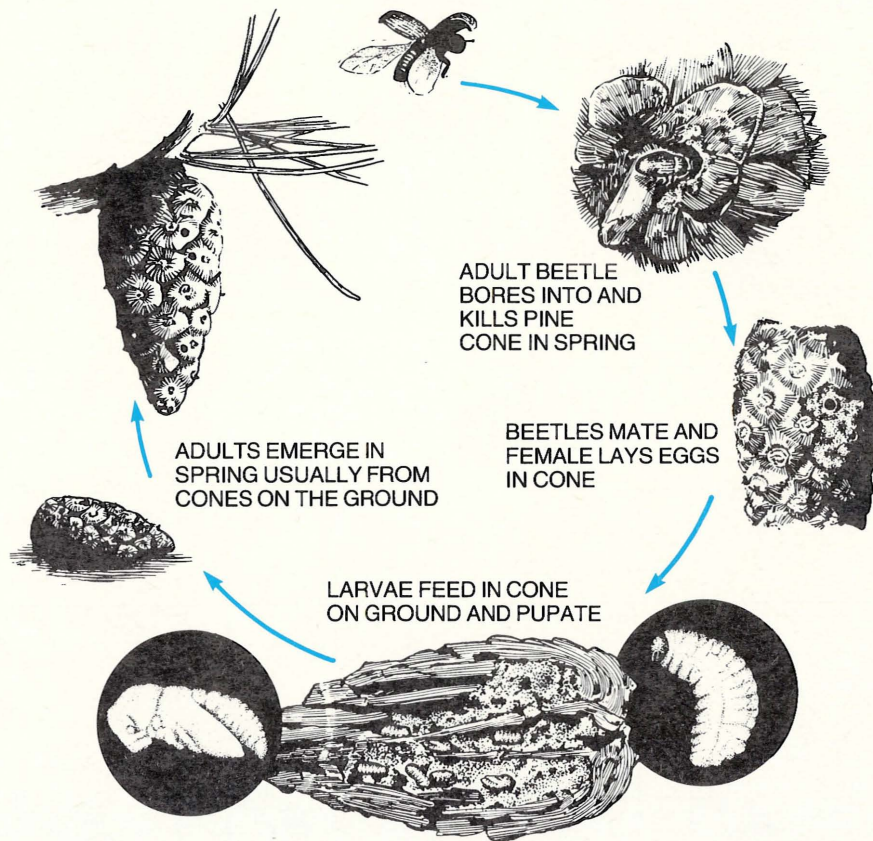
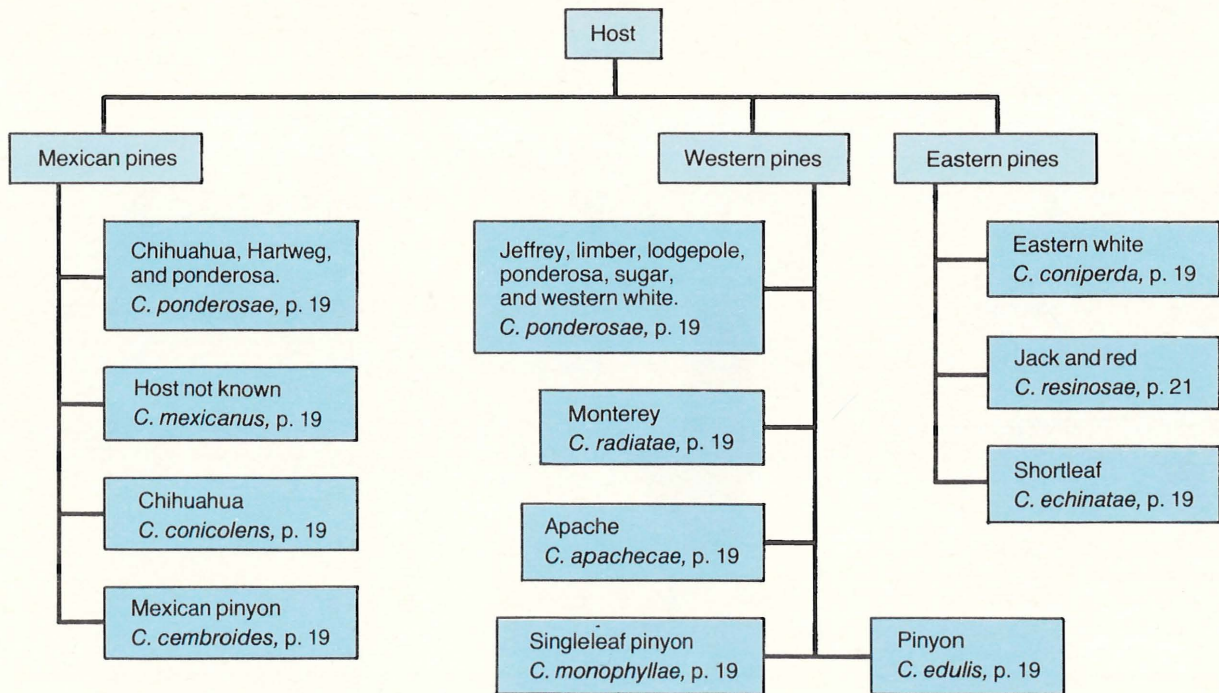
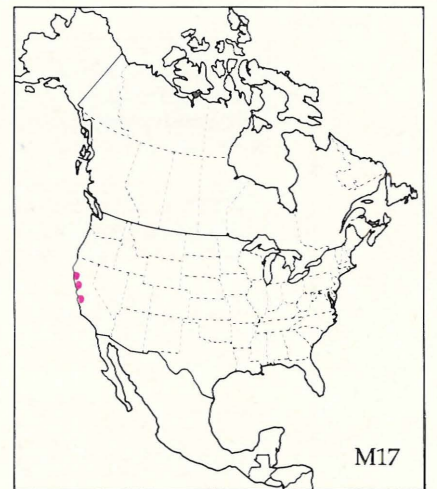
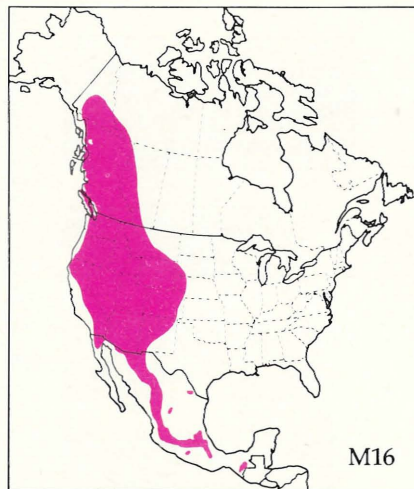
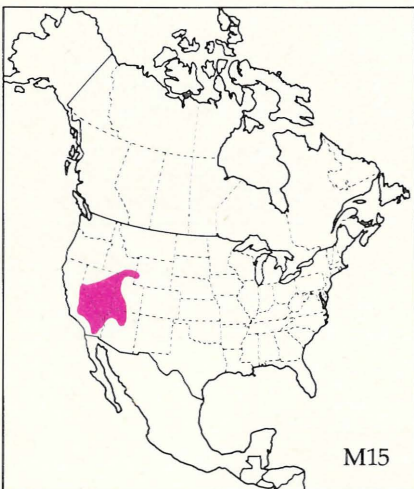
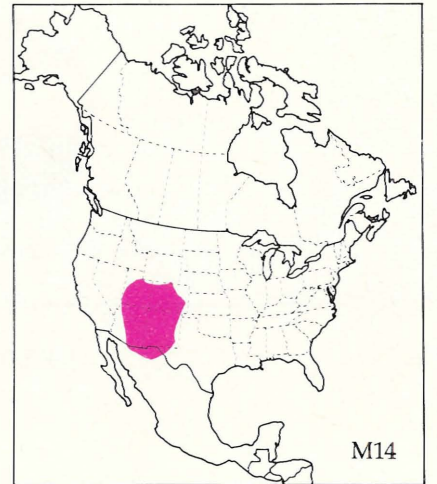
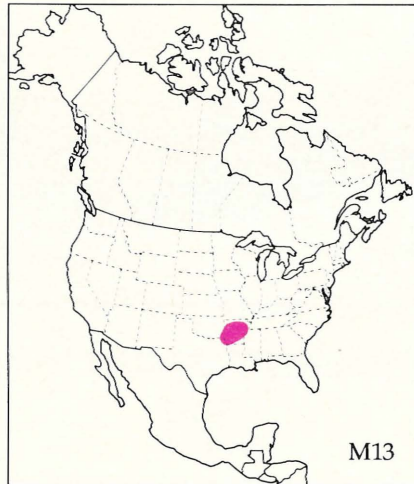
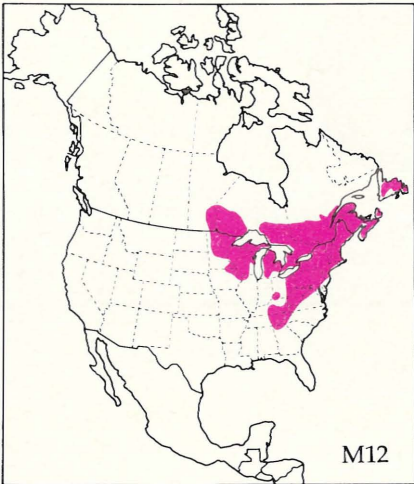
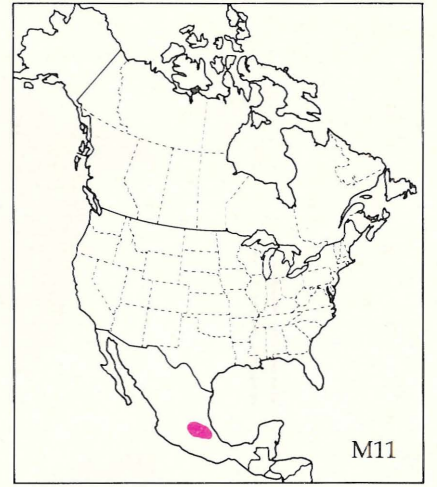
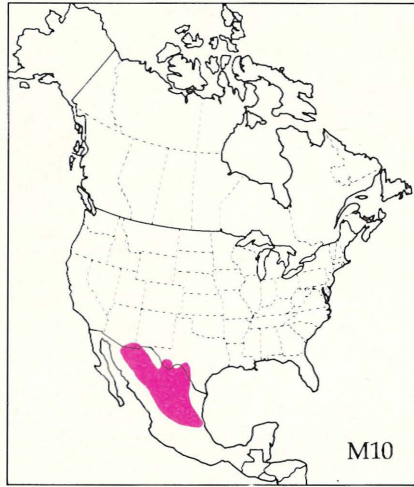
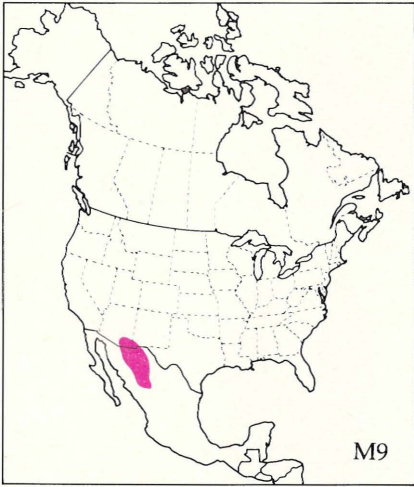


Fig. 11 Life cycle of a *Conophthorus*.

**KEY TO CONE-INFESTING CONOPHTHORUS**









Species include:

***Conophthorus apachecae*** Hopkins - Apache pine cone beetle (66)

*Host:* Apache pine. (M9)

*Comments:* Known only from Arizona (Chiricahua and Santa Rita Mountains).

Details of its biology are unknown.

***Conophthorus cembroides*** Wood - Mexican pinyon cone beetle (66)

*Host:* Mexican pinyon. (M10)

*Comments:* About 15 percent of cones may be killed by this beetle. Since pinyon nuts constitute an important local food, these losses are significant. Collected in southwestern United States.

***Conophthorus conicolens*** Wood (225)

*Host:* Chihuahua pine. (M11)

*Comment:* Collected in Texmelucan, Puebla, Mexico.

***Conophthorus coniperda*** (Schwarz) - white pine cone beetle (32, 70, 73, 170, 180, 226)

*Host:* eastern white pine. (M12)

*Comments:* Synonyms in the literature include *C. clunicus* Hopkins and *C. taedae* Hopkins. This is a common cone pest of eastern white pine (Fig. 12). It has been reported as destroying the entire host cone crop in Maine; in some circumstances it will also attack twigs.

***Conophthorus echinatae*** Wood - shortleaf pine cone beetle (227)

*Host:* shortleaf pine. (M13)

*Comments:* This very small species is known only from Missouri. Its biology is unknown.

***Conophthorus edulis*** Hopkins - pinyon cone beetle (66, 111)

*Host:* pinyon. (M14)

***Conophthorus mexicanus*** Wood (224)

*Host:* pine.

*Comments:* Collected from cones in Puebla, Mexico; host species not known.

***Conophthorus monophyllae*** Hopkins - singleleaf pinyon cone beetle (66, 111)

*Host:* singleleaf pinyon. (M15)

***Conophthorus ponderosae*** Hopkins **ponderosa pine cone beetle** (111, 113, 114, 115, 122, 161, 198, 226) (M16)

*Hosts:* Chihuahua, Hartweg, Jeffrey, limber, lodgepole, ponderosa, sugar and western white pines.

*Comments:* Synonyms in the literature include *C. con-*



Fig. 12 *Conophthorus coniperda* attack on eastern white pine cones. USFS.

*tortae* Hopkins, *C. flexilis* Hopkins, *C. lambertianae* Hopkins (12, 13, 14, 161, 195, 198), *C. monticolae* Hopkins (6, 111, 122, 192, 198, 204, 223) and *C. scopulorum* Hopkins. Life history on major hosts varies in details such as point of initial attack, overwintering habits and diapause (Figs. 13a, b, c, d, e, f).

***Conophthorus radiatae*** Hopkins - **Monterey pine cone beetle** (111, 196, 198, 202, 203)

*Host:* Monterey pine. (M17)

*Comments:* This is the most important insect pest of Monterey pine seed (Fig. 14). The female bores an egg gallery that spirals around the cone axis.



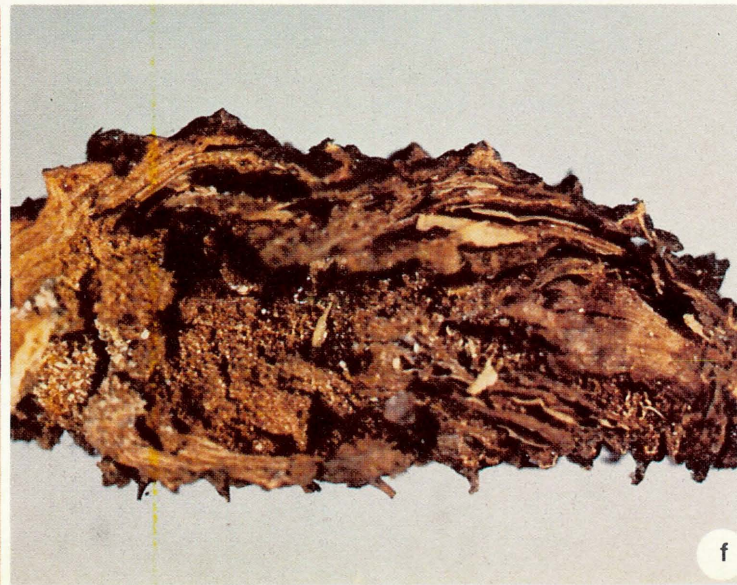
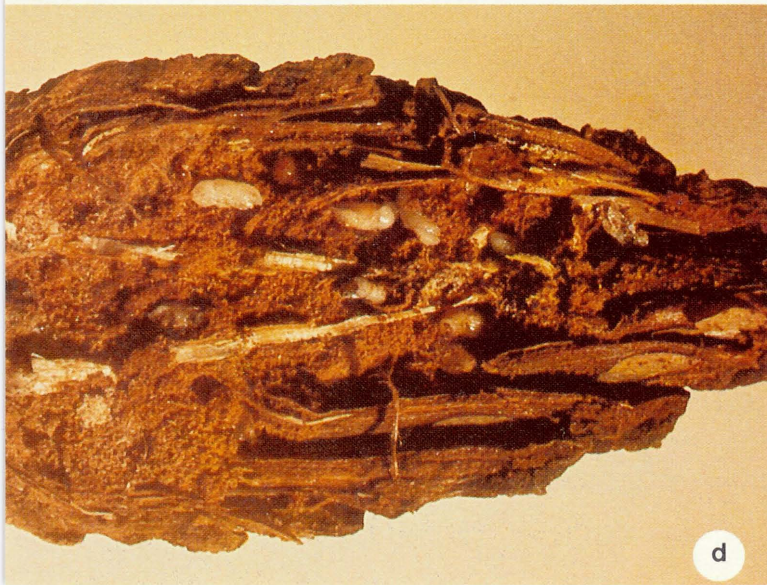
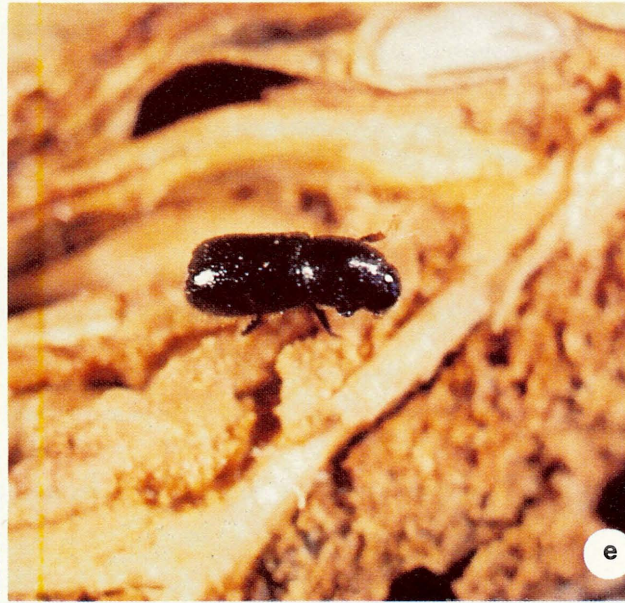
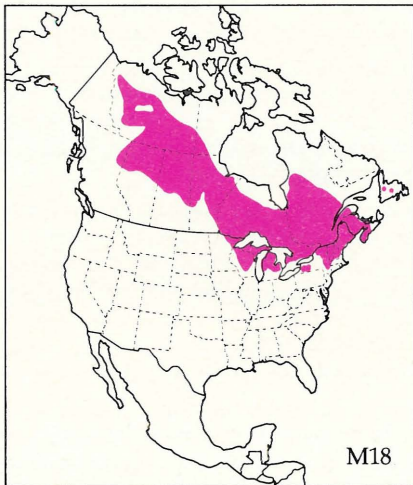






Fig. 14 Monterey pine cone killed by *Conophthorus radiatae*. USFS.



***Conophthorus resinosae* Hopkins - red pine cone beetle** (32, 75, 132, 135, 145, 146, 149, 165, 226)

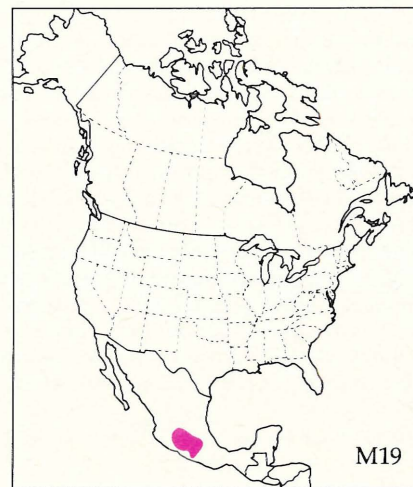
*Hosts:* jack and red pines. (M18)

*Comments:* Synonym, *C. virginiana* Hopkins. This is one of the most destructive insects of red pine cones. Adults leave brood cones and infest host buds to feed and overwinter.

Genus *Pityophthorus* - twig beetles

This genus is one of the largest in the family Scolytidae, with over 120 species described from Canada and the United States. Although closely related to the *Conophthorus* cone beetles, *Pityophthorus* differs in that nearly all species found in dead and dying twigs and small branches.

*Pityophthorus* twig beetles rarely cause serious direct seed losses, but some species may affect future cone crops by destroying shoots containing flower primordia or shoots bearing first-year cones and young maturing cones. Occasionally, twig beetles attack and kill grafted scions and air-layered shoots, thus preventing successful vegetative propagation in genetics research and seed orchard establishment.



*Pityophthorus aztecus* Bright, the Mexican pine cone-scale beetle (19), attacks Mexican white pine in Mexico. Adults bore a sinuous tunnel parallel and near to the axes of mature cones. Larvae feed on cone axes and scales, but not on seeds. Two or three generations may occur each year in the same cone. (M19)

Another species, *Pityophthorus pulicarius* (Zimmerman), the eastern pine twig beetle (208), may cause significant losses of grafted scion material in seed orchards. It is widely distributed on numerous pine species from Ontario and Quebec, south to Florida and west to the Great Plains. Beetles usually breed in weakened or injured twigs, but occasionally they attack apparently healthy twigs. This species has heavily infested and has killed grafted slash pine scions and air-layered shoots in mass vegetative propagation operations in the southern United States. Conelet attack has been reported, but apparently is secondary.

← Fig. 13 *Conophthorus ponderosae*; (a) killed ponderosa pine cone, USFS, (b) larvae in bisected western white pine cone, CFS, (c) killed sugar pine cones, USFS, (d) pupae and callow adults in bisected Chihuahua pine cone, UACH, (e) adult and (f) damage, lodgepole pine cone. CFS.



## DIPTERA - Flies

Adult Diptera are readily recognized by their single pair of membranous front wings; hind wings are reduced to a pair of balancing organs known as halteres. Mouthparts are modified for piercing or sponging. Larvae are legless and the head is often retracted into the thorax. The pupa may be within a silken cocoon or a puparium. Metamorphosis is complete.

This order is represented by several families of important pests in cones. The Cecidomyiidae are the most common and frequently appear in large numbers. The Anthomyiidae and Lonchaeidae are also represented by several serious pests.

It is often difficult to rear dipterous cone feeders to the adult stage for identification, thus many are identified in the larval stage. The larvae are generally flattened with a definite head capsule and very reduced mouthparts modified for piercing-sucking or are cylindrical with no head capsule and a pair of rasping mouthhooks that are normally retracted within the anterior body segments (Figs. 15, 16 and 17). The larvae of the first form are Cecidomyiidae and those of the latter belong to the families Anthomyiidae and Lonchaeidae. Fortunately, larvae can be identified to genus, and a key has been prepared for this purpose. The characters used in this key should be visible at 15X magnification for the Cecidomyiidae and less with the other Diptera. Higher magnification will allow greater confidence with the cecidomyiids. This key should permit reliable identifications of the fly larvae and facilitate determination of their relative importance.

### Generic Key to Larvae of Cone-Infesting Diptera<sup>1/</sup>

1. Body cylindrical, usually longer than 10 mm; no definite head capsule evident, but a pair of rasping mouthhooks present below front end; 2 pairs of spiracles present, an inconspicuous pair near front end and a more prominent pair on hind end (Fig. 15) . . . Families Anthomyiidae, Chloropidae and Lonchaeidae . . . . . 2
2. Body generally flattened, usually shorter than 6 mm; well-defined but small head capsule present; a pair of spiracles present on each segment except second and third segments from front (Figs. 16 and 17) . . . . Family Cecidomyiidae . . 5
2. Hind end surrounded with circle of tubercles (Fig. 15f) . . . . Family Anthomyiidae . . *Hylemya*<sup>2/</sup> . . . . . spp., p. 26
3. Hind end smooth around periphery, without tubercles (Figs. 15e, g) . . . . . 3
3. Hind spiracles on slight but unpigmented prominences (Fig. 15a) . . . Family Chloropidae *Hapleginella* sp., p. 36.
4. Hind spiracles on definite, pigmented prominences (Figs. 15b, e). Family Lonchaeidae . . . 4
4. Top edge of hind spiracle pointed, longer than bottom edge covering the spiracle openings from top view (Fig. 15e). *Lonchaea* sp., p. 36.
4. Top edge of hind spiracle not longer than bottom edge (Fig. 15g) . . . . *Earomyia* spp., p. 37
5. A spatula-shaped, sclerotized structure (hereafter called "spatula") present on underside near front end (Figs. 17a, b, d) . . . . . 6
5. No spatula evident on underside . . . . . 10
6. Two prominent, pointed lobes present at hind end (Figs. 17f, h) . . . . . 7
6. Without prominent lobes at hind end . . . . . 8
7. Skin rough, covered with bumps; spatula with 2 lobes at front end (Fig. 17b). *Resseliella* spp., . . . . . p. 34
7. Skin mostly smooth; spatula concave at front end (Fig. 17d) . . . . . *Camptomysia* sp., p. 30
8. Skin mostly smooth (Fig. 17a); 1 pair of setae on hind end peg-like, pigmented (Fig. 17e) . . . . . *Contarinia* spp., p. 31
8. Skin rough, covered with bumps (Figs. 16a, d); no hind peg-like setae . . . . . 9
9. Head capsule wider than spatula (Fig. 16a); setae on hind end of 2 types (Fig. 16e); 4 short, 4 long and visible at 15X . *Mycodiplosis* sp., p. 36
9. Head capsule no wider than spatula (Fig. 16d); setae on hind end all alike (Fig. 16h), usually not visible at 15X . . . . . *Dasineura* spp., p. 33; *Mayetiola* spp., . . . . p. 34
10. Hind pair of spiracles large, situated at very end of body, each tipped with 3 prongs (Figs. 17c, g) . . . . . *Cecidomyia* sp., p. 30
10. Hind pair of spiracles not conspicuous, not at very end of body (Figs. 16f, g) . . . . . 11
11. Antennae much longer than wide (Fig. 16c); setae and pseudopods apparent (Fig. 16c) . . . . . *Lestodiplosis* spp., p. 36
11. Antennae not longer than wide (Fig. 16b); setae and pseudopods not apparent (Figs. 16b, f) . . . . . *Asynapta* spp., p. 38

<sup>1/</sup> Prepared by R.J. Gagné, USDA Insect Identification and Beneficial Insect Introduction Institute, Washington, D.C.

<sup>2/</sup> Also known as *Pegohylemyia* and *Lasiomma* in literature.



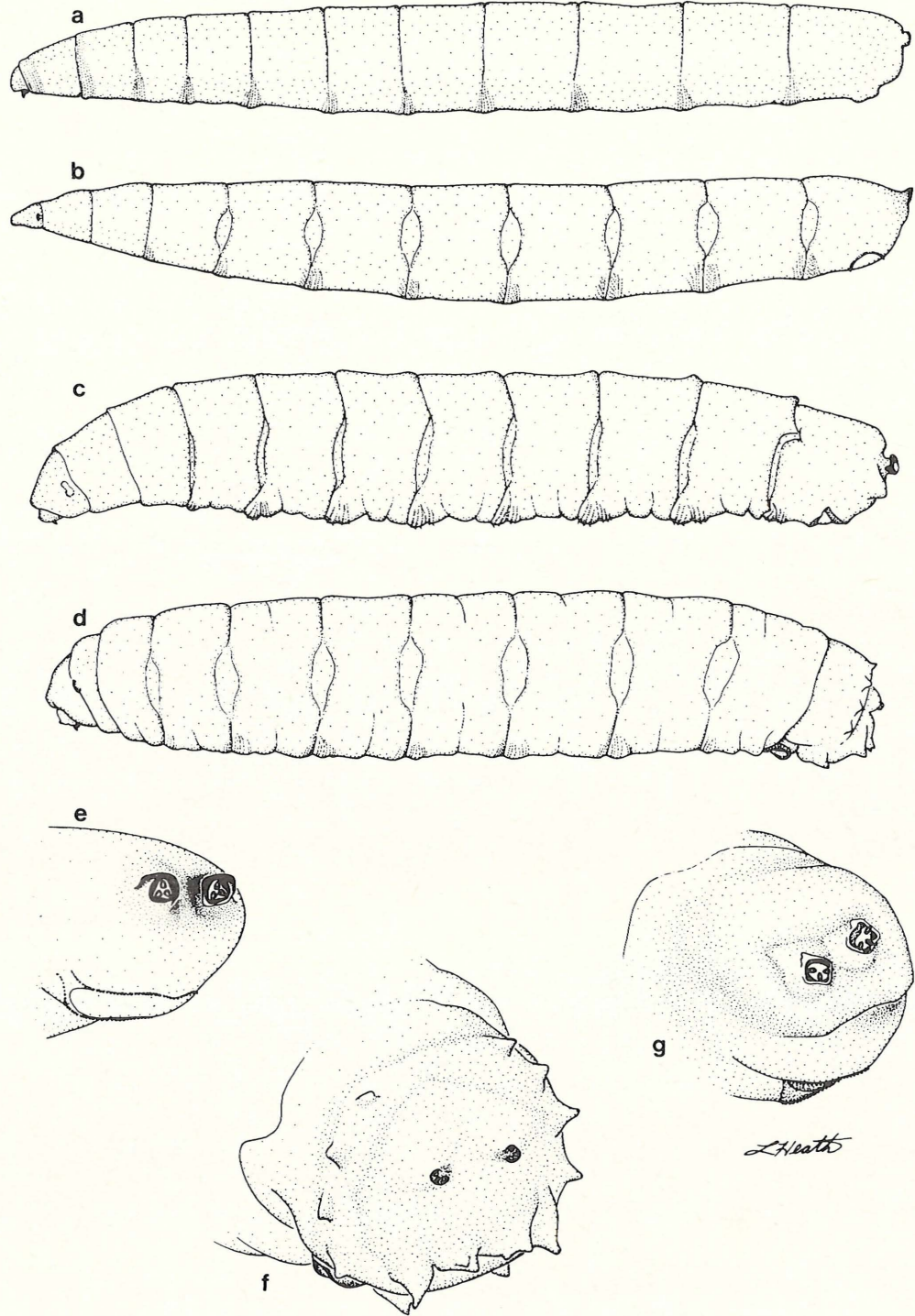


Fig. 15 Diptera larvae, Chloropidae, Lonchaeidae and Anthomyiidae; a-d whole larvae (side view; e-g, hind ends of some. a, *Oscinella frit* L. (similar to *Hapleginella* sp.); b, e, *Lonchaea polita*; c, g, *Earomyia abietum*; d, f, *Hylemya anthracina*.



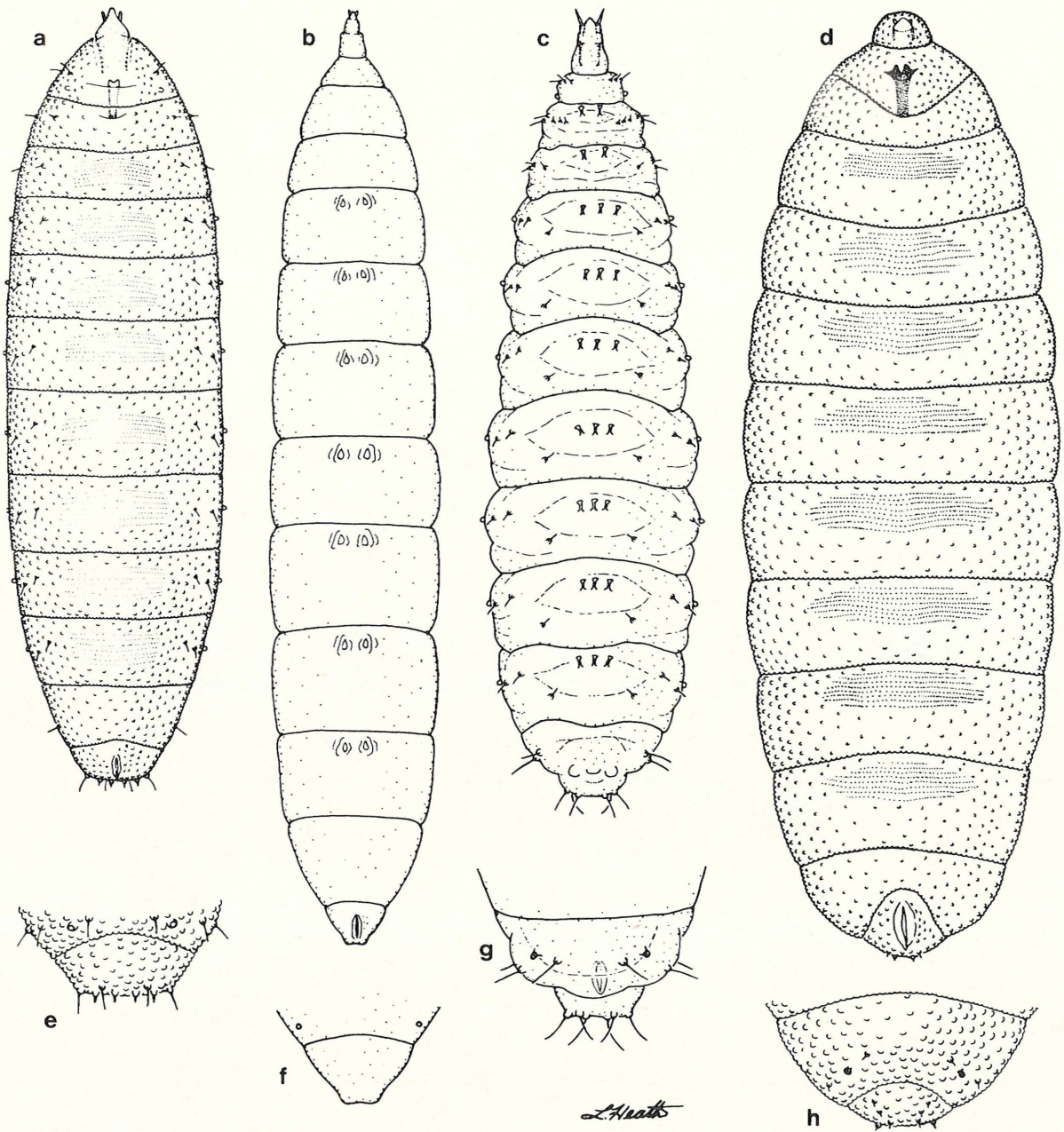


Fig. 16 Diptera larvae, Cecidomyiidae; a-d whole larvae (bottom view); e-h, hind segments of same (top view), a, e, *Mycodiplosis* sp.; b, f, *Asynapta hopkinsi*; c, g, *Lestodiplosis* sp.; d, h, *Dasineura abiesemia*.



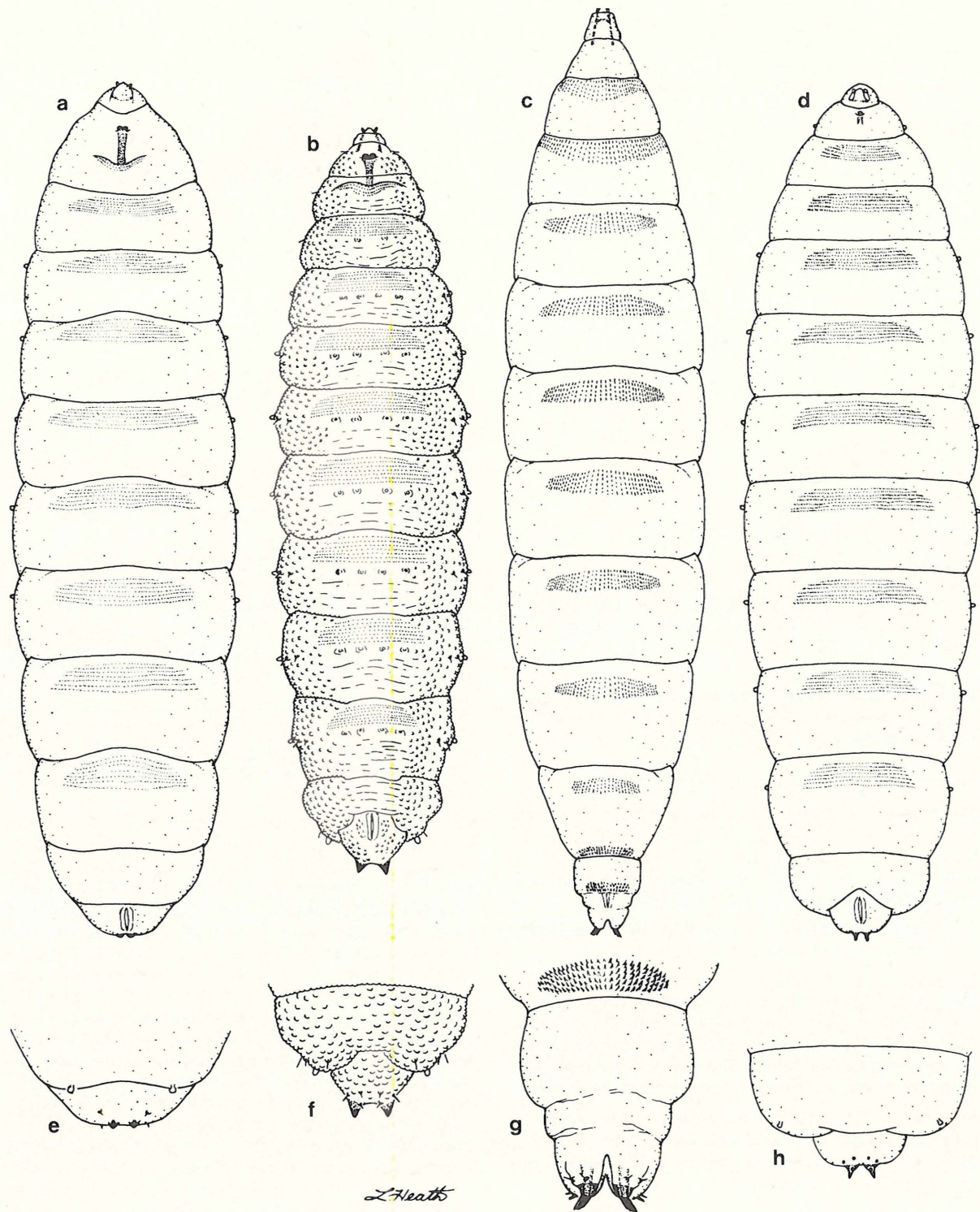
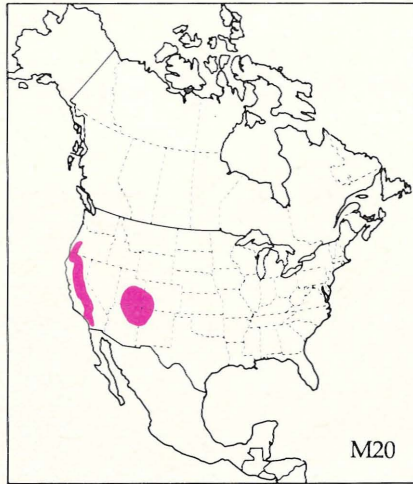


Fig. 17 Diptera larvae, Cecidomyiidae; a-d whole larvae (bottom view); e-h, hind segments of same (top view), a, e, *Contarinia washingtonensis*; b, f, *Resseliella* sp.; c, g, *Cecidomyia bisetosa*; d, h, *Camptomyia pseudotsugae*.



### Family Anthomyiidae

Adults are moderately hairy, small to moderate sized flies, with the arista of the antenna plumose. This group includes both scavengers and plant feeders. Two members of the genus *Hylemya*<sup>1/</sup> are known as serious pests of fir and spruce cones.



***Hylemya (Lasiomma) abietis* Huckett** - fir cone maggot (66, 100, 111, 124) [*H. abietis* Huckett, *Lasiomma abietis* (Huckett)]

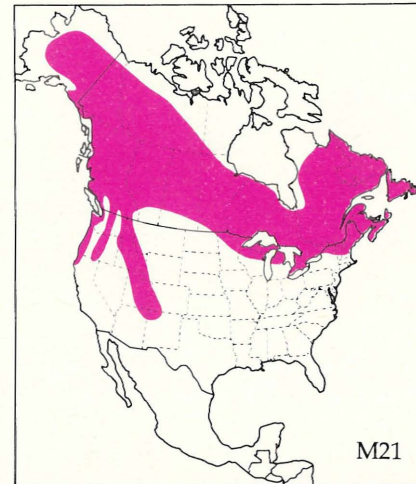
**Hosts:** white and probably other firs. (M20)

**Description:** Adult large, shiny-black or brownish black fly, 8 to 9 mm long; egg pearly white, about 1.5 to 2.0 mm long, elongate; larva typical of this group, white with 2 well-developed mouthhooks; puparium yellowish red to brown, about 6.5 mm long.

**Damage:** The larva feeds vigorously in the cone, boring through scales and seeds.

**Life History and Habits:** Adults emerge during May and early June. Eggs are deposited between cone scales of the young cones during June and early July. Larvae feed during the summer; there may be four or five present in one cone. In late summer, they form puparia in the cone or in the litter after dropping to the ground.

**Importance:** This insect may destroy as much as 30 percent of the seed. When multiple infestations occur, individual cones may be killed in early summer, destroying all their potential seed.



***Hylemya (Lasiomma) anthracina* (Czerny)** - spruce cone maggot (86, 87, 100, 111, 190, 216, 219, 222) [*H. anthracina* (Czerny), *Lasiomma anthracina* (Czerny)]

**Hosts:** mountain hemlock; black, Engelmann, Sitka and white spruces (probably all species of spruce native to North America); possibly western larch and tamarack. (M21)

**Description:** Adult small black fly, about 6 mm long; in general appearance resembles a housefly (Fig. 18a).

**Damage:** The larva is a vigorous feeder, constructing a spiral feeding tunnel around the cone axis, causing considerable damage to scales and seeds. A single larva may destroy more than half of the seeds in one cone (Figs. 18c, d).

**Life History and Habits:** In British Columbia, adults emerge from late May until mid-June (Fig. 19). Females lay eggs singly between scales of conelets (Fig. 18b) which have been pollinated but are still in very early stages of development. The eggs hatch in about 10 days. The larva passes through 3 instars, the first moult occurring within the egg. After feeding for about 1 month, the larva tunnels to the surface of the cone and if conditions are moist or wet, drops to the ground, where it forms a puparium. Because the insect leaves the cone in mid-summer, well before cone maturity, it is not present when cones are being examined for seed condition in late summer. For this reason, damage may be attributed to other insects, such as *Laspeyresia youngana* (Kearfott), which remain in the cone throughout the summer and the following winter. It pupates in late summer or fall and overwinters in the litter. It is normal for a portion of the overwintering population to diapause for an additional year, or more.

**Importance:** This species is a major pest in spruce cones. It is widely distributed and, in localities where infestations are severe, is capable of destroying 100 percent of the seeds.

<sup>1/</sup> Also known as *Pegohylemyia* in literature.





Fig. 18 *Hylemya anthracina*, (a, c, d); (a) adult on flower, (b) egg on tamarack, probably *H. laricicola*, (c) damage to white spruce cone and (d), damage to black spruce cone. CFS.



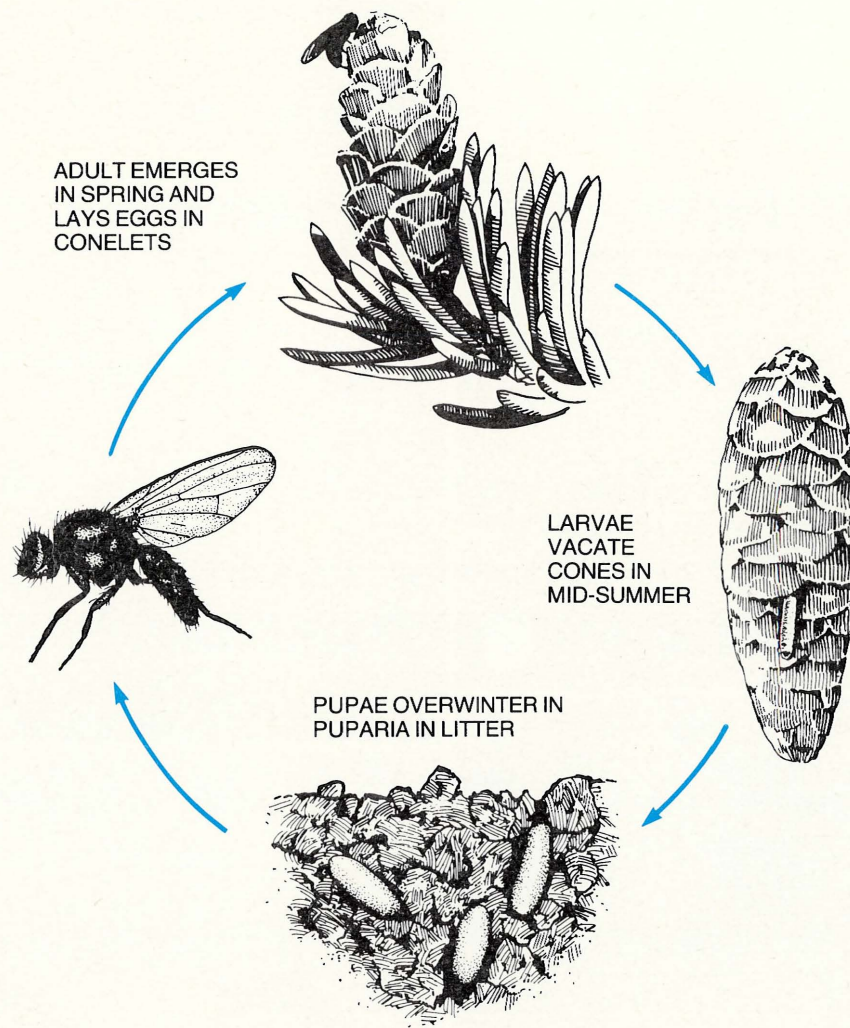


Fig. 19 Life cycle of *Hylemya anthracina*.

