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5
**Spruce
Budworms
Handbook**

**Lepidoptera
Associated With
Western Spruce
Budworm**

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In 1977, the United States Department of Agriculture and the Canada Department of the Environment agreed to cooperate in an expanded and accelerated research and development effort, the Canada/United States Spruce Budworms Program (CANUSA), aimed at the spruce budworm in the East and the western spruce budworm in the West. The objective of CANUSA was

to design and evaluate strategies for controlling the spruce budworms and managing budworm-susceptible forests, to help forest managers attain their objectives in an economically and environmentally acceptable manner. The work reported in this publication was partially funded by the Program. This manual is one in a series on the western spruce budworm.



Canada
United States
Spruce Budworms
Program

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Lepidoptera Associated With Western Spruce Budworm

Introduction

**by Robert E. Stevens,
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Field workers doing surveys, control operations, and research on western spruce budworm often encounter other kinds of foliage-feeding larvae, some of which closely resemble western spruce budworm. Workers must be able to distinguish between the different species and groups.

Western spruce budworm is characterized here, along with its common Lepidoptera associates (table 1); keys are included for separating smaller and larger larvae of common species. The keys are designed for practical separation of species; no attempt has been made to reflect taxonomic conventions or phylogeny. Lindquist (1982) covers some of the same material for the spruce budworm in Eastern North America. Notes on the biology of the species and groups covered are given, and larvae and adults of associates are illustrated.

Sawfly larvae (Hymenoptera) are also found in and on the foliage of budworm hosts, but these larvae are usually less common and, except for the web-spinners in the family Pamphiliidae, easy to identify. Larvae of Lepidoptera and foliage-feeding Hymenoptera can be separated by characters that can be seen with a hand lens. The most important is the

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Table 1—Lepidoptera associates of western spruce budworm

Family	Species, species group	Distribution	Hosts ¹
Gelechiidae	<i>Chionodes abella</i> Busck	Southwest	—
	<i>Chionodes</i> spp.	Pacific region, ² Rocky Mtns.	<i>Abies</i> , <i>Pseudotsuga</i>
	<i>Coleotechnites</i> spp.	Westwide	<i>Abies</i> , <i>Pseudotsuga</i>
	<i>Telphusa sedulitella</i> (Busck)	Pacific region	<i>Abies</i>
Geometridae	<i>Enypia griseata</i> Grossbeck	Southwest	<i>Abies</i> , <i>Pseudotsuga</i>
	<i>Enypia</i> sp. nr. <i>griseata</i>	Pacific region	<i>Pseudotsuga</i>
	<i>Eupithecia annulata</i> (Hulst)	Pacific region, Rocky Mtns.	<i>Pseudotsuga</i>
	<i>E. catalinata</i> McDunnough	Southwest	<i>Pseudotsuga</i>
	<i>Lambdina fiscellaria</i> <i>lugubrosa</i> (Hulst)	Pacific region, Rocky Mtns.	<i>Abies</i> , <i>Pseudotsuga</i>
	<i>Melanolophia imitata</i> (Walker)	Pacific region, Rocky Mtns.	<i>Abies</i> , <i>Pseudotsuga</i>
	<i>Nematocampa limbata</i> (Haworth)	Pacific region, Rocky Mtns.	<i>Abies</i> , <i>Pseudotsuga</i>
	<i>Nepytia phantasmaria</i> (Strecker)	Pacific region	<i>Abies</i> , <i>Pseudotsuga</i>
	<i>Stenoporpia</i> sp.	Pacific region	<i>Pseudotsuga</i>
Lymantriidae	<i>Orgyia pseudotsugata</i> (McDunnough)	Westwide	<i>Abies</i> , <i>Pseudotsuga</i>
Noctuidae	<i>Achytonix epipaschia</i> (Grote)	Westwide	<i>Abies</i> , <i>Pseudotsuga</i>
	<i>Anomogyna mustelina</i> (J. B. Smith)	Pacific region	<i>Abies</i> , <i>Pseudotsuga</i>
	<i>Egira simplex</i> (Walker)	Westwide	<i>Pseudotsuga</i>
	<i>Feralia deceptiva</i> McDunnough	Pacific region	<i>Pseudotsuga</i>
	<i>Syngrapha</i> spp.	Pacific region, Southwest	<i>Abies</i> , <i>Pseudotsuga</i>

¹Only those reported in association with western spruce budworm.²Used here to include the area west of the Rocky Mountains between British Columbia and northern California.