#### Other Species:

Another species, probably *H. (L.) laricicola* (Karl) has been reared from cones of alpine larch and tamarack in Alberta. A species reared from tamarack cones in Manitoba is possibly *H. (L.) carbonarium* (Ringdahl)<sup>1/</sup>

#### Family Cecidomyiidae - midges

This family is represented by a large number of species. The small larvae vary from reddish pink to yellow or orange. They are usually present in large numbers. They are not vigorous feeders but may cause significant indirect damage by forming galls, which

fuse seeds to the scales, or robbing seeds of nutrients. The adults are tiny and fragile (Fig. 20) and not readily identifiable without special preparation.

***Asynapta hopkinsi*** Felt - cone resin midge (53, 60, 111, 114, 122, 123, 177, 213) [*Asynapta keeni* (Foote), *Rubsaamenia keeni* Foote]

**Hosts:** California red, grand, white and possibly sub-alpine firs; Coulter, loblolly, lodgepole, longleaf, ponderosa, slash, sugar and possibly Jeffrey and red pines; possibly mountain hemlock, Engelmann and white spruce. (M22)

**Description:** The larva can be distinguished by the posterior body segments which are smooth, without

<sup>1/</sup> Personal communication, Dr. J.F. McAlpine, Biosystematics Research Institute, Ottawa.



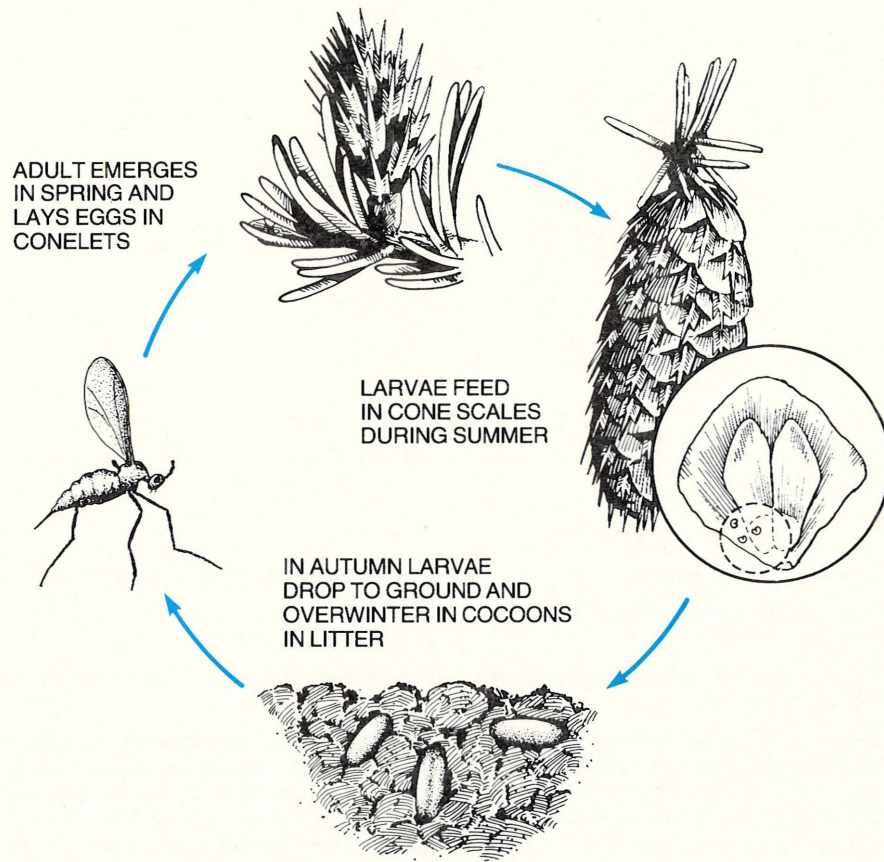
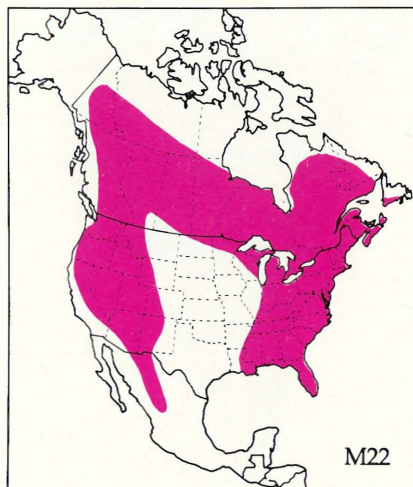


Fig. 20 Life cycle of *Contarinia oregonensis*.



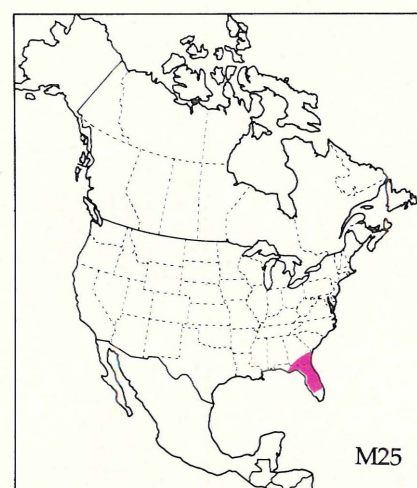
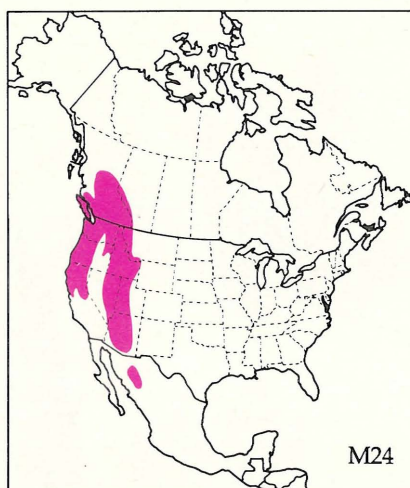
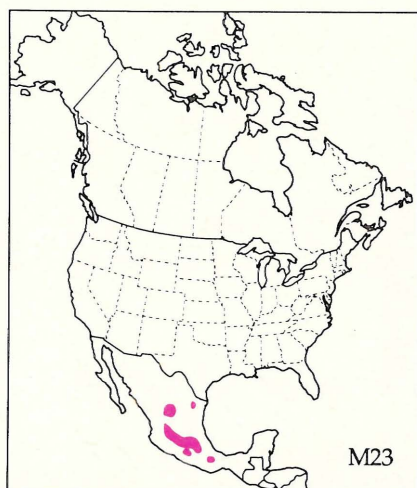
spines on the rather inconspicuous tubercles, and by absence of a spatula on the prothorax.

**Damage:** Larvae often occur in cones damaged by other insects but may be found in otherwise undamaged cones, where they feed between cone scales.

**Life History and Habits:** In the West, there apparently is one full generation per year and a partial second one, adults emerging in fall and spring; in the North, a single generation occurs, with adults emerging in early summer. In the southeastern United States, there are probably more generations, but information on the life cycle is fragmentary. Larvae occur in groups between cone scales of second-year cones, frequently in association with other cecidomyiids or other species of cone insects, and apparently feed on resin exuded from scales or developing seeds.

**Importance:** Larvae of these midges may be abundant in individual cones but, because of the general low incidence of attack, they are of comparatively little importance in seed orchards.





***Asynapta* sp. nr. *strobilophila*** (Foote)

*Hosts:* Montezuma, possibly Chihuahua and rudis pines; possibly sacred fir. (M23)

*Description:* Larva pink, from 2 to 3 mm long; pupa in grayish brown cocoon, 2 mm long.

*Damage:* Larvae live between cone scales, causing resinosis which fuses the scales. Feeding may also retard cone growth so the infested cones are smaller than normal; cones may be killed. External indications of damage are brown scales and cone distortion.

*Life History and Habits:* Adults emerge from May to July. After the eggs hatch the larvae overwinter in the cones; mature larvae are present in cones during April and May, during which time they drop to the ground and pupate in the soil. There may be up to 100 larvae per infested cone. There is probably only one generation per year.

*Importance:* Although insect populations may be high, only a small percentage of the cones are infested. Damage is usually not significant.

***Camptomyia pseudotsugae*** Hedlin and Johnson  
(89)

*Host:* Douglas-fir. (M24)

*Description:* This insect cohabits, in the larval stage, with *Contarinia washingtonensis* Johnson. All stages of both species are similar in size and gross appearance, but the larva *C. pseudotsugae* has two prominent anal hooks which aid in distinguishing the species.

*Damage:* The insect occurs only in cones infested by larvae of its cohabitant. The species feed together, causing the same type of damage.

*Life History and Habits:* The life history is similar to that of *C. washingtonensis*.

*Importance:* Minor.

***Cecidomyia bisetosa*** Gagné - southern cone gall midge (67, 222)

*Host:* slash pine. (M25)

*Description:* Mature larva pale reddish orange, about 3 mm long.

*Damage:* Larvae feed between the scales during the first year of cone development, causing enlargement of three or four adjacent scales. Each larva feeds in a pitch-filled cavity formed by lateral fusion of these scales. The hypertrophied scales, or galls, eventually project beyond the surface of the conelet (Fig. 21).



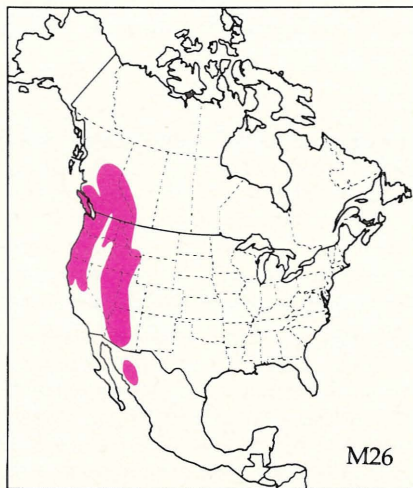
Fig. 21 Slash pine conelet damaged by *Cecidomyia bisetosa*. USFS.



Abnormal cone scale development usually becomes noticeable in March or April. A droplet of pitch on the tip of the galled scale indicates the location of the feeding cavity. Severely galled conelets may die during the first winter, but if they survive to maturity cones are severely deformed and fail to release seeds from the galled portions.

*Life History and Habits:* Adults have been observed to emerge in late January in Florida from infested conelets of the previous year. Since adult emergence coincides with the period of female flower pollination, it is presumed that eggs are deposited between the flower scales. Larvae develop slowly between the scales throughout the first year of conelet development, producing characteristic galls. They do not feed on seeds. Larvae mature in August and September and pupate in the conelet in mid-January. There is probably only one generation a year.

*Importance:* This species was first observed in a slash pine seed orchard in northeast Florida; its geographic distribution is unknown. As high as 32 percent of the conelets on a single tree have been found infested by this midge and mortality of infested cones has been as high as 40 percent. However, cone infestation within the orchard studies has been confined to specific clones, and midge populations, based on damage, have varied greatly from year to year.



***Contarinia oregonensis*** Foote - Douglas-fir cone gall midge (41, 60, 80, 82, 83, 102, 104, 105, 106, 107, 111, 115, 117)

*Host:* Douglas-fir. (M26)

*Description:* Adult 3 to 4 mm long; egg smooth, shiny white, oblong, about 0.1 by 0.3 mm; fully developed larva pink to orange, about 2.8 mm long, with distinctly notched spatula; pupa orange in early stages but later turns dark, encased in oblong delicate cocoon.



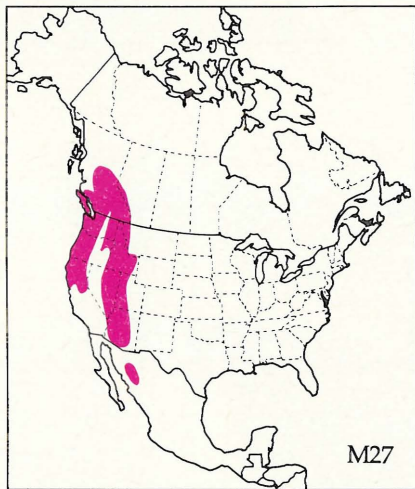
Fig. 22 *Contarinia oregonensis*; (a) adult female on Douglas-fir flower, WC, (b) bisected Douglas-fir cone showing damage. CFS.



**Damage:** Larvae form galls in cone scales, usually near or adjacent to seeds. A gall may be formed by a single larva but, usually, there are several in each infested scale. Seeds may be fused to the scale when only a few larvae are present, or completely destroyed when numbers are large. In severe infestations, there may be hundreds of larvae in a single cone, in which case all seeds are destroyed (Fig. 22b), and scales die and turn red in July or August.

**Life History and Habits:** Adults emerge in early spring, when Douglas-fir flowers are open for pollination (Figs. 20, 22a). The females oviposit near the young ovules, where their spindle-shaped eggs often become mixed with pollen grains. The eggs hatch during May and early June after an incubation period of 2 to 3 weeks. Larvae tunnel into scale tissue and settle, usually near the ovules where they develop throughout the summer, each larva in a separate cell. A swelling or gall forms wherever larvae are located. The larvae pass through three instars; in the third, they assume a U-shape in the gall. When the mature cones become wet in the fall, larvae drop to the litter and form delicate cocoons in which to overwinter, often in the old male flowers. They pupate during late winter and early spring. A portion of the population remains in diapause in the larval stage for 1 or more years.

**Importance:** This insect is a major destroyer of Douglas-fir seeds. It probably occurs throughout the range of the host, but is more abundant and a more serious pest in wet coastal than in drier interior areas. When infestation is severe, almost 100 percent of the seed crop may be destroyed.



***Contarinia washingtonensis*** Johnson - Douglas-fir cone scale midge (82, 83, 88, 102, 103, 106, 122)

**Host:** Douglas-fir. (M27)

**Description:** Adult and other stages superficially indistinguishable from that of *Contarinia oregonensis*, larva deeper orange than that of *C. oregonensis*.

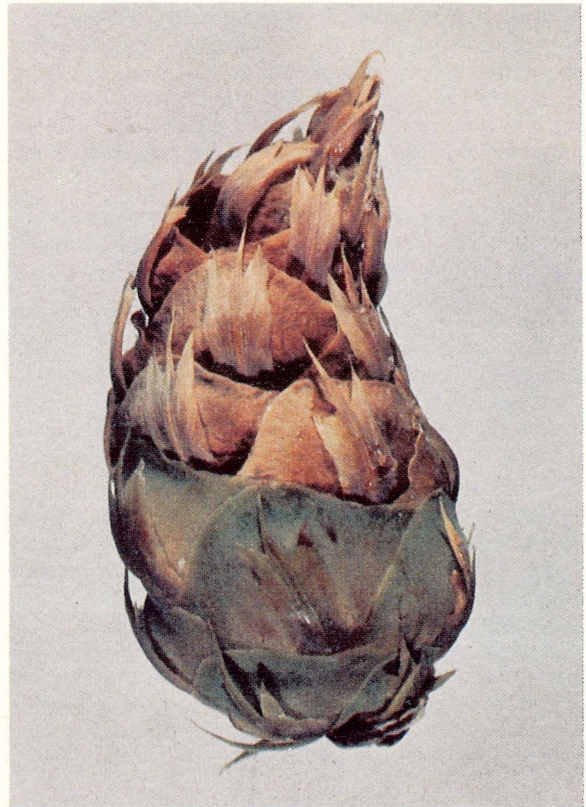


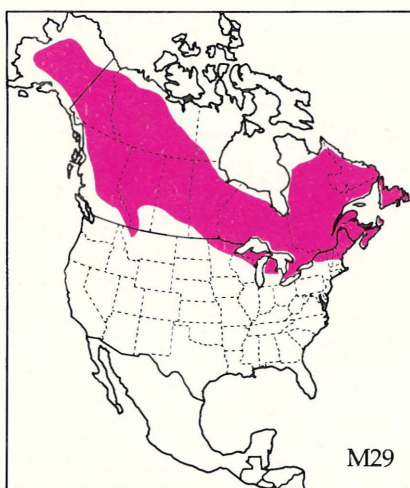
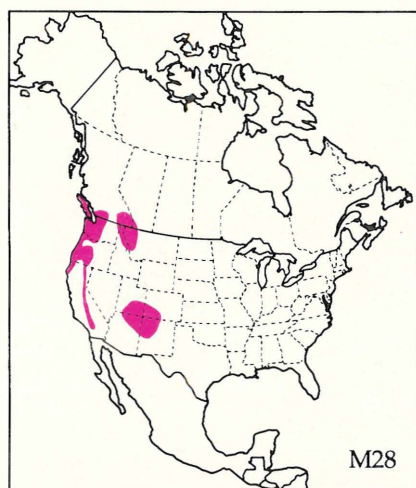
Fig. 23 *Contarinia washingtonensis* damage to Douglas-fir cone. CFS.

**Damage:** The larvae feed in cone scales of the host, forming longitudinal mines beneath the surface of the scale under the seed wing, but they do not cause direct damage to seeds. They do not form galls. When cones are severely infested, cone scales die and turn red in late July or August (Fig. 23). There is no external evidence of damage on cones which are lightly infested.

**Life History and Habits:** Adults emerge in early summer, about 1 month later than those of the Douglas-fir cone gall midge. At this time, young cones of the host are closed and pendent, or nearly so. The female lays eggs beneath the cone bracts and when these hatch, the larvae enter scale tissue, where they remain throughout the summer. When cones reach maturity in late summer, the mature third-instar larvae drop to the litter. Unlike *C. oregonensis*, which lie in a U-shaped position, the larvae of this species lie fully extended. They apparently do not require moist conditions prior to leaving the cone. Larvae quickly evacuate mature cones that have been picked and frequently cover the floor in Douglas-fir cone drying sheds. They overwinter as larvae in cocoons in the litter, and may remain in diapause for several years.

**Importance:** Although this species is common in Douglas-fir cones, it is not a major seed-destroying pest.





***Dasineura abiesemia*** Foote - fir seed midge (60, 66, 111)

*Hosts:* California red, grand, white and probably noble firs. (M28)

*Description:* Adult dark midge; mature larva pink with distinct spatula.

*Damage:* Larvae feed in the seeds, one per infested seed.

*Life History and Habits:* These are not well known. Adults emerge in spring and lay their eggs in or near the micropyles of the young ovules at time of pollination. Larvae feed during the summer and drop to the ground with the seeds when cones disintegrate in the fall. Larvae pupate and adults emerge in the spring.

*Importance:* This insect is probably not an important pest.

***Dasineura canadensis*** Felt - spruce cone gall midge (59, 66, 86, 111, 217, 218, 221)

*Hosts:* white and probably other species of spruce. (M29)

*Description:* Adult about 2 mm long; egg oblong, whitish, 0.1 by 0.3 mm; mature larva yellow, about 3 mm long, without spatula; pupa about 2.5 mm long, whitish in early stages, turning dark later.

*Damage:* The larva forms a gall in the cone scale. Unless the gall occurs adjacent to the developing seed, damage is probably slight.

*Life History and Habits:* The adult female lays eggs during May and June on the inner surface of the scales of young spruce flowers which are open for pollination. When the egg hatches, the young larva mines into scale tissue and forms a gall. When the larva is fully developed by mid- to late-summer, it makes a small exit hole from the gall and seals this with silken webbing. It then forms a cocoon within the gall and over-

winters. It pupates in April or May and the adult emerges when host flowers begin to open for pollination.

*Importance:* This insect is plentiful in some areas and has infested almost 100 percent of white spruce cones in localities of Ontario, Canada. In spite of its abundance, it is probably relatively unimportant as a seed destroyer.

***Dasineura rachiphaga*** Tripp - spruce cone axis midge (86, 111, 217, 218, 221)(M30)

*Hosts:* black, **Engelmann**, Sitka and **white** spruces.

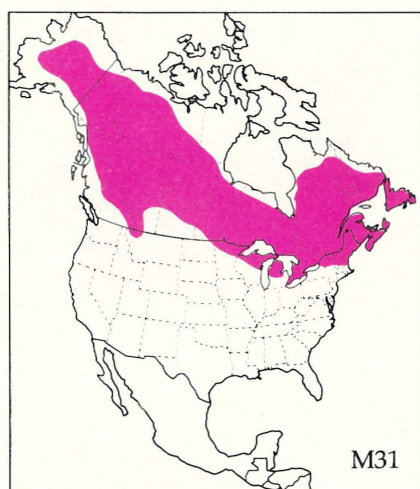
*Description:* Adult small, dark brown, about 2.2 mm long; larva yellowish orange, about 3 mm long, spatula lacking. Pupa about 2.5 mm long, whitish in early stages, later turning dark.

*Damage:* During larval development, the insect mines through scale tissue into the cone axis. Although some conductive tissue is damaged, there is little apparent damage to seeds.

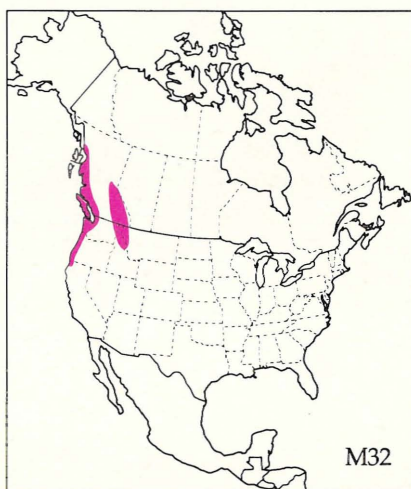
*Life History and Habits:* The adult emerges from the pupal cocoon in the cone axis during May or June and lays eggs near ovules of spruce flowers which are open for pollination. The young larva enters scale tissue near an ovule and gradually mines toward the cone axis, through the point of attachment of the scale. By early summer, all larvae have reached the cone axis (Fig. 25b). There is usually only one larva per cone scale, but there may be many in each cone. Each larva mines an exit tunnel almost to the surface of the scale near the junction of scale and axis. It then forms a delicate cocoon, usually about mid-summer, and overwinters. Pupation occurs in spring and adults emerge in about 10 days.

*Importance:* This midge causes no direct damage to seeds and is not of major importance.

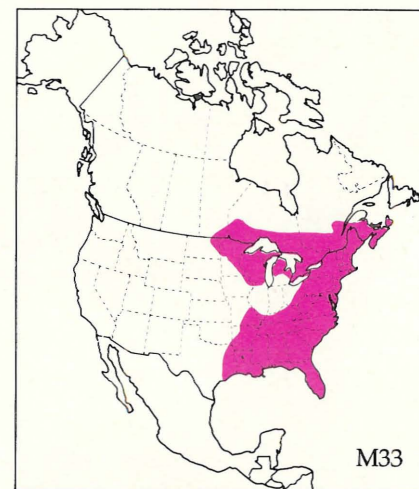




M31



M32



M33

***Mayetiola carpophaga*** (Tripp) - spruce seed midge (60, 84, 111, 213, 217, 218, 221)

*Hosts:* white and possibly other spruces. (M31)

*Description:* Adult about 2.4 mm long; larva yellowish pink, about 3.0 mm long, spatula present.

*Damage:* Larvae feed in seeds, one per infested seed. All infested seeds are destroyed.

*Life History and Habits:* The adult emerges in May or June and the female lays eggs near the micropyles of young ovules. The young larva enters a seed where it feeds, develops, and forms a cocoon by mid-summer. It pupates in April or May.

*Importance:* Each larva destroys 1 seed. This insect is not a significant seed destroyer because, although infestations may be severe in some localities, it does not consistently occur in large numbers.

***Mayetiola thujae*** (Hedlin) - western redcedar cone midge (78, 81) (*Phytophaga thujae* Hedlin)

*Host:* western redcedar. (M32)

*Description:* Adult about 3 mm long; mature larva orange with distinct spatula.

*Damage:* Larvae feed beneath the cone scales of the host, damaging both scales and seeds. They differ from most phytophagous midges in that they do not settle in one location in the cone, so each larva may damage more than one seed.

*Life History and Habits:* Adults emerge in March and April after flowers of the host have been pollinated. The female lays eggs in clusters on the inner surface of cone scales. There may be up to 45 eggs in each cluster, with up to 150 in a cone. Eggs hatch during April and May after an incubation period of about 1 month. The young larvae move from one scale to another but do

not tunnel into scales or seeds. In late summer, when feeding is completed, the larva spins a delicate light gray cocoon which may be located in a larval mine in the scale, either covered by a seed or exposed on the inner surface of the scale. Cocoons are formed during August and early September. Pupation in coastal areas occurs during the period December to February. Pupae may diapause for 1 or more years.

*Importance:* This insect is capable of destroying significant quantities of seed and has the potential of being a serious pest.

***Resseliella silvana*** (Felt) (25, 52, 53)

*Hosts:* loblolly, longleaf and slash pines. (M33)

*Description:* Larva pale yellowish to bright orange, 2 to 3 mm long (Fig. 24b); terminal body segment forked, each fork with an obvious stout seta, other terminal setae inconspicuous; puparium brown.

*Damage:* Larvae feed on surfaces of scales within the cones. A number of scales or even entire cones may be killed (Figs. 24a, b).

*Life History and Habits:* Infestations by this midge are most prevalent in spring and early summer in the southeastern United States. Larvae feed in groups amid the cone scales and on the developing seed surfaces, usually in normal cones, but may also attack rust-infected conelets. Pupation occurs in the cones

*Importance:* While this midge damages or kills cones, the percentage infested is usually low.

Other species of *Resseliella* (114) (*Thomasiniana*) occur in and cause varying amounts of damage to cones of grand fir, Montezuma and ponderosa pines, spruce and probably other conifers (Figs. 25a, 26).



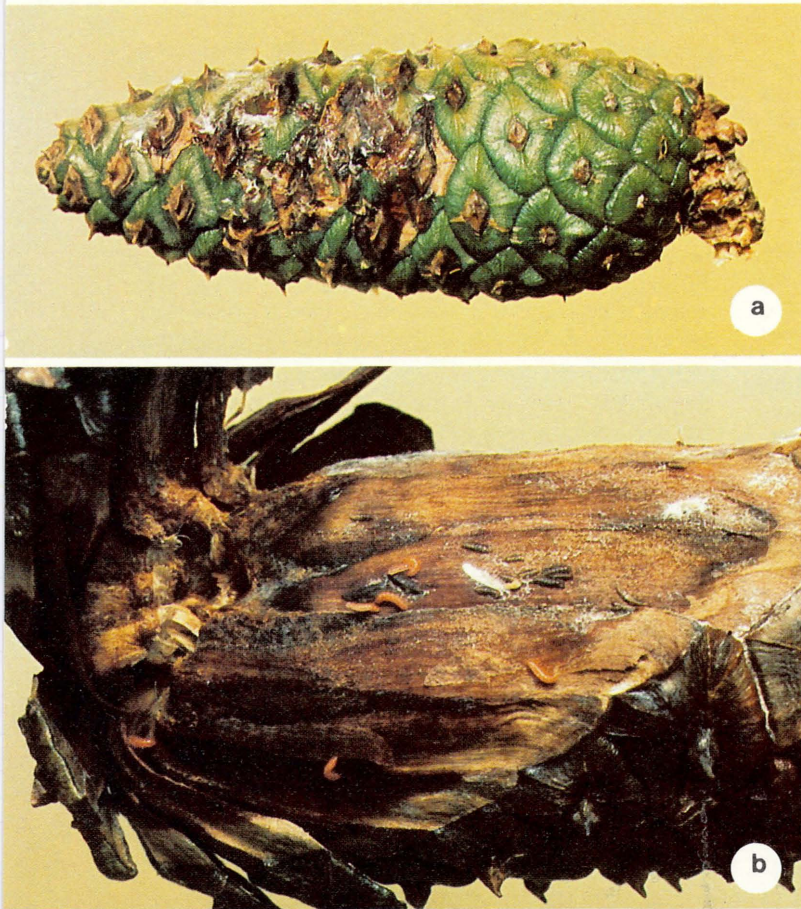


Fig. 24 *Resseliella silvana* on loblolly pine cone; (a) larval damage, (b) larvae and cocoons on cone scale. USFS.



Fig. 25 Midges in spruce; (a) *Resseliella* on scales, (b) *Dasineura rachiphaga* in axis. CFS.



Fig. 26 *Resseliella* sp. in Montezuma pine cone. UACH.



### Miscellaneous Cone-inhabiting Midges:

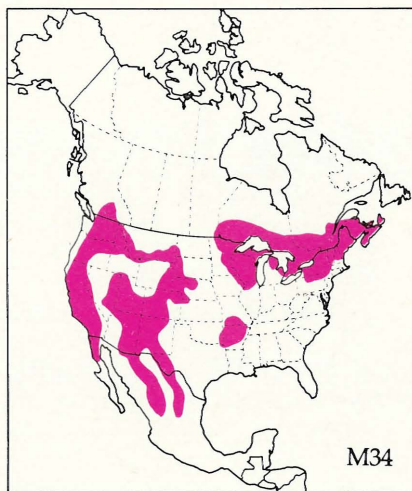
The baldcypress seed midge, *Taxodiomyia cupressi* (Schweinitz) [(*Retinodiplosis taxodii* Felt, *Sequoiomyia taxodii* (Felt)], causes round galls to develop in baldcypress cones (59). Little is known about the biology or the impact this midge has upon viable seed production.

Cecidomyiid larvae are frequently present in damaged, diseased and dead cone material. It is often difficult to determine whether these larvae are the cause of cone damage or are feeding on dead cone material or associated fungi, or are predatory. Further, the larvae of secondary species, which may occur in association with primary cone-infesting Cecidomyiidae, readily cause confusion. In the southeastern United States, the secondary species from cone material include:

*Mycodiplosis thoracica* (Fitch), a fungus feeder found primarily in conelets infected by the southern cone rust, *Cronartium strobilinum* Hedgc. and Hahn; *Lobodiplosis triangularis* Felt, a species so infrequently encountered that it is an unlikely primary pest; *Lestodiplosis* spp. (25, 134, 213), known to be predators, and *Hyperdiplosis* spp. (26), known to be general feeders on decaying material.

### Family Chloropidae - chloropid flies

Adults are small flies; head hemispherical with obvious frontal triangle. Larval habits vary; many feed in stems of grasses and cereals; a few are scavengers or predators. Their occurrence in cones appears to be of little importance.



***Hapleginella conicola*** (Greene) (111, 236) (*Oscinella conicola* Greene)

**Hosts:** Shasta red and white firs; Jeffrey and ponderosa pines; also probably loblolly, pinyon, red, shortleaf

and sugar pines. (M34)

**Description:** Adult minute, shiny black fly, about 1 mm long; larva elongate, tapered and posteriorly truncate almost colorless to whitish maggot, about 2 mm long; puparium golden, about 1 mm long.

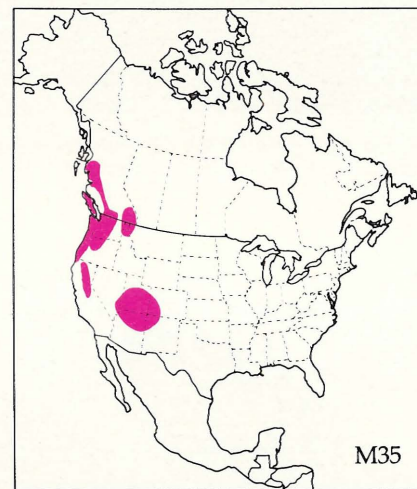
**Damage:** Fir cones may be riddled; this species is probably a secondary pest in red pine.

**Life History and Habits:** Larvae are present during fall and early winter, feeding upon seeds and scales of wet fir cones or in frass of other insects in dead red pine cones. Pupation and adult emergence occur from spring to mid-summer. A second late-summer generation may occur.

**Importance:** Damage to fir in late summer may be notable, but the lack of consistent reports of damage and the secondary occurrence of this maggot in red pine suggests that it is of minor importance. Its role in various hosts should be carefully considered in the light of its occurrence in cones killed by other insects.

### Family Lonchaeidae

Adult lonchaeids are small, dark flies superficially similar to houseflies, with oval, flattened abdomens. As a group, the larvae are characterized as scavengers or predators. A few species feed on seeds in cones, but are of minor importance.



***Earomyia abietum*** McAlpine - fir seed maggot (66, 84, 111, 136)

**Hosts:** California red, grand, Pacific silver and white firs. (M35)

**Description:** Adult small black fly; egg opaque, white and sausage-shaped; larva white with distinct sharp, black mouthhooks; puparium shiny oblong, dark brown, about 1.6 mm by 4.5 mm.

**Life History and Habits:** Adults emerge during April and May and lay eggs, usually singly, on the inner surfaces





Fig. 27 *Earomyia abietum*; (a) destroyed seed, (b) larva emerging from seed. OSU.

of cone scales. Larvae hatch during May and June and move toward the cone axis, where they enter and feed on young seeds (Figs. 27a, b). In addition to feeding on seeds, the larvae are predacious on other seed-feeding insects such as chalcids and midges. In late summer, the mature larvae drop to the ground, where they enter the litter and form puparia. The insects overwinter in the pupal stage. They may remain in diapause for several years.

**Importance:** This insect is one of the most abundant in red and white firs in California, but the extent of damage has not been recorded. It is not considered a serious pest.

Minor species of *Earomyia* include the following:

Although there are no records of detailed studies of any of them, they appear to be similar in behavior. They are probably basically phytophagous, feeding mainly on seeds; although, as indicated below, *Earomyia barbara* has predacious habits. Life history and

habits are generally similar to those of *Earomyia abietum*.

***Earomyia aquilonia*** McAlpine (111, 136)

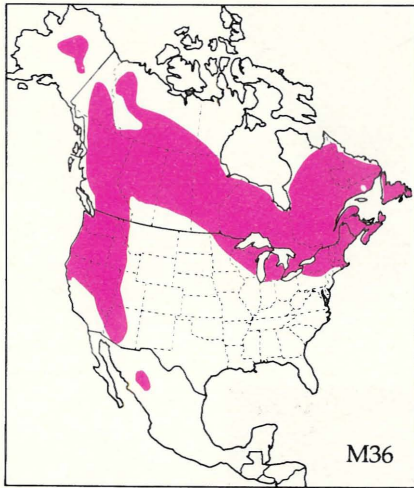
**Hosts:** Douglas-fir; subalpine fir; tamarack. (M36)

***Earomyia barbara*** McAlpine (66, 111, 136)

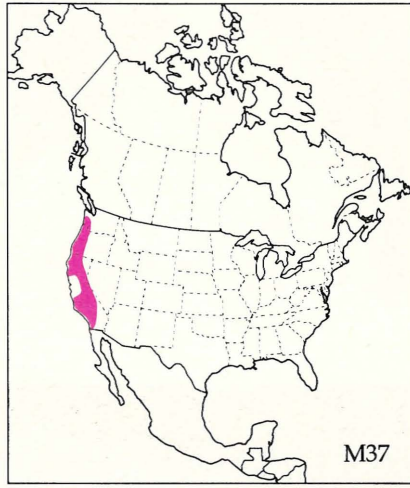
**Hosts:** Douglas-fir; California red and white firs; mountain hemlock; ponderosa pine; Engelmann and white spruces. (M37)

**Comments:** Similar to but smaller than *Earomyia abietum*. The larvae are present in cones during the summer and, at least in Douglas-fir cones, may be predacious on other insects, particularly midge larvae. They also destroy seeds. They leave the cones in late summer and pupate in the litter. It is not a major pest.

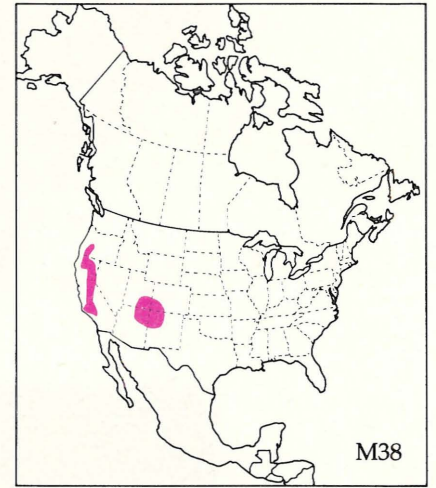




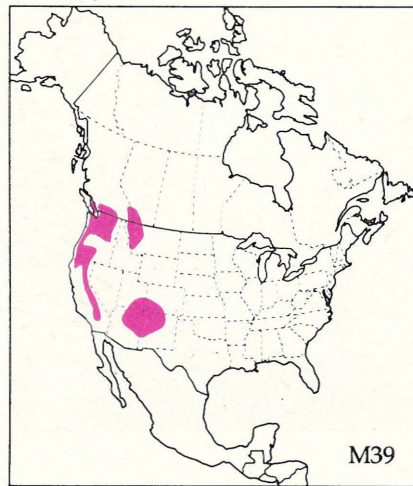
M36



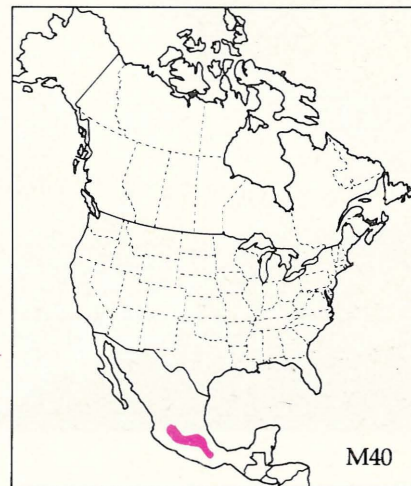
M37



M38



M39



M40

***Earomyia brevistylata* McAlpine (111, 136)**

*Hosts:* California red and white firs. (M38)

*Comments:* There are very few records on this insect. It apparently overwinters in the pupal stage in a puparium and may remain in diapause for 1 or more years in this stage.

***Earomyia longistylata* McAlpine (111, 136)**

*Hosts:* California red, grand and white firs. (M39)

*Comment:* There are no detailed records available on this insect.

***Lonchaea polita* Say - pine cone maggot**

*Host:* Montezuma pine. (M40)

*Description:* Adult about 4.5 mm long, shiny black, wings longer than the body; larva whitish; puparium dark red, about 5.5 mm long.

*Damage:* Larvae tunnel in scales and seeds, each larva destroying from 1 to 2 seeds.

*Life History and Habits:* Adults emerge during July and August. Larvae feed in the cones.

*Importance:* Not an important pest.

## HEMIPTERA - true bugs

Hemiptera are readily recognized by their leathery fore wings with membranous tips. The hind wings are entirely membranous and usually slightly shorter than the fore wings. Both pairs of wings lie flat over the abdomen. Mouthparts consist of a bundle of needle-like stylets within a segmented sheath which forms a beak. This beak arises from the front part of the head and extends backward along the underside of the body. The interlocking stylets comprise a duct to chan-



nel salivary fluid into the food and a food duct through which food material is sucked. Metamorphosis is gradual, with the immature forms of nymphs resembling the adult in form and feeding habits. In contrast to damage caused by chewing insects, there is little external evidence of feeding.

Members of two families, Coreidae and Pentatomidae, that emit obvious odors when disturbed, are represented by species that feed upon the seed of conifers, mainly pines, in North America. Of the Coreidae, two species of the genus *Leptoglossus* feed on the ovules and seeds of pines and other conifers. *Tetyra bipunctata*, a member of the family Pentatomidae, feeds on seeds of developing pine cones.

### Family Coreidae - coreid bugs

These are elongate, narrow-headed bugs, of moderate to large size, with many obvious longitudinal veins in the wing membrane.

#### Genus *Leptoglossus* - leaffooted bugs

This genus belongs to a group in which the tibiae of the hind legs are laterally expanded and leaf-like, and the femora are obviously spined. Two species damage conifer seeds in North America. One, *L. corculus* (Say), is eastern and is limited to pine hosts; the other, *L. occidentalis* Heidemann, is western and feeds on seeds of pines and several other conifers. A

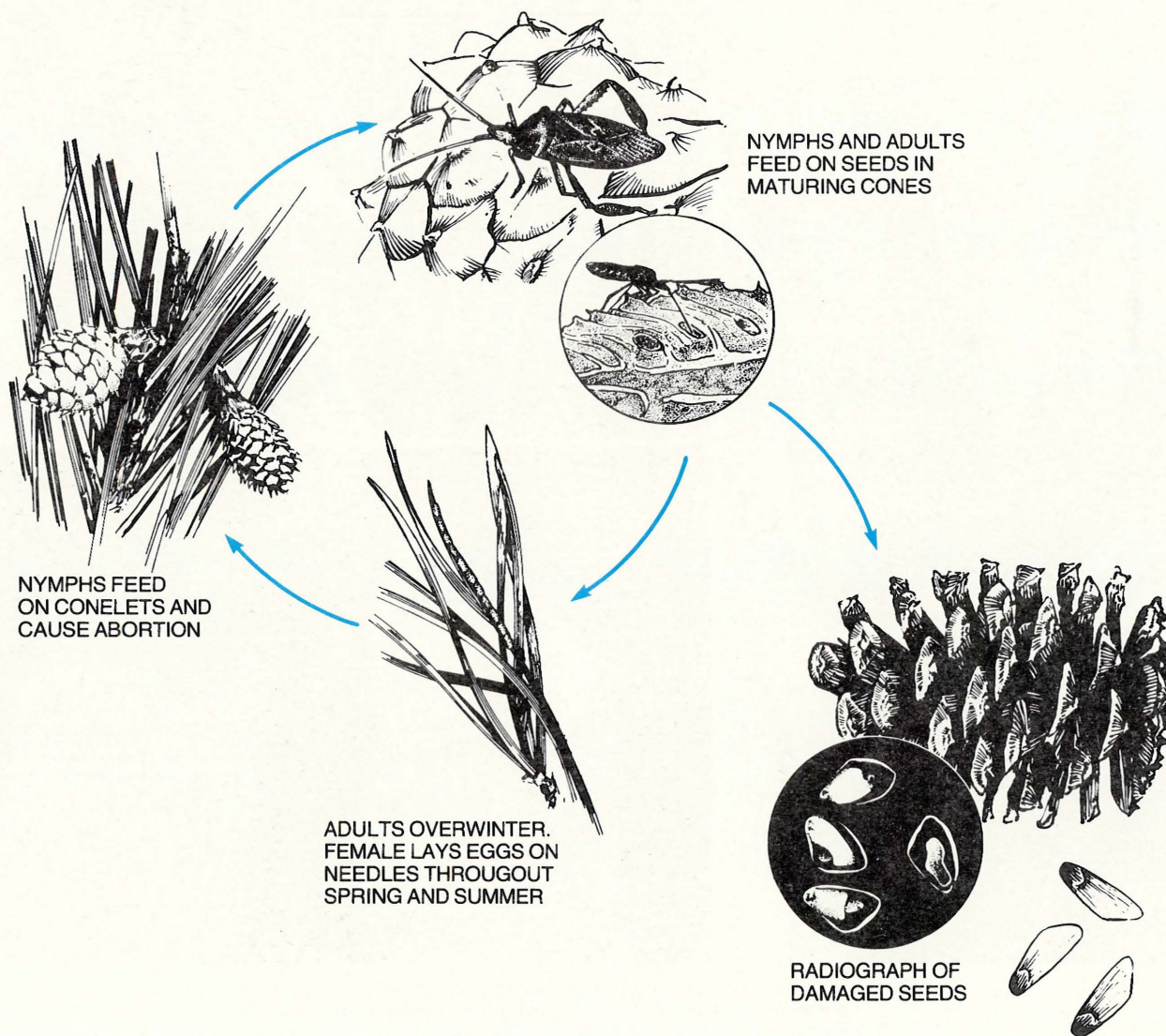


Fig. 28 Life cycle of *Leptoglossus corculus*.

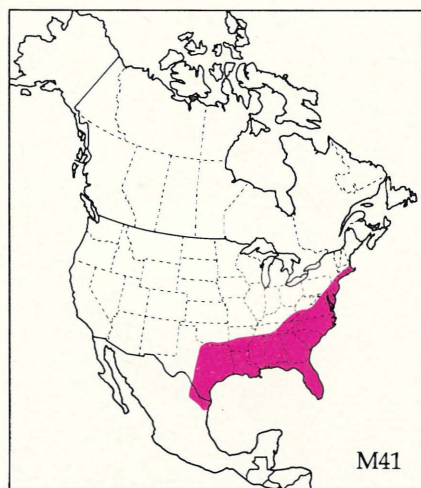




Fig. 29 *Leptoglossus corculus*; (a) adult on loblolly pine cone, (b) egg masses on shortleaf pine needles (first-stage nymph on needle at lower left), (c) shortleaf pine conelet aborted due to feeding on ovules, (d) damage to developing seeds (right), normal on left. USFS.



typical life cycle is illustrated in Fig. 28.



***Leptoglossus corculus* (Say)** - southern pine seed bug (15, 16, 35, 37, 38, 39, 71)

**Hosts:** All pines of the southeastern United States, with the possible exception of sand pine. These include eastern white, loblolly, longleaf, pitch, pond, shortleaf, slash, spruce and Virginia pines. (M41)

**Description:** Adult elongate, about 19 mm long, with an obviously elongated, narrow head (Fig. 29a); body reddish brown marked with black and with dense appressed creamy pubescence; wings brown with narrow zigzag whitish crossbands; head black with three obvious dorsal yellowish to reddish brown longitudinal stripes; hind tibia, or "leaf", with obvious semi-medial white blotch, together with smaller scattered white spots; eggs hemicylindrical, reddish brown, about 1 by 2 mm, with a fine honeycomb-like surface pattern and an obvious operculum; nymph similar in form to the adult; nymphal instars 1 to 4 mottled reddish brown but the last instar shaded heavily with gray.