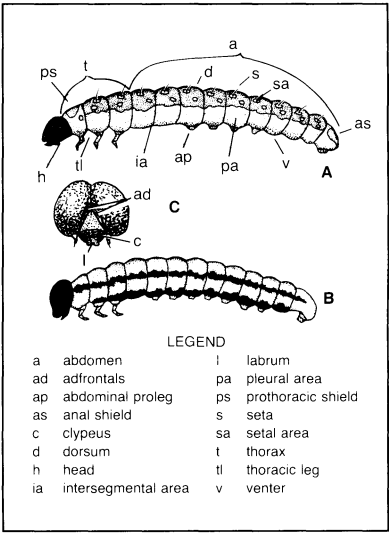
Table 1—*Continued*

Family	Species, species group	Distribution	Hosts ¹
Plutellidae	<i>Ypsolopha nella</i> (Busck)	Southwest	<i>Abies</i>
	<i>Ypsolopha</i> sp. prob. <i>cervella</i> (Walsingham)	Pacific region	<i>Pseudotsuga</i>
Pyralidae	<i>Dioryctria</i> spp.	Westwide	<i>Abies</i> , <i>Pseudotsuga</i>
Tortricidae	<i>Acleris gloverana</i> (Walsingham)	Westwide	<i>Abies</i> , <i>Pseudotsuga</i>
	<i>Archips</i> sp.	Pacific region	<i>Pseudotsuga</i>
	<i>Argyrotaenia dorsaliana</i> (Dyar)	Westwide	<i>Abies</i> , <i>Pseudotsuga</i>
	<i>A. klotsi</i> Obraztsov	Southwest	<i>Abies</i> , <i>Pseudotsuga</i>
	<i>A. provana</i> (Kearfott)	Westwide	<i>Abies</i> , <i>Pseudotsuga</i>
	<i>Choristoneura retiniana</i> (Walsingham)	Pacific region	<i>Abies</i>
	<i>Choristoneura</i> n. sp.	Pacific region	<i>Abies</i> , <i>Pseudotsuga</i>
	<i>Clepsis persicana</i> (Fitch)	Westwide	<i>Pseudotsuga</i>
	<i>Epinotia radicana</i> (Heinrich)	Westwide	<i>Abies</i> , <i>Pseudotsuga</i>
	<i>Zeiraphera</i> spp.	Westwide	<i>Abies</i> , <i>Pseudotsuga</i>

number of abdominal prolegs—a maximum of five pairs in caterpillars and seven to nine pairs in the sawflies (fig. 1). Larval characters used in the keys are also shown in figure 1.

The roles of associates in budworm habitat are compared—where, when, and how these species live and, particularly, how they obtain their food. Differences in host preference, life history, feeding sites, and natural enemies result in a unique role being played by each associate. The kind

Figure 1—A. Typical lepidopterous larva; B. hymenopterous larva of sawfly genus *Neodiprion*; C. features of lepidopterous head capsule.



Keys to Larvae of Western Spruce Budworm and Associates

and amount of damage caused to the tree, interaction with the western spruce budworm, and the reaction of the host are important factors in considering impact on the habitat, and particularly in proper assessment of budworm-caused impact on the forest. Basic information on the role of budworm associates in the habitat is limited; what information is available is summarized here, and suggestions for further work are included.

Some of the groups included pose difficult taxonomic problems. As more detailed studies of life history and habits are carried out, these taxonomic problems will gradually be unraveled.

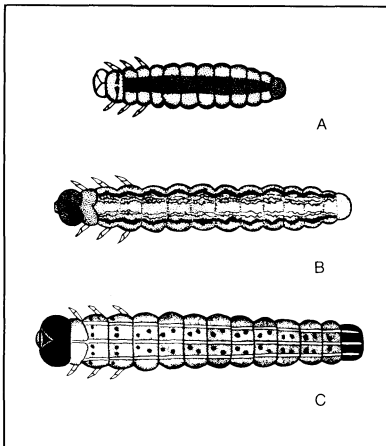
These keys are revisions of Carolin and Stevens (1979 and 1981). Large and small larvae are discussed separately because many larvae change in appearance as they pass through successive instars. Feeding habitat also changes with maturity: the smaller larvae feed inside buds, and larger larvae usually feed openly on developing needles.