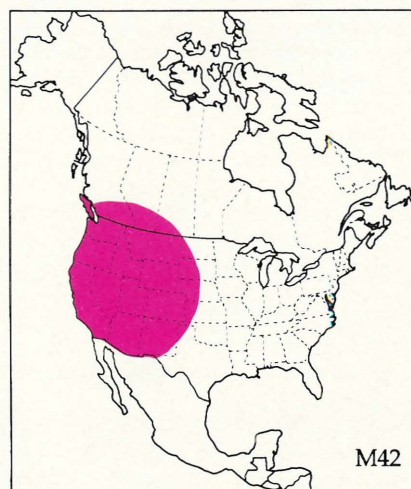
**Damage:** This seed bug causes two major types of damage. Second-instar nymphs feed on ovules in conelets, frequently destroying the ovules and also causing conelet abortion (Fig. 29c). Later nymphal instars and adults feed on seeds. These seeds may appear to be undeveloped, collapsed or hollow, or they may retain residues of tissue, depending upon the extent of seedcoat development at the time feeding occurs (Fig. 29d). Discoloration of the seedcoat may occur around the minute feeding holes, but these are usually difficult to detect. Late-season damage of seed with traces of tissue may be detected by radiography.

**Life History and Habits:** Adults hibernate in various protected spots. They appear on host pines at flowering time and can be found feeding primarily on the developing male flowers. Following the flowering season, the adults may feed on succulent shoots. When

cones begin to enlarge, the adult bugs and later third- to fifth-instar nymphs feed on them until the cones ripen in the fall. Bud feeding may also occur in late fall.

Overwintered adults commence laying eggs about a month after the pine-flowering season, and thereafter repeated generations occur until fall; when mating ceases, the bugs continue to attack maturing cones until late fall, then hibernate. The eggs are laid on pine needles in rows of 10 to 20 eggs (Fig. 29b). First-instar nymphs remain in groups and feed on the needles. Second-instar nymphs seek conelets, where several may feed on a single cluster. Third- to fifth-instar nymphs disperse to cones, where they feed individually.

**Importance:** The southern pine seed bug ranks among the most destructive of southeastern United States cone and seed insects, possibly the single most detrimental insect in seed orchards. Data for 3 years indicated that 10 percent of seed from loblolly and 15 percent from slash pine seed orchards were destroyed by seed bugs. These percentages reflect only seed damage detectable by radiography. Additionally, only about one-half of the total potential seed yield per cone was attained. Much of this loss is attributed to seed destruction by the southern pine seed bug in spring to early summer before seedcoats harden. Abortion is a major cause of conelet loss under natural conditions. Although it is not possible to place all blame for this on this seed bug, shortleaf and loblolly conelets seldom abort when protected in cages.



***Leptoglossus occidentalis* Heidemann** - western conifer seed bug (66, 116, 121, 122, 123)

**Hosts:** Douglas-fir; grand fir; incense-cedar; Jeffrey, knobcone, lodgepole, Monterey, ponderosa and western white pines. (M42)

**Description:** Adult robust, elongate, 15 to 18 mm long, 4 to 6 mm wide, with long legs and antennae; body surface reddish brown to dark gray with dense whitish



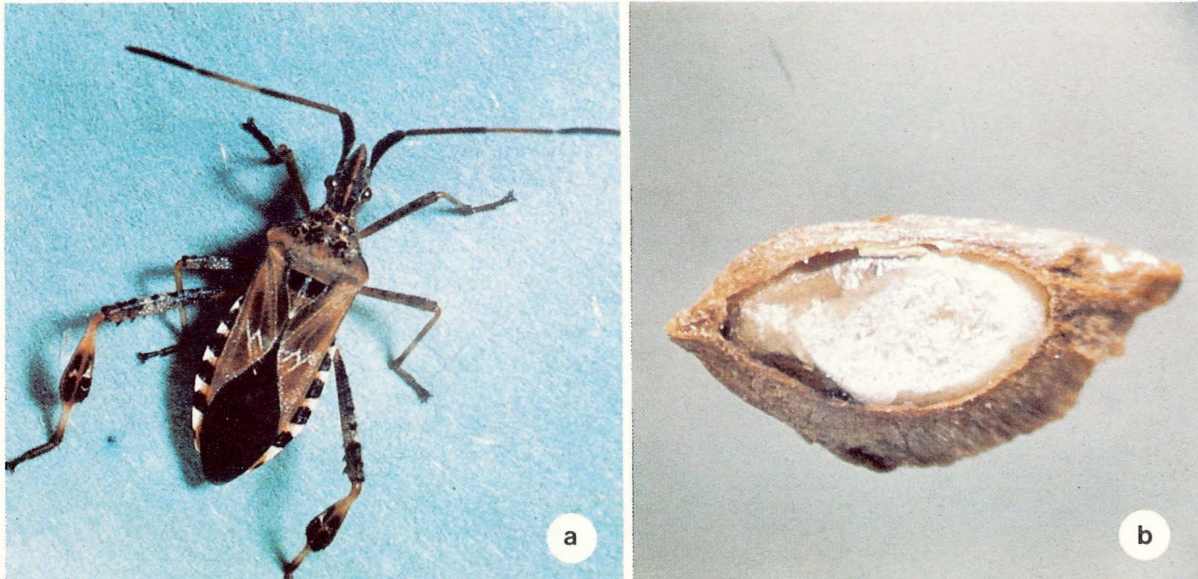


Fig. 30 *Leptoglossus occidentalis*; (a) adult, (b) Douglas-fir seed damage. USFS.

pubescence; fore wing marked by distinctive narrow zigzag white line (Fig. 30a); egg semi-cylindrical, about 2 mm long, 1.2 mm wide and 1 mm high; light brown when deposited, becoming reddish brown when the color of the developing nymph shows through the chorion; nymphs orange to reddish orange.

**Damage:** This insect feeds by piercing through the cone scales into the developing seeds. The character of feeding damage depends on the time of feeding and the length of the feeding period. When feeding occurs before the seedcoat hardens, the contents of the seed are completely removed and the seedcoat collapses and turns gray-brown. These seeds darken as the cone develops and are reduced to flattened seedcoats which adhere tightly to the cone scale but are almost as large as mature seeds. After the seedcoats harden, the damaged seeds do not collapse even though all of the contents are removed. Microscopic examination reveals a very small hole in the seedcoat. Feeding on the mature seeds causes the tissues to shrink and to take on a spongy white appearance (Fig. 30b). This is readily detected on radiographs.

The adults emerge from hibernation in the spring and feed on the developing male flowers, causing them to become stunted or deformed. They pierce the pollen sacs and dissolve the immature pollen grains, causing necrotic areas around the feeding sites and thus reduce pollen production.

**Life History and Habits:** This insect is active and quite conspicuous. Neither the adults nor the brightly colored nymphs seek concealment. They tend to congregate on branch tips and cones on the sunny sides of trees. The adults are strong flyers and in flight produce a loud buzzing sound which, together with their size, manner of flight and the orange and black pattern of the upper abdomen, is strongly suggestive of a

bumblebee. They fly readily if disturbed.

There is one generation per year. Oviposition extends from late May to early July. The eggs are firmly glued in a row of 4 or 5 per needle on the host tree. They hatch in about 10 days. The nymphs feed upon the developing cones or seeds. They pass through five nymphal instars during the summer months and reach maturity by late August. The adults continue to feed on the ripening seed crop until the onset of cold weather and then seek sheltered locations in which to hibernate. They reappear about mid-May and feed on the 1-year-old cones and also on the developing male flowers of pines.

**Importance:** Heavy feeding by this insect lowers the quality of the seed crop, but the frequency of large populations and their impact on seed crops has not been documented. However, seed losses up to 41 percent have been recorded in Douglas-fir, and up to 26 percent in western white pine.

#### Family Pentatomidae - stink bugs

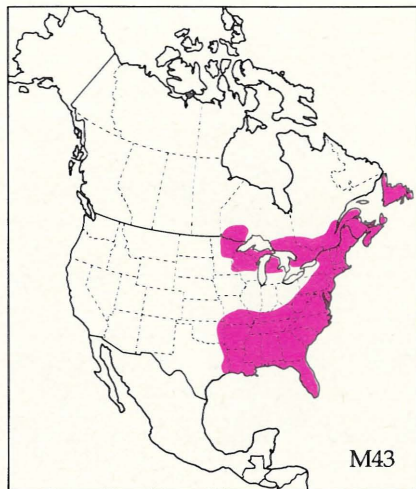
Members of this family are characterized by a shield-like outline. Some have an enlarged scutellum that essentially covers the wings; members of the genus *Tetyra* have this feature.

#### *Tetyra bipunctata* (Herrich-Schäffer) - shield-backed pine seed bug (16, 35, 37, 69, 71)

**Hosts:** eastern white, jack, loblolly, longleaf, pitch, red, shortleaf, slash and Virginia pines are known hosts; likely all pines in the eastern United States. (M43)

**Description:** Adult shield-shaped, about 11 to 15 mm long (Fig. 31a), and from yellowish to dark reddish brown, densely marked with dark pits and gray-black





mottling, producing an overall muted velvet-like color pattern; egg nearly spherical, about 1.4 by 1.7 mm, dark green changing to reddish as the embryo develops (Fig. 31b); egg operculum ringed with bead-like tubercles; nymphs broadly oval, rather flattened and tick-like in appearance; young nymphs grayish, older nymphs reddish brown with blackish mottling, more like the adult.

**Damage:** Nymphs and adults feed on seeds, but apparently may also feed on shoots. Damaged seeds may be partially or completely hollow.

**Life History and Habits:** This seed bug has a single generation per year, even in the southeastern United States, where the overwintered adults usually remain inactive until summer. Eggs are laid in summer in double rows on pine needles or on cones in groups of 8

Fig. 31 *Tetyra bipunctata*; (a) adult, (b) egg mass on loblolly pine cone. USFS.



to 14. First-instar nymphs do not feed. Succeeding instars and the adults feed upon the seeds of developing cones. In the later instars, the insect may also feed on shoots. In the fall, the new adults become gregarious, sometimes appearing in large numbers on a particular tree or groups of trees, where they feed on the maturing cones until entering hibernation under loose bark or logs.

**Importance:** Since this seed bug delays activity and reproduction until summer and produces only one generation per year, its damage to host seeds is more limited than that of the southern pine seed bug. Its habit of feeding gregariously in southern seed orchards in fall has been reported frequently. Such aggregations undoubtedly contribute heavily at times to late season seed damage which, at present, is indistinguishable from that of the southern pine seed bug.

## HOMOPTERA - aphids and scales

Homoptera are sucking insects rather like those in the order Hemiptera. However, they differ in having fore wings of similar texture throughout. Mouthparts arise from the ventral surface of the head. Many of the more important groups lack wings and have sac-like bodies covered by various waxy secretions. Metamorphosis is gradual.



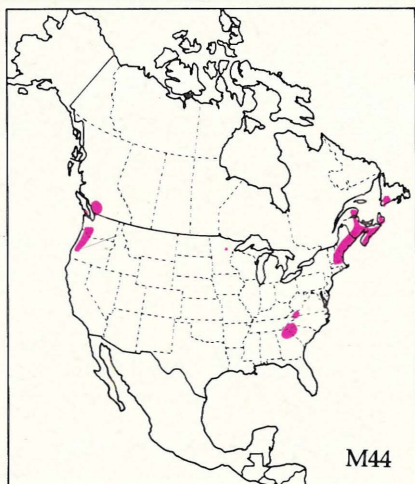
This order contains a large and diverse group of insects which suck liquids from the plant tissue. The life history of some Homoptera is very complex, involving bisexual and parthenogenetic generations, winged and wingless individuals and generations, and sometimes regular alternations of food plants.

#### Family Phylloxeridae - adelgids

Many members of this family have complex life cycles. The most commonly observed form of the insect is a minute, sac-like body covered with dense woolly wax. Winged adults may occur, usually in conjunction with sexual reproduction or dispersal between alternate host plants.

Very little is known about the direct or indirect effect of homopteran insects on cone and seed production of North American conifers, one noteworthy exception being the balsam woolly aphid, *Adelges piceae* (Ratzeburg) (57, 169, 205, 206). (M44). Hosts include balsam, Fraser, grand, Pacific silver, subalpine and other firs planted in the insect's range. While the balsam woolly aphid is recognized mainly as a pest of trees rather than cones and seeds, cone production of the balsam fir may be reduced significantly. Most homopterans have been noted by their conspicuous but apparently incidental appearance on cones such as *Adelges cooleyi* (Gillette), the cooley spruce gall aphid, on Douglas-fir cones (Fig. 32).

*Adelges lariciatus* (Patch) (66) is an eastern species that extends westward into Alberta. It attacks buds and cones of tamarack. Another species, *Adelges laricis* Vallot [*A. strobilobius* (Kaltenbach)], has been found in tamarack cones in New Brunswick (112). In the spring, when tamarack cones are open for pollination, some of the young nymphs enter the open cones and find suitable feeding sites. Damage is not externally visible, but appears as a desiccation of cone scale tissue at the feeding site. Apparently this does not affect seed production.



M44



Fig. 32 *Adelges cooleyi* on Douglas-fir cones. CFS.

#### Families Coccidae - soft scales, and Diaspididae - armored scales (44)

The Coccidae and Diaspididae are two of the largest families of the order Homoptera. Numerous species occur on forest trees, shade trees and ornamental shrubs, but few have been reported feeding specifically on cones of North American conifers. Of the scale insects that have been reported on cones, many are still not identified to species and nothing is known about their impact on cone and seed production and seed viability.

A soft scale, identified as *Toumeyella* nr. *corrugatum neglectum* (Pettit & McDaniel), is found on stalks of first-year conelets and early second-year cones of slash and longleaf pines in north Florida. Another scale, identified only as a species of *Toumeyella*, has been found on loblolly, shortleaf and slash pines (Fig. 33). These scales were not abundant and no distinct injury to cones has been associated with their occurrence.





Fig. 33 *Toumeyella* sp. scale on shortleaf pine cone stalk. USFS.

Several other scale insects found infrequently on cones or cone stalks of slash or longleaf pines are: *Diaspidiotus* sp. nr. *bumeliae* Ferris [*Aspidiotus* sp. nr. *bumeliae* (Ferris)]; *Acutaspis perseae* (Comstock); *Matsucoccus* sp. poss. *alabamiae* Morrison; *Oracella acuta* (Lobdell); (*Pseudococcus acutis* Lobdell); *Dysmicoccus* nr. *aciculatus* Ferris [*Pseudococcus* nr. *aciculatus* (Ferris)], and *Pseudophilippia quaintancii* Cockerell, the woolly pine scale (44).

## HYMENOPTERA - sawflies and seed chalcids

Adults have four membranous wings. Wing venation is sparse and hind wings are distinctly smaller than fore wings. Metamorphosis is complete. Mouthparts are of the chewing type. The larvae are quite

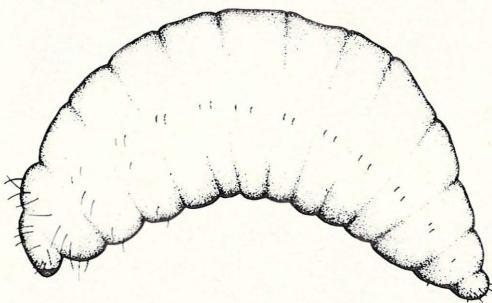


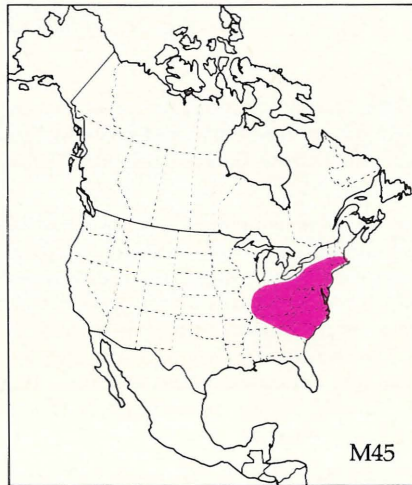
Fig. 34 A typical *Megastigmus* larva.

variable, those of the family Diprionidae resembling lepidopterous larvae, but with three pairs of legs on the thorax and six pairs of prolegs on the abdomen. Unlike those of Lepidoptera, prolegs do not bear terminal rows of hooks or "crochets". Larvae of the Xyelidae have head capsules but the legs are weakly developed or consist of only slight swellings. Larvae of the families Eurytomidae and Torymidae lack obvious head capsules and are grub-like or maggot-like (Fig. 34). Legs are absent. The pupa is frequently encased in a cocoon and resembles the adult.

In the family Torymidae, a single genus, *Megastigmus* — the seed chalcids — is of particular importance. The life cycle of *Megastigmus spermotrophus*, typical for the seed chalcids, is shown in Fig. 35. Three other families, Diprionidae, Eurytomidae and Xyelidae, are of minor importance.

### Family Diprionidae — conifer sawflies

Adults are typical sawflies, with broad transparent wings and without an obvious constriction between thorax and abdomen, as occurs in wasps. Females have sturdy serrated ovipositors. Larvae are caterpillar-like. They feed primarily on foliage, but may destroy flowering structures as well.



### *Neodiprion pratti pratti* (Dyar) - Virginia pine sawfly (18, 52)

*Hosts:* jack, loblolly, pitch, red, shortleaf and Virginia pines. (M45)

*Description:* Adult fly-like in appearance, but has two pairs of wings; body dark brown to black; egg flattened, about 2 mm in diameter; young larva pale green with shiny black head capsule; full-grown larva same color, but with row of black spots on each lateral surface and two longitudinal black stripes extending full length of dorsum, 16 to 23 mm long; pupa in oblong cocoon, 4 by 10 mm.



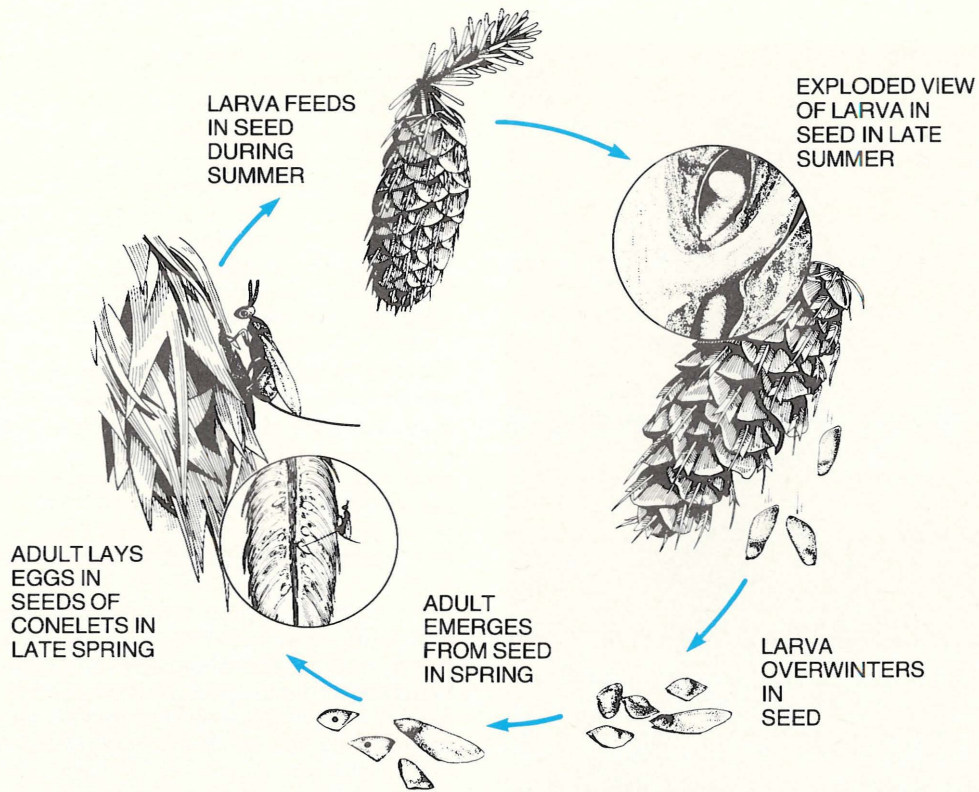


Fig. 35 Life cycle of *Megastigmus spermotrophus*.

**Damage:** This sawfly periodically causes extensive defoliation of pines; however, instances of feeding on both male and female flower buds and flowers have also been reported (Fig. 36).

**Life History and Habits:** This sawfly overwinters in the egg stage; hatching occurs in the early spring. Larvae feed on the needles and male and female flower buds. In mid-May, larvae mature, drop to the ground and spin cocoons in the surface litter or in the soil. Pupation occurs in September and the adults emerge in October and November. They are seldom observed in the field. The female deposits eggs individually in slits along the flat sides of pine needles.

**Importance:** Pollen loss is not considered to be important; however, mortality of female conelets can be serious. During two successive years, up to 10 percent of the female flower crop of shortleaf pine was destroyed in one area of Virginia.

***Augomonotenus libocedrii* Rohwer**, the incense-cedar cone sawfly (111, 172).

This sawfly has caused cone and seed losses of incense-cedar in California and Oregon. Very little is known about its biology or impact on seed production.



Fig. 36 Shortleaf pine flower buds killed by *Neodiprion pratti pratti*; larvae with black heads, below. USFS.



### Family Eurytomidae - eurytomids (172, 182)

There are records of members of this family in seeds of conifers, but few details on life history and habits exist. *Eurytoma conica* Provancher has been reared from seeds of western white pine, and *E. juniperina* Marcovitch has been reared from Utah juniper, western juniper and eastern redcedar. Undetermined species of this genus have been recorded from Douglas-fir and ponderosa and western white pines. The species reared from Douglas-fir seeds was apparently parasitic on the seed chalcid *Megastigmus spermotrophus* Wachtl.

### Family Torymidae - torymids

Females are small to moderate sized wasps, measuring up to 5 mm in length, with enlarged and elongate hind coxae, laterally compressed abdomens and very noticeable long ovipositors. Larvae are grub-like, legless with poorly defined body parts. Habits vary from parasitic to seed-feeding, being parasitic on hymenopterous and dipterous gall makers (Cynipidae and Cecidomyiidae), and phytophagous on seeds of various trees and other plants. Among the phytophagous species, the seed feeders are important economically.

Genus *Megastigmus* - seed chalcids (120, 168, 172, 182)

Those species of this genus which are phytophagous include pests of a wide range of conifers. All species are highly specialized in their method of attack and feeding habits. The type of damage caused is

characteristic of all members of the genus. There is no external evidence of damage on infested seeds, and there is little difference in weight between infested and normal seeds. Presence of larvae can easily be detected by radiography (Fig. 37). The adult (Fig. 39) is a small wasp with a large dilated knob-like, usually darkened, stigma on the anterior margin of the fore wing. The adult emerges by cutting a smooth round exit hole in the seedcoat, providing the only externally visible evidence that a seed has been infested (Fig. 38). One variation from this is exhibited by the Montezuma pine seed chalcid *Megastigmus grandiosus* which must bore, not only out of the seed, but to the surface of the cone which is still firmly closed at time of insect emergence.

*Megastigmus albifrons* Walker - ponderosa pine seed chalcid (66, 111, 114, 168)

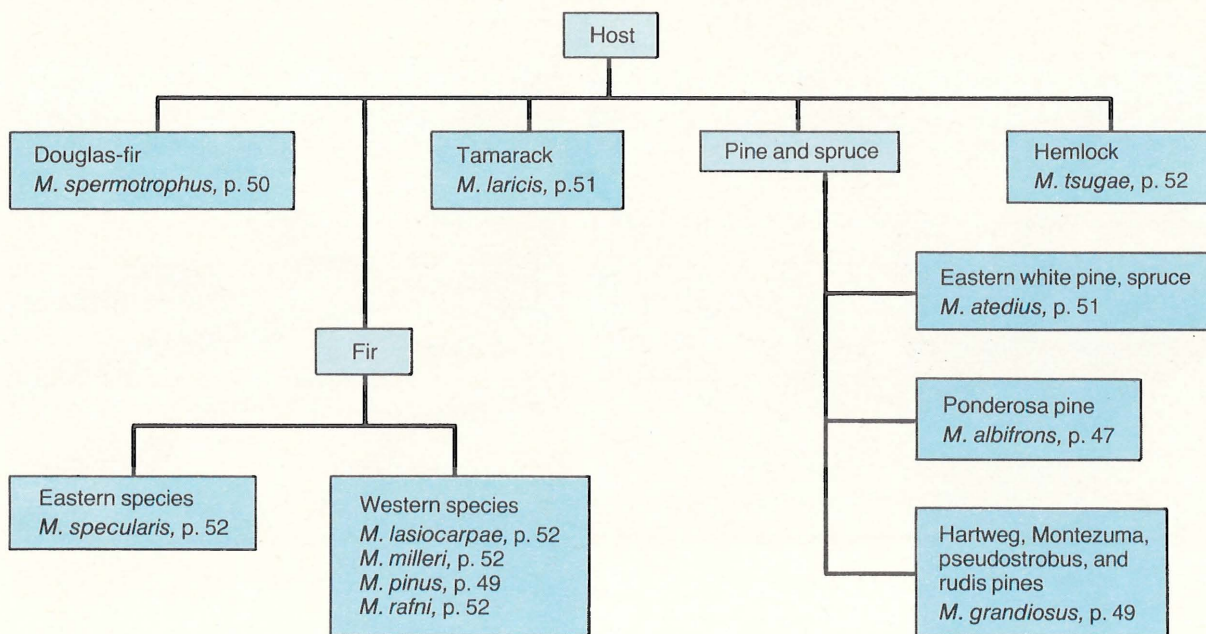
Host: ponderosa pine. (M46)

Description: Adult yellowish brown, 6 to 6.5 mm long, with clear wings; female has a black ovipositor, 4.5 mm long; males slightly smaller than females.

Damage: The contents of the seed are completely consumed by the larva.

Life History and Habits: Adults emerge from late March to May, depending on the location. The female inserts her ovipositor through the cone scales into the seeds of young cones to deposit eggs. As many as six eggs have been found in one seed but only one larva per seed completes development. Larvae are present in the seeds from early June and feed throughout the summer. Adults emerge in spring by chewing exit holes through the seedcoats. A small percentage of the in-

### KEY TO SEED-INFESTING MEGASTIGMUS





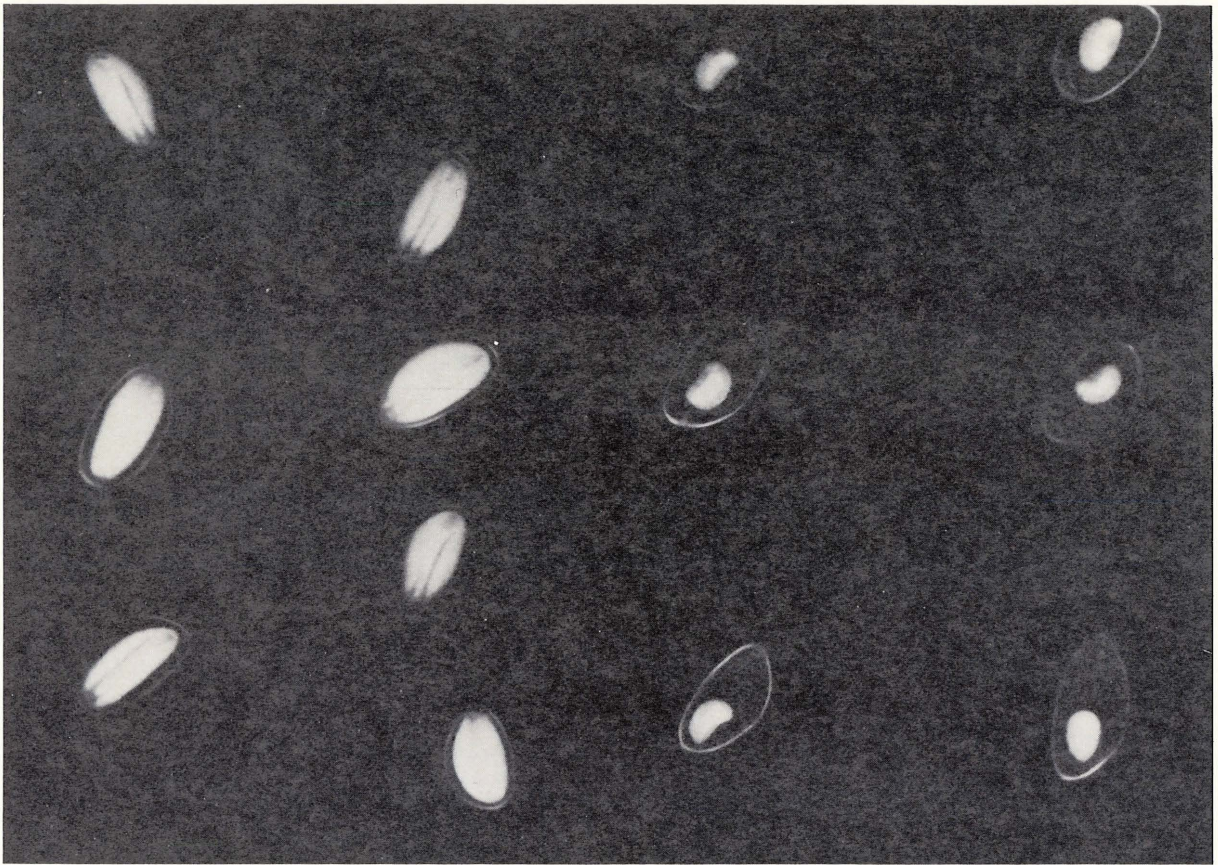


Fig. 37 Radiograph of eastern white pine seed infested with larvae of *Megastigmus atedius* (right), normal on left. USFS.



Fig. 38 Emergence holes of *Megastigmus specularis* in seeds of balsam fir. CFS.

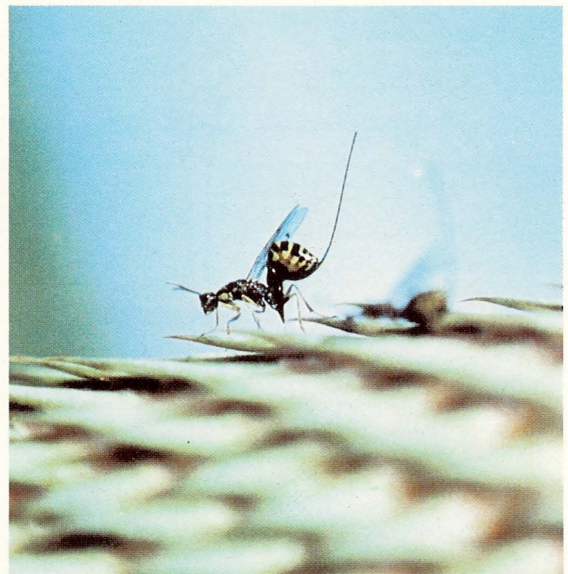
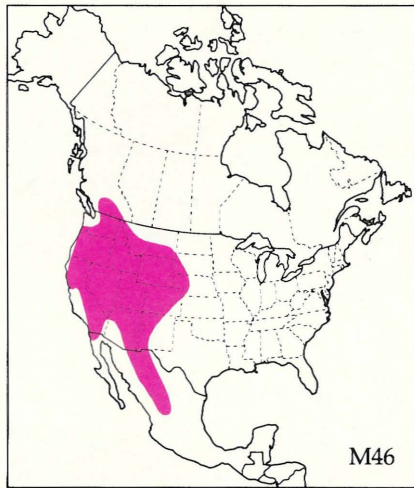


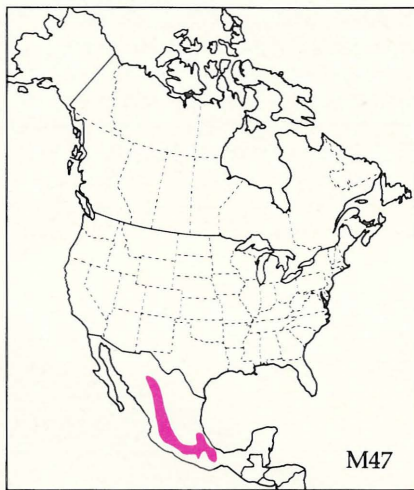
Fig. 39 *Megastigmus* adult ovipositing in noble fir cone. OSU.





sects remain in diapause and thus serve to carry the population through years when the host cone crop fails.

*Importance:* This chalcid has been reported to destroy up to 25 percent of the ponderosa pine seed crop. In New Mexico, from 1965 to 1967, an average of 17 percent of the cones were infested and 8 percent of the seeds in the infested cones were destroyed.



***Megastigmus grandiosus*** Yoshimoto - Montezuma pine seed chalcid (237)

*Hosts:* Hartweg, **Montezuma**, pseudostrobus and **rudis** pines. (M47)

*Description:* Adult 5 to 7.5 mm long, ovipositor of female curved, almost as long as body; egg small, whitish; larva curved, segmented, whitish, about 6 mm long; pupa whitish at first, later turning dark.

*Damage:* At time of adult emergence, the cone is still tightly closed so each insect must tunnel, not only out



Fig. 40 Emergence holes of *Megastigmus grandiosus* from mature Montezuma pine cone. UACH.

of the seed, but to the exterior of the cone (Fig. 40).

*Life History and Habits:* Adults are present from December to May, with peak emergence occurring during January. Females oviposit in 1- or 2-year-old cones from February to May. Frequently ovipositors remain protruding from the cone, indicating that oviposition has occurred. Larvae are present in seeds from April to October and pupae from October to December.

*Importance:* This seed chalcid is a major seed destroyer in Montezuma pine and is important in rudis pine, but of less importance in the other hosts. Up to 57 percent of Montezuma pine seed has been destroyed by this insect.

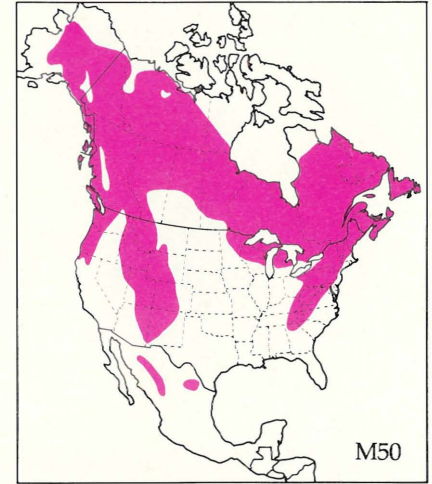
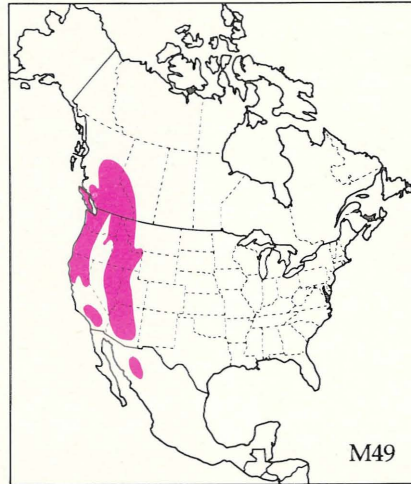
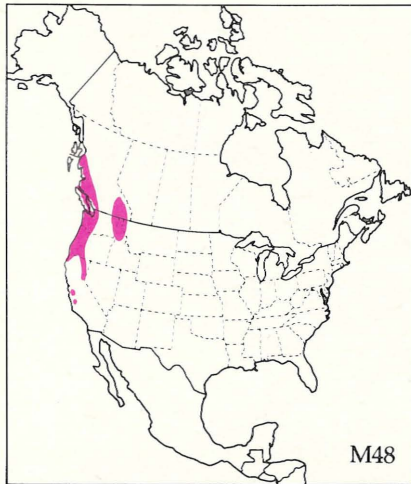
***Megastigmus pinus*** Parfitt - fir seed chalcid (66, 84, 87, 111)

*Hosts:* bristlecone, **grand**, noble, Pacific silver, Shasta red, subalpine and white firs. (M48)

*Description:* Adult black with yellow markings, female about 5.1 mm long; egg about 2 mm long.

*Damage:* Each larva consumes the contents of a single seed, leaving no external evidence of damage (Fig. 41). Infested seeds are about the same weight as normal seeds. A clean round hole is cut in the seedcoat by the emerging adult.





**Life History and Habits:** The adult emergence period may be from mid-April to mid-June, depending on location, and continues for about 1 month. The adult chalcid oviposits in cones which are 2 to 5 weeks old, depositing an egg in a developing seed. Females may live for about 14 days and males somewhat less. The egg hatches in 3 to 5 days. The larva passes through five instars and matures in 6 to 8 weeks, each larva remaining within an individual seed. The mature larva passes the winter in the seed. Pupation and adult emergence take place in early spring. A variable portion of the population, as much as 50 percent, may remain in the larval stage for another year or longer.

Larvae of this species can be separated from those of *M. rafni* Hoffmeyer when both are present in seeds of grand fir. Females of *M. pinus* oviposit about 3 weeks earlier than *M. rafni* and therefore larvae are more advanced; *M. pinus* lays its eggs near the micropyle and *M. rafni* at the opposite end of the seed; mature *M. pinus* larvae are extremely active when disturbed and, by contrast, *M. rafni* are very sluggish. Because of the earlier development of *M. pinus*, the larva of this species destroys that of *M. rafni* when both are feeding in the same seed.

**Importance:** This insect is an important destroyer of seed of grand fir and probably other species. Observations show that it is much more serious than *M. rafni* in grand fir; however, its cannibalistic tendencies may account for this difference.

***Megastigmus spermatrophus* Wachtl** - Douglas-fir seed chalcid (41, 66, 82, 83, 87, 101, 106, 111, 126, 160, 168, 190, 192, 199)

**Hosts:** bigcone Douglas-fir, **Douglas-fir.** (M49)

**Description:** Adult 3.4 mm long, body yellow, reddish eyes.

**Damage:** Infested seeds are identical to normal seeds in size and color and show no external evidence of damage. They may be slightly lighter in weight, but the

difference is so small as to be within the normal range of variation of uninfested seeds. When the adult has emerged, a clean-cut exit hole remains as evidence of seed chalcid infestation (Fig. 42b).

**Life History and Habits:** The emergence period may be from mid-April to late May, depending on location, and continues for about 1 month (Fig. 35). The adults have been reported to feed on the excretion of adelgids and flower nectar, but it is not certain that they must feed to produce viable eggs. The sex ratio is normally 1:1 but unmated females are capable of producing viable eggs; all of which develop into males. The female inserts her ovipositor through the scales of young cones to deposit an egg in the developing seed. Each female may lay up to 150 eggs. Normally, only one egg is laid per seed, but if more are deposited, only one larva will reach maturity. The egg hatches in 3 to 5 days. The larva passes through five instars and



Fig. 41 *Megastigmus pinus* larva in red fir seed. USFS.





Fig. 42 *Megastigmus spermotrophus*; (a) larva in Douglas-fir seed, (b) adult emergence holes in Douglas-fir seed. USFS.

matures in 6 to 8 weeks, each insect remaining within an individual seed and consuming the entire contents. The mature larva overwinters in the seed (Fig. 42a) and pupates there in early spring. As much as 20 percent of the population remains in diapause in the larval stage for another year or longer.

**Importance:** This insect is a major seed-destroying pest of Douglas-fir. Extent of damage varies, but is frequently in the range of 2 to 15 percent of the seed crop. It is difficult to distinguish and separate infested from normal seeds because there is no difference in external appearance prior to adult emergence and weight difference is slight. As a result, this insect has been widely distributed in seed shipments and has become an established pest in many countries of the world where Douglas-fir has been planted.

#### Other species of *Megastigmus*:

A number of other seed chalcid species are pests. Most conifers, other than firs, have only one species infesting the seeds, leaving little doubt as to the identity of the seed chalcid at any stage of development. However, firs may be infested by several species, which may make identification more difficult.

***Megastigmus atedius* Walker (*M. piceae* Rohwer)** (52, 209, 221)

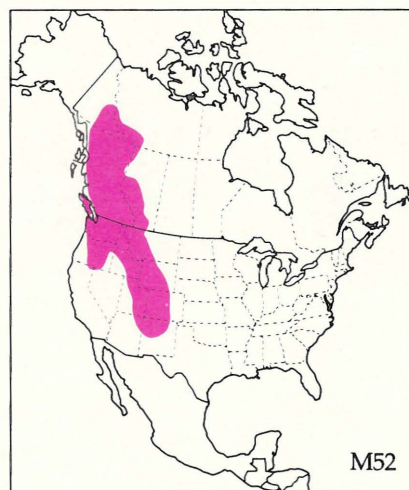
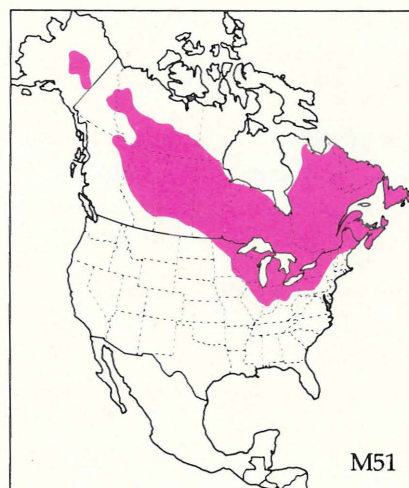
**Hosts:** eastern white pine and spruce. (M50)

**Comment:** Occurs in Canada and northern United States.

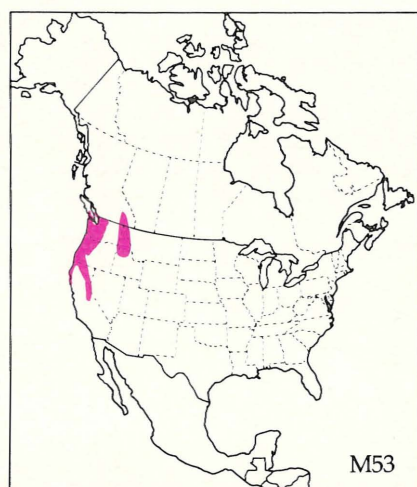
***Megastigmus laricis* Marcovitch (4)**

**Host:** tamarack. (M51)

**Comment:** Adult black and yellow; occurs in Canada and northern United States.







***Megastigmus lasiocarpae*** Crosby (111, 122, 125, 190)

*Hosts:* Pacific silver and subalpine firs. (M52)

*Comments:* Adult black and yellow; occurs in Colorado, Washington, British Columbia and Alberta.

***Megastigmus milleri*** Milliron (66, 111, 168)

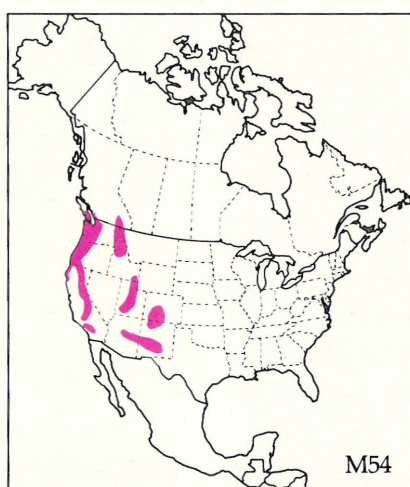
*Hosts:* grand and Shasta red firs. (M53)

*Comments:* Adult black and yellow, similar to *M. pinus* but smaller; occurs in California and British Columbia.

***Megastigmus rafni*** Hoffmeyer (66, 84, 87, 111)

*Hosts:* California red, grand, Shasta red, white and probably other fir species. (M54)

*Comments:* Records of *M. spermotrophus* reared from the seeds of fir almost certainly represent misidentified specimens of *M. rafni*; occurs in California, Oregon, Idaho, Colorado, New Mexico and British Columbia.



***Megastigmus specularis*** Walley - balsam fir seed chalcid (77, 168) (M55)

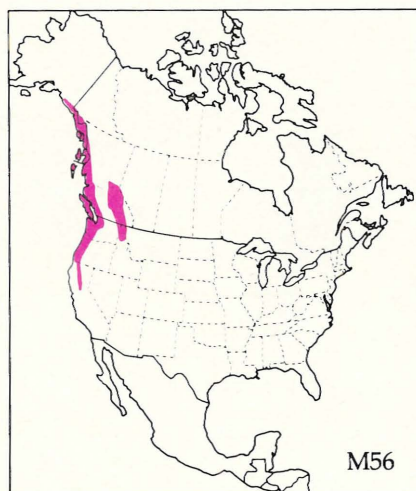
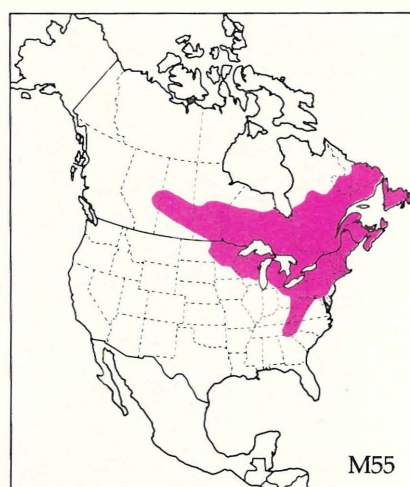
*Hosts:* balsam and Fraser firs and eastern white pine.