In the keys, patterns of lines and stripes are frequently used as identifying characters (fig. 2). Two cautions to keep in mind when using the keys are:

- Although all the common associated species have been included in the keys, other species may sometimes develop high populations and become local budworm "associates."
- Insects, like other organisms, vary individually and may have slightly different color patterns than described and illustrated. We have sometimes included several photographs of a single species to show this variability. With experience you will learn to recognize it and find the keys easier to use.

Figure 2—Examples of longitudinal dorsal markings: A. central stripe (*Zeiraphera hesperiana*); B. irregular lines (*Dioryctria reniculelloides*); C. regular lines (*Egira simplex*).

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Key to Small² Lepidopterous Larvae in Opening Buds and on New Shoots of Douglas-fir and True Firs

- A. Larvae with 2 pairs of prolegs, moving with an inching or looping motion based on use of anal prolegs Section I. Geometridae
- B. Larvae with 5 pairs of prolegs, moving at a constant pace, but often wiggling violently when disturbed Section II. Tortricidae, Gelechiidae, Pyralidae, and Noctuidae

Section I. Geometridae

- 1. Dorsum banded dark brown and white on first 5 abdominal segments; head dark brown to black; body 4 to 7 mm long 1st instar *Lambdina fiscellaria lugubrosa*
- 1. Dorsum either unicolorous, or with longitudinal lines; head brown, green, or reddish 2
 - 2. Dorsum light to dark green, with one pair of longitudinal whitish lines 3
 - 2. Dorsum other than green; unicolorous or with dark lines 5
- 3. Head pale yellow-brown; dorsum light bluish-green and lines whitish yellow; pleural area with similar lines and also a very thin line; larvae on new shoots 10 to 12 mm long and often larger *Enypia* sp.
- 3. Head green; dorsum apple green to dark green and lines white; pleural area with a yellow line or stripe; larvae on new foliage up to 8 to 10 mm long before moving to old foliage 4
 - 4. Head green with no markings *Melanolophia imitata*
 - 4. Head green with 10 black dots *Nepytia phantasmaria*
- 5. Pair of long, knobbed projections on dorsum of 2d abdominal segment; head and dorsum brown *Nematocampa limbata*
- 5. No body projections; head reddish or brown; dorsum yellow, yellowish brown, or orange red 6
 - 6. Dorsum orange red, with 3 longitudinal purple lines; head pale orange-red; body 9 to 12 mm long *Eupithecia annulata*
 - 6. Dorsum without longitudinal lines; head light to dark brown 7

²Up to about 12 mm long.

- 7. Head medium to dark brown; dorsum yellowish brown to pinkish brown, and each segment with 4 dark dots; pleural area with 3 dark-brown lines; body 6 to 15 mm long 2d and 3d instars *Lambdina fiscellaria lugubrosa*
- 7. Head light brown; dorsum yellow to reddish brown, without conspicuous dots 8
 - 8. Dorsum bright yellow; pleural area light brown; body 6 to 9 mm long; feeds under bud sheath on Douglas-fir *Eupithecia annulata*
 - 8. Dorsum orange-red-brown, with yellow pleural area and venter; body 10 mm long and longer; open feeder *Stenoporpia* sp.

Section II. Tortricidae,³ Gelechiidae, Pyralidae, and Noctuidae

- 1. Dorsum marked with longitudinal lines; setal bases conspicuous only in *Achytonix* and *Egira* (Noctuidae) 17
- 1. Dorsum unicolorous; setal bases often a lighter or darker color, causing a slightly spotted or spiny appearance 2
 - 2. Dorsum yellow green, bright green, or olive green 15
 - 2. Dorsum dirty white to brown, but sometimes with a greenish tint in *Egira simplex*, *Choristoneura retiniana*, and *Epinotia radicana*..... 3
- 3. Head and prothoracic shield yellow, yellow brown, light brown, or chestnut brown 13
- 3. Head dark brown to black; prothoracic shield brown to black; anal shield conspicuous, light brown to black 4
 - 4. Dorsum orange brown or olive brown 5
 - 4. Dorsum yellow, dirty white to light brown, or cinnamon brown ... 7

³Includes Olethreutidae as a subfamily, Olethreutinae, per revised “Check list of the Lepidoptera of America north of Mexico” (Hodges et al. 1983).