*Comments:* Adult black, yellow and brown; occurs in Canada and northern United States.

***Megastigmus tsugae*** Crosby (66, 111)

*Hosts:* mountain and western hemlocks. (M56)

*Comments:* Adult black and yellow. There are few records of damage by this species and it does not usually cause serious losses. It has been recorded from Oregon and Washington.



### Family Xyelidae - xyelid sawflies

These sawflies are superficially similar to the common sawflies of the family Diprionidae in that they have short broad bodies and paired tibial spurs. The xyelids are easily distinguished from other sawflies by the antennae, the third segment large and elongate with a varying number, depending on the genus, of considerably smaller terminal segments. Members of one genus, *Xyela*, commonly infest male flowers.

***Xyela* spp.** - pine catkin sawflies (20, 48, 74, 120, 172)

Larvae feed in the developing male flowers of pines. Adults may be about 5 mm long, exclusive of the saw-like blades of the ovipositor of the female. It is presently not possible to identify different species on the basis of larval characters. About 16 species are known in the United States and Canada. Of these, six species are either transcontinental or eastern, and the remainder are western. All have similar life cycles and cause similar damage.

*Description:* Adults variably yellow to black, frequently with contrasting markings; wings transparent, broad blades of the ovipositor conspicuous; eggs white, more



or less oval-elongate; larva about 7 mm long or less, white to creamy with brown head capsule, grub-like in general appearance and has rudimentary abdominal prolegs.

**Damage:** Infested male flowers may be obviously deformed by the effects of egg laying. Small flecks of pitch may also be extruded at the point of ovipositor entry (Fig. 43a). Larvae are often present in extracted pollen (Fig. 43b).

**Life History and Habits:** Adults emerge in early season and first feed upon pollen of various wind pollinated plants such as willow, alder or even early flowering pines. As the male flower buds of pine start to elongate, the female sawflies begin laying eggs in them, singly. When the eggs hatch larvae move from pollen sac to pollen sac, chewing them open and eating the pollen. Larvae develop rapidly in 2 to 4 weeks, emerging as mature larvae when the male flowers shed pollen. Emerging larvae drop to the soil and burrow as deep as 75 mm, where they remain in earthen cells as prepupae for 1 to 2 seasons before pupating. The pupae wriggle to the surface prior to adult emergence.

**Importance:** Pollen production is probably not appreciably reduced by larval feeding; however, on particular clones used in artificial breeding work, these insects could significantly reduce or possibly contaminate available pollen.

Fig. 43 *Xyela* sp.; (a) damaged male slash pine flowers (note resin droplets and sunken areas), (b) larvae emerged from drying male slash pine flowers. USFS.





### Species of *Xyela* that occur on pines in North America

Species	Range	Host
<i>X. alberta</i> (Curran) (20)	Alberta, Montana, Wyoming	lodgepole.
<i>X. alpigena</i> (Strobl) ( <i>X. brunneiceps</i> Rohwer and <i>X. middlekauffi</i> Burdick) (20)	Quebec, Ontario, New York, Maryland, Illinois, Colorado	eastern white; in Colorado the host is not known.
<i>X. bakeri</i> Konow (20, 48, 74)	Quebec south to Florida and eastern Texas; Ontario, Michigan; Washington south to New Mexico and British Columbia south to California	Digger, longleaf, ponderosa, slash and Virginia.
<i>X. californica</i> Rohwer (20)	California, Oregon, Idaho and Utah	Coulter.
<i>X. cheloma</i> Burdick	Idaho, Nevada, British Columbia, Washington, Oregon, California	ponderosa.
<i>X. concava</i> Burdick (20)	California	singleleaf pinyon.
<i>X. deserti</i> Burdick (20)	California	singleleaf pinyon.
<i>X. dodgei</i> Greenbaum (74)	Florida	unknown.
<i>X. linsleyi</i> Burdick (20)	Idaho, Washington, California	ponderosa.
<i>X. lunata</i> Burdick (20)	California	Digger and probably Coulter.
<i>X. minor</i> Norton-pine flower sawfly (20, 48, 74)	Quebec, Ontario south to Texas; Washington south to New Mexico; British Columbia south to California	bishop, Coulter, Digger, longleaf, ponderosa, singleleaf pinyon and slash.
<i>X. obscura</i> (Strobl) ( <i>X. pini</i> Rohwer) (20, 48, 74)	Newfoundland and Ontario south to Florida and east Texas; Northwest Territories to Alberta, Montana, British Columbia south to California	jack, loblolly, longleaf, ponderosa and Virginia.
<i>X. priceae</i> Burdick (20)	California	Coulter.
<i>X. radiatae</i> Burdick (20)	California	Monterey.
<i>X. serrata</i> Burdick (20)	California	bishop and knobcone.
<i>X. styrax</i> Burdick (20)	Maryland, Virginia, Georgia	Virginia.

## LEPIDOPTERA - Moths

Adults have four membranous wings almost wholly covered with minute overlapping scales. Mouthparts of most species consist of a long tube-like structure that is coiled when not in use. Moths commonly fly at night, and usually close their wings around their bodies or hold them horizontally when at rest. Antennae are thread- or feather-like. Metamorphosis is complete. Larvae are commonly called caterpillars (Fig. 44). They are usually cylindrical with well-developed heads, and chewing mouthparts; three pairs of thoracic legs, up to five pairs of abdominal prolegs; the prolegs are short and fleshy and bear a number of tiny hooks or "crochets" apically. Larvae produce silk to construct cocoons or shelters. Pupae are compact with appendages fused to the body.

A greater number of important cone- and seed-feeding insect species occur in this order than in any

other. Characteristically, the larvae tunnel within the cones, feeding on scales, bracts and seeds. Feeding by a variety of lepidopterous species may cause losses of all stages of seed-producing structures. There may be little external evidence of damage in spite of internal feeding, or there may be considerable evidence in the form of discolored scales, frass and webbing. Often there is an opening to the surface through which pitch may exude and frass be discharged.

### Family Blastobasidae

Adults are small moths with narrow fringed wings. Members of this family are relatively unimportant pests of cones and seeds. Most are scavengers in the larval stage.

#### *Holcocera lepidophaga* Clarke (24, 44)

*Hosts:* longleaf and slash pines, and possibly other eastern hard pines. (M56a)



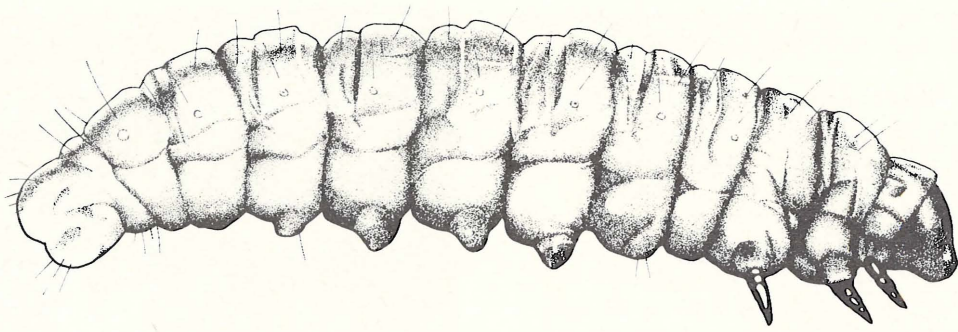


Fig. 44 A typical Lepidoptera larva.

**Description:** Adult wingspan 11 to 17 mm; wings glossy golden-tan, except for leading edge of fore wings, bordered by long, pale, buff-colored scales (Fig. 45a); mature larva 8 to 11 mm long, purplish brown.

**Damage:** Male flower buds and flowers are mined.

**Life History and Habits:** Larvae bore into the male flower buds and flowers but rarely in the female flowers. Silken tubes are constructed by the larvae among the buds. Frass and fine webbing are often evident among infested male flower clusters (Fig. 45b). Larvae also feed on the dry scale-leaves of buds, shoots and cone stalks, and in diseased cones or cones deteriorating following attack by other insects. Occasionally, larvae prey on *Toumeyella* scale insects on cone stalks. Several generations occur annually in Florida.

**Importance:** This insect is not a major pest affecting seed production of pines.

Minor *Holcocera* species include:

***Holcocera augusti*** Heinrich (66, 92, 111)

This species is found on Douglas-fir. The larva is about 12 mm long and dark red or reddish brown, with

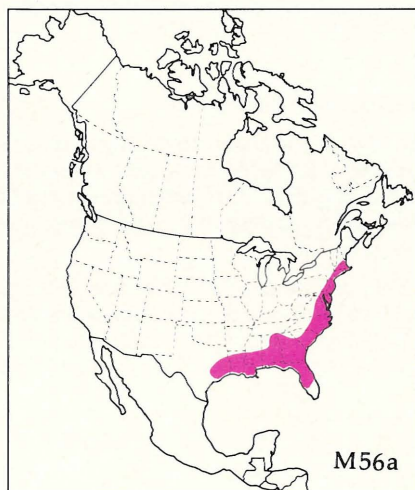


Fig. 45 *Holcocera lepidophaga*; (a) adult, (b) larva feeding in male slash pine flowers. USFS.



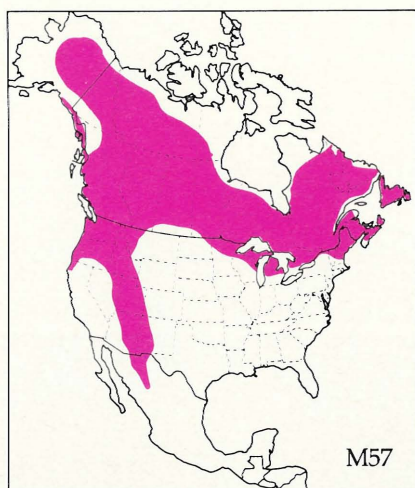
a dark brown head. Larvae feed in cones during the summer but are probably only secondary pests.

***Holcocera immaculella*** McDunnough (135, 189, 192)

This species feeds on cones of Douglas-fir; jack, lodgepole and red pines. It is not a serious pest.

### Family Cochylidae

Adults similar to Olethreutidae but differing by reduced wing venation. Larvae of many species are borers of herbaceous plants. Only a few species are important cone and seed pests.



***Henricus fuscodorsana*** (Kearfott) - cone cochylid (66, 111, 192)

**Hosts:** Douglas-fir; western larch; redwood; Sitka and white spruces. (M57)

**Description:** Adult wingspan 16 to 18 mm (Fig. 46); mature larva 10 to 16 mm long, green with conspicuous white spots.

**Damage:** Larvae feed in the cones, damaging scales and seeds.

**Life History and Habits:** Moths emerge in the spring from early May until early July. They may lay eggs from late April through July, depending on the locality; the peak period of oviposition is late June. Larvae leave the cones and pupate during the fall, probably in October and November.

**Importance:** This insect is capable of causing up to 10 percent loss of the seed crop.

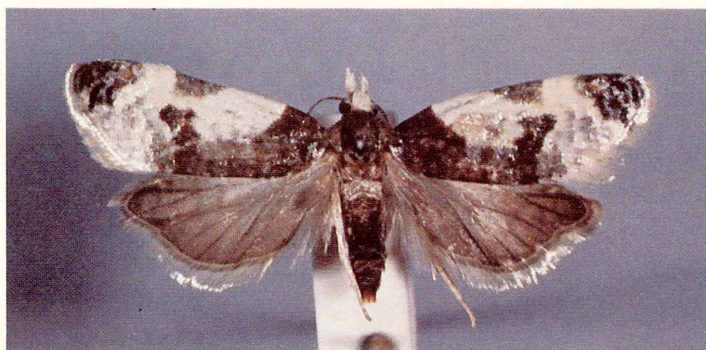
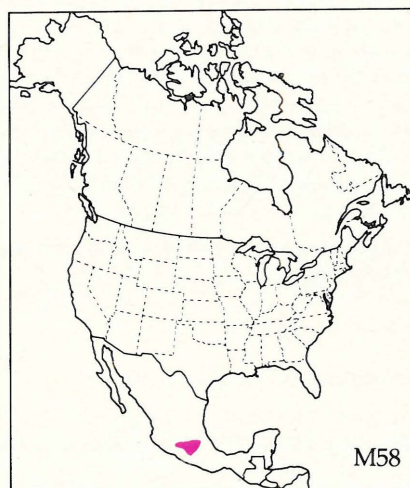


Fig. 46 *Henricus fuscodorsana* adult. USFS.

Other species:

***Henricus macrocarpana*** (Walsingham) (61) is a pest of Monterey cypress in California. The larva feeds on seeds in young cones. There are at least two undescribed Mexican species of the family Cochylidae which are designated simply as species A and B.



Species A <sup>1/</sup>

**Host:** Mexican white pine. (M58)

**Description:** Adult wingspan 16 to 20 mm (Fig. 47); fore wing light gray with three broad gray transverse lines; mature larva about 10 mm long, greenish blue with conspicuous setae; abdomen of young pupa greenish, later turning brown.

**Damage:** This insect attacks cones that are 1½ years old. Each larva bores singly in a scale toward the cone axis until it reaches a seed, but usually does not feed on the seed. If the attack is light, frass is present only near

<sup>1/</sup> This and other species which have not been identified at this time are listed in alphabetical order.





Fig. 47 Species A adult. CFS.

the base of the cone, but when severe, it is present on all cone scales. There may be up to 30 larvae per cone.

**Life History and Habits:** There are probably two generations per year. Adults emerge in abundance during January and February and lay eggs during February and March near the base of 1½-year-old cones. Larvae are present from March to July and pupae during July and August. A few moths emerge in August and lay eggs on mature cones. Larvae of this second generation are present from September to November. Pupae are present in December in delicate cocoons in the larval feeding tunnels.

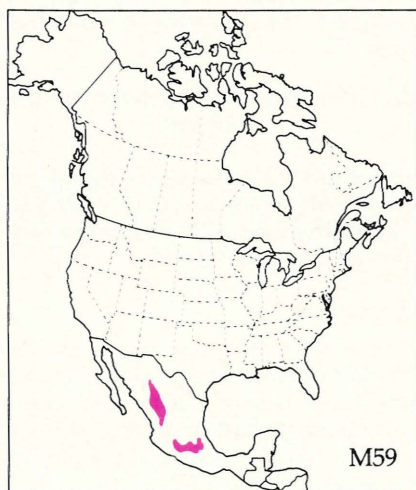
**Importance:** This is the most important pest of cones of Mexican white pine. Although it does not feed on seeds, losses are significant because high populations and severe attack on scales kill the cones.

#### Species B

**Host:** white cypress. (M59)

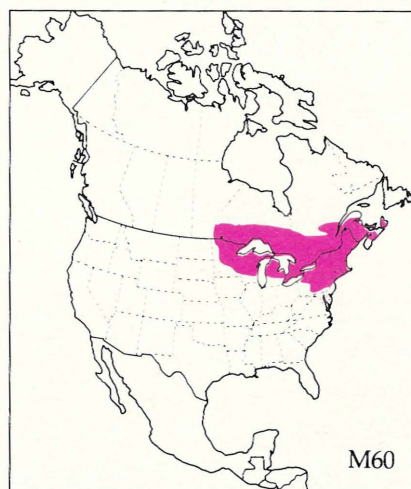
**Description:** Adult wingspan about 20 mm; grayish with broad light-colored transverse bar on fore wing.

**Comments:** The larva draws two or three cones together with silken threads; it makes irregular galleries through the cones, feeding on seeds and scales, and the entire mass becomes filled with frass.



#### Family Gelechiidae - gelechiid moths

Adults are small moths with narrow fore wings and wider blunt hind wings. Members of this family are of little importance as cone and seed pests.



**Exoteleia nepheos** Freeman - pine candle moth (65, 128)

**Hosts:** red and Scotch pines. (M60)

**Description:** Adult wingspan 9 to 11 mm; fore wings golden brown with three grayish and white granular transverse bands, fringe on fore wings dark gray; hind wings blackish with dark gray fringe; head and thorax shiny steel-gray (Fig. 48); egg 0.2 by 0.5 mm, cylindrical with rounded ends, patterned with fine granulations, silvery white becoming yellowish as embryo develops; mature larva 6.5 mm long, body pale yellow with reddish hue; pupa yellow-brown, somewhat flattened, about 4 mm long.

**Damage:** This insect is a needle miner throughout most of its larval development, but mines in male flowers and vegetative buds prior to pupation. Larval feeding stunts the growth of new shoots, giving branches a tufted appearance.



Fig. 48 *Exoteleia nepheos* adult. CFS.



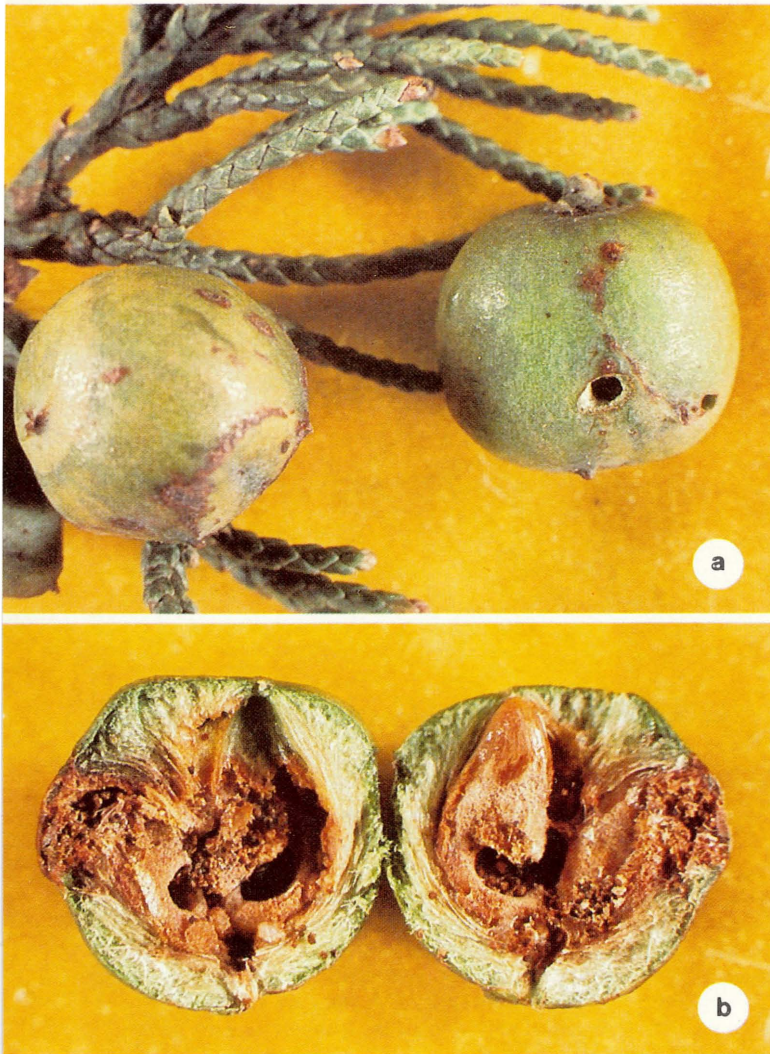


Fig. 49 Species C; (a) larval emergence holes from alligator juniper cone, (b) cone bisected to show damage. UACH.

*Life History and Habits:* Adult flight occurs from early July to early August in southern Ontario. Eggs are usually laid singly on the needle sheaths of the previous year's foliage or occasionally under loose bark scales of twigs. In early August, the first instar mines along the edges of the apical portion of the needle. The entrance hole to the mine is covered with silk and occurs on the flat side of the needle. By mid-November, the larva is in the fourth instar which overwinters in the needle mine. In the spring, the larva vacates this mine and enters the same needle at a lower point or an adjacent needle. It ceases mining by mid- to late-May, when it migrates to and feeds in male flowers or elongating vegetative buds. Pupation occurs in mid-June in the male flowers and buds which have been honeycombed by the larvae.

*Importance:* This insect destroys much pollen when trees are severely infested, but nothing has been recorded on its impact on female flower production or seed yield and quality in seed production areas.

### Species C

*Host:* alligator juniper.

*Description:* Adult wingspan about 10 mm; fore wing light brown, hind wing plumose; larvae about 6 to 7 mm long, light reddish when mature.

*Damage:* Each larva infests a single cone and destroys all the seeds (Figs. 49a, b). Infested cones change from green to brownish. After the adult has emerged, the pupal skin remains on the surface of the cone.

*Life History and Habits:* Adults are present during July and early August. Larvae occur from July to May, and pupae from May to July. Larvae pupate within the cones. A single generation occurs each year.

*Importance:* The insect is very abundant and destroys about 50 percent of the juniper cones where it occurs in central Mexico. However, alligator juniper is not an important tree species.

### Other species:

*Chionodes sabinianae* Powell (21, 66) mines male flowers of Digger pine in California.

*C. periculella* (Busck) mines in cones of pinyon and ponderosa pine and Douglas-fir.

*Duvita vittella* Busck (25, 44) has been reared from dead eastern white pine cones. It is doubtful that this species is of any importance as a cone and seed insect.

*Exoteleia burkei* Keifer, the Monterey pine shoot moth (21, 66), occurs on several species of pine in California. Early larval instars mine the needles, and later feed in bud shoots and male flowers.

*Periploca atrata* Hodges (184) has been reared from cones of alligator and California junipers in California and Arizona.

### Family Geometridae - measuring worms or loopers

Larvae of this family usually have only two well-developed pairs of prolegs and they move by a looping process. Adults have broad wings, frequently marked by fine contrasting transverse lines.

### Genus *Eupithecia*

A few members of this genus are cone borers. In general, these are similar in appearance and have similar life cycles. Adults are medium-sized, grayish, with distinct wing crossbanding of varying shades of brown (Fig. 50). They are not usually abundant so are not considered serious pests.





Fig. 50 *Eupithecia mutata* adult. USFS.

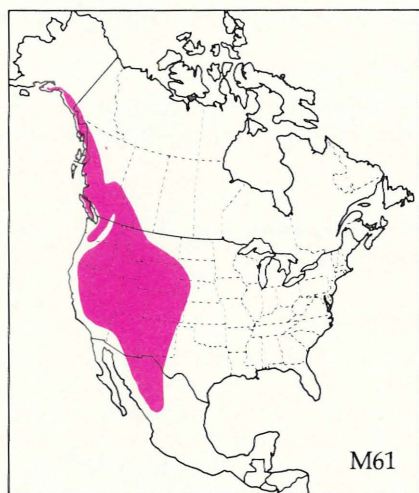
***Eupithecia spermaphaga* (Dyar) - fir cone looper**  
(66, 109, 111, 138, 141)

**Hosts:** Douglas-fir; California red, Pacific silver and white firs; mountain hemlock; ponderosa and western white pines. (M61)

**Description:** Adult wingspan 20 to 25 mm; wings gray; the fore wings have irregular reddish brown bands near both extremities; hind wings speckled with brown, bordered with broken black line at apical end; body reddish brown; larva pale greenish or gray, about 20 mm long; pupal cocoon formed on surface of cone or on ground.

**Damage:** The larva bores large tunnels through scales and seeds.

**Life History and Habits:** The adult emerges in spring and



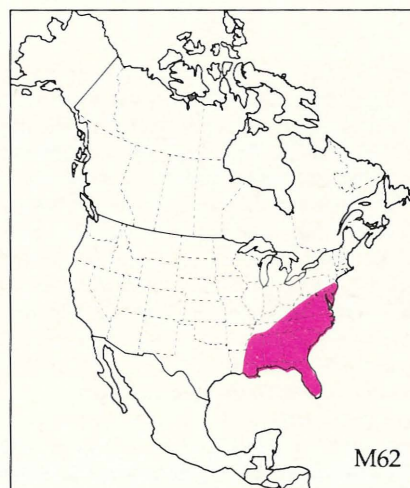
lays eggs on young cones. The larvae feed during summer and pupate in fall.

**Importance:** Although this insect may infest a high percentage of cones and destroy up to 10 percent of the seeds in infested cones, it is not generally a serious pest.

Other cone-feeding species include: *E. mutata* Pearsall (137, 138, 141, 190) (Fig. 50), attacking balsam fir and blue and white spruces; *E. albicapitata* Packard (109, 111, 137, 138, 190) attacking Douglas-fir; balsam fir; western hemlock; lodgepole pine; black, Engelmann and white spruces; and *E. columbrata* McDunnough (137, 138, 190) attacking Pacific silver and subalpine firs; western hemlock; lodgepole pine; white and Sitka spruces. All are believed to be insignificant solitary cone feeders.

**Genus *Nepytia***

This is another genus of defoliators of which one species has adapted to regular feeding upon female flowers and conelets.



***Nepytia semiclusaria* (Walker) - pine conelet looper**  
(44, 51, 55, 96, 234)

**Hosts:** loblolly, sand, shortleaf and slash pines. (M62)

**Description:** Adult wingspan 25 to 30 mm; wings grayish tan, fore wing crossed by pair of brown scalloped lines, a single similar line occurs on hind wing (Fig. 51a); egg pale green, oval, slightly flattened; mature larva 25 to 30 mm long or, in Florida, up to 50 mm; vividly marked with broad, brick-red dorsal stripe flanked by paired bright yellow lateral stripes separated by a series of fine black and white lines; head and prolegs bright orange, spotted black; thoracic legs orange (Fig. 51b); earlier instars less vividly marked; pupa tan, streaked and mottled with white.

**Damage:** Larvae feed on or completely devour pine female flowers and conelets or foliage (Fig. 51c).



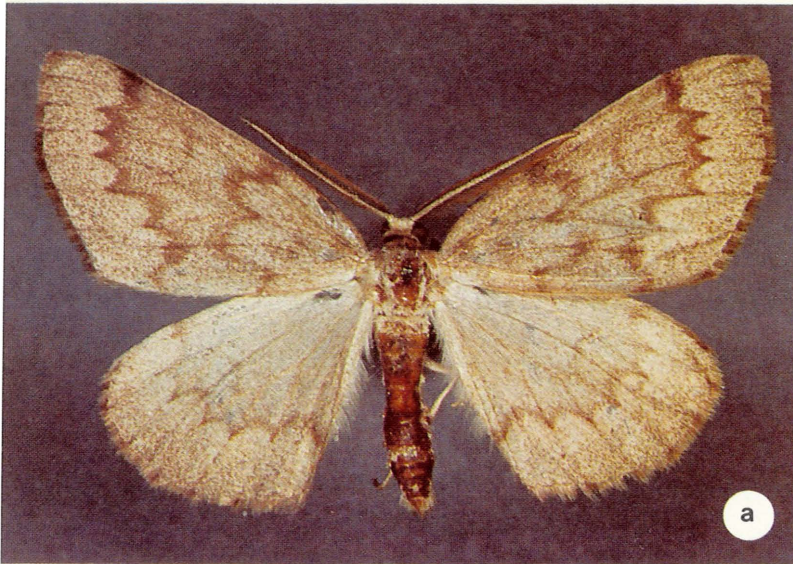


Fig. 51 *Nemytia semiclusaria*; (a) adult, (b) mature larva, (c) killed and damaged shortleaf pine conelets. USFS.

**Life History and Habits:** This insect overwinters in the egg stage. Eggs hatch in the spring and the larvae feed on the female flowers of slash, loblolly, shortleaf and possibly sand pine. At this time, the flowers comprise one of the most succulent materials available. In slash pine, the larvae soon disperse to new foliage, where they feed until they are mature. In sand pine, old-growth is the principal larval food. In loblolly and shortleaf pines, however, the developing larvae continue to feed on the conelets throughout larval development. No evidence of foliar feeding has been observed on these two pines, although the larvae tend to retreat onto foliage when not feeding.

The mature larva spins coarse strands of silk to form a very open web-like shelter in which it pupates. Pupation occurs from late spring to early summer in southeastern United States. Moth emergence occurs in late spring to early summer and adults are frequently caught in light-traps during this season.

**Importance:** Flower damage to slash pine seems to be occasional. In loblolly and shortleaf pines, the continuous larval feeding on the conelets increases the damage. The year-to-year occurrence of noticeable damage tends to be sporadic.

#### Family Olethreutidae - olethreutid moths

Adults are small to moderate-sized moths, often with barred or mottled fore wings. Wings are moderately broad, the fore wings truncated at the apex. The species are technically separated from the closely related Tortricidae by a fringe of long hairs on the mid-wing area of the underside of the hind wing. Larvae tend to be borers in various plant tissues. Some



members of this group are very important pests (92).

#### Genus *Barbara* - cone moths

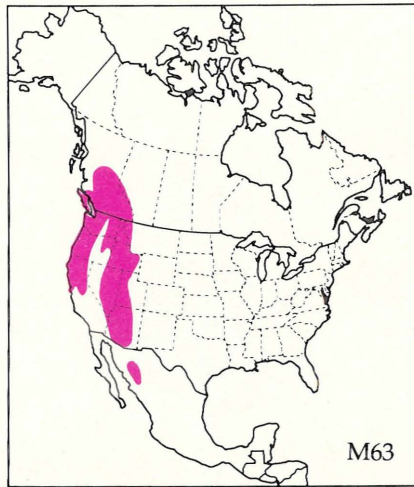
This is a small though important genus, members of which are pests of a relatively small number of host species.

***Barbara colfaxiana* (Kearfott) - Douglas-fir cone moth** (23, 79, 82, 83, 87, 93, 106, 110, 111, 176, 189, 192)

**Host:** Douglas-fir. (M63)

**Description:** Adult wingspan 15 to 20 mm; grayish brown with fore wings transversely banded with gray, silver and brown (Fig. 52a); egg about 0.7 by 0.8 mm, pearl colored, with dimpled surface, oval; attached to surface of cone bract by glue clearly visible around egg (Fig. 52b); larva whitish with black head capsule in first





instar; pinkish to yellowish with brown head capsule in final instar; pupa dark reddish enclosed in tough pitch-coated cocoon.

*Damage:* External evidence of damage differs, depending to quite an extent on cone size. Damage is usually more easily noticed in the smaller cones, characteristic of trees growing in interior regions. These cones may be misshapen and there is usually frass on the surface, indicating the presence of one or more larvae. Larger cones common on trees in wetter coastal areas frequently have no external evidence of damage even though one or several larvae may be feeding within. Douglas-fir cones are frequently coated with pitch; this

Fig. 52 *Barbara colfaxiana*; (a) adult, CFS, (b) egg on cone bract, USFS, (c) bisected Douglas-fir cone showing larva and damage. CFS.





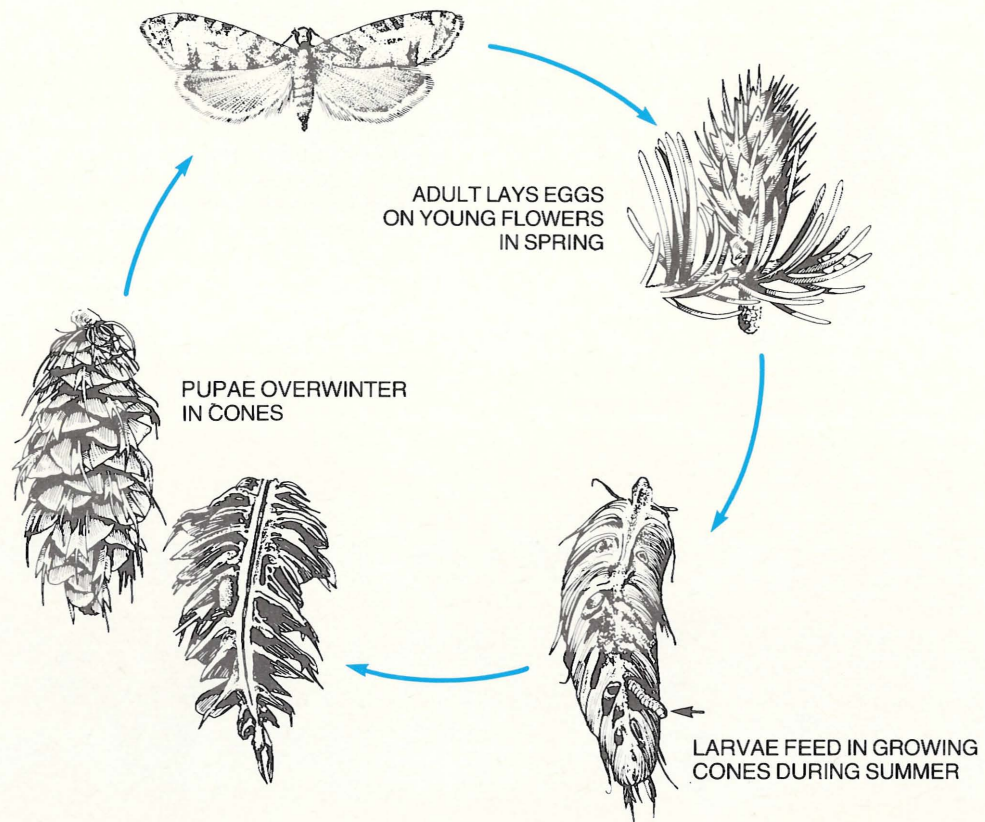


Fig. 53 Life cycle of *Barbara colfaxiana*.

is common on normally developing cones therefore is not necessarily an indication of insect infestation. Damage can be readily detected by bisecting cones longitudinally (Fig. 52c).

*Life History and Habits:* The moth emerges in spring when Douglas-fir flowers are being pollinated (Fig. 53). Depending on season and location, this may occur from late March to mid-May. Moths fly only during the evening and are particularly active after dusk when weather is warm. The female lays its eggs on the cone bract, usually on the outer surface. Normally, there is only one egg on a bract. In severe infestations, three to five larvae may occur per cone, while in extreme situations, even nine or ten larvae may develop in one cone. The larva feeds first on scale tissue, but soon moves to the central seed-producing portion of the cone, where it feeds mainly on seeds. Tortuous feeding tunnels around the cone axis through much of the seed-bearing portion of the cone sharply reduce seed production. The larva feeds for about 2 months. When

feeding is completed by about mid-July, it spins a tough cocoon in the cone adjacent to the cone axis, pupates within a few days, and remains in the pitch-covered cocoon in the cone until the following spring. Each spring, a number of insects remain in extended diapause for 1 or more years.

*Importance:* This insect is one of the major insect pests in Douglas-fir cones throughout the range of the host in North America. It is a persistent pest in drier interior areas and common, although usually less important, in coastal areas. One larva may destroy up to 60 percent of the seeds in a cone; three will usually destroy all the seed.

***Barbara mappana* Freeman (111, 189)**

This species has been reported from cones of balsam fir and white spruce. The moth is slightly smaller than that of *B. colfaxiana*. It is not an important seed-destroying insect.



**Barbara** sp.<sup>1/</sup> - fir cone moth (66, 84, 90, 94, 111)

**Hosts:** California red, grand, noble and white firs. (M64)

**Description:** Adult wingspan 21 to 24 mm (Fig. 54a); egg 1.0 by 1.5 mm, pearl colored.

**Damage:** Cones are partially to completely killed by mid-summer due to internal larval feeding. Cone scales turn brown and heavy pitch flow causes scales to fuse. Partly killed cones are distorted; completely killed cones may remain intact on the tree long after normal cones disintegrate (Fig. 54b).

**Life History and Habits:** The moth emerges in spring when female flowers are in early stages of development. The female lays its eggs on cone bracts, showing preference for the extremities of the cone. Young larvae start feeding on cone scales and by early summer have penetrated the cone, where they feed on both seeds and scale tissue. Multiple infestations are common and when these occur, larvae feed in separate tunnels. Larval feeding is completed by mid-summer. The larva soon pupates and the pupa overwinters in a silken pitch-coated cocoon, perpendicular to the cone axis (Fig. 54c).

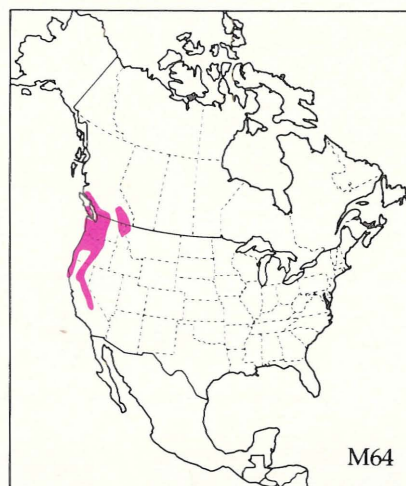
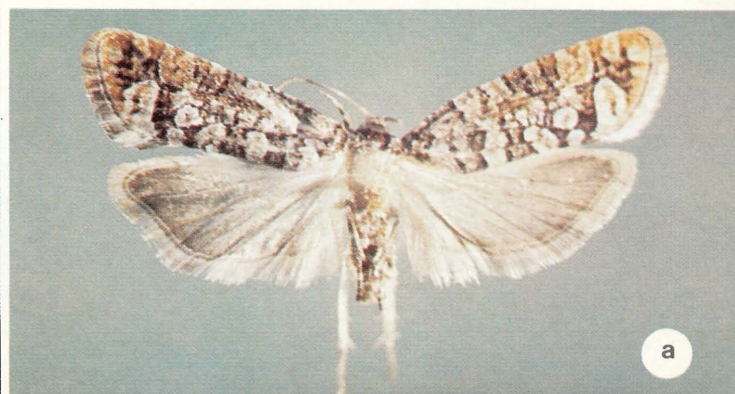


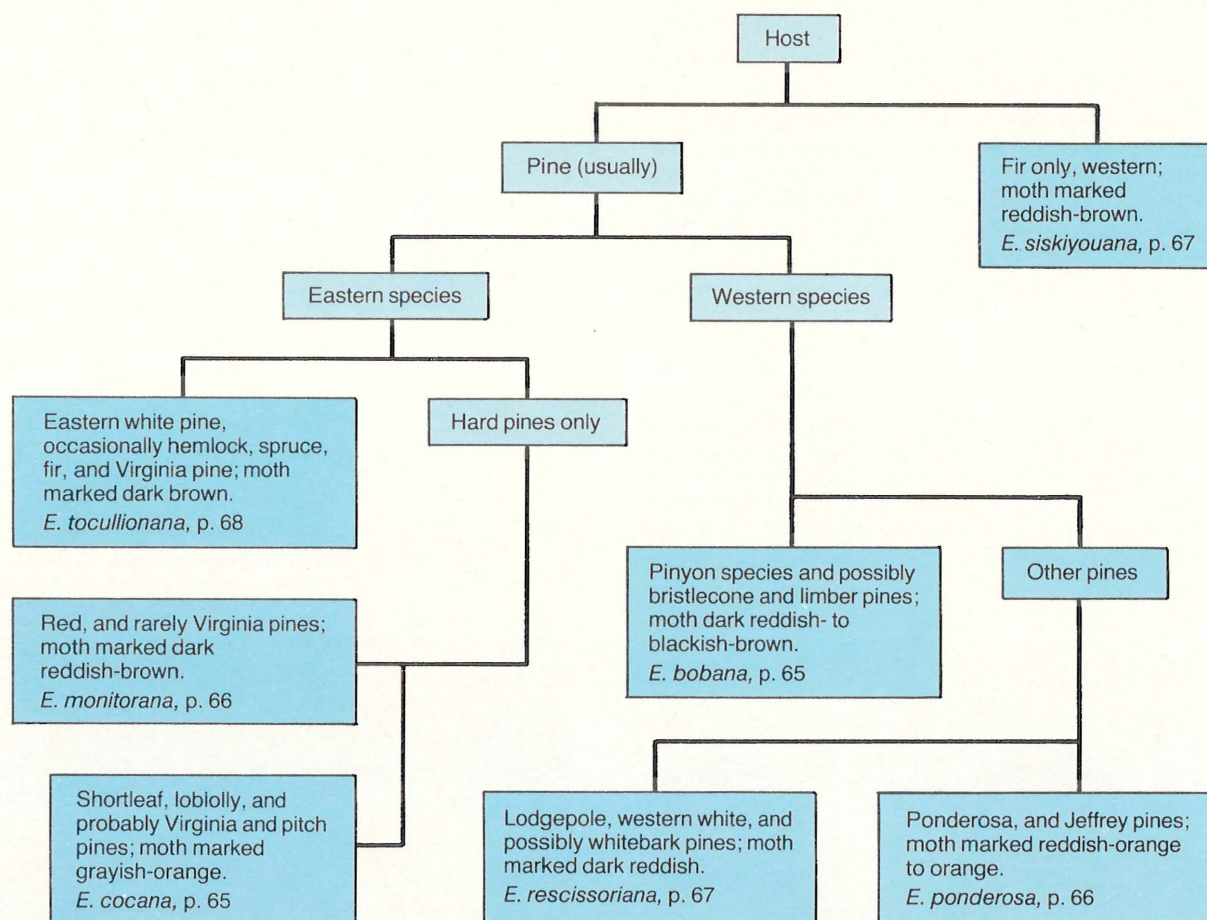
Fig. 54 *Barbara* sp.: (a) adult, CFS, (b) exterior damage to grand fir cone, CFS, (c) pupa in noble fir cone. OSU.



<sup>1/</sup> Formerly known as *Barbara colfaxiana siskiyouana* (Kearfott), an unfortunate misapplication of the specific name of *siskiyouana* which pertains to another moth, *Eucosma siskiyouana* (Kearfott). The biology of *Barbara* sp. as it occurs in British Columbia differs sufficiently from *B. colfaxiana* to merit consideration of description as a separate species.



## HOST KEY TO CONE-INFESTING *EUCOSMA*



**Importance:** Infestations vary from year to year and between localities. Up to 50 percent of the seed crop may be destroyed.

### Genus *Epinotia*

This genus is represented by a number of species which feed on broadleaved trees and shrubs, and a few which feed in cones.

#### *Epinotia hopkinsana* (Kearfott) (66, 111)

**Hosts:** firs; bishop and Monterey pines; Sitka spruce. Occurs in California, Oregon, Washington and British Columbia.

**Description:** Adult wingspan 16 to 19 mm; fore wings mottled with brown and green scales; larva 8 to 10 mm long, dirty white to purplish.

**Damage:** Larvae feed in terminal shoots, foliage buds and cones.

**Importance:** Not a major pest.

#### *Epinotia hopkinsana cupressi* Heinrich (111)

**Host:** Monterey cypress.

**Comment:** Adult darker and larva larger than *E. hopkinsana*. Larvae feed on foliage, in cones and under bark of limbs of Monterey cypress in California.

### Genus *Eucosma* (93)

Adults are variously mottled in tones of orange-brown to gray with a pale background. Larvae of some species of this genus are cone borers, their damage being similar to that of *Dioryctria* spp. (Pyralidae). In contrast to the *Dioryctria*, the larva has a V-shaped suture on the head as opposed to Y-shaped, and is usually smaller, up to about 15 mm long. Pupae have transverse rows of short stout spines on the abdomen. They have single yearly generations.





Fig. 55 *Eucosma bobana* adult. USFS.

***Eucosma bobana*** Kearfott - pinyon cone borer (66, 111, 187, 189, 192)

*Hosts:* pinyon and singleleaf pinyon; possibly bristlecone and limber pines.

*Description:* Adult wingspan 17 to 28 mm, tan with bands of rust-red markings on fore wings (Fig. 55); larva about 15 mm long, pinkish when full grown.

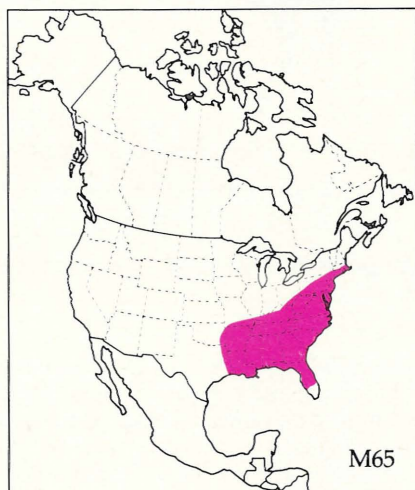
*Damage:* Larvae feed on scales and seeds of second-year cones.

*Life History and Habits:* Eggs are laid on cone scales near the tip of the cone during June and July. Larvae feed on scales and seeds during summer and fall. They pupate in parchment-like cocoons in the cones or in litter on the ground. Pupae overwinter and moths emerge the following spring.

*Importance:* This species is not a major pest.

***Eucosma cocana*** Kearfott - shortleaf pine cone borer (54, 142, 187)

*Hosts:* loblolly, **shortleaf** and probably pitch and Virginia pines. (M65)



*Description:* Adult wingspan 18 to 22 mm; fore wing patterned in tan and reddish brown with variable gray shading; hind wing dark gray (Fig. 56a); egg about 0.5 by 0.6 mm, oval, flattened, with characteristic surface pattern suggestive of coarse meshwork; larva about 10 to 15 mm long, usually pinkish purple, with prominent dark patch on dorsum of last abdominal segment.

*Damage:* Larvae cause gross destruction of the cone interior without forming obvious feeding galleries. Most frass and chewings are packed in the cone as a spongy mass. Infested cones usually soon die, although occasionally the basal portion of the cone remains green (Fig. 56b). Since eggs are laid in groups and the larvae disperse from cone to cone, all cones on a branch may be destroyed.

*Life History and Habits:* In the Piedmont Region of southeastern United States, adult emergence begins in

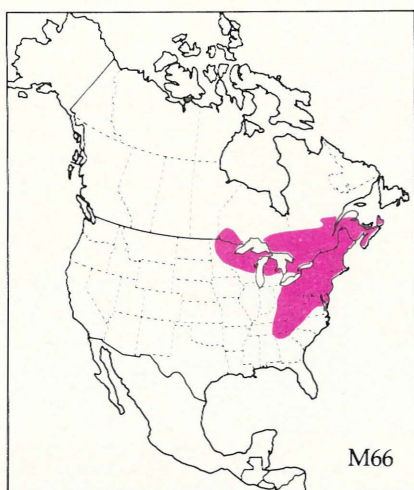


Fig. 56 *Eucosma cocana*; (a) adult, (b) larval damage to shortleaf pine cones. USFS.



late April and adult flight continues through most of May. Typically, eggs are laid overlapping in small groups tucked between the scale leaves of the cone stalks appressed to the inner scale surface or to the underlying cone stalk. Young larvae bore into the cone and feed gregariously. As they develop, they soon devour the cone interior and then disperse to nearby cones, each larva usually entering near a cone base. Mature larvae drop to the ground by early summer and pupate in the soil, where they overwinter. There is one generation per year.

*Importance:* In the Georgia Piedmont, this species is particularly destructive to shortleaf pine, where it causes about 20 percent of the cone losses. It is of minor importance on loblolly pine.



***Eucosma monitorana*** Heinrich - red pine cone borer (8, 9, 134, 135, 149, 150, 187)

*Hosts:* red and Virginia pines. (M66)

*Description:* Adult wingspan approximately 15 mm; fore wing reddish brown with tan and silver markings; hind wing pale to dark gray with paler fringe (Fig. 57); egg about 0.8 mm long, orange, ovoid; larva approximately 12 mm long, grayish white with brown head and pronotum; pupa brown.

*Damage:* Two types of damage are caused by this insect. Cones infested early by groups of larvae are characterized by multiple minute surface holes from which small amounts of light brown frass are extruded; the cone interior is riddled. Cones infested by larvae that have moved from other cones have oblong entrance holes, 1 to 2 mm long. Such cones are relatively free of webbing. They remain moist and green about a week after attack, then shrink, discolor and become hard. Occasionally the larva may sever the cone stalk. Damage is distinguishable from that of the red pine cone beetle in that the stub is longer and lacks a transverse groove at the distal end.

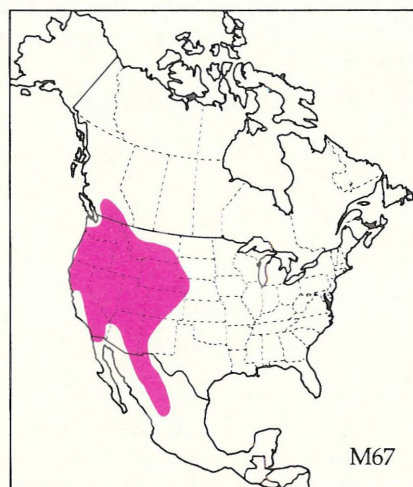
*Life History and Habits:* Adults emerge during May.



Fig. 57 *Eucosma monitorana* adult. USFS.

Larvae enter cones during the first week of June, tunnel to the cone axis and feed on immature seeds. Sometimes 25 or more young larvae are found in each cone, which suggests that the eggs are deposited on or very near the cones. Later, larvae leave cones that have been consumed and enter new cones, boring toward the axis, where they continue feeding. About mid-July, fully grown larvae begin to leave the cones and drop to the ground, where they construct cocoons 7 to 8 mm long, pupate and overwinter.

*Importance:* Larvae destroy the whole cone. Seed losses attributed to this insect tend to be very localized and seldom exceed 40 percent. However, losses as high as 90 percent have been reported.



***Eucosma ponderosa*** Powell - western pine cone borer (66, 187)

*Hosts:* Jeffrey and ponderosa pines. (M67)

*Description:* Adult wingspan 17 to 28 mm; fore wings banded in rust red and pale yellow (Fig. 58); egg about 1.0 by 1.5 mm, pale yellow, flattened, scale-like; larva about 15 mm long when mature, pale tan with pink cast; head brown; distinct brown dorsal shield on first body segment; pupa brown, 10 to 12 mm long.





Fig. 58 *Eucosma ponderosa* adult. USFS.

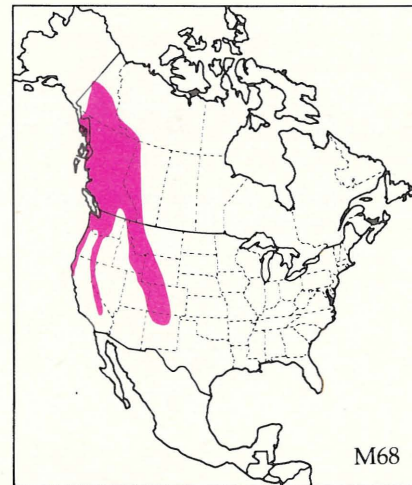


Fig. 59 *Eucosma rescissoriana* adult. USFS.

**Damage:** The larvae feed on the scales and seeds of cones, consuming the softer parts, leaving the woody veins and paper-thin layers at the surface of the cone scales. The larval mine is packed with fine-grained dark-brown fecal pellets. Damaged scales may fail to open at cone maturity, causing otherwise sound seed to remain trapped within the cone.

**Life History and Habits:** Adults emerge in June and July. Eggs are deposited singly on the tip of a cone scale against the base of the terminal spine. Eggs hatch in about 2 weeks. The young larvae bore into the cone scales, consume the scale tissues and pack fecal pellets into the irregular mines. Each larva mines in several scales and then feeds in seeds. The mature larva returns to the outer end of the cone scale and leaves through a round or oval hole, 2 to 3 mm wide. During September and October pupation occurs in the soil, where the pupa overwinters.

**Importance:** Individual cones are often damaged to the extent that over half of the seeds are consumed by the larvae or trapped in the cone when damaged cone scales fail to open properly. However, the percentage of cones seriously damaged is usually low.



***Eucosma rescissoriana* Heinrich** - lodgepole pine cone borer (66, 72, 111, 142, 181, 187, 204)

**Hosts:** grand and subalpine firs; **lodgepole, western white** and possibly whitebark pines. (M68)

**Description:** Adult (Fig. 59) similar in size and color to *E. bobana*; fully grown larva about 13 mm long, dirty white; pupa dark brown, in silken cocoon.

**Damage:** The larva feeds on scales and seeds of cones. Holes on the surface of the cone are surrounded by brown frass.

**Life History and Habits:** Adults emerge in spring and lay eggs in small clusters on cone scales, usually one cluster per cone. Larvae hatch in about 1 week and usually tunnel between cone scales directly to a seed. Subsequently, larvae feed on seeds and scale tissue. Some larvae may leave a severely damaged cone to continue feeding on one nearby. Upon completing the fifth instar, the larva vacates the cone, pupates and overwinters in a cocoon in the litter.

**Importance:** Damage to lodgepole cones has been recorded from central California north through eastern Oregon. In Canada, it occurs sporadically in British Columbia, probably throughout the range of the hosts. There are no records of widespread damage.

***Eucosma siskiyouana* (Kearfott)<sup>1/</sup>** - fir cone borer (66, 187)

**Host:** white fir.

**Description:** Adult wingspan approximately 20 to 25 mm, fore wings evenly checkered in dark brown and gray, hind wing dark brown; immature forms un-

<sup>1/</sup> Erroneous application of the name *siskiyouana* to a form of *Barbara colfaxiana* occurring on firs has caused confusion in the biology of *E. siskiyouana*. Essentially the detailed biology recorded applied to *Barbara colfaxiana* as it occurs on firs, and only the records of Powell (187) pertain to *E. siskiyouana* which was originally described from a single male moth without host record.

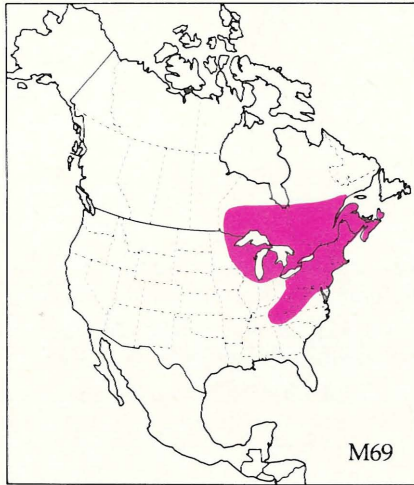


known.

*Damage:* Unknown, except larvae may occur with those of *Barbara colfaxiana* in fir cones.

*Life History and Habits:* Unknown; adults usually present from June to August, most frequently in July. Egg or young larva probably overwinters.

*Importance:* Probably of minor importance; has been reared only rarely from host cones.



***Eucosma tocullionana* Heinrich - white pine cone borer (52, 142, 187, 189)**

*Hosts:* balsam fir; eastern hemlock; eastern white and possibly Virginia pines; spruce. (M69)

*Description:* Adult wingspan 12 to 19 mm; fore wings have distinct patches of alternating dark-brown and light-tan scales; hind wings dark brown with fringe brownish gray (Fig. 60a); larvae pale greenish brown and in contrast to larvae of shortleaf pine cone borer do not have distinct dark anal shield.

*Damage:* Larvae hollow out and kill the cone as they feed on scales and seeds. Frass is noticeable on the cone surface (Fig. 60b).

*Life History and Habits:* Details of the life history of the white pine cone borer are not known. The first signs of damage occur in late spring. Attacked cones are peppered with many small holes and covered with patches of extruded frass. Movement to adjacent cones apparently occurs, but multiple infestation appears to continue during larval development. Larvae probably pupate in the cones. Moths emerge in late summer. Presumably the egg is the overwintering stage. There is one generation per year. Eastern white pine is the principal host of this cone borer.

*Importance:* Limited observations have been made on this insect, but recent damage in young eastern white pine seed orchards in western North Carolina indicates it is potentially a serious pest.

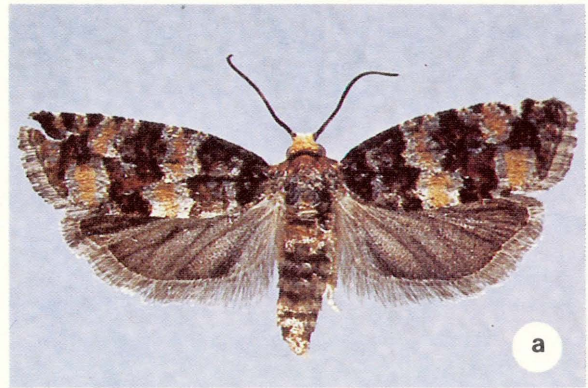
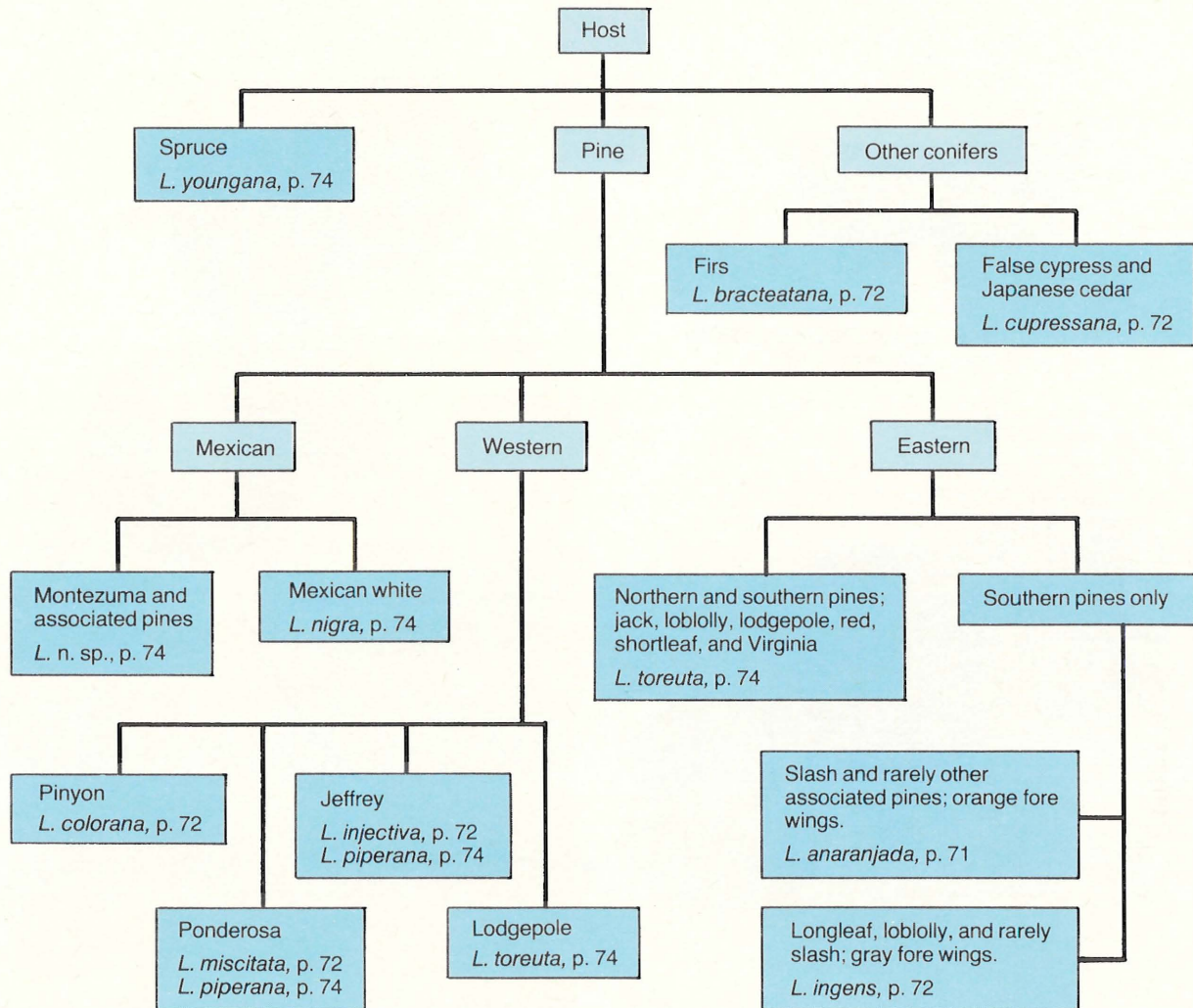


Fig. 60 *Eucosma tocullionana*; (a) adult, (b) damage to eastern white pine cones (larvae killed cone on left and migrated to adjoining green cone). USFS.



KEY TO CONE-INFESTING *LASPEYRESIA*Genus *Laspeyresia*<sup>1/</sup> - seedworms

These insects get the common name "seedworms" from the fact that the larvae feed almost entirely on seeds. The flowers or conelets of firs and spruces, which mature in 1 year, are infested shortly after pollination. Pines are attacked during the second year of cone development, almost 16 months after pollination.

Seedworms attacking North American conifers

include 12 species of *Laspeyresia*. Because of similarities among members of the group, a single discussion of life history and habits will cover all species except a new species infesting various Mexican pines, which is discussed separately because no previous published information is available.

*Description:* Adult wingspan 10 to 20 mm; fore wings usually metallic gray with distinct silver crossbars or bands; slash pine seedworm is an exception and has orange background with white banding; rather flat-

<sup>1/</sup> Although members of this genus have always been referred to as *Laspeyresia* in North America, they are now correctly known as *Cydia*. Brown, R.L. 1979. The valid generic and tribal names for the codling moth. *Cydia pomonella* (Olethreutinae: Tortricidae). Ann. Entomol. Soc. Am. 72:565-567.



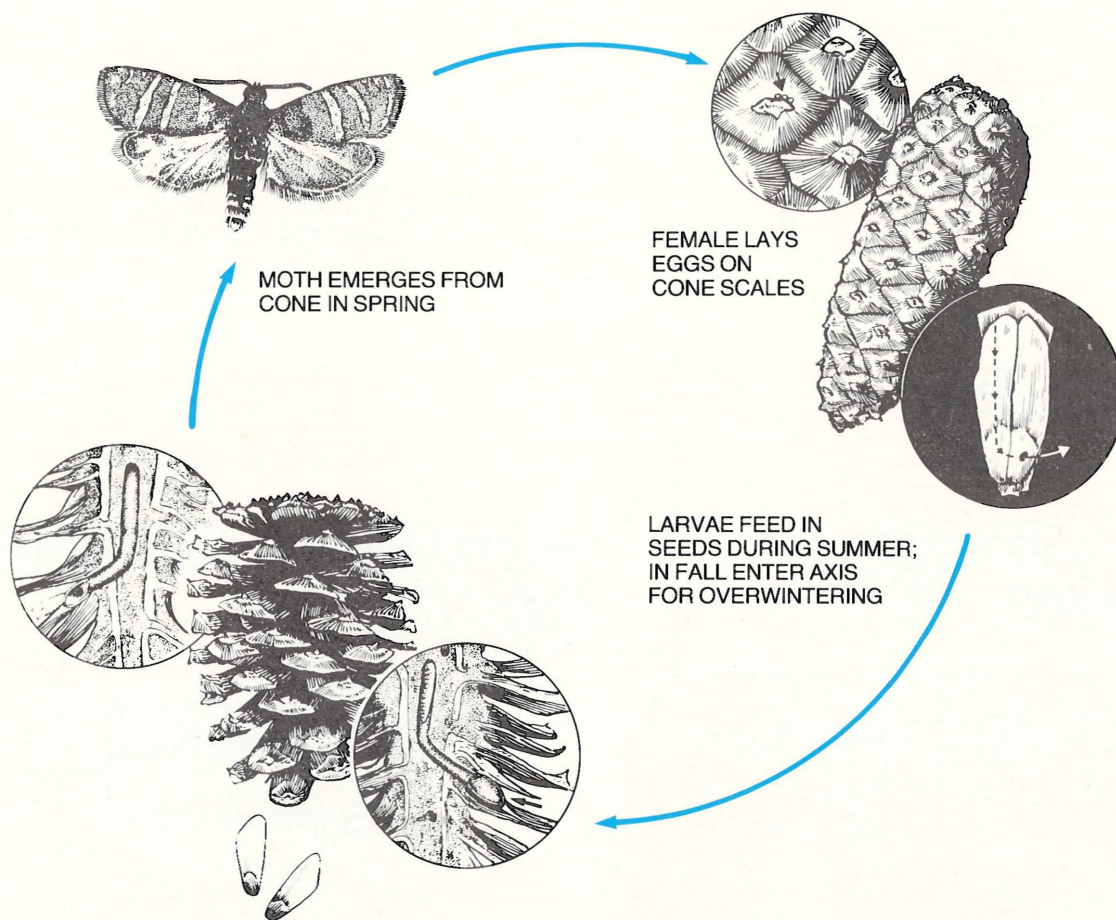


Fig. 61 Life cycle of a cone-infesting *Laspeyresia*.

tened eggs usually laid in small overlapping masses; larvae 10 to 15 mm long when mature, white to cream-colored; pupae 6 to 10 mm long.

**Damage:** These insects leave no external evidence of damage. However, when infested cones are bisected, damage to seeds can be readily observed; throughout the larval feeding period, the insects migrate from one seed to another, devouring the contents and leaving frass. Seed pairs on the same scales may become fused by silk-lined tunnels constructed between them. After seed maturity, the fully developed larvae tunnel from the seeds into the cone axis. Damage to seeds which have been extracted is readily seen on a radiograph. Damaged seeds tend to adhere to scales and remain in the cones.

**Life History and Habits:** The period of moth activity is synchronized closely with cone development of the host (Fig. 61). Eggs are laid between the scales of female flowers of spruce and fir; but on pine, they are laid at the base of spines, on the surface of the cone scales or on the cone stalk. The young larva bores between cone scales, enters a seed and consumes the contents, leaving the seed filled with frass. It makes a silk-lined tunnel to the next seed. This procedure is repeated for each successive seed fed upon. As the cone matures, the larva burrows from the last seed destroyed into the cone axis where the mature larva overwinters in a tunnel (Fig. 62). Usually, only 1 to 3 larvae inhabit a cone, but there may be 12 or more in cones of some host trees.

The larva tunnels a passage to the surface of a



previously hollowed out seed or the cone surface of serotinous cones, leaving a protective cap of host tissue over the tunnel exit. It then retreats into the cone axis. In the spring, the insect pupates in the cone axis tunnel and, after about 2 weeks, the pupa forces its way through the thin exit hole cover, and the moth emerges.

Most North American species of this group may undergo extended diapause. The proportion of the population remaining in diapause varies among species and from year to year within species. This phenomenon is almost non-existent in *L. anaranjada* on slash pine in the southern United States, while another southern species, *L. ingens*, in one longleaf pine crop was reported to have 11 and 1 percent of the larvae enter diapause for the second and third winters, respectively. Up to 80 percent of the population of *L. piperana* has been reported in extended diapause.

Some species display a strong host tree preference, such as *L. anaranjada* on slash pine and *L. injectiva* on Jeffrey pine. Other species, e.g., *L. toreuta*, occur on numerous pine species over the eastern half of North America and *L. cupressana* attacks at least three different genera of conifers.

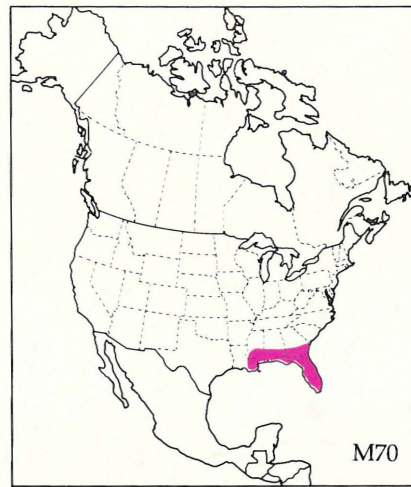
For *L. anaranjada*, *L. ingens* and *L. toreuta* in eastern North America, reasonably precise host and geographic distribution information is available. Similarly, reliable data have been obtained for *L. miscitata*,



Fig. 62 *Laspeyresia miscitata* larva and pupa in axis of mature ponderosa pine cone. USFS.

*L. piperana* and *L. injectiva* on Jeffrey and ponderosa pines in western North America. However, there are many gaps in knowledge of the occurrence of seedworms on conifers of minor economic importance.

**Importance:** Seedworms may destroy an appreciable proportion of the seed crop of certain hosts. For example, *L. ingens* commonly destroys an average of 20 percent of the maturing longleaf pine seed crop in the Gulf Coast Region of the United States; in contrast, in the Piedmont Region of Georgia, *L. toreuta* destroys an average of only 4 percent of the loblolly pine seed crop. *L. youngana* is a major pest of Engelmann and white spruces, causing varying amounts of damage across the continent. *Laspeyresia* n. sp. is an important pest of several species of pines in Mexico.



Species include:

***Laspeyresia anaranjada* Miller - slash pine seedworm** (44, 52, 152, 153, 154, 158, 162) (Fig. 63)

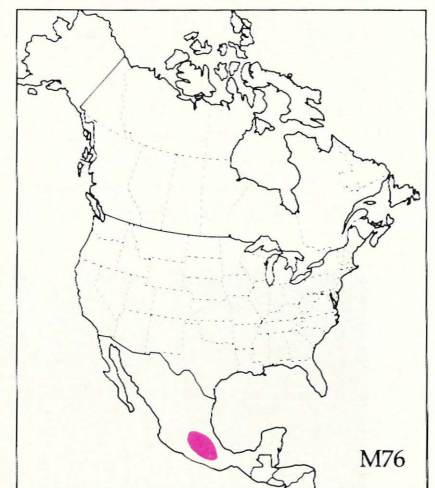
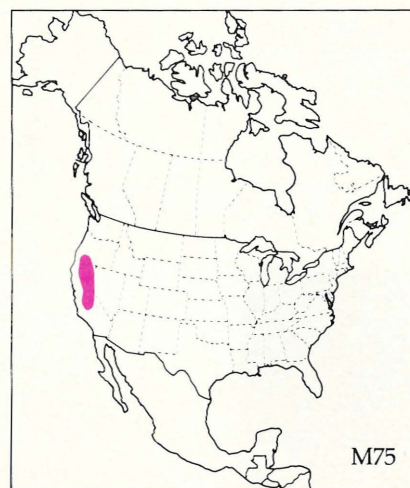
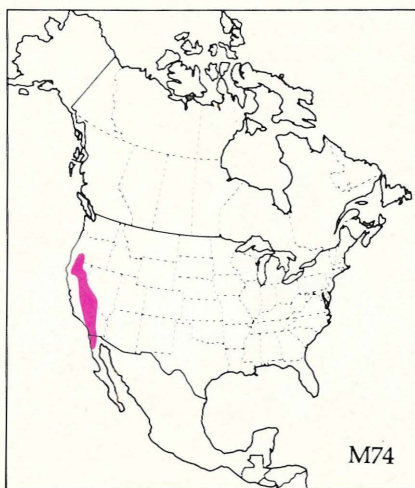
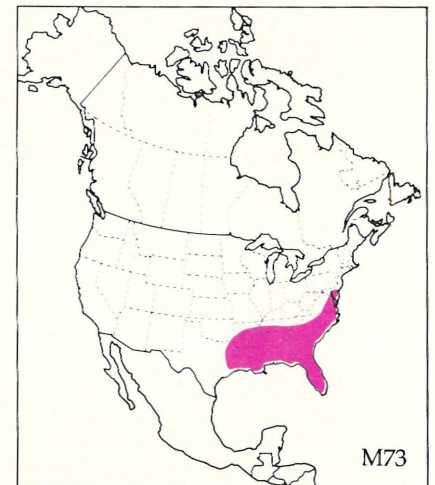
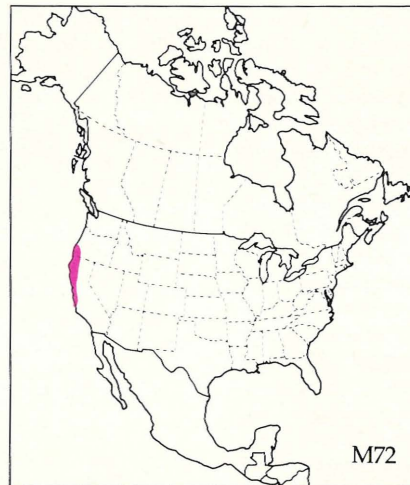
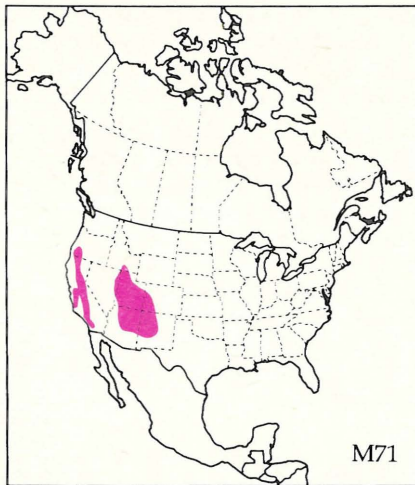
**Hosts:** loblolly, longleaf and slash pines. (M70)

**Comment:** This is the only species of the genus with orange fore wings.



Fig. 63 *Laspeyresia anaranjada* adult. USFS.





***Laspeyresia bracteata* (Fernald) - fir seed moth** (66, 92, 94, 111, 123) (Fig. 64)

*Hosts:* bristlecone, California red, white, and probably other west coast firs. (M71)

*Comment:* Larvae leave the cones at maturity and pupate on the ground.

***Laspeyresia colorana* (Kearfott) - pinyon seed-worm**

*Host:* pinyon.

*Comment:* This species has been reared from pinyon cones in California.

***Laspeyresia cupressana* (Kearfott) - cypress bark moth** (62, 66, 111) (Fig. 65)

*Hosts:* Gowen and Monterey cypresses, false cypress and exotic Japanese cedar. (M72)

*Comment:* This species also infests bark and phloem.

***Laspeyresia ingens* Heinrich - longleaf pine seed-worm** (31, 44, 49, 52, 152, 158, 177, 232) (Fig. 66)

*Hosts:* loblolly, longleaf and slash pines. (M73)

***Laspeyresia injectiva* (Heinrich) - Jeffrey pine seed-worm** (66, 111, 142) (Fig. 67) (*Hedulia injectiva* Heinrich)

*Host:* Jeffrey pine. (M74)

*Comment:* This is the only cone-infesting species of *Laspeyresia* that pupates in the fall.

***Laspeyresia miscitata* Heinrich** (66, 93, 111, 122, 189, 192) (Fig. 68)

*Host:* ponderosa pine. (M75)

*Comments:* Eggs laid on scales of cone stalk. Larval head capsule uniformly tan. Reports of this species as pest on Jeffrey pine are believed to be erroneous.



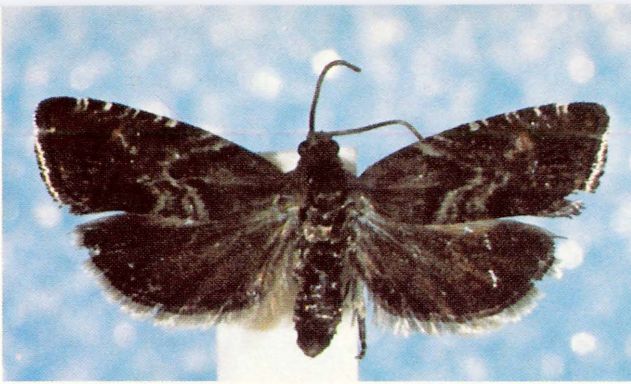


Fig. 64 *Laspeyresia bracteatana* adult. USFS.



Fig. 68 *Laspeyresia miscitata* adult. USFS.



Fig. 65 *Laspeyresia cupressana* adult. USFS.



Fig. 69 *Laspeyresia nigra* adult. USFS.

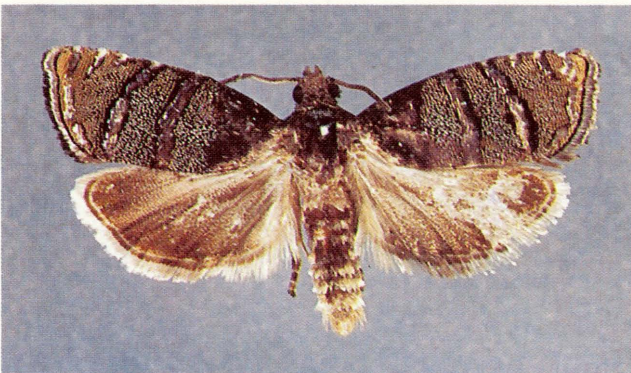


Fig. 66 *Laspeyresia ingens* adult. USFS.

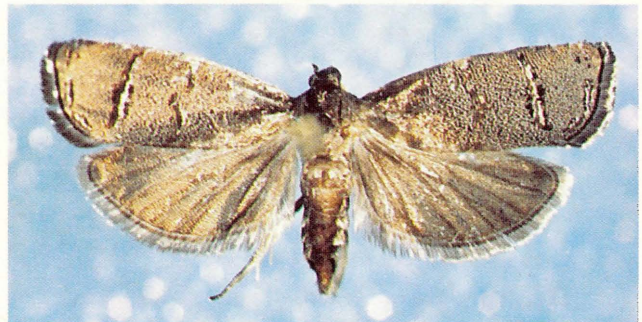


Fig. 70 *Laspeyresia piperana* adult. USFS.



Fig. 67 *Laspeyresia injectiva* adult. USFS.

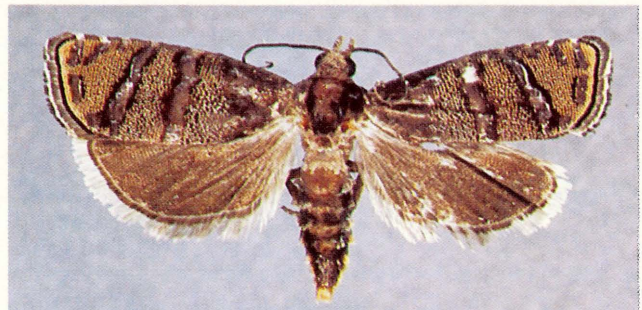
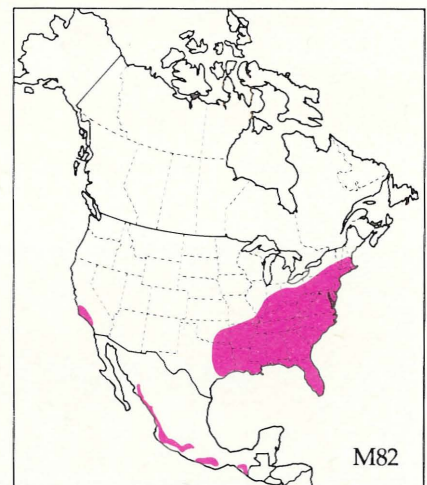
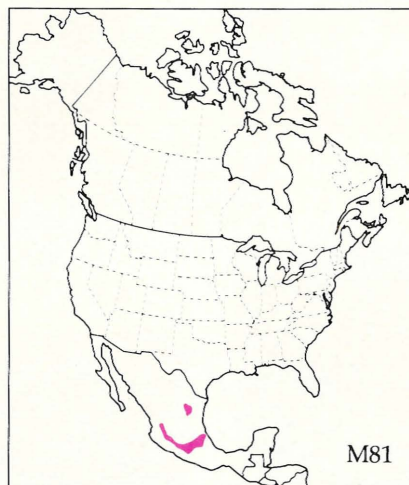
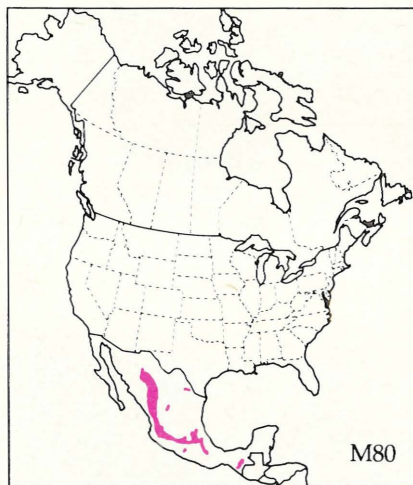
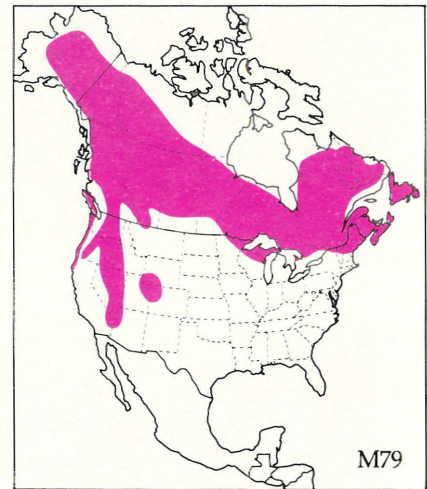
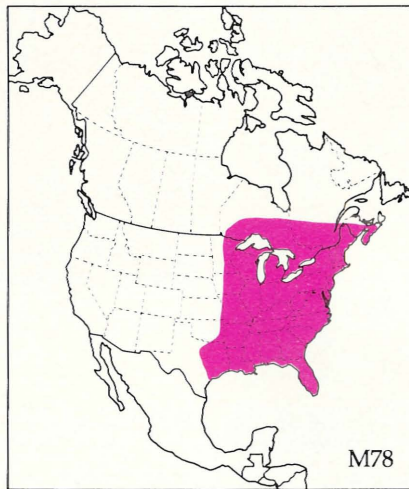
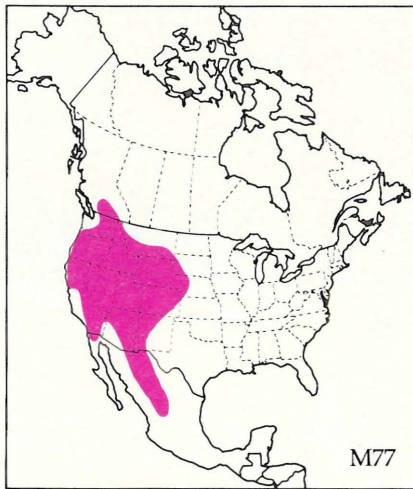


Fig. 71 *Laspeyresia toreuta* adult. USFS.





***Laspeyresia nigra* Miller (163) (Fig. 69)**

*Host:* Mexican white pine. (M76)

*Comment:* Each larva feeds in only 1 or 2 seeds.

***Laspeyresia piperana* (Kearfott) - ponderosa pine seedworm (85, 87, 111, 189, 192) (Fig. 70)**

*Hosts:* Jeffrey and ponderosa pines. (M77)

*Comments:* Larval head capsule is mottled. This is the most important of the western species occurring in the northern part of the range.

***Laspeyresia toreuta* (Groté) - eastern pine seedworm (1, 22, 49, 52, 94, 111, 118, 119, 134, 135, 149, 150, 232) (Fig. 71)**

*Hosts:* jack, loblolly, lodgepole, red, shortleaf and Virginia pines. (M78)

*Comment:* Widely distributed over eastern North America.

***Laspeyresia youngana* (Kearfott) - spruce seed moth (66, 86, 87, 111, 171, 189, 190, 193, 216, 218, 221) (Fig. 72)**

*Hosts:* black, blue, Engelmann, red, Sitka and white spruces. (M79)

*Comment:* This species is a major pest of spruce.

***Laspeyresia n. sp.* - Mexican pine seedworm**

*Hosts:* Hartweg, Mexican white, Montezuma, pseudostrobus and rudis pines. (M80)

*Description:* Adult wingspan about 15 mm; dark brown; fore wings have 5 silver-colored (Fig. 73) transverse bars; egg 0.6 by 0.7 mm, oval whitish.

*Damage:* Damage to cones of Montezuma pine, the principal host, commences when cones are 1½ to 2 years old. Each larva feeds in and destroys 8 to 10 seeds. There are usually 4 or 5 larvae, with a maximum of 12, per infested cone.



**Life History and Habits:** The adult lays eggs on the cone scales from March to May. When the eggs hatch, each young larva bores into the cone and locates a seed, in which it feeds; it continues to feed from March to November, moving from one seed to another. From October to January, larvae which are then mature bore into the cone axis. Before pupating, each larva bores an exit tunnel through a seed to the cone exterior to allow for the escape of the adult later. Pupae are present in the cone axis from January to April. Adults emerge from March to May.

**Importance:** This insect is an important pest, particularly in cones of Montezuma, rudis and Hartweg pines.

***Petrova* sp. poss. *edemoidana* (Dyar)**

**Hosts:** Mexican white and rudis pines. (M81)

**Description:** Adult wingspan about 23 mm; fore wings magenta, reddish near tip; hind wings uniform gray with reddish tinge (Fig. 74); larva about 15 mm long, cream-colored.

**Damage:** This species is a more serious pest on rudis than on Mexican white pine. On rudis pine, it lives only in branches, where the larval galleries destroy the phloem and kill branches. A pitch globule, 2 to 3 cm in diameter, exudes from the larval entry hole and turns white. By the time the larva has reached maturity, the foliage on the killed twig has turned reddish or brownish red; when a number of branches have been attacked, the tree assumes a flagged appearance. On Mexican white pine, the insect attacks only cones; it mines through scales and destroys some seeds.

**Life History and Habits:** This insect has one generation per year. Adults emerge from late April to early June and usually lay eggs in shoots of rudis pine, often several eggs per shoot; however, eggs may be laid near the bases of twigs. Eggs hatch in about 2 or 3 weeks. The young larva burrows into the new shoot, where it feeds on the phloem. Larvae overwinter and complete feeding by March or April of the following year; pupae are present from late March to early May. Following adult emergence, pupal skins may be observed on the surface of the twig.

**Importance:** This insect is of major importance in rudis pine because all potential cones on attacked twigs are killed. It is of major importance on Mexican white pine.

***Polychrosis piceana* Freeman**, an unimportant member of this family has been taken in cones of white spruce in Alberta, and Engelmann spruce and Douglas-fir in British Columbia.

**Genus *Rhyacionia*** - tip and shoot moths (66, 92, 97, 111, 188, 189, 230)

*Rhyacionia* spp. are small moths with fore wings variously mottled in tones of reddish to brown and gray. Larvae are creamy to yellow, or light brown.

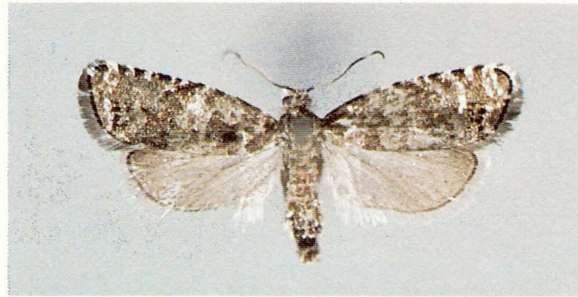


Fig. 72 *Laspeyresia youngana* adult. CFS.

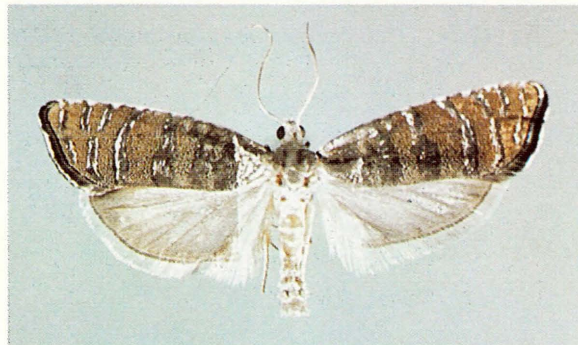


Fig. 73 Mexican pine seedworm, *Laspeyresia* n. sp., adult. CFS.



Fig. 74 *Petrova* sp. poss. *edemoidana* adult. CFS.

*Rhyacionia* spp. are well known bud and shoot borers of pines. However, losses of cones caused by larvae feeding on flowers and conelets or killing shoots that bear flower primordia are of particular concern. There are 24 species in North America, of which two, the Nantucket pine tip moth, *Rhyacionia frustrana* (Comstock), and the European pine shoot moth, *R. buoliana* (Schiffermüller), are known to affect seed production of pines.

***Rhyacionia frustrana* (Comstock) - Nantucket pine tip moth** (11, 52, 66, 71, 97, 228, 229, 231, 233)

**Hosts:** Caribbean, Cuban, jack, loblolly, lodgepole,



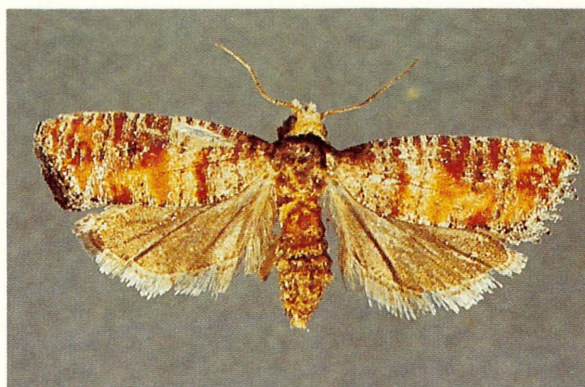


Fig. 75 *Rhyacionia frustrana* adult. USFS.

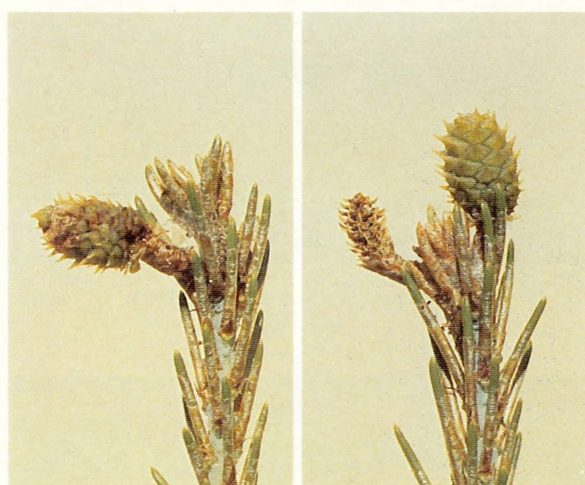


Fig. 76 Shortleaf pine conelets killed by *Rhyacionia frustrana* larvae. USFS.

Monterey, oocarp, pitch, pond, ponderosa, red, sand, Scotch, **shortleaf**, slash, sonderegger, spruce, Table-Mountain and Virginia pines. (M82)

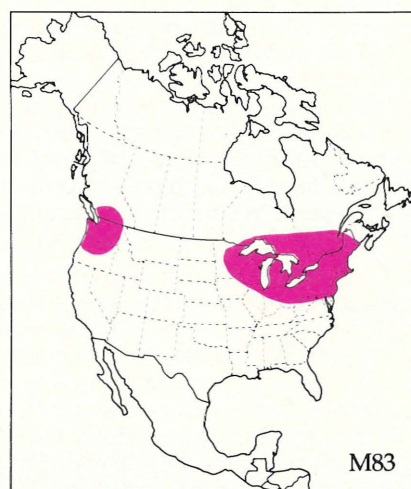
**Description:** Adult wingspan 9 to 15 mm (Fig. 75); head, body and appendages covered with silvery gray scales. Fore wings with irregular brick-red and copper-colored patches separated by irregular bands of gray scales; hind wings smoky gray; egg approximately 0.5 by 0.8 mm, elliptical, flattened, opaque whitish; mature larva 8 mm; pupa 6 mm.

**Damage:** This insect has long been recognized as a major pest of pine plantations. The developing buds and shoots are killed by the larvae boring into them, causing loss of height growth and poor tree form. During the establishment phase of a seed orchard, grafted scion material may be destroyed. On cone-producing trees, flower primordia and cones may be destroyed. Larvae bore into, feed internally, and kill flowers and conelets (Fig. 76).