5. Prothoracic shield light to medium brown; anal shield light brown; body orange brown, 5 to 7 mm long (3d instar) or light olive-brown, 6 to 10 mm long (early 4th instar) *Choristoneura occidentalis*
5. Prothoracic shield, setal areas, and anal shield dark brown to black 6
 6. Dorsum dark olive-brown with yellowish brown in intersegmental areas; setal areas raised; anal shield orbicular, dark brown; body 4 to 5 mm long *Achytonix epipaschia*
 6. Dorsum light orange-brown, sometimes with greenish tinge; setal areas not raised; anal shield black, occupying most of segment; body 4 to 7 mm long *Egira simplex*
7. Dorsum pale yellow to lemon yellow 10
7. Dorsum dirty white (pale gray) or cinnamon brown 8
 8. Dorsum pale to dirty white; head wider than long; spots of sclerotization on penultimate abdominal segment 9
 8. Dorsum cinnamon brown; head as wide as long; head and prothoracic shield black; setal bases pale; anal shield large, pale ivory; no penultimate sclerotization; body 6 to 12 mm long
..... 4th instar *Choristoneura occidentalis*
9. Head dark brown; prothoracic shield chestnut brown; setal bases dark; anal shield large, dark brown; body 6 to 8 mm long; on Douglas-fir
..... intermediate instar *Zeiraphera hesperiana*
9. Head and prothoracic shield light brown, both darker posteriorly; setal bases inconspicuous; anal shield light brown; body 7 to 9 mm long; on true firs last 2 instars *Zeiraphera pacifica*
10. Prothoracic shield and thoracic legs dark brown to black; setal areas inconspicuous 12
10. Prothoracic shield and thoracic legs medium brown; setal areas visible 11

11. Anal shield dark brown, orbicular; body form slender, 3 to 5 mm long
..... *Epinotia radicana*
11. Anal shield outlined on edges by dots of sclerotization; body form moderately stout, 3 to 5 mm long 3d instar *Choristoneura retiniana*
12. Head, prothoracic shield, prespiracular sclerotization, and outside of thoracic legs jet black; anal shield medium brown, orbicular; body 3 to 8 mm long *Acleris gloverana*
12. Head black, prothoracic shield and prespiracular sclerotization dark brown; thoracic legs annulated dark brown and white; anal shield represented by a few dots of sclerotization; body 5 to 8 mm long 4th instar *Choristoneura retiniana*
13. Head and prothoracic shield chestnut brown; head narrower than body; dorsum pinkish brown, yellowish brown, or cinnamon brown; setal bases prominent; anal shield semicircular, pale chestnut-brown and occupying most of segment; body slender, 5 to 7 mm long *Coleotechnites* sp.
13. Head and prothoracic shield yellow to yellow brown; dorsum yellow brown to yellow green; setal bases and anal shield inconspicuous 14
14. Head as wide as body, wider than long, yellow brown to pale chestnut-brown; anal segment long, yellow, with small shield; body 6 to 8 mm long *Epinotia radicana*
14. Head narrower than body, longer than wide; anal segment of moderate length, with shield inconspicuous; body 4 to 7 mm long
..... *Argyrotaenia dorsalana*
15. Head green with yellow-brown tinging around labrum and adfrontals; thorax, thoracic legs, and abdomen emerald green; anal shield represented by a few dots of sclerotization; body 8 to 12 mm long
..... *Argyrotaenia provana*
15. Head unicolorous, light brown to black; dorsum pale yellow-green; legs light brown; anal shield orbicular; body 8 to 10 mm long 16
16. Head, prothoracic shield, and anal shield yellow brown to pale chestnut-brown, with fine, black markings in center rear of prothoracic shield; anal shield orbicular *Argyrotaenia dorsalana*
16. Head and thoracic legs dark brown to black; prothoracic shield paler; anal shield inconspicuous *Acleris gloverana*