**Life History and Habits:** The insect overwinters as a pupa

in damaged shoots or buds of the host. In late winter or early spring during warm days, adults emerge, mate and lay eggs on the needles, buds, developing shoots, young female flowers or conelets. Depending on the weather, the incubation period may last as long as 30 days. Larvae bore into shoots, female flowers and conelets of the host, and later pupate. Emerging adults mate and again eggs are laid on shoots and needles of pines. Depending on the latitude, there are from one to eight generations each season. Incubation, larval development and pupal periods are shortened during the summer season.

**Importance:** This pine tip moth can reduce survival of outplanted grafted stock during seed orchard establishment as well as cause considerable shoot damage in young seed orchards. When shoots are infested during the summer and fall, buds containing flower primordia are killed and thus flower production is reduced the following year. Serious conelet losses may also occur. This is particularly true of shortleaf pine, where 20 to 30 percent of the conelets have been lost to this insect. Conelet losses have also been recorded on Virginia and occasionally on loblolly pines.



***Rhyacionia buoliana* (Schifferrmüller) - European pine shoot moth (66, 164, 166, 167)**

**Hosts:** eastern white, jack, Jeffrey, loblolly, lodgepole, Monterey, pitch, ponderosa, **red, Scotch**, Swiss mountain and Virginia pines. (M83)

**Description:** Adult wingspan about 18 mm; fore wings rusty orange-red marked with several irregular, silvery white transverse bands; hind wings dark brown (Fig. 77); egg elliptical opaque-white at first, soon becoming light yellow, gradually turning deep orange; mature larva 12 to 14 mm long; pupa approximately 9 to 11 mm long, reddish brown.

**Damage:** In Ontario, the insect often destroys cones on young trees and on the lower branches of larger trees. The damage may cause severe distortion of the grow-





Fig. 77 *Rhyacionia buoliana* adult. USFS.

ing cone and a copious flow of resin which usually hardens into a yellowish lump around the injured part of the cone.

**Life History and Habits:** Adults emerge from the damaged shoots and buds during June and July, mate, and deposit eggs on the twigs, buds and needles of the host. Hatching occurs in a week or two and the young larva constructs a tent-like web, coated with resin and debris, between the needle sheath and the stem of the current year's growth. Initial feeding is on the needle within the needle sheath; however, as the larva grows, it migrates to a bud, constructs another tent and continues feeding. Developing larvae also feed on cones. Overwintering takes place in the bud. In April, the larva again moves to another bud, constructs another web tent and feeds upon one or more buds or needle sheaths. Pupation occurs in late May or early June and adults emerge 2 or 3 weeks later.

**Importance:** Although this insect is capable of destroying cones, damage to buds results in more significant flower losses, particularly to red and Scotch pines.

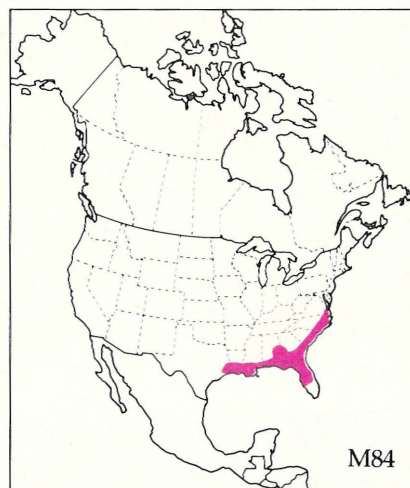
***Satronia tantilla* Heinrich** - southern pine catkin-worm (44, 94)

**Hosts:** longleaf and slash pines. (M84)

**Description:** Adult wingspan about 9 mm; fore wings light brown with grayish white banding (Fig. 78); mature larva 6 mm long, white with dark anal comb, anal shield and head capsule.



Fig. 78 *Satronia tantilla* adult. USFS.



**Damage:** Larvae bore into male flower buds and clusters of developing male flowers, producing fine yellow frass inconspicuously webbed together on the flower surfaces. In Florida, damage by this insect is more prevalent on longleaf than on slash pine.

**Life History and Habits:** Eggs are laid on bud scales of expanding male flower clusters and larvae feed on the flowers. Pupation occurs within infested flowers, often in the base of shriveled flower parts. During May and June, a second generation of moths has been reared from conelets infected by southern cone rust, *Cronartium strobilinum* Hedgc. & Hahn. Occasionally, moths have emerged in the fall from branch and stem galls caused by southern fusiform rust, *Cronartium fusiforme* Hedgc. & Hunt ex Cumm., indicating at least three generations per year.

**Importance:** This species feeds primarily on male flowers. Its impact on pollen production is not considered to have an important effect on seed production.

### Family Pyralidae

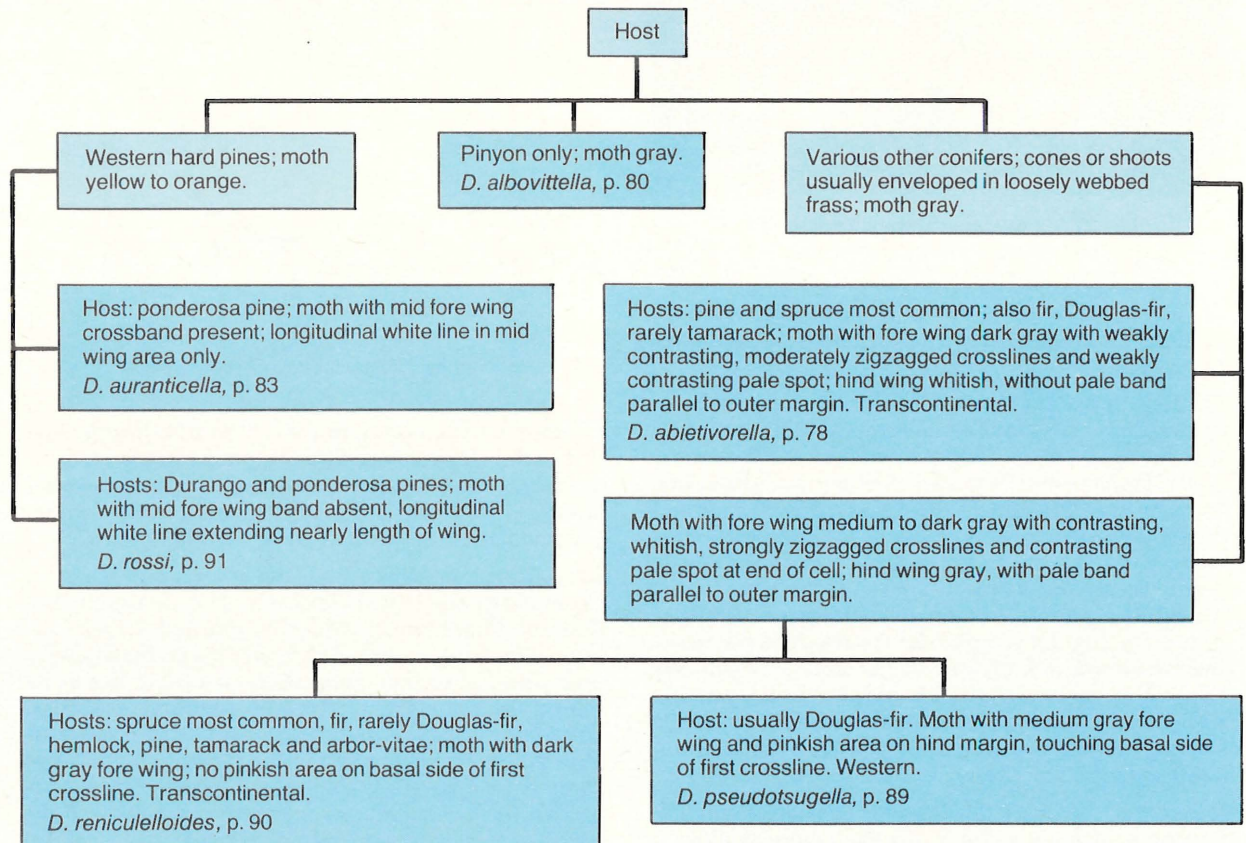
Adults of this group vary from small to medium-sized moths frequently with fore wings marked with contrasting crossbands. Fore wings are moderately narrow. Larval habits vary.

### Genus *Dioryctria* - coneworms

As a group, the coneworms are undoubtedly the most important North American lepidopterous cone pests. Cone damage is internal, but holes and often frass are apparent on the cone surface. Besides cones, these insects often infest such host parts as shoots and galls. From one to several generations may occur yearly, depending upon the coneworm species or geographical location, or both. The following keys are presented as a guide for tentative identification of the species by major geographical areas: A) Eastern USA and Canada, B) Northern transcontinental and Western, and C) Mexican and Central American.



## KEY TO NORTHERN TRANSCONTINENTAL AND WESTERN *DIORYCTRIA*



### Mexican and Central American *Dioryctria*

Few *Dioryctria* species are known from Mexico-Central America. Since it is probable, in view of the number of conifer species of the area, that these represent but a fragment of the actual coneworm species present, the following synopsis of the known *Dioryctria* species, rather than a definitive key, seems appropriate:

Adults reddish brown.

Known from Cuba only. *D. horneana* (Dyar), p. 93.

Known from southwestern United States and Nicaragua, likely to range through Mexico. *D. erythropasa* (Dyar), p. 88

Adults grayish.

Wings smooth, from Guatemala. *D. sysstratiotes* Dyar, p. 94

Wings with obvious raised scales, from Mexico.

*D. n. sp.* (*baumhoferi* group), p. 84

Wing pattern indistinct; white crosslines dull. *D. majorella* Dyar p. 94

***Dioryctria abietivorella*** (Groté) - fir coneworm (4, 66, 87, 111, 125, 133, 140, 173, 189) (*D. abietella* (D. & S.) in part) (M85)

*Hosts*: Douglas-fir; balsam, California red, grand, sub-alpine and white firs; eastern white, jack, lodgepole, ponderosa, red, Scotch and Swiss mountain pines; black and white spruces; infrequently western larch, limber and western white pines, blue and red spruces.

*Description*: Adult gray and white with wingspan about 25 mm; fore wings smooth, blended dark and light gray with somewhat diffuse white crossbands and flecking; hind wings unmarked, pale gray (Fig. 79a); egg oval, 0.65 by 1.0 mm; first-instar larva amber;



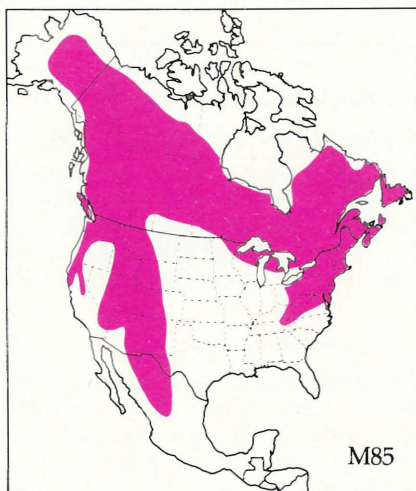


Fig. 79 *Dioryctria abietivorella*; (a) adult, (b) larva, (c) damage to Douglas-fir cones. CFS.

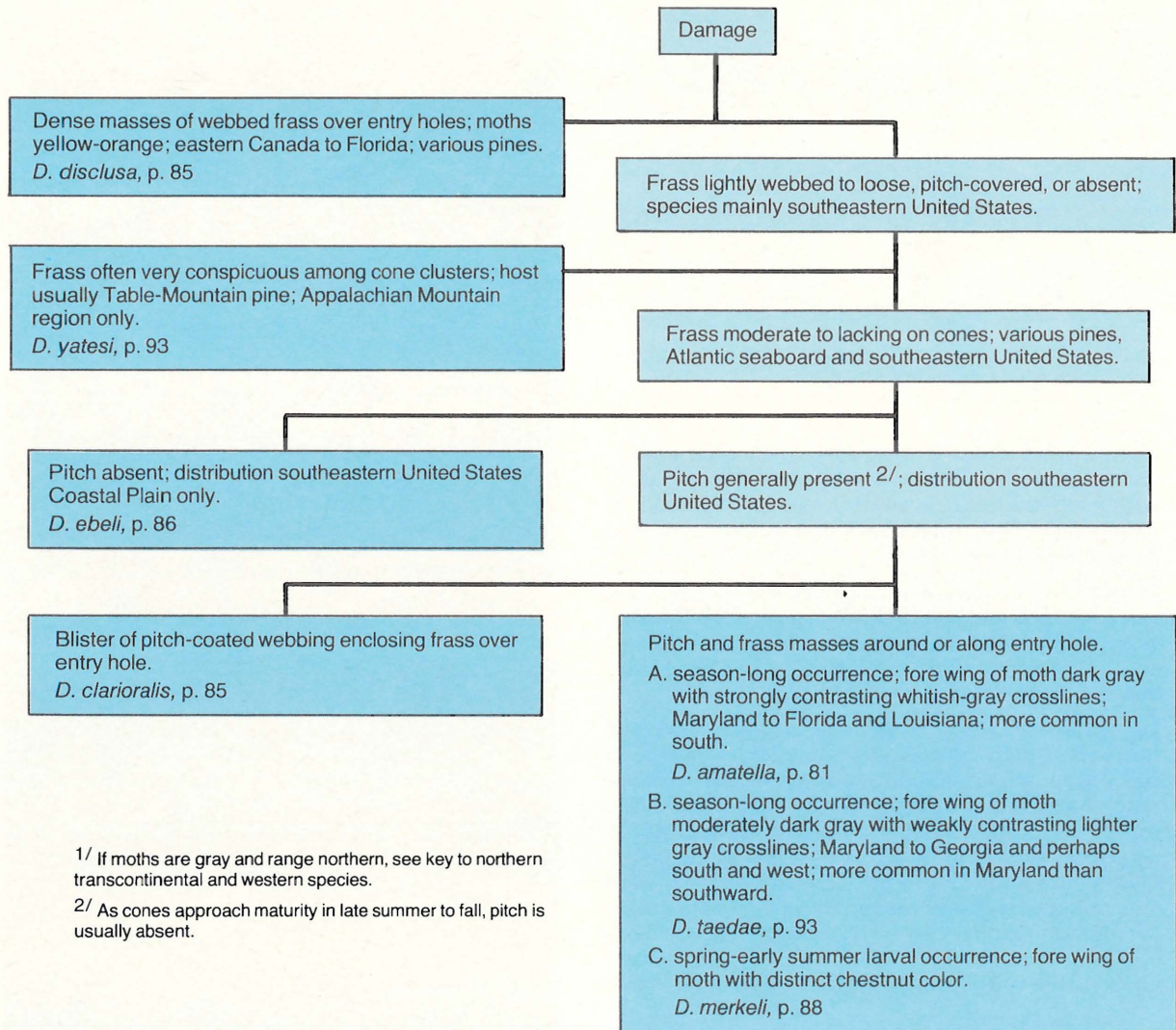
mature larva about 18 mm long with deep amber-brown head and thoracic shield, amber-brown body with faint dark dorsal lines and broad pair of subdorsal stripes (Fig. 79b); pupa about 10 mm long, amber to dark reddish brown.

**Damage:** Larvae mine and riddle the host cones. Conspicuous frass and webbing are deposited on the cone surfaces (Fig. 79c). Twigs, graft unions of Douglas-fir and, occasionally, the cambium of young tree trunks may also be infested.

**Life History and Habits:** The life history is variable and not well known. Apparently some larvae pupate in cocoons on the ground during July, August and September and adults emerge shortly after to lay eggs, which overwinter. Others overwinter in cocoons as prepupae, pupate in March and April and emerge as moths during May and June. Eggs are laid soon after emergence and larvae feed from June to September. Records on this species have probably become confused by the previous inclusion of this and several other similar coneworm species as *D. abietella* (D. & S.).





KEY TO EASTERN *DIORYCTRIA* <sup>1/</sup>

It appears from most reports that in the northern part of its range, *D. abietivorella* has a single full generation per year, sometimes composed of two broods in terms of time of adult emergence, i.e., spring versus summer-fall. The insects are apparently attracted to pitch so that in addition to feeding in cones, larvae may tunnel beneath the surface of the bark, making entry through a wound.

**Importance:** While the overall importance of this coneworm is not well documented, it appears to cause damage ranging from light in years of good cone crops to nearly complete destruction of cones in poor years. In seed orchards, where cone crops are more consistent, the potential for populations to build up may be greater than in natural stands.

***Dioryctria albobittella*** (Hulst) (66, 95, 111)

**Hosts:** pinyon and singleleaf pinyon. (M86)

**Description:** Adult wingspan 23 to 30 mm; fore wing gray heavily dusted with white, marked by white and dark lines; raised scales present; hind wing nearly white (Fig. 80). There is considerable variation in the moths, and possibly more than one species is involved.

**Damage:** Larva tunnels in cones.

**Life History and Habits:** Adults reported from July to September; no other details of life history known. While this coneworm has been specifically reared from singleleaf pinyon, the majority of collection records are in the range of pinyon.



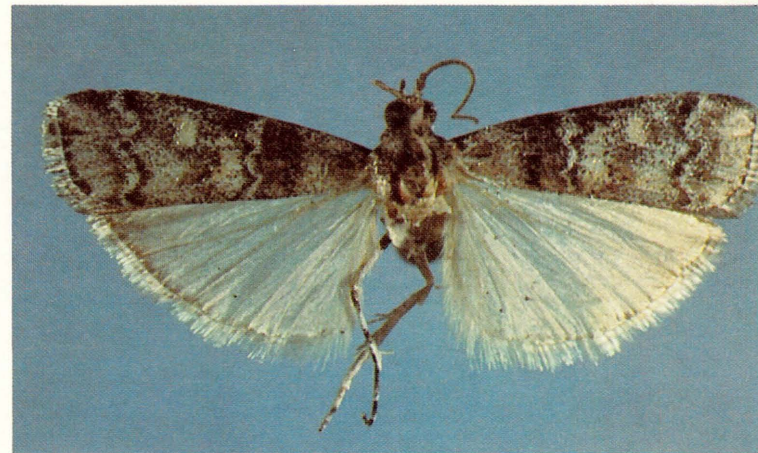
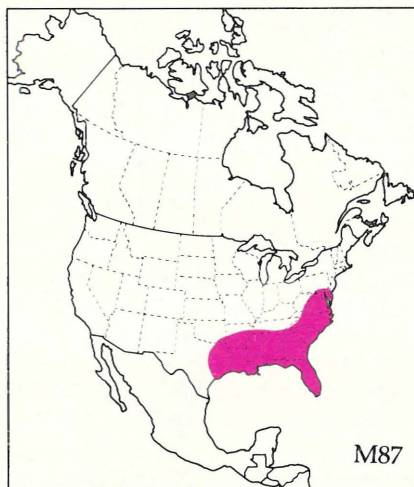
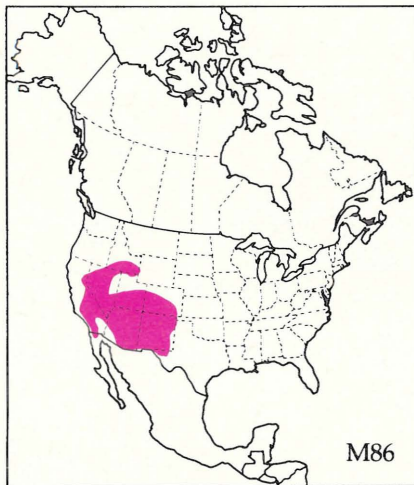


Fig. 80 *Dioryctria albiovittella* adult. USFS.

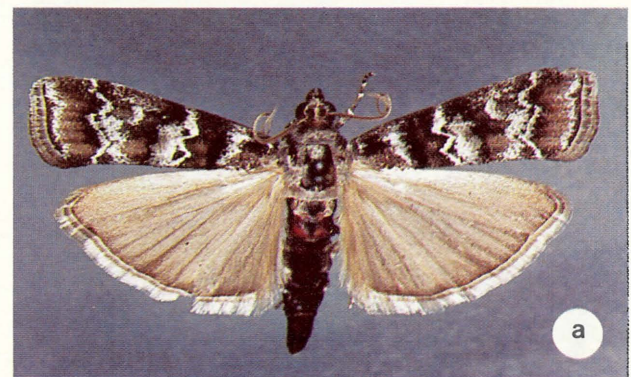


Fig. 81 *Dioryctria amatella*; (a) adult, (b) larval damage. USFS.

**Importance:** Its widespread occurrence suggests it is likely to be common enough to affect the pinyon nut food crop.

***Dioryctria amatella* (Hulst) - southern pine cone-worm** (25, 26, 27, 28, 29, 44, 47, 52, 158, 177, 178, 179, 200, 235, 236)

**Hosts:** baldcypress, pondcypress; **loblolly, longleaf, shortleaf, slash,** and Virginia pines; probably most pine species within southeastern United States. (M87)

**Description:** Adult (Fig. 81a) wingspan about 30 mm; fore wing ground-color dark gray-brown shaded black, marked with sharply contrasting white patches and crossbands; hind wings light grayish brown; egg cream, 0.6 by 1 mm, reticulated by wavy striations; young larva pale with obvious dark setal bases (tubercles) and seven longitudinal stripes; mature larva reddish to purplish brown above, paler often tinted green



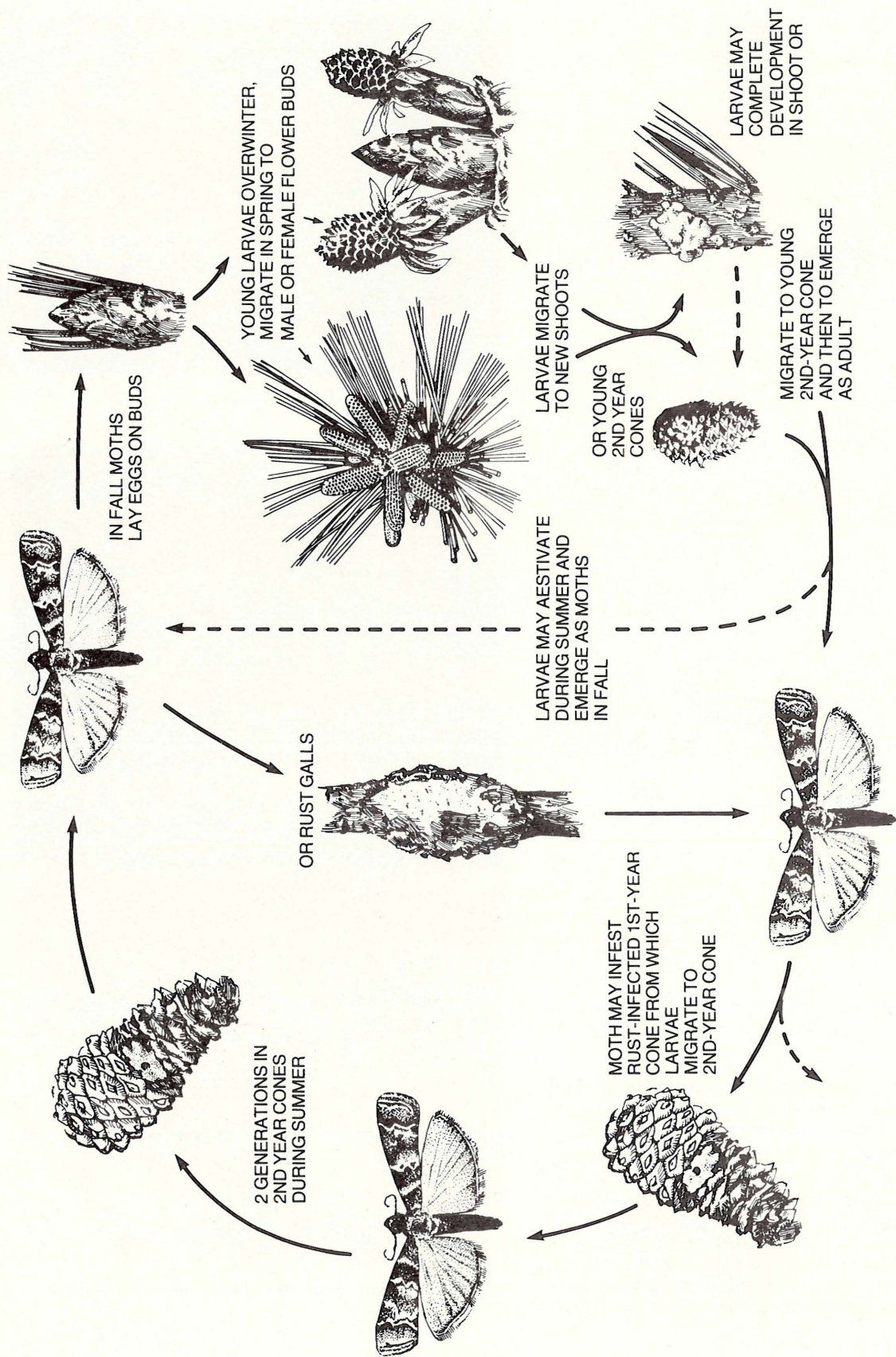


Fig. 82 Diagram of major aspects of complex life cycle of *Dioryctria amatella*. On loblolly pine the cones-to-gall cycle (left) is typical; in slash-longleaf pines a variety of additional host parts may be fed upon in the spring.



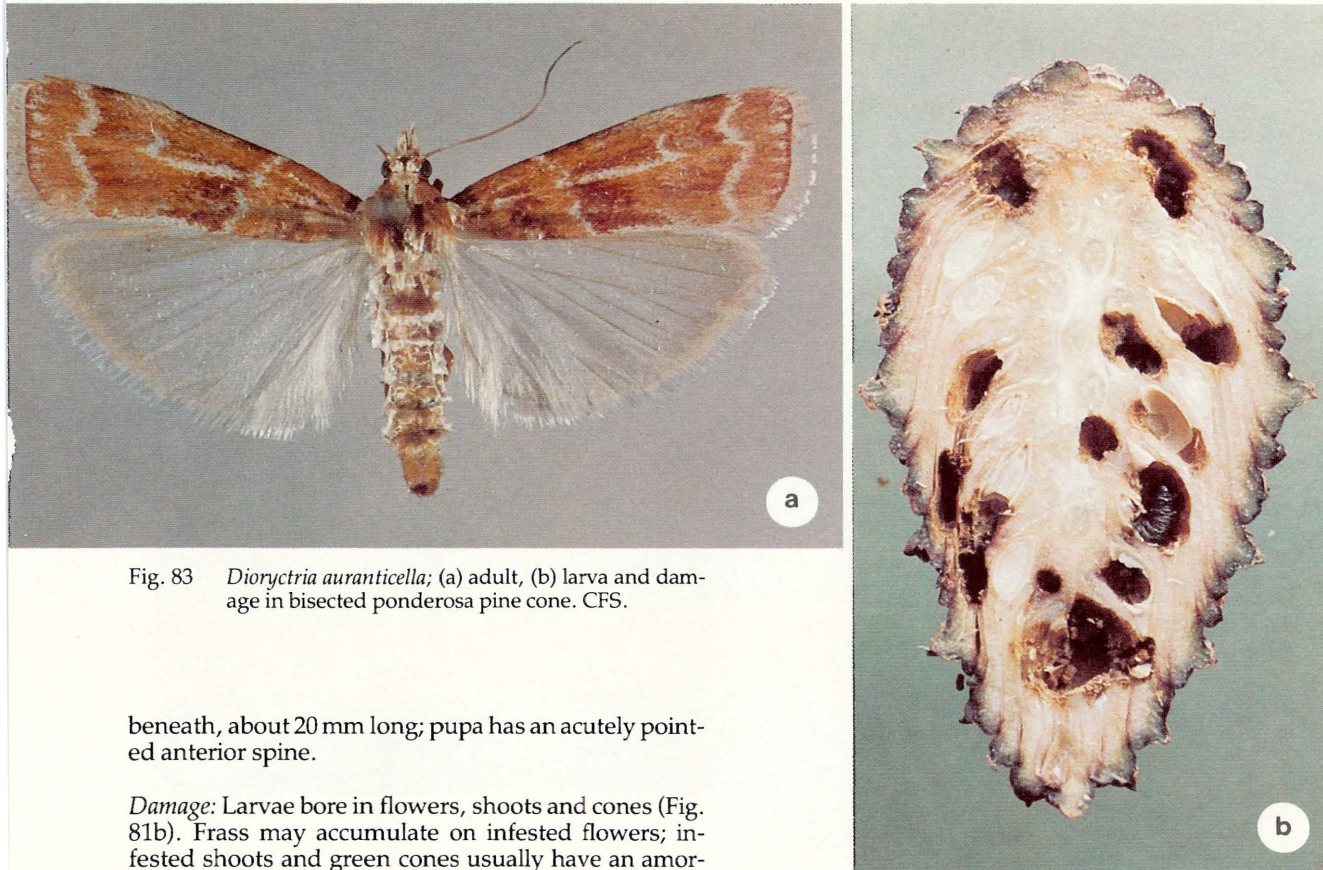


Fig. 83 *Dioryctria auranticella*; (a) adult, (b) larva and damage in bisected ponderosa pine cone. CFS.

beneath, about 20 mm long; pupa has an acutely pointed anterior spine.

**Damage:** Larvae bore in flowers, shoots and cones (Fig. 81b). Frass may accumulate on infested flowers; infested shoots and green cones usually have an amorphous mass of mixed resin and frass at entry holes. External evidence of feeding in maturing cones, which are usually less resinous, is less obvious.

**Life History and Habits:** The insect infests flowers, shoots, cones, rust-infected conelets, as well as stems and branches galled by fusiform rust and mechanically injured tree trunks (Fig. 82). Flowers and cones of slash and longleaf pines are first infested at flowering time (February). The small larvae feed first in male and female flowers and then in new shoots. Here, they may mature or may transfer as well-developed larvae to cones. Rust-infected conelets may also be attacked during May and June. Cones are infested from summer to fall. Concurrent with infestations of flowers and shoots, the insects infest fusiform galls on slash pine and produce a non-cone-infesting brood. While fusiform galls and tree trunk wounds support a limited population throughout the summer, most adults which emerge from spring-attacked galls probably lay eggs on cones in the early summer.

In loblolly pine, the spring generation appears to limit its activities to fusiform galls, followed by repeated infestation of cones from summer to fall by several overlapping generations of this coneworm.

**Importance:** The southern pine coneworm is considered the most destructive of the coneworms of the southeastern United States and ranks among the most serious insect pests of southern pine seed orchards.

***Dioryctria auranticella*** (Groté) - ponderosa pine coneworm (66, 87, 111, 114, 173, 189, 192, 193, 194)

**Hosts:** knobcone and ponderosa pines. (M88)

**Description:** Adult has orange-brown forewings with white crossbands (Fig. 83a); wingspan ranges from 22 to 34 mm; mature larva blackish to light-gray body; thorax darker than abdomen, may have reddish or purplish tinge, about 26 mm long.

**Damage:** One or more round holes, 4 to 7 mm in diameter, lead from the surface to large irregular cavities within a cone infested by this species (Fig. 83b). These cavities are partly filled with reddish brown fecal pellets and webbing. The larva severs many cone scales from the axis; these shrivel and turn brown. Undamaged portions of the cone may continue to grow but the affected cones are usually badly distorted and do not open to release surviving seed.

**Life History and Habits:** The adult moths emerge from infested cones, mate and lay eggs in late summer. The oviposition site and appearance of the eggs are not known. It is believed that larvae hatch from eggs in the fall and the early-instar larvae hibernate during the



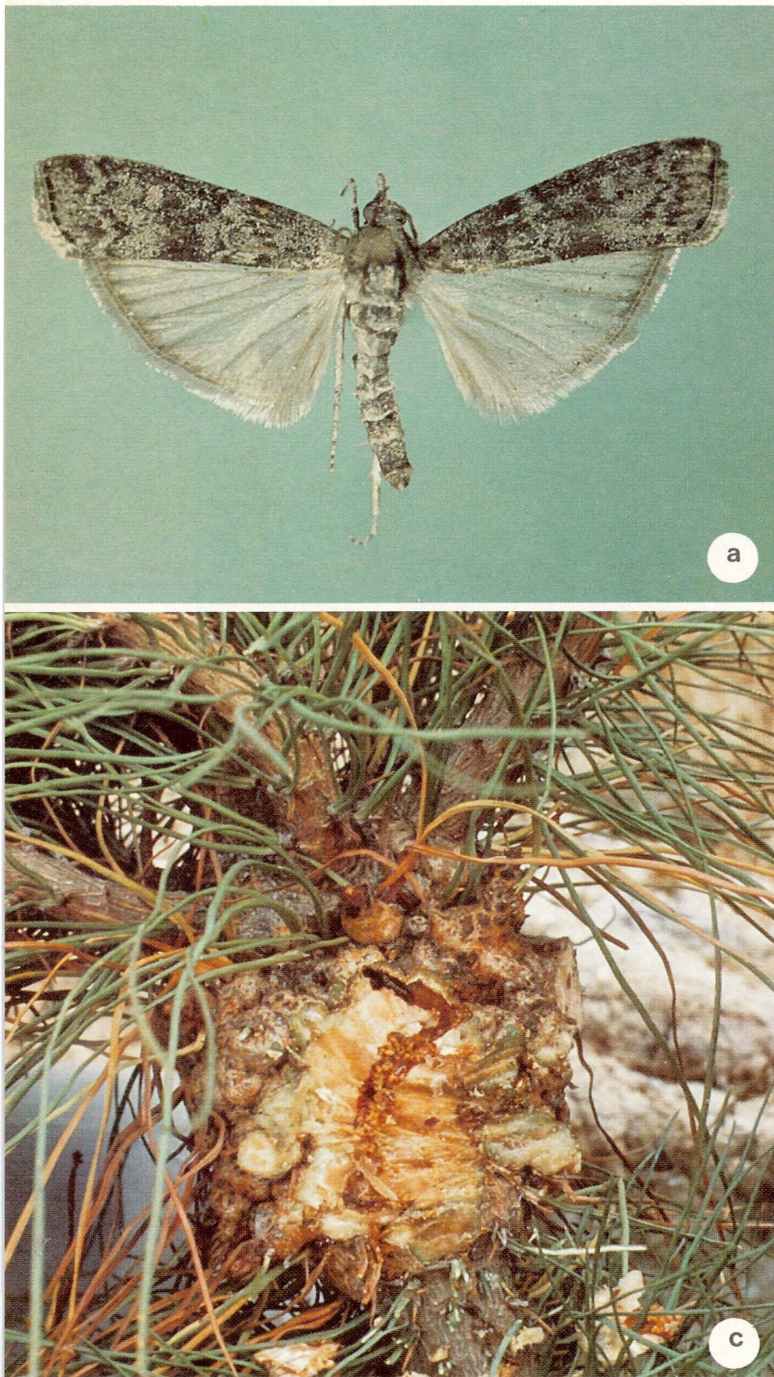


Fig. 84 *Dioryctria* n. sp. (*baumhoferi* group); (a) adult, CFS, (b) bisected Montezuma pine cone showing damage, CFS, (c) frass-filled larval gallery in *Cronartium* gall on Monterey pine. UACH.



winter. The larvae appear in the cones of ponderosa pine in late spring or early summer. An entry hole is usually made in the basal part of the cone and is enlarged as the larva grows. Larvae feed indiscriminately on seeds and scale tissues, making large irregular cavities in the cones, and reach maturity by mid- to late-July. A thin white cocoon is constructed for pupation in one of the cavities inside the cone and the entry hole is closed by a thin sheet of silk. The pupal stage lasts from 10 to 14 days.

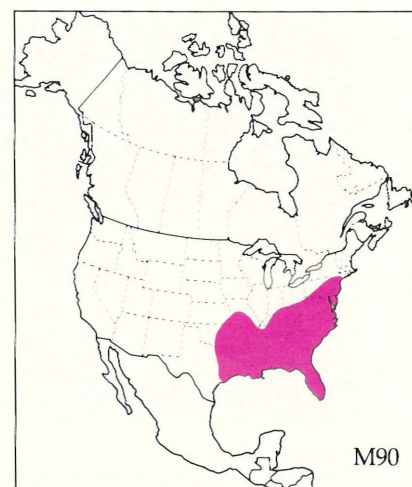
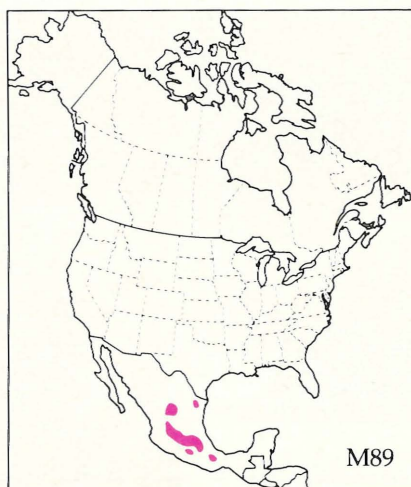
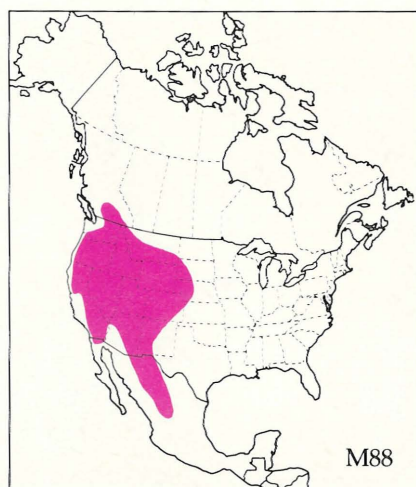
*Importance:* The insect sometimes occurs in large numbers, although it appears to be restricted to the drier parts of the range of ponderosa pine. Usually only a small percentage of the cones are attacked, but virtually all of the seed in damaged cones is lost. In New Mexico, an average loss of about 8 percent has been recorded.

*Dioryctria* n. sp. (*baumhoferi* group) - Mexican coneworm

*Hosts:* sacred fir; Montezuma and rudis pines; *Cronartium* sp. galls of Monterey pine, and *C. conigenum* galls of other pines. (M89)

*Description:* Adult wingspan about 30 mm; fore wing gray with two light gray-colored zig-zag crossbands (Fig. 84a); egg pale yellow, oval, 0.6 by 0.8 mm; young larva is light red but in later instars turns purplish,





sometimes becoming greenish; pupa dark brown, about 10 mm long.

**Damage:** The larva mines the scales, seeds and axes of pine cones, forming large irregular galleries; usually there is not more than one larva per infested cone (Fig. 84b). Larval feeding kills the cone, causing it to turn brownish gray. Frass mixed with silk and resin around the larval entry hole also provides external evidence of damage. The Mexican coneworm frequently infests *C. conigenum* and other galls, where larvae form large irregular galleries and leave frass and silk on the surface (Fig. 84c).

**Life History and Habits:** This insect has three generations per year, one in cones and two in *Cronartium* galls. During December and January, adults oviposit on scales of pine cones. Larvae bore into the cones and feed from January to May. Pupae are present from May to June; adults emerge from cones in June and lay eggs on *Cronartium* galls. Mature larvae pupate in the galls or drop to the ground and pupate in the soil. During September, adults emerge and infest other galls. A second emergence from galls occurs during December and adults from this generation oviposit on cones, completing the cycle. The life cycle of this coneworm in sacred fir has not been studied.

**Importance:** This insect is more common in rudis than in Montezuma pine. The ability to breed in *Cronartium* galls enables the population to build up and later attack young cones. Insects occasionally attack and kill young shoots, reducing cone production and suppressing tree growth.

***Dioryctria clarioralis* (Walker) - blister coneworm**  
(26, 29, 44, 47, 55, 95, 158, 179, 234, 236)

**Hosts:** loblolly, longleaf, shortleaf and slash pines; probably also in other southern pines. (M90)

**Description:** Adult wingspan about 25 mm; fore wing rusty brown heavily shaded with darker brown to

black and with pale crossbands and blotches; a wide, dark band across basal part of wing is particularly distinctive of this species; hind wings dusky brown (Fig. 85a); eggs with indefinitely rugose surface; young larva marked with five lines; when mature, amber to orange-brown, often shaded with gray, about 20 mm long; pupa rounded apically.

**Damage:** This insect infests flowers, shoots, buds and young cones (Figs. 85b, c). Typically, the infested material is hollowed out and a distinctive blister of resin-coated webbing, retaining extruded frass, covers the entry hole.

**Life History and Habits:** In the southern United States, immature larvae overwinter in buds, flowers, new shoots and young cones. From early summer through fall, two more distinct generations occur, primarily in conelets and shoots or vegetative buds. In Arkansas, the second generation also frequently infests cones of loblolly pine. Early instars feed externally, apparently on scale-leaves. The partly grown larva, probably the third instar, enters host material at the base and cuts a shallow spiral tunnel that internally severs the bud or conelet. The inner cut surface is covered with webbing and the larva then tunnels outward, eventually hollowing out the infested material. The mature larva leaves the food source and pupates on a twig in a cocoon covered with bark scales.

**Importance:** The fact that buds and shoots provide an alternate food source reduces the impact of the blister coneworm on cones. It seems to be most common in longleaf pine but has been reported as a major pest of loblolly pine in Arkansas.

***Dioryctria disclusa* Heinrich - webbing coneworm**  
(55, 56, 75, 95, 133, 135, 149, 150, 173, 177, 178, 179, 189, 235, 236)

**Hosts:** jack, loblolly, longleaf, pitch, red, Scotch, shortleaf and Virginia pines; white spruce. (M91)



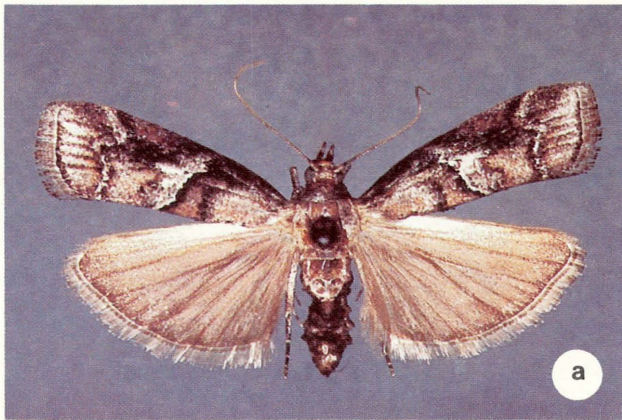
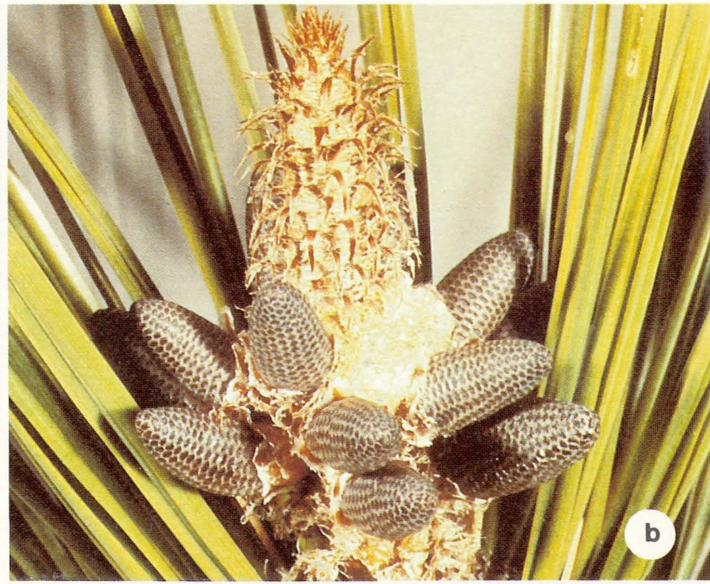


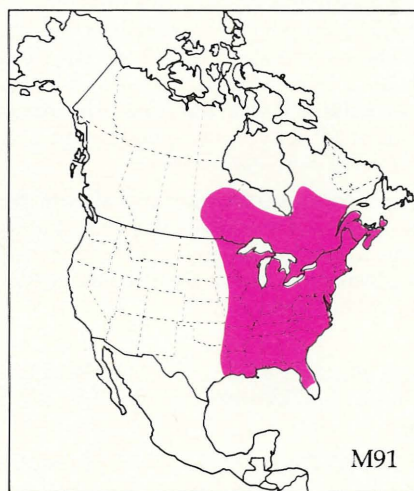
Fig. 85 *Dioryctria clarioralis*; (a) adult, (b) damage to slash pine bud, (c) damage to shortleaf pine cones. USFS.



**Description:** Adult (Fig. 86a) wingspan about 27 mm; fore wing golden to orange shading variably to reddish brown; markings white; hind wings pale smoky-tan; egg 0.4 by 0.5 mm, lightly striated; first-instar larva eleven-striated; mature larva 15 to 25 mm long, grayish buff to olive-green; pupa rounded apically.

**Damage:** Infested cones have a characteristic mass of tightly webbed frass over the entry hole and are essentially hollowed out inside (Fig. 86b). Damage occurs to young cones in spring and early summer.

**Life History and Habits:** In the northern part of the range, overwintered first-instar larvae infest male flowers and after developing to the third instar, enter cones. In north Georgia, loblolly and Virginia pine cones are attacked by third-instar larvae in early spring. It seems likely that the first two instars infest flowers as in the North, but this has not been confirmed. Moths emerge from late spring to midsummer, depending on latitude. Only one generation occurs each year.



M91

**Importance:** The webbing coneworm can cause moderate cone losses, but seems to be quite variable from area to area and from year to year.

***Dioryctria ebelsi*** Mutuura and Munroe - south coastal coneworm (3, 44, 47, 52, 151, 179) (*D. abietella* (D. & S.) and *D. abietivorella* (Groté) in part) (M92)

**Hosts:** loblolly, longleaf and slash pines; pondcypress.

**Description:** Adult (Fig. 87a) wingspan about 20 mm; fore wing ground-color dark gray profusely sprinkled with lighter scaling and with diffuse white crossbands; hind wings light grayish tan; egg pale yellow, about 0.4 by 0.6 mm, with reticulated surface pattern; newly hatched larva uniform amber; mature larva dark purple to brown above, paler below, about 15 mm long.



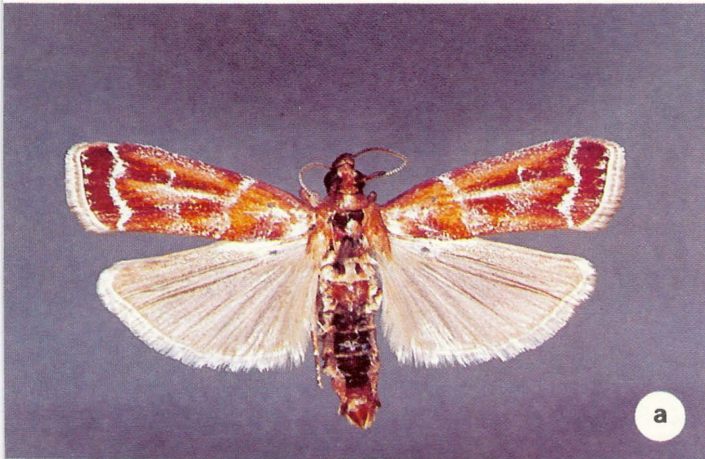


Fig. 86 *Dioryctria disclusa*; (a) adult, (b) larval damage to loblolly pine cone. USFS.

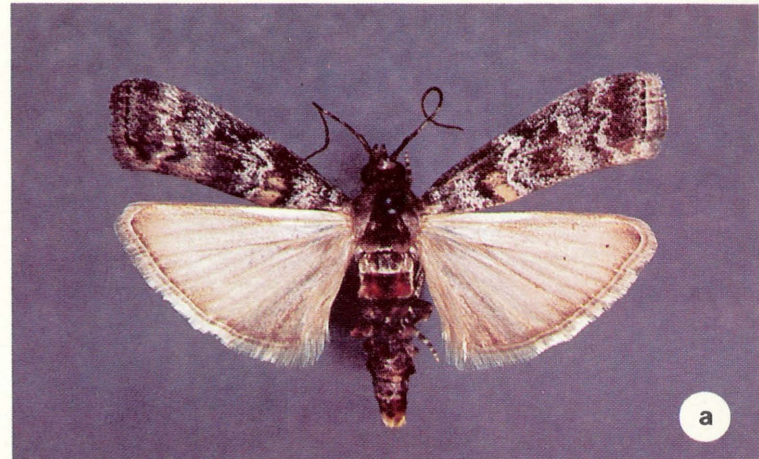


Fig. 87 *Dioryctria ebeli*; (a) adult, (b) larval damage to loblolly pine cone. USFS.

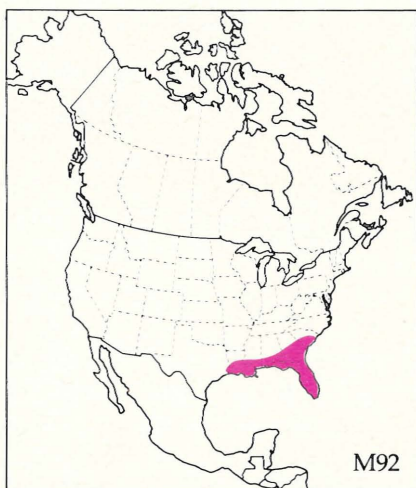
**Damage:** Larvae bore into cones in a random manner (Fig. 87b).

**Life History and Habits:** This coneworm is frequently associated with hypertrophied conelets infected by southern cone rust, *Cronartium strobilinum*. It is found almost exclusively in these conelets during spring and early summer. Throughout the remainder of summer to early fall, it occurs in cones, often in conjunction with other cone-infesting insects. Overwintering

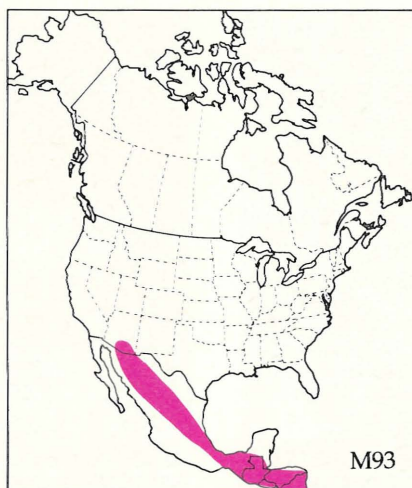
larvae infest shoots or, more frequently, cankers of the fusiform rust, *C. fusiforme*. There may be as many as six generations per year. Pupation apparently takes place in a thin cocoon in soil litter.

**Importance:** This insect seems to be intermediate in importance as a cone-destroying pest. Two factors tend to diminish its damage. The spring generation occurs primarily in rust-infected conelets; it also has a tendency to infest cones damaged by other insects.

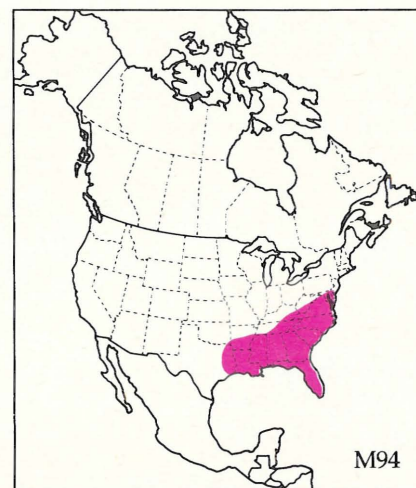




M92



M93



M94

***Dioryctria erythropasa* (Dyar) (95, 111)**

*Hosts:* Caribbean and Chihuahua pines. (M93)

*Description:* Adult wingspan about 25 mm; fore wings red-brown with white markings; hind wings smoky-white with darker veins (Fig. 88a); larva about 15 to 20 mm long, head medium orange-brown, body pale, nearly white to greenish, variably shaded above; it superficially resembles *D. amatella*, but differs in minute morphological detail.

*Damage:* Feeds in cones on the pine host; observations made in Nicaragua (Fig. 88b).

*Life History and Habits:* Not known; moths in Arizona reported in May and August, suggesting multiple generations.

*Importance:* The extent of damage has not been studied.

***Dioryctria merkeli* Mutuura and Munroe - loblolly pine coneworm (30, 50, 52, 55, 175, 235)**

*Hosts:* loblolly, longleaf, shortleaf, slash and Virginia pines. (M94)

*Description:* Adult (Fig. 89a) wingspan 25 to 30 mm; fore wing medium brown blended with rust brown and darker shading; crossbands and lighter areas grayish, subtly blending into ground color; hind wings pale grayish tan; egg and first-instar larva similar to those of *D. amatella*; mature larva about 25 mm long with dark tubercles and pits as in *D. amatella* but body color is dark blue-black above and blue-green beneath; pupa has obtusely angled anterior spine.

*Damage:* Early-instar larvae bore into flowers and usually leave a small amount of frass on the surface. There is usually a mass of resin and frass at the point of larval entrance to infested shoots and cones, which are irregularly tunneled (Fig. 89b, c).

*Life History and Habits:* First-instar larvae overwinter

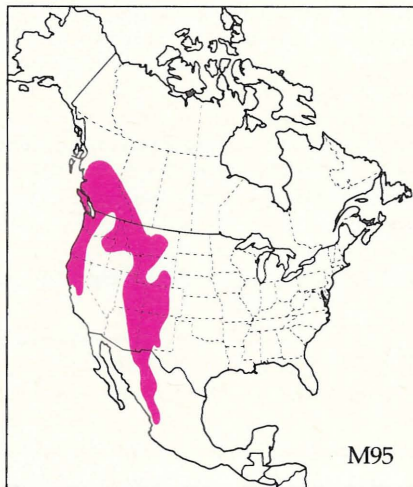


Fig. 88 *Dioryctria erythropasa*; (a) adult, (b) damage. USFS.



under bark scales and in spring infest both male and female flowers. Then they enter new shoots; in loblolly pine, they disperse again to feed on rapidly growing cones, while in slash and longleaf pines, they may mature in shoots or attack cones. Feeding is completed by early summer and the larvae remain inactive in the dead host material until fall. They then pupate and the adults emerge, completing a single annual generation. In north Florida the population infesting slash and longleaf pines, while most closely resembling the loblolly-infesting species, intergrades toward *D. amatella*. Rearings from larvae aestivating in dead spring-killed shoots and cones have yielded a majority of brown type moths, but also some typical *D. amatella*. Recent evidence suggests that these two species do not usually interbreed; however, it appears possible that some gene flow has occurred between them along the southern fringe of the range of the loblolly pine cone-worm.

**Importance:** This insect is a major pest of loblolly pine, approaching *D. amatella* in importance as a pest of this host.



***Dioryctria pseudotsugella* Munroe (66, 174, 193)**

**Host:** Douglas-fir; may also occur on firs. (M95)

**Description:** Adult (Fig. 90) wingspan 20 to 24 mm; resembles the spruce coneworm, but ground color is paler and transverse lines much less strongly contrasting.

**Damage:** The larva feeds in cones and also mines in cambium. It has been taken from graft unions of Douglas-fir, where it may cause damage to grafted stock in seed orchards.

**Life History and Habits:** Larvae feed during spring and early summer. Adults emerge in July in British Columbia. Details of egg laying and early larval development have not been recorded.

**Importance:** When abundant, it may be a serious pest in cones and to grafted seed orchard stock.

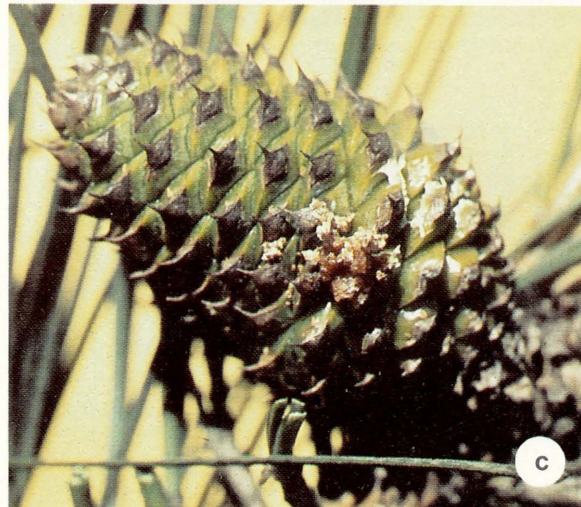
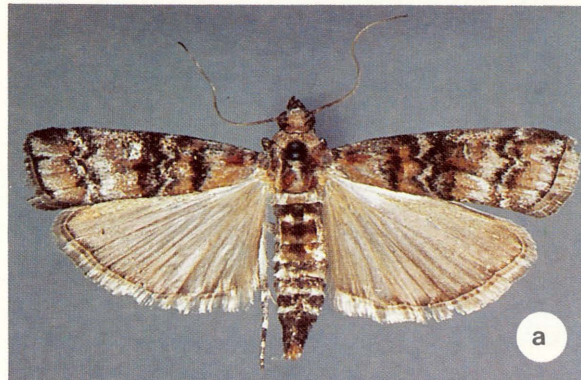


Fig. 89 *Dioryctria merkeli*; (a) adult, (b) larval damage to loblolly pine conelet (larva killed conelet on left, then entered shoot below), (c) larval damage to loblolly pine cone. USFS.



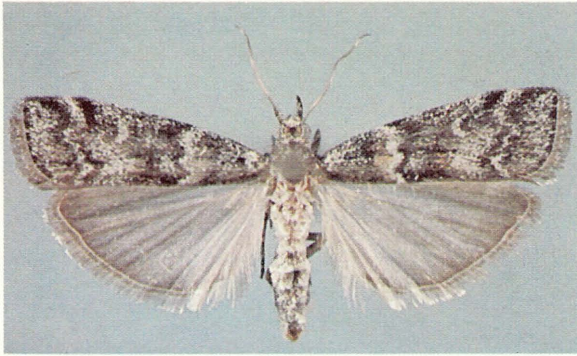
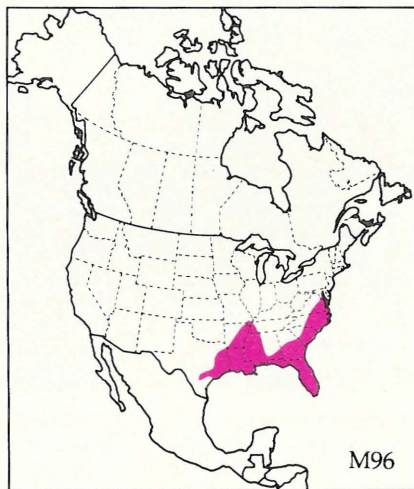


Fig. 90 *Dioryctria pseudotsugella* adult. CFS.

***Dioryctria pygmaeella*** Ragonot - baldcypress coneworm (95, 179)

*Hosts:* baldcypress and pondcypress. (M96)

*Description:* Adult wingspan about 18 mm, fore wing purplish gray variably blended with reddish brown toned with lighter gray to whitish markings and cross-bands, usually paler at middle than at base or tip giving wing a distinctly banded appearance, wing surface with few roughened scales, hind wings smoky gray (Fig. 91a); newly laid eggs white with finely reticulated surface, oval, 0.3 by 0.7 mm; mature larva 12 to 15 mm long, head and prothorax generally dark brown with pale yellow markings, anal shield pale yellow with few dark brown marks, body segments vary in color from creamy white to brownish pink with four white longitudinal lines on either side of the brownish pink mid-dorsal line, the fourth white line running through or slightly above the spiracles; a pair of lateral, black, ring-like tubercles (pinacula), each bearing a long seta, obvious on mesothorax and eighth abdominal segment, also four dorsal black tubercles very evident on abdominal segments 1 through 8, the black tubercles



M96

prominent on all larvae except first instar; pupa 2.5 by 9 mm with rounded anterior end.

*Damage:* The larvae feed internally on all cone tissues. Little, if any, evidence of frass or entrance holes (Fig. 91b) are present; one may occasionally observe a single brown dead scale. Until mid-July, it is not unusual to find completely green cones with the interior severely damaged and containing mature larvae (Fig. 91c) and pupae. From early August until cone maturation, infestation is readily apparent because of dead cone scales and entrance holes bored by other *Dioryctria* larvae.

*Life History and Habits:* Two distinct generations are indicated by light-trap collections from mid-May to mid-September. Studies on the life cycle from fall to spring are yet to be completed. Pupation occurs in the cones. It is presumed that this insect overwinters in the egg or early larval stages but this needs verification. During the period of cone development, eggs are laid singly on the cone surface. After eclosion the first-instar larva consumes the egg shell and then bores into the cone leaving only minute frass pellets and webbing over the entrance hole. Larval development is completed entirely within the cone and there is no evidence to indicate that developing larvae move to non-infested cones as is the case with some of the southern pine-infesting *Dioryctria* species. Usually one, and occasionally two, larvae will mature in a single cone. Prior to pupation, the mature larva cuts a circular exit hole to the cone surface and closes it with a smooth thin parchment-like substance completely lacking any frass pellets. From early August until cone maturation, increasing numbers of *D. amatella* and *D. ebeli* are found in the same cones with the baldcypress coneworm.

*Importance:* Little information has been obtained on the impact of the baldcypress coneworm on seed yields. During the summer of 1978, a survey in northeast Florida revealed that 80 to 100 percent of the baldcypress and pondcypress cone crops were destroyed.

***Dioryctria reniculelloides*** Mutuura and Munroe - spruce coneworm (32, 66, 111, 140, 144, 173, 174, 189, 192, 194, 218) (*D. reniculella* Groté)

*Hosts:* Douglas-fir; alpine, balsam and Pacific silver firs; western hemlock; lodgepole pine; black, blue, Engelmann, red, Sitka, and white spruces; possibly arbor-vitae, jack pine and tamarack. (M97)

*Description:* Adult (Fig. 92a) wingspan about 24 mm; fore wing mottled dark gray with sharp white cross-bands; hind wing dark gray with obvious pale sub-terminal band, egg cream colored, 0.7 by 1 mm, striated; first-instar larva has nine broken stripes and is cinnamon brown; mature larvae about 17 mm long, with dark-brown head, body brown, five wide longitudinal stripes, three dorsal cinnamon colored and two lateral dark brown (Fig. 92b); pupa has anterior projection intermediate between rounded and spined.

*Damage:* Infested cones and shoots are enveloped in a



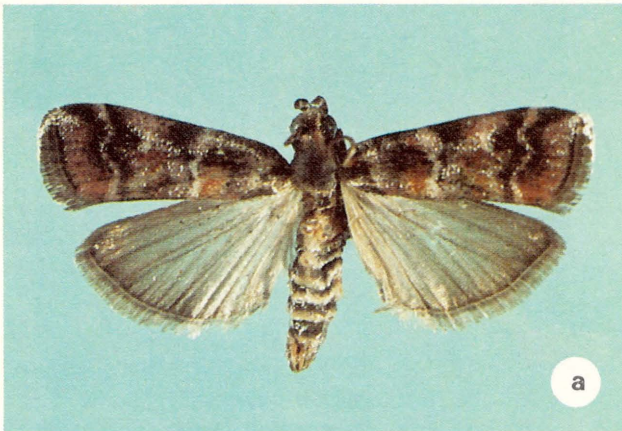
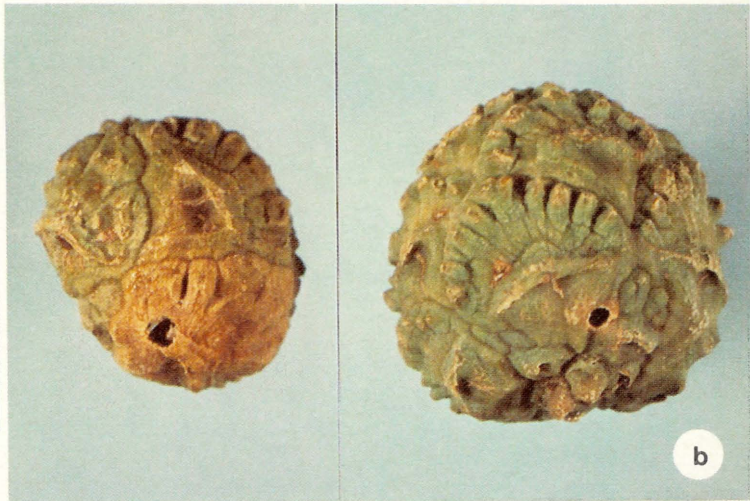


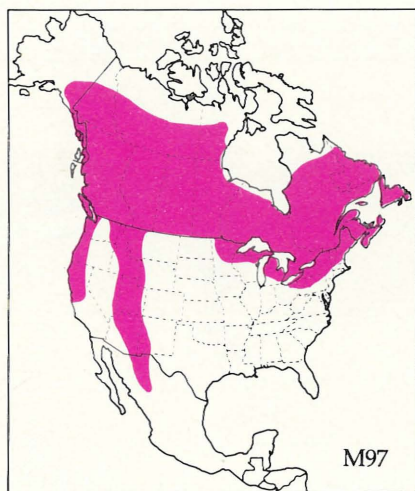
Fig. 91 *Dioryctria pygmaeella*; (a) adult, (b) larval emergence holes from baldcypress cones, (c) bisected cone showing damage. USFS.



mass of webbed frass. Infested cones are hollowed out.

*Life History and Habits:* This coneworm overwinters as a first-instar larva in a hibernaculum. In spring, it feeds first as a needle miner, molts and then enters a bud, male flower or cone, or it may enter a bud without first mining a needle. It may also feed on foliage, particularly in the absence of cones, but seems to be most abundant in years of good cone crops. Pupation may be in cones or on foliage. Moths emerge in July and August and lay eggs, usually singly, in bark crevices and similar niches on the host tree. There is one generation per year.

*Importance:* When abundant, this coneworm can be a serious pest, particularly on white spruce. It is however, rather sporadic in occurrence.



M97

***Dioryctria rossii* Munroe (87, 139, 173, 189, 193)**

*Hosts:* Durango and ponderosa pines. (M98)

*Description:* Adult (Fig. 93) wingspan range 22 to 34 mm; fore wing color similar to that of the webbing coneworm and ponderosa pine coneworm, but insect easily distinguished from both by absence of the inner transverse line across fore wings; larva about 30 mm long, head reddish brown, body brownish with subdorsal dark gray stripe.

*Damage:* The larva feeds in cones, causing damage similar to that of *D. auranticella*.

*Life History and Habits:* Larvae are present in cones in early summer. Pupae develop by mid-July; adults emerge in late July or August.

*Importance:* Probably of relatively minor importance.



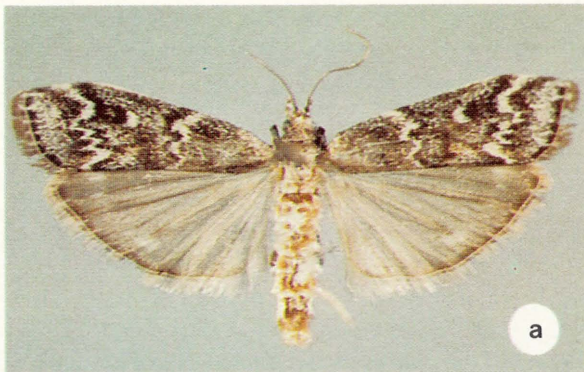
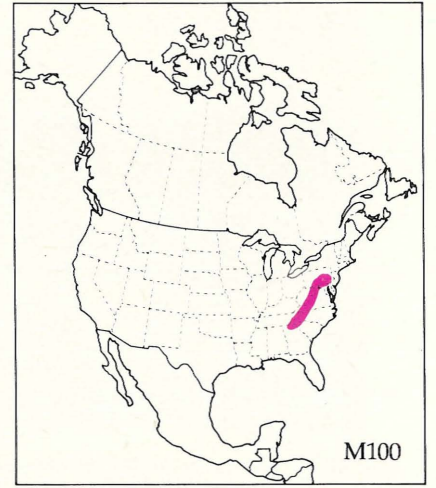
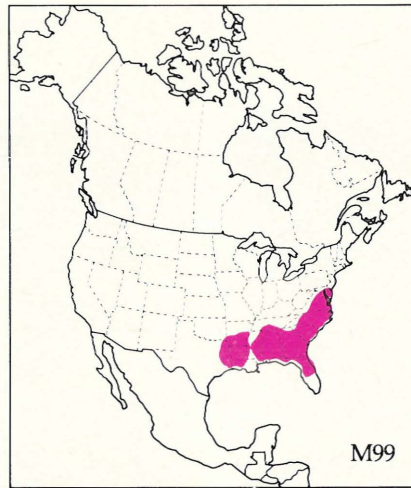
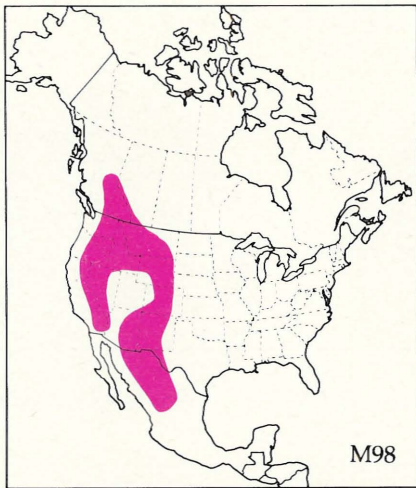
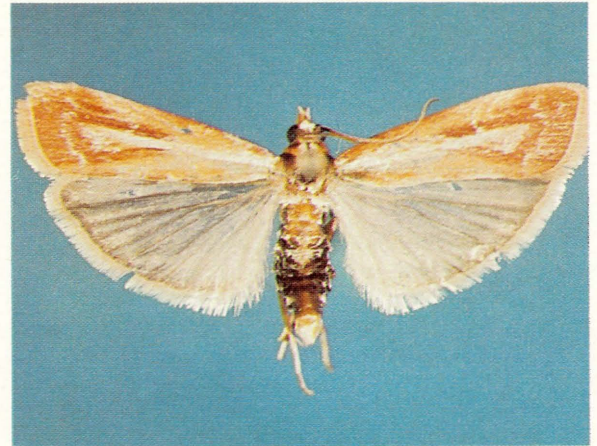


Fig. 92 *Dioryctria reniculelloides*; (a) adult, (b) larva. CFS.





***Dioryctria taedae*** Schaber and Wood - Atlantic pine coneworm (52, 201)

*Host:* loblolly pine. (M99)

*Description:* Fore wing dark gray-brown, flecked with reddish scales; transverse lines and other markings light gray; hind wing light smoky gray darkening along the margin (Fig. 94).

*Damage:* Young larvae tunnel in terminals, but in general larvae infest cones; published reports do not differentiate damage by this species from that by *D. merkei*.

*Life History and Habits:* The life cycle of this coneworm is not completely known. It was reared from loblolly pine in Maryland. Adults emerge from June to November. The authors of this species did not distinguish it from *D. merkei* and included specimens of that species and of the southern pine coneworm, in the type-series of other material identified by them as *D. taedae*. Adding to the confusion was the misidentification of the mountain pine coneworm, *D. yatesi*, as *D. taedae*<sup>1/</sup>.

*Importance:* Most of the damage attributed to the loblolly pine coneworm in Maryland and adjacent areas probably is caused by this species. Like the southern pine coneworm and unlike the loblolly pine coneworm, it appears to have a wide range of emergence dates.

***Dioryctria yatesi*** Mutuura and Munroe - mountain pine coneworm (52, 175)

*Host:* Table-Mountain pine. (M100)

*Description:* Adult wingspan about 25 mm; fore wing slate gray, usually without strong brown tints, but with diffuse gray or grayish white scaling and crossbands; dark scaling beyond second crossband extending less than halfway to outer margin; hind wing whitish, with weak to strong smoky gray suffusion along veins and outer margin (Fig. 95a); egg and first-instar larva unknown; mature larva about 20 mm long; head capsule orange-brown; body whitish to pale green, usually with tints of pale pinkish purple; pupa has an anterior spine.

*Damage:* The larva tunnels extensively in cones of Table-Mountain pine leaving a heavy accumulation of sawdust-like, lightly webbed frass on the surface (Fig. 95b).

*Life History and Habits:* The life cycle of this coneworm is not completely known. Infestations of cones occur during late summer and early fall. Maturing larvae tunnel randomly in the cones, often breaking through the cone surface. Moths emerge in late summer. The absence of early damage suggests that there is only one generation each year.

*Importance:* This insect may be locally abundant on Table-Mountain pine. Since the host is not an im-



Fig. 95 *Dioryctria yatesi*; (a) adult, (b) larval damage to Table-Mountain pine cone. USFS.

portant tree species, this coneworm is a relatively minor pest.

#### Lesser known species of *Dioryctria*

The three species listed below have been reported to occur in the areas indicated, but there are no detailed records available on damage, life history and habits, or importance for any of them.

***Dioryctria horneana*** (Dyar) (95, 98)

*Host:* pines.

*Description:* Adult fore wing bright reddish brown with white markings including patches of raised scales; hind wings yellowish white; wingspan 25 to 30 mm.

*Comments:* This species is known only from Cuba. It has been recorded recently as a plantation pest infesting shoots.

<sup>1/</sup> Personal communication from Drs. A. Mutuura and E. Munroe.



***Dioryctria majorella*** Dyar (95)

*Host:* Caribbean pine.

*Description:* Similar to *D. abietivorella*; wing pattern less distinct; the white crosslines dull and dark areas preceding them more obvious; wingspan 28 to 33 mm, exceeding that of *D. abietivorella*. Other stages are unknown.

*Comment:* This species has been recorded from Mexico and British Honduras.

***Dioryctria sysstratiotes*** Dyar (95)

*Host:* Unknown.

*Description:* This moth (Fig. 96) is similar in appearance to *D. abietivorella*, differing in that it has noticeable brownish shading. The wingspan is from 23 to 28 mm.

*Comments:* Adults were collected in Guatemala in June and July. There are no records on hosts, damage, life history or importance.

**Genus *Vitula***

*Vitula* sp. near *lugubrella* (Ragonot) and *V. pinei* Heinrich have been recorded as pests in cones of Mexican white pine, and singleleaf pinyon, respectively. There are very few records on the type and extent of damage caused by the larvae of these species.

**Family Tortricidae - leafroller moths**

Adults are similar to Olethreutidae, but lack the fringe of hairs on the underside of the hind wing. Larvae tend to be foliage feeders, often as leaf rollers or tiers. Few members of this family are important cone and seed pests.

***Argyrotaenia* sp. prob. *urbana*** Busck

*Host:* Mexican white pine.

*Description:* Adult wingspan about 16 mm; fore wings are uneven rusty red (Fig. 97).

*Comments:* Cones of the host are attacked when about 1½ years old. There are no detailed records available of life history and habits or the importance of this species.

**Species D**

*Hosts:* sacred fir; Chihuahua, Hartweg, Mexican white, **Montezuma** and rudis pines. (M101)

*Description:* The insect complex involved here has not been studied in detail; there are probably several species. In Montezuma pine, the adult has a wingspan ranging from 11 to 19 mm; fore wings brown with lighter patch on proximal ⅓ of wing; larva dark reddish in all instars. Species attacking Chihuahua pine similar to above, but the adult is smaller with wingspan of 10 mm. Adult from sacred fir has wingspan of 16 mm and is darker than moths from pine cones.

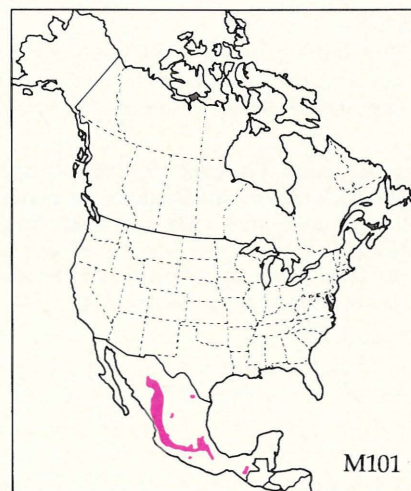


Fig. 96 *Dioryctria sysstratiotes* adult. USFS.



Fig. 97 *Argyrotaenia* sp. prob. *urbana* adult. CFS.

*Damage:* The larva bores a large tunnel through scales and seeds. There may be three to eight larvae per infested cone in Montezuma pine, each destroying 10 to 12 seeds. Damage is indicated externally by a hole surrounded by pitch and frass. In Mexican white pine, the larva feeds mainly in scale tissue, boring in one or two scales; if it enters a seed, it will not destroy more than one, because the seeds are very large. In sacred



M101



fir, the larva feeds in scales, tunneling parallel to the cone axis. Feeding causes resin exudation which fuses scales and traps the seeds in the cone. Species of this insect complex occur in cones, *Cronartium* galls, and midge-caused galls.

*Life History and Habits: Cone feeding.* — There are two generations per year in all hosts except Hartweg pine, where there is one per year. Adults of the first generation are present from July to September. Larvae are present from August to November and pupae during October to December. The pupae which are naked remain in the larval feeding gallery near the cone axis. Prior to emergence, the pupa wriggles along an exit tunnel to the cone exterior; the adult emerges and the pupal exuvia remains at the mouth of the exit hole. Second generation adults emerge during January to April. Larvae are present from March to June and pupae from June to August. In sacred fir, adults emerge in March and again during November and December.

*Cronartium canker and midge gall feeding.* — Moths may lay eggs on cankers which have formed when cones or twigs become infected with the rust *Cronartium conigenum*. Eggs are laid during February and March and again from August to October. Up to 150 larvae may feed in one gall, consuming the inner portion. Frass on the surface indicates the presence of insects in galls; following moth emergence, pupal exuviae are also present. Cecidomyiid galls, formed in twigs at the bases of needles, may also be infested by this species. These galls may expand to 350 mm in diameter and may support 300 or more larvae.

*Importance:* This insect complex comprises one of the major pests of cones and seeds in Mexico. Its ability to reproduce in galls of insect and disease origin has a positive influence on insect populations. In Montezuma pine, the principal host, as much as 70 percent of cones may be attacked and up to 12 percent of seeds in infested cones destroyed. Other pine hosts, rudis, Hartweg and Chihuahua in this order, suffer less damage. Up to 75 percent of the cones of sacred fir may be infested and 25 percent of the seeds in these cones destroyed.

#### *Choristoneura* spp. - budworms (212)

Members of this genus, including the well-known spruce budworms and also pine-feeding species, are not only defoliators, but often feed directly on flowers and young cones, especially when populations are high.

*Description:* Adults are medium-sized moths with wingspans of about 20 to 30 mm (Fig. 98a). They are variably mottled, usually in shades of brown and gray. Eggs are about 1 mm long, flattened and ovoid and are laid overlapping in elongate masses on host needles. Mature larvae are about 20 to 25 mm long with shiny yellow to brownish black head capsules (Fig. 98b). Body color varies owing to longitudinal bands of darker and lighter shades; prominent pale spots occur on the upper surface.

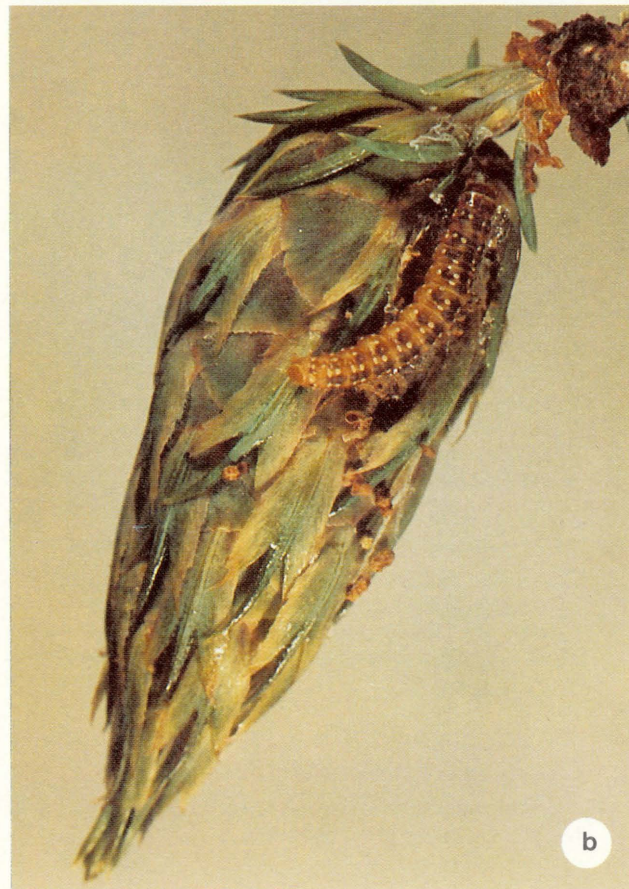


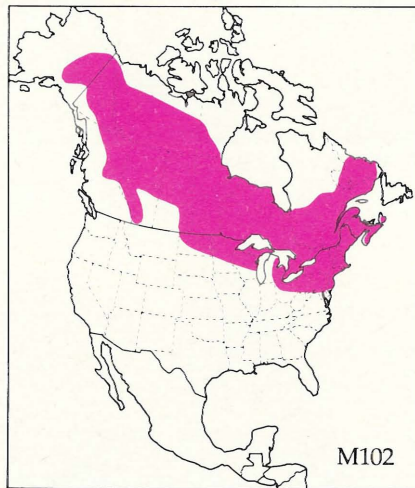
Fig. 98 *Choristoneura occidentalis*; (a) adult, (b) larva feeding on Douglas-fir cone. CFS.

*Damage:* While defoliation is the most obvious indication of damage, male and female flowers and cones, or both, may be fed upon by preference, if available. Infested material usually has obvious external frass and webbing. Cone-feeding larvae bore holes into developing cones (Fig. 98b) or completely consume male and female flowers.

*Life History and Habits:* Adults emerge in mid to late summer and lay eggs in masses on host tree needles. The young larvae molt once and overwinter, without



feeding, in small webbed tents called hibernacula. In spring, larvae begin feeding by mining in old needles or in buds and flowers, then on new growth foliage and, in some cases, cones. Pupation occurs by mid-summer. There is one generation per year.



M102

Species that damage flowers and cones include:

***Choristoneura fumiferana* (Clemens) - spruce budworm** (10, 64, 66, 68, 76, 183) (M102)

**Hosts:** balsam fir; eastern hemlock; black, red and white spruces; tamarack; several species of pine.

**Comments:** Young larvae feed freely on flower buds and may destroy up to 90 percent of the female flowers of balsam fir. Heavy defoliation during years of severe outbreaks may seriously inhibit cone production for 1 or more years.

***Choristoneura lambertiana* (Busck)**

This species has several recognized subspecies, of which two have been reported as destroying flowers and cones.

subspecies ***lambertiana*** (Busck) - sugar pine tortrix (66, 76, 111)

**Host:** sugar pine. (M103)

**Comment:** Young larvae have been reported as feeding on buds and flowers of the host in much the same manner as spruce budworm on balsam fir.

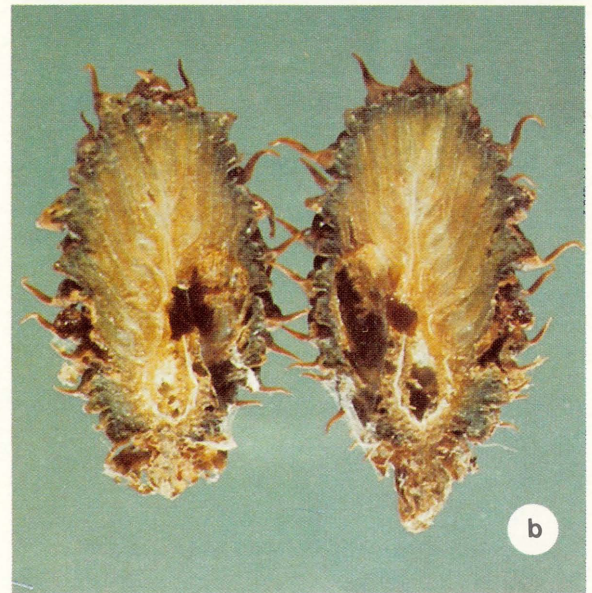
subspecies ***subretiniana*** Obraztsov (76, 185, 211, 212)

**Hosts:** lodgepole and ponderosa pines. (M104)

**Comment:** Larvae prefer male flower buds and overwintered cones of lodgepole pine as food (Figs. 99a, b).



a



b

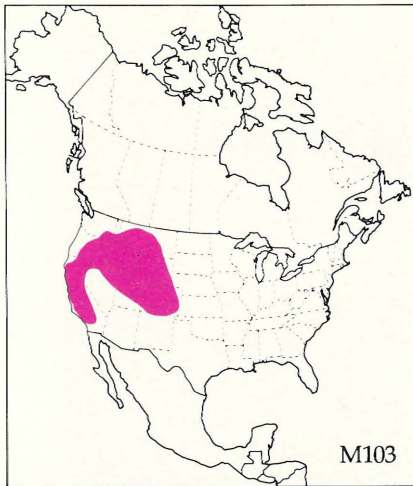
Fig. 99 *Choristoneura lambertiana subretiniana* on lodgepole pine; (a) pupa and damage, (b) bisected cone showing internal damage. USFS.

***Choristoneura occidentalis* Freeman - western spruce budworm** (42, 58, 64, 66, 76, 87) (Figs. 98a, b).

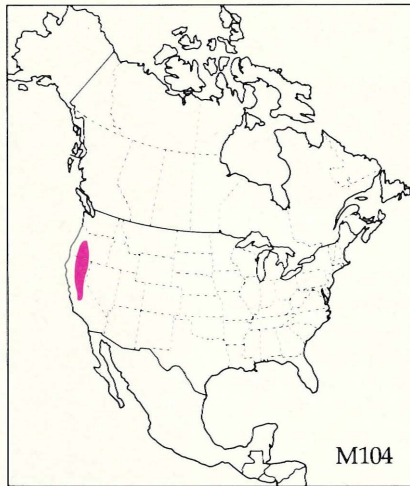
**Hosts:** Douglas-fir; grand, subalpine and white firs; larch; Engelmann and white spruces. (M105)

**Comment:** Larvae feed on flower buds, flowers and developing cones.

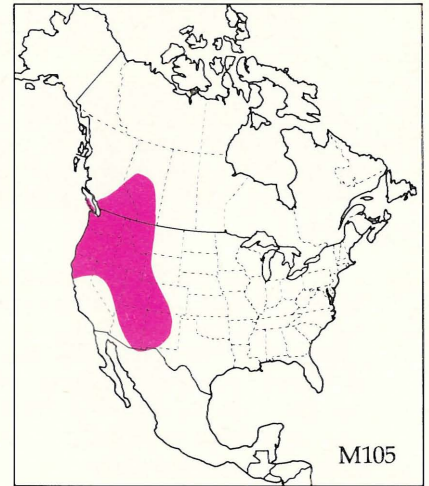




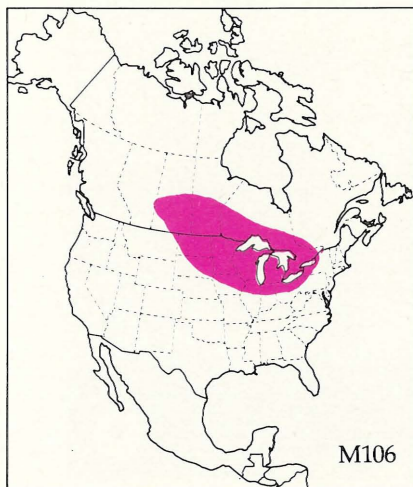
M103



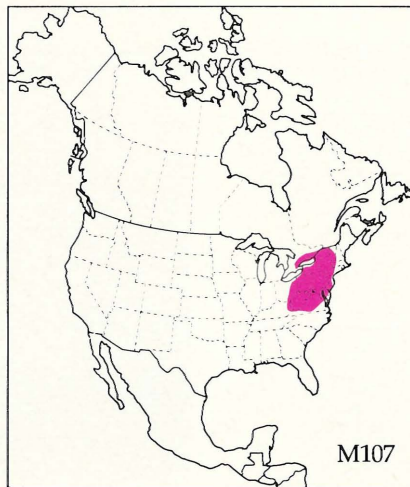
M104



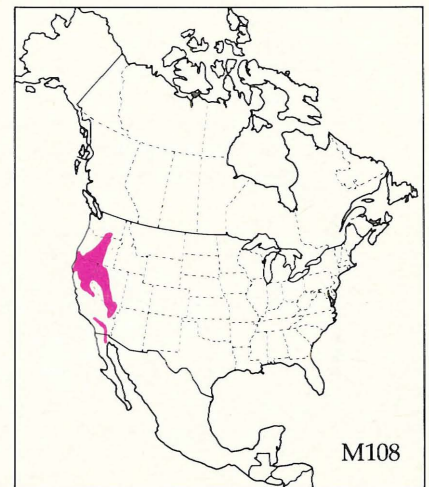
M105



M106



M107



M108

***Choristoneura pinus* Freeman (63, 64, 66, 76)**

There are two subspecies.

subspecies *pinus* Freeman - jack pine budworm (63, 64)

*Hosts:* jack, lodgepole and red pines. (M106)

subspecies *maritima* Freeman (64) (M107)

*Hosts:* pitch, Table-Mountain and Virginia pines.

*Comment:* Male flowers appear to be preferred larval food.

**Family Yponomeutidae - ermine moths**

Adults are moderately small moths with fore wings usually patterned in contrasting coloration. Larvae are variable in habits, frequently having web

structures associated with foliage feeding habits or are miners or borers.

***Argyresthia libocedrella* Busck - incense-cedar tip moth (66, 111)**

*Hosts:* incense-cedar; Port-Orford-cedar. (M108)

*Description:* Moth wingspan about 8 mm; glossy, light golden color with two dark brown narrow bands across fore wing; larva small, green, with red dorsal bands.

*Damage:* Larvae mine cones and seeds.

*Life History and Habits:* The insect overwinters in the pupal stage in a papery cocoon in the soil. Adults emerge from March to May. Larvae feed in cones throughout the summer. Some insects enter diapause as pupae and the adults emerge 1 or more years later.

*Importance:* This insect may destroy practically the entire cone crop.



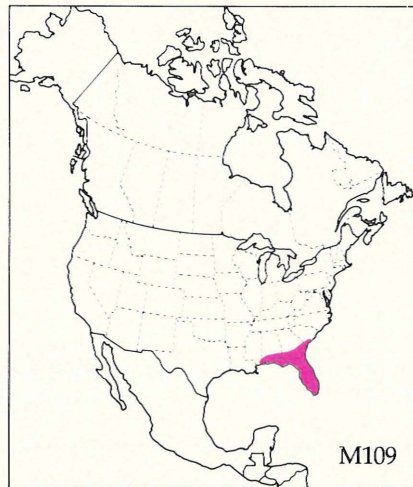
## THYSANOPTERA - Thrips

The Thysanoptera are minute insects with elongate fusiform bodies, narrow fringed wings, and mouthparts modified for scraping and sucking. Metamorphosis is essentially gradual; however, the last nymphal stage may be a quiescent form similar to a pupa.