17. Dorsum reddish brown or brownish gray, with 8 to 10 interrupted, white longitudinal lines; a large, white eyespot around lateral seta on 8th abdominal segment *Dioryctria reniculelloides*
17. Dorsum yellow, greenish brown, or pale brown; longitudinal lines either dark, or, if white, few in number 18
18. Dorsum with white longitudinal lines or stripes 21
18. Dorsum with dark longitudinal lines or stripes 19
19. Dorsum yellow with 3 orange-brown longitudinal lines; head almost as wide as body and light brown; prothoracic shield light brown; body stout, 8 to 10 mm long *Epinotia radicana*
19. Dorsum pale brown or gray; head narrower than body; head and prothoracic shield light chestnut-brown; body slender, up to 8 or 9 mm long ... 20
20. Dorsum pale brown, with 3 to 5 reddish-purple longitudinal lines....
..... *Chionodes* spp.
20. Dorsum very pale-yellow or pale-gray, with 7 to 9 fine, brown-to-lavender longitudinal lines *Telphusa* sp. (probably *sedulitella*)
21. Dorsum pale olive-green, with a narrow, central, white line; head jet black; prothoracic and anal shields dark brown; setal areas dark brown; body 5 to 7 mm long *Achytonix epipaschia*
21. Dorsum green or greenish brown with 3 rather broad, white longitudinal lines; prothoracic shield, anal shield, and setal areas either conspicuous or inconspicuous 22
22. Dorsum greenish brown; head, prothoracic shield, and setal areas black; anal shield dark brown; body 8 to 10 mm long.....
..... *Egira simplex*
22. Dorsum apple green; head pale yellow-green; prothoracic and anal shields not visible—body striping covering them; body 7 to 10 mm long *Achytonix epipaschia*

Key to Larger⁴ Lepidopterous Larvae on New Foliage of Douglas-fir and True Firs

- A. Larvae with 2 pairs of abdominal prolegs, moving with an inching or looping motion based on use of anal prolegs Section I. Geometridae
- B. Larvae with 5 pairs of abdominal prolegs, moving at a constant pace, but often wiggling violently when disturbed
....Section II. Tortricidae, Gelechiidae, Plutellidae, Pyralidae, and Noctuidae

Section I. Geometridae

- 1. Dorsum unicolorous or color blotchy, without lines 5
- 1. Dorsum with longitudinal lines or stripes 2
 - 2. Dorsum orange red, with 3 longitudinal purple lines; head pale orange-red; body 12 to 15 mm long *Eupithecia annulata*
 - 2. Dorsum green, with 1 pair of whitish longitudinal lines; head green or brown; body 12 to 37 mm long 3
- 3. Head green to pale yellow-brown; dorsum light bluish-green with wide, whitish-yellow lines; pleural area with 1 wide and 1 narrow, whitish-yellow line; body up to 25 mm long *Enypia* spp.
- 3. Head green; dorsum apple green to dark green with white lines; pleural area with a single whitish line or stripe 4
 - 4. Head green with no markings; body up to 37 mm long; feeds mostly on old foliage *Melanolophia imitata*
 - 4. Head green with 10 black dots; body up to 28 mm long; feeds on both new and old foliage..... *Nepytia phantasmaria*
- 5. Pairs of long, flexible, knobbed projections on dorsum of 2d and 3d abdominal segments; pairs of short knobs on 1st and 8th abdominal segments; head brown; body with blotches of dull brown or greenish brown; body up to 20 mm long *Nematocampa limbata*
- 5. No body projections; head light brown or mottled with brown; dorsum orange brown in toto or in intersegmental areas 6
 - 6. Head light brown, unicolorous; dorsum orange red brown; pleural area with yellow stripe; body up to 30 mm long; on both new and old foliage *Stenoporpia* sp.

⁴Twelve millimeters or more in length.

6. Head with brown mottling; dorsum brownish or greenish, with orange brown in intersegmental areas; network of lines in pleural area; on old foliage..... 7
7. Head with brown streaking as well as mottling, and 4 black dots visible above; dorsum pale orange-brown or pale green; body 12 to 20 mm long ..
..... 4th instar *Lambdina fiscellaria lugubrosa*
7. Head with brown mottling and 10 black dots visible above; dorsum light yellow-brown to gray-brown, with orange brown on prothorax as well as in intersegmental areas; body 18 to 30 mm long
..... 5th instar *Lambdina fiscellaria lugubrosa*