Many thrips are plant feeders, attacking flowers, leaves, fruit, twigs and buds. They destroy plant cells by their feeding and some species are vectors of plant diseases. A few species feed on fungus spores and others are predators of small arthropods. Only two species, *Gnophothrips fuscus* (Morgan) and *Leptothrips* sp., are known to seriously affect seed production of North American conifers.

### Family Phlaeothripidae

Adults are minute, yet larger and sturdier than members of other thrips families. The adult is characterized by a tubular terminal body segment and in having a single trace of a longitudinal vein in the fore wing. They are comparatively slow-moving thrips and vary greatly in habits from plant feeders to predators.



#### *Gnophothrips fuscus* (Morgan) - slash pine flower thrips (32, 33, 36, 40, 43, 44, 46, 71, 127, 210)

*Host:* slash pine. (M109)

*Description:* Adult winged or wingless, brownish black, about 2 mm long, slender body ends in tube-like structure; wings, if present, consist of narrow, fleshy bars fringed with long hairs and held flat over back when at rest; immature thrips wingless, somewhat resembling the adults (Fig. 100a).

*Damage:* The slash pine flower thrips is a seed production pest on only slash pine; damage to foliage of Austrian and jack pines has been reported in north-

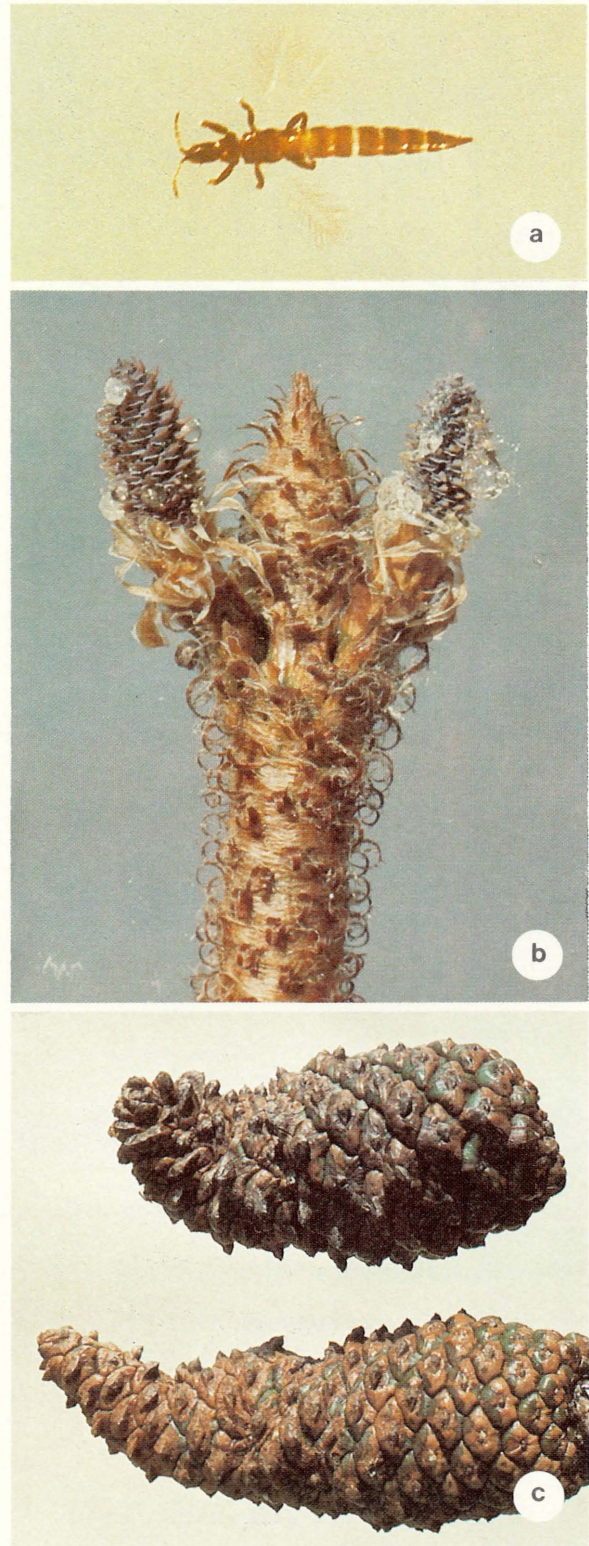


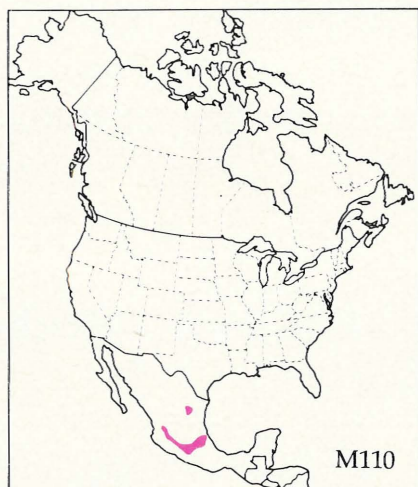
Fig. 100 *Gnophothrips fuscus*; (a) adult, (b) damage to female slash pine flowers, (c) slash pine cones distorted as a result of flower damage. USFS.



eastern North America. The insect has been found on female flowers of slash pine and current shoots of both slash and loblolly pines in Florida. Feeding among the flower scales and bracts causes beads of clear resin to exude to the surface of the flower (Fig. 100b). When feeding is severe, flowers shrivel, become encrusted with dried resin, and soon drop off the trees. Less damaged flowers may survive to maturity, but because individual cone scales are killed, cones are often distorted owing to asymmetrical growth (Fig. 100c)

*Life History and Habits:* Very little is known about the life history and behavior. In northeastern Florida the adults are present overwinter (December-February) and feed in and around the female flower buds throughout the flowering period. They have been observed on the current shoots of slash pines of all ages and within the needle fascicles of seedlings from April through September. The species undoubtedly has multiple generations in the southern portion of its range.

*Importance:* This is one of the most destructive insects affecting slash pine seed production in Florida. Reported thrips-caused mortality to female flowers has ranged up to 45 percent with as high as 28 percent additional non-lethal injury. Cones which develop from thrips-damaged flowers are deformed, significantly shorter, yield fewer total and filled seeds per cone, and do not open as well as undamaged cones.



*Leptothrips* sp. is a pest on rudis pine in the vicinity of Mexico City. Conelets, about 18 mm long, are damaged by immature and mature forms of the insect. Feeding causes resin to exude from the conelet; later the conelet dies and drops from the tree. Little is known about the life cycle, but adults occur during September and October. The insect may destroy significant numbers of conelets. (M110)

Other phlaeothripid species associated with pine flowers in the southeastern United States include *Oxythrips pallidiventris* Hood, collected from slash pine male flowers and female flowers of a pine in Florida, and *Leptothrips pini* (Watson) [*Cryptothrips pini* (Watson)], collected from slash pine female buds, flowers and conelets (44). *Chilothrips pini* Hood, the pine flower thrips, occurs in California. Nothing is known of its importance in seed production (99).

### Family Thripidae - common thrips

Most thrips of economic importance belong to this family. The last abdominal segment of the female is conical and that of the male is broadly rounded.

*Frankliniella tritici* (Fitch), the **flower thrips**, is frequently found in male flowers of slash pine. It is often present in extracted pollen, from which it is difficult to remove because of its small size. *Frankliniella bispinosa* (Morgan) is another species that has been collected from slash pine conelets. Its importance in seed production is unknown. The western flower thrips, *F. occidentalis* (Pergande), is common on mature male flowers of pinyon and apparently feeds on the pollen. It also occurs on Douglas-fir and fir in California (66).





A Douglas-fir seed orchard, Vancouver Island, B.C.



### III

## INSECT DETECTION AND DAMAGE APPRAISAL IN SEED ORCHARDS

The first step in carrying out a seed orchard insect control program is to determine whether there is an insect problem. If there is a problem, it is necessary to determine the insect species involved and to predict possible potential losses. If it appears that control is justified, based on estimated potential losses, the next step is to decide on a program suited to the particular situation, and to carry it out.

**Insect Detection** - This phase of seed orchard management requires basic entomological information on the insect pests of the tree species involved. The manager may require assistance from an entomologist to assess his insect problems effectively. First, it is necessary to determine the major pests. To accomplish this, the following steps should be taken:

**1. Detect the insect and its damage.** Certain insects and their damage are obvious; others may be minute, cryptic or otherwise difficult to detect. Detection requires a thorough knowledge of the insects and their damage. Losses may be due not only to damage which is readily visible, but also to less obvious factors which cause flowers and young cones to drop from the trees when killed.

**2. Identify the insect.** Once the orchard manager determines, or suspects, that he has an insect problem, he needs to identify the insect. This must be done promptly if a control program is to be initiated. Insects should be identified by a specialist unless the seed orchardist is already thoroughly familiar with the species involved. A number of methods are useful in obtaining information that will aid in accurate identification of the pest. These include collection of the following:

- a) insect eggs. Presence of insect eggs may be one of the first indications of a problem. Identification of the insect and estimation of expected numbers is important in initiating prompt effective damage prevention.
- b) damaged material, containing pest larvae, if possible, from which he or cooperating entomologists may identify the pest. Care must be taken that the primary insect, such as a boring larva, is present, either feeding or dormant and that secondary insects, if present, are recognized as such. Immature stages of the causal insect should, if sufficient material is available, be preserved, since these also may be fully or partially

identified in case of rearing failure. Even if no insects are present, damaged material can be useful in making a determination.

- c) conelets and cones at specific stages of development. Such collections may be needed to detect hidden insects and their damage. The collections may be used for rearing of the insect or for detection by cutting open to find the insect. Examination by radiography is an effective means of detecting hidden insect damage, particularly in seeds.
- d) adult insects, and other active stages that occur on or in the vicinity of damaged material. Specific methods include use of attractants, such as light-traps or pheromones; sticky boards; Berlese funnels to extract minute insects from damaged host material, and use of nets to capture insects.

**Damage appraisal.** - Once the seed orchardist has determined what potentially destructive insect species are present, he is still not ready to plan a control operation until he has appraised the potential impact on total annual seed yield in the orchard. For example, a seed orchard may harbor many potentially destructive insect species, but a quantitative evaluation may reveal that only a few of these cause sufficiently high seed losses to justify a control program.

The quantification of annual seed production and viability for an entire orchard implies the development of sampling procedures which give a representative, unbiased and accurate estimate of total seed yield. Various studies have been conducted in North America to evaluate the impact of an insect species on the seed production of a limited number of trees of one host species. However, no sampling procedures have been developed for estimating the impact of all insect and non-insect agents on the total annual seed yield of an orchard; an impact-evaluation sampling system of this nature is currently being developed for pine seed orchards in the southern United States. The purpose of this will be to estimate the impact of various destructive agents, including insects, on seed orchard yields. Monthly observations, made during cone development, will be used to construct cone life tables for use in developing seed yield predictive models. Such sampling methods can also be used for evaluating the effectiveness of different insect control methods.



## IV PREVENTION AND CONTROL

(46, 83, 86, 104, 106, 108, 115, 154, 155, 156, 157, 159,  
165, 191)

The control of destructive cone and seed insect populations is practical only in selected seed production stands and seed orchards. More intensive insect control methods can be used in seed orchards than in large forested areas and plantations, because: (a) high product value per unit area in seed orchards justifies greater expenditures of money; (b) physical aspects of seed orchards such as relatively small size, gentle topography and evenly spaced rows of trees allow for easy use of mechanical equipment, and (c) the availability of skilled labor and close supervision often permits greater latitude in the use of a variety of preventive and control practices.

Many seed orchard management practices differ from those employed in standard forestry and may affect pest insect populations and the damage they cause. Cultural and other practices such as use of fertilizers, irrigation, weed and grass control, pruning, cultivation and use of tree shakers are followed without knowledge of possible effects on trees and their pests.

There are several ways in which insect control in seed orchards differs from usual forest insect control methods. Firstly, although pest management is aimed primarily at protecting the seed crop and therefore pests which directly affect flowers, cones and seeds, pests which indirectly affect seed yield and quality by reducing tree vigor, e.g., defoliators, cambial miners, root feeders, scales and aphids, are also of concern. Pest management begins as soon as grafts are made and continues when they are outplanted in the orchards. It is essential to insure a high degree of protection from insects during orchard establishment because trees are often weakened by stock-scion incompatibility and transplant shock, and are thus susceptible to insect attack. Therefore, insects of minor economic importance under normal forest situations can often assume roles of major importance in seed orchards.

Secondly, in the absence of accurate methods of predicting seed orchard insect populations, orchardists today are relying on routine, preventive insecticide spray schedules to minimize losses to the high-value

crops. As research progresses, it is hoped that the application of insecticides can be greatly reduced or even eliminated.

**Insecticidal control.** - Just as insecticides have played a major role historically in control of fruit- and nut-crop insects, so also the use of insecticides is the principal means of combating insects in coniferous seed orchards. However, because of stringent requirements by federal agencies for obtaining pesticide registration, only a limited number of insecticides are available to the seed orchardist.

Within the next 10 years, insecticides should be registered for use against the major seed-destroying insects affecting most of the commercially important North American conifers. Research scientists must develop insecticides that specifically control the target pest with the least possible effect on other beneficial forms of plant and animal life. Furthermore, insecticides should be applied as seldom and at as low concentrations and dosage rates as possible. Machinery and equipment must be developed that will make insecticide application safe, effective and efficient.

There are several different techniques for applying insecticides to natural stands and seed orchards. In orchards accessible to power equipment, hydraulic sprayers, mist blowers, and granular spreaders. Airblast sprayers have proved to be effective and efficient. Natural seed production stands, on the other hand, are often situated in areas of rough terrain and are less accessible to ground spray equipment; here, aerial application of insecticides has been attempted but results by this method have been mediocre at best.

Hydraulic sprayers apply large volumes of low-concentration insecticides and usually give thorough tree coverage, but they are slow and their use is limited to trees up to 15 metres in height.

Mist blowers apply low volumes of highly concentrated insecticide formulations. Trees 30 metres tall can be sprayed with the more powerful machines. Mist blowers are considerably less costly to operate than



hydraulic sprayers because less insecticide is used and treatment is faster. However, it is more difficult to obtain thorough tree coverage.

A versatile spray machine widely accepted by fruit and nut growers is the air-blast sprayer, which can be regulated to apply concentrate, semi-concentrate or dilute materials. In seed orchards, sprayers can be driven between rows of trees, spraying simultaneously from both sides.

Ground application of granular insecticides requires that specialized equipment designed to spread the insecticide be used. Materials hazardous to wildlife must be spread and covered; spreaders manufactured for agricultural use can be modified for this particular purpose.

In addition to discussion of sprayers and methods of spray application, some mention of insecticides is in order. Contact and stomach insecticides have been in use for many years against many kinds of insects and therefore will not be discussed further here. Systemic insecticides, developed more recently, are based on a concept that lends itself to seed insect control. These chemicals when applied externally or internally to various parts of a tree, are absorbed and translocated to untreated plant tissue, rendering the tissue toxic to insects.

Insecticides are only one of the useful tools for controlling insects. There is every reason to anticipate many problems accompanying continuous use of insecticides on seed-producing trees. As has happened in fruit orchards, insects may build up resistance to insecticides in seed orchards, particularly in those isolated from surrounding forest stands. Repeated heavy dosages of chemicals may build up toxic residues in the soil which could be harmful to trees and seeds, and to soil flora and fauna. Insecticides should always be handled with extreme caution.

**Noninsecticidal control.** - The future looks bright for noninsecticidal control methods. Progress in developing sophisticated control depends, however, upon obtaining detailed information on insect biology and behavior — often a slow and tedious research process.

In recent years, entomologists have found that radiation and certain chemicals can sterilize one or the other sex of an insect species. Sterile insects, when introduced into wild populations, compete for mates, causing an overall reduction in numbers. The success of these methods depends on intimate knowledge of mating behavior and movement of insects.

Parasites and predators, if they are effective against eggs, nymphs, or larvae, could be considered for introduction into seed orchards as part of a control program; also, insect pathogens could be effective in

some situations.

Insect attractants offer possibilities for reducing insect-caused losses in seed orchards. Pheromones may be used to attract insects to traps, or to confuse them and thus prevent them from locating their mates or their normal oviposition sites. Further studies are required in this area of insect control but sufficient research has been conducted to demonstrate the possibilities. Insects which are attracted to lights may be captured in light-traps. The results obtained from using this technique may indicate insect population size and periods of activity. These may be used as a basis for determining whether control measures are necessary, and when they should be carried out. The technique may even prove to be a practical means of controlling those species that are strongly attracted to lights.

We must not overlook the possibility of employing relatively simple, mechanical and cultural methods of controlling seed-destroying insects. For example, insects such as seedworms, which hibernate in cones on the tree or the ground, or others in litter may be controlled effectively by removing all mature cones and burning all litter at harvest time. Preliminary results with fire to control certain red pine cone insects have shown considerable promise. This method is likely to succeed only if reinfestation of the orchard from outside is negligible. Orchards on sites remote from trees of the same species will be less susceptible to heavy invasions of cone and seed insects than those surrounded by naturally growing stands.

Techniques used by seed orchard managers to influence flowering time of orchard trees and to avoid pollen contamination from surrounding natural stands could also affect insect infestations. For example, flowers that are retarded for several weeks by a cold-water spray treatment could escape peak insect flights and thus be infested to a lesser extent than those that are in synchrony with natural stands of the same species in the same area.

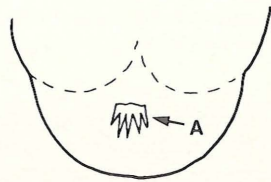
Geneticists, seed orchardists, entomologists and pathologists should be alert to opportunities for observing, selecting and breeding trees for insect and disease resistance. Such resistance often appears in certain clones in seed orchards, progeny tests and racial variation studies. By using trees that exhibit unusually high resistance or susceptibility to insect attack, and through intensive research, entomologists can learn more about the reasons for insect selection of hosts and the variations in host tree susceptibility.

Because of continuing research for better methods of preventing insect-caused losses in seed orchards, frequent changes occur. For this reason, no specific control recommendations are made here; the reader is advised to contact the nearest forest research establishment for the most recent information regarding his particular problem.

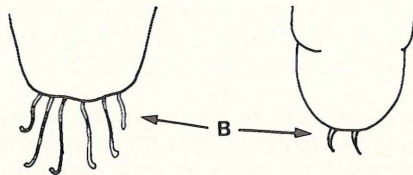


## V GLOSSARY OF TERMS

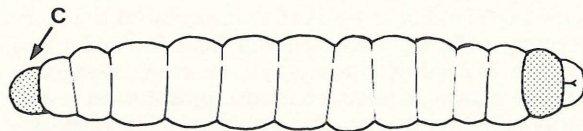
**AESTIVATE:** To remain inactive during hot or dry periods.



**ANAL COMB:** A structure found on the underside near the rear of the abdomen of certain caterpillars, consisting of a series of spines fused in a comb-like arrangement (A).



**ANAL HOOKS:** Spines at the rear end of the pupa of various Lepidoptera, frequently used as a means of attachment of a pupa to substrate material; also prominent paired curved terminal processes of certain fly larvae (B).



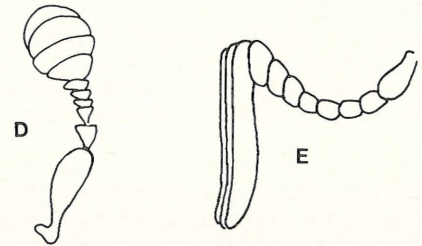
**ANAL SHIELD:** In caterpillars, the upper part of the last body segment, plate-like in appearance (C).

**ANTEMEDIAL:** Before the mid-point.

**ANTENNAE** (types of):

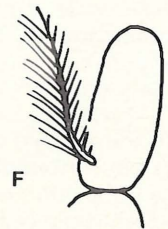
*clubbed:* Ending in a flattened, enlarged, rounded group of segments (D).

*lamellate:* Ending in a series of segments with lateral plate-like extensions on one side (E).

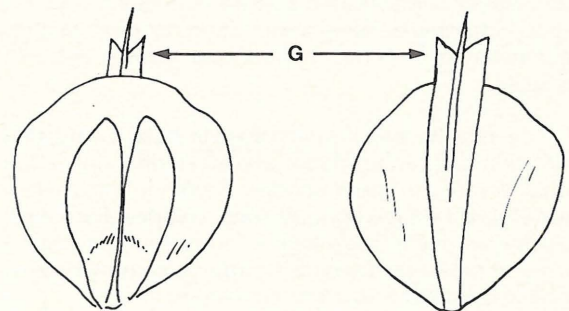


**APODEMAL PITS:** Small, usually sunken plate-like areas of the integument, obvious in certain caterpillars because they differ in texture and often color from the adjoining areas and form characteristic patterns on the body. They are actually surface indicators of internal points of muscle attachment.

**ARISTA:** An obvious hair-like process of an antenna of some flies; may be smooth or bear fine hairs (F).



**AXIS (of cone):** The central rod-like core of a cone to which scales and bracts are attached.



**BRACT:** A thin leaf-like structure interspersed with the scales of cones. In certain cones, bracts are very noticeable, e.g., Douglas-fir (G).



**BROOD:** A single generation of insects developing within a specific timespan.

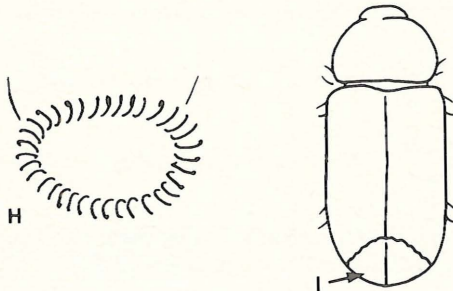
**CHORION:** The shell or covering of the insect egg.

**CONE:** The female strobilus of pines during the second season of development or of most conifers during the single season of development.

**CONELET:** The female strobilus of: (a) pines during the first season of development following pollination, and (b) early stages of cone development of conifers in which cones develop in one season.

**CONE STALK:** The pedicel, or attachment of the cone to the branch.

**CREMASTER:** A terminal abdominal structure of lepidopterous pupae, frequently bearing a group of hooked spines.

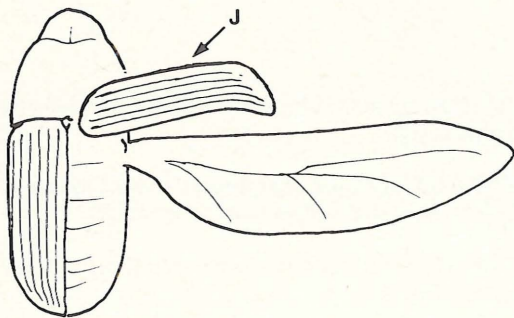


**CROCHETS:** Hook-like structures at end of larval proleg of Lepidoptera (H).

**DECLIVITY:** Truncated or scooped-out termination of the elytra of certain beetles (I).

**DIAPAUSE:** A condition of suspended animation or arrested development during the life cycle of an insect.

**DORSUM:** The upper surface.



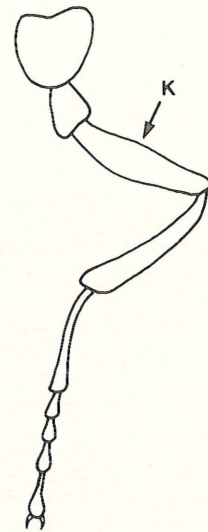
**ELYTRA:** The leathery or chitinous fore wings of beetles (J).

**ENDOSPERM:** As applied to conifers, the food reserve tissue surrounding the embryo.

**EXUVIAE:** The skins of larvae or nymphs cast off in molting.

**FEMALE FLOWERS:** The female strobili of conifers prior to and during pollination.

**FEMUR (FEMORA):** The third segment of an insect leg (K).



**FRASS:** The solid excrement of an insect, particularly of larvae.

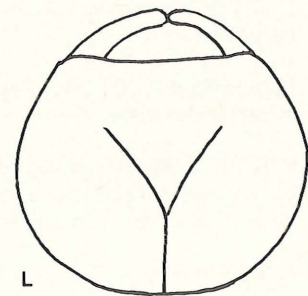
**FRONTAL TRIANGLE:** An obvious triangular area of the front part of a fly head.

**FUSIFORM:** Broad at the middle and narrowing toward the ends.

**GALL:** A swelling of plant tissue in response to insect feeding, disease or other stimulus.

**HALTERE:** In flies, the modified second wing, which is a rod-like balancing organ.

**HEAD CAPSULE:** The consolidated hard plates which form a hard compact case that encloses the larval head (L).



**HIBERNACULUM:** A silk sheath or tent in which a larva overwinters.



**HIBERNATION:** A period of inactivity in response to cold weather.

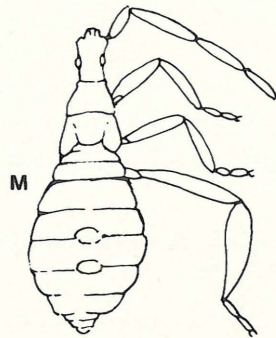
**HYPERTROPHY:** Abnormal enlargement or excessive development.

**INSTAR:** The form of an immature insect between molts.

**MALE FLOWERS:** The male strobili of conifers which produce pollen.

**METAMORPHOSIS:** The process of change through which an insect develops to maturity: *Complete metamorphosis* is that process in which 4 insect stages occur: egg, larva, pupa and adult. In this, the larva usually differs greatly in appearance and often in habits from the adult. *Gradual metamorphosis* is the process in which only 3 stages occur: egg, nymph and adult. Nymphs in general resemble the adult both in form and habits.

**MICROPYLE:** A minute opening into an ovule that facilitates penetration of the pollen nucleus for fertilization.



**NYMPH:** The immature feeding stage of insects that develop to the adult without a pupal stage. Nymphs are usually similar in form to the adult (M).

**OPERCULUM:** A lid or cap of an egg.

**OVULE:** The female tissue of a seed before fertilization by pollen.

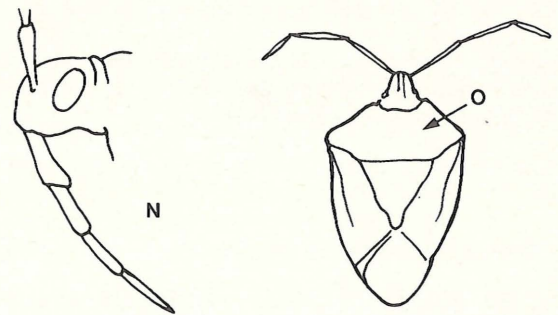
**PARTHENOGENESIS:** Reproduction without fertilization by the male.

**PITCH TUBE:** An extrusion of resin and often frass or borings at the point of entry of an insect tunnel into bark, cones, etc., of various conifers.

**POLLEN SAC:** The structure in which developing pollen of a coniferous male flower is enclosed.

**PREPUPA:** The insect form during the period between the completion of larval development and the pupa.

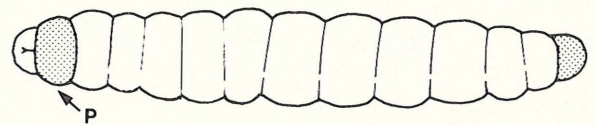
**PRIMORDIUM:** The tissue giving rise to a specific structure such as a flower bud.



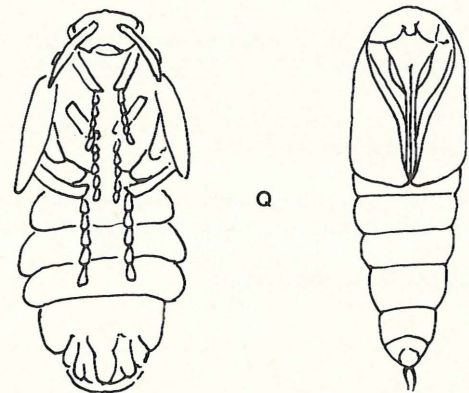
**PROBOSCIS:** Any extended mouth structure (N).

**PROLEG:** A fleshy, unsegmented abdominal leg as in a caterpillar.

**PRONOTUM:** The upper surface of the prothorax (O).



**PROTHORACIC SHIELD:** The plate-like upper part of the prothorax, especially of larvae (P).



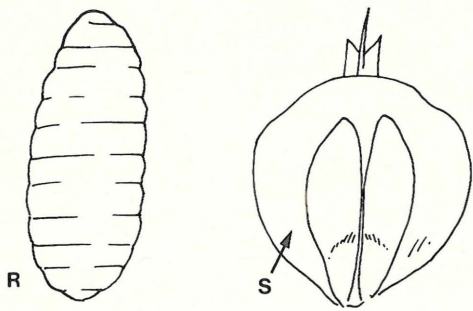
**PUPA:** Resting stage of insects having complete metamorphosis (Q).

**PUPARIUM:** A pupal covering of some Diptera consisting of the hardened skin of the larva (R).

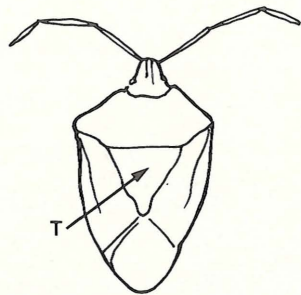
**SCALE:** The structures of a cone upon which the seeds are borne (S).

**SCALE LEAF:** Thin, more or less appressed and membranous structures along the stems of young shoots.





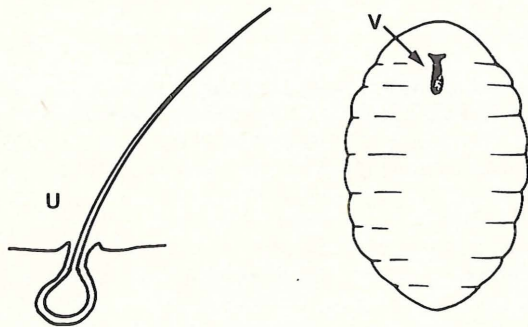
**SCION:** The selected twig or bud material used in grafting.



**SCUTELLUM:** In Hemiptera, the triangular mid-dorsal plate of the mid-thorax between the fore wings (T).

**SEEDCOAT:** The hard covering of a seed.

**SEROTINOUS:** Pertaining to cones that remain closed on the tree for several months to a year or more after maturity.

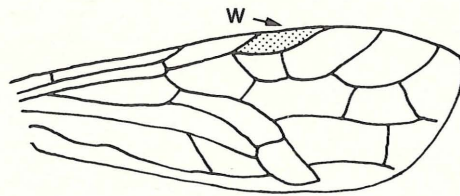


**SETA:** Movable hair-like structure on various insect body parts (U).

**SHOOT:** The current new growth of a branch tip.

**SPATULA:** A hard, darkened area near the front end of the lower surface of certain larvae of Diptera (=breast plate) (V).

**STAGE (of an insect):** A major differentiation of form of an insect in the course of development (e.g., egg, larva).



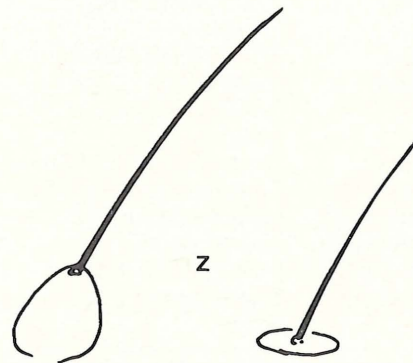
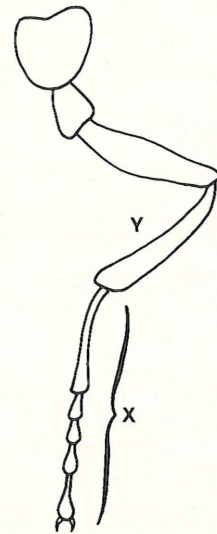
**STIGMA:** A dark, thickened area along the front of an insect fore wing, especially in Hymenoptera (W).

**STROBILUS:** The reproductive structure of conifers.

**TARSUS:** The terminal region of an insect leg consisting of one to five segments (X).

**TENERAL:** The condition of the adult insect shortly after emergence, when it is not entirely hardened or of the normal mature color.

**TIBIA:** The fourth segment of an insect leg (Y).



**TUBERCLE:** An elevated and/or hardened pimple-like protrusion of the body wall of an insect, usually bearing one or more setae (Z).

**VERMIFORM:** Worm-shaped.



## VI HOST LIST

### A. ALPHABETICAL BY COMMON NAME

(129, 130, 147, 148, 219, 220)

COMMON	SCIENTIFIC		
alligator juniper	<i>Juniperus deppeana</i> Steud.	Jeffrey pine	<i>Pinus jeffreyi</i> Grev. & Balf.
alpine larch	<i>Larix lyallii</i> Parl.	juniper	<i>Juniperus</i>
Apache pine	<i>Pinus engelmannii</i> Carr.	knobcone pine	<i>Pinus attenuata</i> Lemm.
arbor-vitae	<i>Thuja</i>	larch	<i>Larix</i>
Austrian pine	<i>Pinus nigra</i> Arnold	limber pine	<i>Pinus flexilis</i> James
baldcypress	<i>Taxodium</i>	loblolly pine	<i>Pinus taeda</i> L.
baldcypress	<i>Taxodium distichum</i> (L.) Rich. var. <i>distichum</i>	lodgepole pine	<i>Pinus contorta</i> Dougl.
balsam fir	<i>Abies balsamea</i> (L.) Mill.	longleaf pine	<i>Pinus palustris</i> Mill.
bigcone Douglas-fir	<i>Pseudotsuga macrocarpa</i> (Vasey) Mayr	Mexican pinyon (pine)	<i>Pinus cembroides</i> Zucc.
bishop pine	<i>Pinus muricata</i> D. Don	Mexican white pine	<i>Pinus ayacahuite</i> Ehrenb.
black spruce	<i>Picea mariana</i> (Mill.) B.S.P.	Monterey cypress	<i>Cupressus macrocarpa</i> Hartw.
blue spruce	<i>Picea pungens</i> Engelm.	Monterey pine	<i>Pinus radiata</i> D. Don
Brewer spruce	<i>Picea brewerana</i> S. Wats.	Montezuma pine	<i>Pinus montezumae</i> Lamb.
bristlecone fir	<i>Abies bracteata</i> D. Don	mountain hemlock	<i>Tsuga mertensiana</i> (Bong.) Carr.
bristlecone pine	<i>Pinus aristata</i> Engelm.	noble fir	<i>Abies procera</i> Rehd.
California juniper	<i>Juniperus californica</i> Carr.	oocarp pine	<i>Pinus oocarpa</i> Schiede
California red fir	<i>Abies magnifica</i> A. Murr. var. <i>magnifica</i>	Pacific silver fir	<i>Abies amabilis</i> (Dougl.) Forbes
Caribbean pine	<i>Pinus caribaea</i> Morelet	pine	<i>Pinus</i>
Chihuahua pine	<i>Pinus leiophylla</i> Schiede & Deppe	pinyon (pine)	<i>Pinus edulis</i> Engelm.
Coulter pine	<i>Pinus coulteri</i> D. Don	pitch pine	<i>Pinus rigida</i> Mill.
Cuban pine	<i>Pinus cubensis</i> Griseb.	pond pine	<i>Pinus serotina</i> Michx.
cypress	<i>Cupressus</i>	pondcypress	<i>Taxodium distichum</i> var. <i>nutans</i> (Ait.) Sweet
Digger pine	<i>Pinus sabiniana</i> Dougl.	ponderosa pine	<i>Pinus ponderosa</i> Laws.
Douglas-firs	<i>Pseudotsuga</i>	Port-Orford-cedar	<i>Chamaecyparis lawsoniana</i> (A. Murr.) Parl.
Douglas-fir	<i>Pseudotsuga menziesii</i> (Mirb.) Franco	pseudostrobus pine	<i>Pinus pseudostrobus</i> Lindl.
Durango pine	<i>Pinus durangensis</i> Martínez	red pine	<i>Pinus resinosa</i> Ait.
eastern hemlock	<i>Tsuga canadensis</i> (L.) Carr.	red spruce	<i>Picea rubens</i> Sarg.
eastern redcedar	<i>Juniperus virginiana</i> L.	redwood	<i>Sequoia</i>
eastern white pine	<i>Pinus strobus</i> L.	redwood	<i>Sequoia sempervirens</i> (D. Don) Endl.
Engelmann spruce	<i>Picea engelmannii</i> Parry	rudis pine	<i>Pinus rudis</i> Endl.
false cypress	<i>Chamaecyparis</i>	sacred fir	<i>Abies religiosa</i> Schl. & Cham.
fir	<i>Abies</i>	sand pine	<i>Pinus clausa</i> (Chapm.) Vasey
Fraser fir	<i>Abies fraseri</i> (Pursh) Poir.	Scotch pine	<i>Pinus sylvestris</i> L.
Gowen cypress	<i>Cupressus goveniana</i> Gord.	Shasta red fir	<i>Abies magnifica</i> var. <i>shastensis</i> Lemm.
grand fir	<i>Abies grandis</i> (Dougl.) Lindl.	shortleaf pine	<i>Pinus echinata</i> Mill.
Hartweg pine	<i>Pinus hartwegii</i> Lindl.	singleleaf pinyon (pine)	<i>Pinus monophylla</i> Torr. & Frém.
hemlock	<i>Tsuga</i>	Sitka spruce	<i>Picea sitchensis</i> (Bong.) Carr.
incense-cedar	<i>Libocedrus decurrens</i> Torr.	slash pine	<i>Pinus elliotii</i> Engelm. var. <i>elliottii</i>
jack pine	<i>Pinus banksiana</i> Lamb.		
Japanese cedar	<i>Cryptomeria</i>		



sonderegger pine	<i>Pinus X sondereggeri</i> H. H. Chapm.	Virginia pine	<i>Pinus virginiana</i> Mill.
spruce	<i>Picea</i>	western hemlock	<i>Tsuga heterophylla</i> (Raf.) Sarg.
spruce pine	<i>Pinus glabra</i> Walt.	western juniper	<i>Juniperus occidentalis</i> Hook.
subalpine fir	<i>Abies lasiocarpa</i> (Hook.) Nutt. var. <i>lasiocarpa</i>	western larch	<i>Larix occidentalis</i> Nutt.
Swiss mountain pine	<i>Pinus mugo</i> Turra	western redcedar	<i>Thuja plicata</i> Donn
sugar pine	<i>Pinus lambertiana</i> Dougl.	western white pine	<i>Pinus monticola</i> Dougl.
Table-Mountain pine	<i>Pinus pungens</i> Lamb.	white cypress	<i>Cupressus lindleyi</i> Klotzsch
tamarack	<i>Larix laricina</i> (Du Roi) K. Koch	whitebark pine	<i>Pinus albicaulis</i> Engelm.
Utah juniper	<i>Juniperus osteosperma</i> (Torr.) Little	white fir	<i>Abies concolor</i> (Gord. & Glend.) Lindl.
		white spruce	<i>Picea glauca</i> (Moench) Voss

## B. ALPHABETICAL BY SCIENTIFIC NAME

SCIENTIFIC	COMMON		
<i>Abies</i>	fir	<i>Picea</i>	spruce
<i>Abies amabilis</i> (Dougl.) Forbes	Pacific silver fir	<i>Picea brewerana</i> S. Wats.	Brewer spruce
<i>Abies balsamea</i> (L.) Mill.	balsam fir	<i>Picea engelmannii</i> Parry	Engelmann spruce
<i>Abies bracteata</i> D. Don	bristlecone fir	<i>Picea glauca</i> (Moench) Voss	white spruce
<i>Abies concolor</i> (Gord. & Glend.) Lindl.	white fir	<i>Picea mariana</i> (Mill.) B.S.P.	black spruce
<i>Abies fraseri</i> (Pursh) Poir.	Fraser fir	<i>Picea pungens</i> Engelm.	blue spruce
<i>Abies grandis</i> (Dougl.) Lindl.	grand fir	<i>Picea rubens</i> Sarg.	red spruce
<i>Abies lasiocarpa</i> (Hook.) Nutt. var. <i>lasiocarpa</i>	subalpine fir	<i>Picea sitchensis</i> (Bong.) Carr.	Sitka spruce
<i>Abies magnifica</i> A. Murr. var. <i>magnifica</i>	California red fir	<i>Pinus</i>	pine
<i>Abies magnifica</i> var. <i>shastensis</i> Lemm.	Shasta red fir	<i>Pinus albicaulis</i> Engelm.	whitebark pine
<i>Abies procera</i> Rehd.	noble fir	<i>Pinus aristata</i> Engelm.	bristlecone pine
<i>Abies religiosa</i> Schl. & Cham.	sacred fir	<i>Pinus attenuata</i> Lemm.	knobcone pine
<i>Chamaecyparis</i>	false cypress	<i>Pinus ayacahuite</i> Ehrenb.	Mexican white pine
<i>Chamaecyparis lawsoniana</i> (A. Murr.) Parl.	Port-Orford-cedar	<i>Pinus banksiana</i> Lamb.	jack pine
<i>Cryptomeria</i>	Japanese cedar	<i>Pinus caribaea</i> Morelet	Caribbean pine
<i>Cupressus</i>	cypress	<i>Pinus cembroides</i> Zucc.	Mexican pinyon (pine)
<i>Cupressus goveniana</i> Gord.	Gowen cypress	<i>Pinus clausa</i> (Chapm.) Vasey	sand pine
<i>Cupressus lindleyi</i> Klotzsch	white cypress	<i>Pinus contorta</i> Dougl.	lodgpole pine
<i>Cupressus macrocarpa</i> Hartw.	Monterey cypress	<i>Pinus coulteri</i> D. Don	Coulter pine
<i>Juniperus</i>	juniper	<i>Pinus cubensis</i> Griseb.	Cuban pine
<i>Juniperus californica</i> Carr	California juniper	<i>Pinus durangensis</i> Martinez	Durango pine
<i>Juniperus deppeana</i> Steud.	alligator juniper	<i>Pinus echinata</i> Mill.	shortleaf pine
<i>Juniperus occidentalis</i> Hook.	western juniper	<i>Pinus edulis</i> Engelm.	pinyon (pine)
<i>Juniperus osteosperma</i> (Torr.) Little	Utah juniper	<i>Pinus elliotii</i> Engelm. var. <i>elliottii</i>	slash pine
<i>Juniperus virginiana</i> L.	eastern redcedar	<i>Pinus engelmannii</i> Carr.	Apache pine
<i>Larix</i>	larch	<i>Pinus flexilis</i> James	limber pine
<i>Larix laricina</i> (Du Roi) K. Koch	tamarack	<i>Pinus glabra</i> Walt.	spruce pine
<i>Larix lyallii</i> Parl.	alpine larch	<i>Pinus hartwegii</i> Lindl.	Hartweg pine
<i>Larix occidentalis</i> Nutt.	western larch	<i>Pinus jeffreyi</i> Grev. & Balf.	Jeffrey pine
<i>Libocedrus decurrens</i> Torr.	incense-cedar	<i>Pinus lambertiana</i> Dougl.	sugar pine
		<i>Pinus leiophylla</i> Schiede & Deppe	Chihuahua pine
		<i>Pinus monophylla</i> Torr. & Frém.	singleleaf pinyon (pine)
		<i>Pinus montezumae</i> Lamb.	Montezuma pine



<i>Pinus monticola</i> Dougl.	western white pine	<i>Pseudotsuga</i>	Douglas-firs
<i>Pinus mugo</i> Turra	Swiss mountain pine	<i>Pseudotsuga macrocarpa</i>	
<i>Pinus muricata</i> D. Don	bishop pine	(Vasey) Mayr	bigcone Douglas-fir
<i>Pinus nigra</i> Arnold	Austrian pine	<i>Pseudotsuga menziesii</i>	
<i>Pinus oocarpa</i> Schiede	oocarp pine	(Mirb.) Franco	Douglas-fir
<i>Pinus palustris</i> Mill.	longleaf pine	<i>Sequoia</i>	redwood
<i>Pinus ponderosa</i> Laws.	ponderosa pine	<i>Sequoia sempervirens</i>	
<i>Pinus pseudostrobus</i> Lindl.	pseudostrobus pine	(D. Don) Endl.	redwood
<i>Pinus pungens</i> Lamb.	Table-Mountain pine	<i>Taxodium</i>	baldcypress
	Monterey pine	<i>Taxodium distichum</i> (L.)	
<i>Pinus radiata</i> D. Don	red pine	Rich. var. <i>distichum</i>	baldcypress
<i>Pinus resinosa</i> Ait.	pitch pine	<i>Taxodium distichum</i>	
<i>Pinus rigida</i> Mill.	rudis pine	var. <i>nutans</i> (Ait.) Sweet	pondcypress
<i>Pinus rudis</i> Endl.	Digger pine	<i>Thuja</i>	arbor-vitae
<i>Pinus sabiniana</i> Dougl.	pond pine	<i>Thuja plicata</i> Donn	western redcedar
<i>Pinus serotina</i> Michx.	eastern white pine	<i>Tsuga</i>	hemlock
<i>Pinus strobus</i> L.	Scotch pine	<i>Tsuga canadensis</i> (L.) Carr.	eastern hemlock
<i>Pinus sylvestris</i> L.	loblolly pine	<i>Tsuga heterophylla</i> (Raf.) Sarg.	western hemlock
<i>Pinus taeda</i> L.	Virginia pine	<i>Tsuga mertensiana</i> (Bong.) Carr.	mountain hemlock
<i>Pinus virginiana</i> Mill.			
<i>Pinus</i> X <i>sondereggeri</i>	sonderegger pine		
H.H. Chapm.			



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