Section II. Tortricidae, Gelechiidae, Plutellidae, Pyralidae, and Noctuidae

1. Dorsum with prominent longitudinal lines or stripes 11
1. Dorsum unicolorous or rarely with very fine lines 2
 2. Head, prothoracic shield, and remainder of body emerald green; prothoracic shield collarlike; setal areas and anal shield inconspicuous; body form slender, 12 to 18 mm long *Argyrotaenia provana*
 2. Head and prothoracic shield brownish or black; body form stout or moderately stout, except for *Argyrotaenia dorsлана* 3
3. Head and prothoracic shield yellow brown, light brown, or chestnut brown; outside of thoracic legs brownish or either tipped or annulated with black; setal areas conspicuous (in *Acleris* changing to inconspicuous during 5th instar) 5
3. Head, prothoracic shield, and outside of thoracic legs jet black; setal areas inconspicuous 4
 4. Body yellow green to green; prothoracic shield sometimes pale in front; body form flattish, 10 to 14 mm long
..... 4th instar *Acleris gloverana*
 4. Body lemon yellow; prothoracic shield solid black; body form terete and stout, 12 to 16 mm long *Archips* sp.
5. Head pale brown to chestnut brown with no dark markings above; prothoracic shield a shade of light brown or greenish 7

5. Head chestnut brown with 2 dark triangles on each side, dorsally; prothoracic shield dark brown to black 6
 6. Dorsum olive brown to dark brown, with prominent, ivory setal areas; pleural areas and venter pale yellow to light tan; body 10 to 16 mm long 5th instar *Choristoneura occidentalis*
 6. Dorsum lime green with olive tinge, with pale-yellow setal areas; pleural areas and venter usually greenish but sometimes yellowish; body 9 to 14 mm long 5th instar *Choristoneura retiniana* (= *viridis*)
7. Head mostly light brown but with greenish color around labrum and dark streak on lower head; prothoracic shield indistinct, concolorous with body; body pale green with small, yellowish setal areas and with yellow inter-segmental areas; body slender, 10 to 14 mm long *Argyrotaenia dorsalana*
7. Head without greenish color; prothoracic shield distinct; body form stout 8
 8. Dorsum reddish brown or olive brown, with large, ivory setal areas and large, ivory anal shield; head and prothoracic shield orange brown to chestnut brown 10
 8. Dorsum grass green, with small or moderately large, pale setal areas; head usually a light brown; prothoracic shield a lighter shade of brown than head 9
9. Prothoracic shield pale brown to transparent, with a thick black line at base of shield; head yellow brown, becoming chestnut brown; setal areas pale but conspicuous at start of stadium, later becoming inconspicuous; anal shield orbicular, concolorous with green anal segment; body 12 to 16 mm long 5th instar *Acleris gloverana*
9. Prothoracic shield pale yellow-brown with 2 black dots at base on each side of split in shield; head light tan; setal areas pale yellow and conspicuous; anal shield oblong-orbicular, pale yellow; body 16 to 22 mm long 6th instar *Choristoneura retiniana* (= *viridis*)
10. Setal areas oblong; anal shield oblong-orbicular, ivory to pale yellow; body 17 to 28 mm long 6th instar *Choristoneura occidentalis*
10. Setal areas round; anal shield round, ivory to light brown; dorsum occasionally with 2 very fine white lines; colors brighter than in *occidentalis*; body 12 to 18 mm long last 2 instars *Choristoneura* n. sp.

11. Dorsum various shades of yellow, orange, red, or brown, marked with either lines or stripes 16
11. Dorsum various shades of green, sometimes with brownish tint, with either lines or stripes 12
 12. Dorsum with 3 narrow to wide white longitudinal lines 13
 12. Dorsum with 3 wide, brown longitudinal lines; head brown; prothoracic shield green; body 12 to 18 mm long *Argyrotaenia klotzi*
13. Head black, globose, and wider than body; prothoracic shield very pale; body light green to olive; setal areas large and black 15
13. Head green to brown, no wider than body; prothoracic shield either invisible or pale brown; body apple green; setal areas small and black 14
 14. Head green, narrower than body; body bright green, sometimes with bluish tinge; setal areas inconspicuous; longitudinal lines extended over prothorax and anal segment; body 10 to 17 mm long penultimate instar *Achytonix epipaschia*
 14. Head brown, as wide as body; body pale green; setal areas conspicuous; central longitudinal line extended over prothoracic shield, and all 3 lines extended over brown anal segment; body 18 to 22 mm long last instar *Achytonix epipaschia*
15. Anal shield very pale; dorsum olive, with setal areas scarcely raised; body 10 to 14 mm long intermediate instar *Egira simplex*
15. Anal shield dark brown, occupying whole segment; dorsum mottled green, setal areas large and raised; body 15 to 30 mm long last 2 instars *Egira simplex*
 16. Large, white eyespot around lateral seta on 8th abdominal segment; 2 irregular (undulating) white lines running through dorsocentral tae; head and prothoracic shield light brown 20
 16. No eyespot on 8th abdominal segment; longitudinal lines or stripes with even margins; head and prothoracic shield light brown to chestnut brown 17
17. Body form stout; head wider than long; head and prothoracic shield orange brown to chestnut brown, the latter usually margined at the rear with a black line; dorsum pale yellow to orange yellow, with a broad, central olive-brown or chocolate-brown stripe; body 12 to 15 mm last instar *Zeiraphera hesperiana*

17. Body form slender; head no wider than long; head and prothoracic shield pale brown to chestnut brown; dorsum with either narrow or wide longitudinal lines 18
18. Dorsum purplish, with 2 narrow and 1 broad, yellowish-green longitudinal lines on either side of the dorsal midline; setae and setal bases black and conspicuous; venter light greenish-white; body 9 to 14 mm long; larvae web ends of new needles together and feed inside enclosure *Ypsolopha nella*
18. Dorsum yellow or brown; setae and setal bases inconspicuous; venter same color as dorsum 19
19. Body pale yellow to bright yellow; dorsum with 3 orange-red or orange-brown, narrow to wide lines; body 9 to 14 mm longlast instar *Epinotia radicana*⁵
19. Body pale brown; dorsum with 3 wide, red-lavender lines; body 12 to 14 mm long unidentified species Gelechiidae
20. Dorsum pinkish brown or reddish brown; an irregular white line in pleural area; body 10 to 15 mm long penultimate instar *Dioryctria* spp.
20. Dorsum pale orange to orange red; 1 irregular, chocolate-brown stripe on each side of dorsum; body 16 to 20 mm long last instar *Dioryctria* spp.

⁵*Epinotia radicana* later enters a 3- to 4-week nonfeeding period in which it loses its markings and coloration, becoming a whitish nondescript larva. It hides among foliage debris, where it pupates late in summer.

Biological Notes on Species and Groups

The following information on life histories and synoptic features is provided to help identify associate species or groups. The western spruce budworm is presented first as a basis for comparison; the associate genera are listed in alphabetical order, without regard to taxonomic position.

Many budworm associates are well-known forest insects; information on their life histories and habits is given by Furniss and Carolin (1977). The available information is summarized here for insects that are less well known.

Western Spruce Budworm (*Choristoneura occidentalis* Freeman)

Biology—Oviposition occurs usually in late July or early August; eggs are deposited, overlapping, in masses on needles of host conifers. The newly hatched larva crawls under bark scales and among lichens, spins a silken hibernaculum, molts into the second instar, and overwinters. In spring, the larva may mine needles, enter staminate flowers, or go directly to opening buds. In attacking opening buds, the larva spins a small web outside the bud before chewing its way inside; most early feeding is by third and fourth instars. As the shoots elongate, the larva spins a web between the needles, which becomes especially conspicuous during the sixth (last) instar. The large larva is easily disturbed, dropping from its web when disturbed by wind and other factors, and many larvae drop to the lower branches and to the undergrowth. The larva pupates in a web when feeding is completed. The pupal period is 10 to 14 days.

Synoptic Features

First Instar—The larva is about 2 mm long and light green, with a light-brown head and prothoracic shield. It does not feed, and does not increase in size.

Second Instar—During its spring feeding, the larva ranges from 2 to 4 mm long, is yellow orange with tiny, dark setal areas, and has a dark brown, squarish head and a lighter brown prothoracic shield. Its anal shield is barely discernible as a few dots of sclerotization.

Third Instar—The larva ranges from 4 to 7 mm long and has an orange-brown body. Its head is brown black with lighter adfrontals, a black mark on each side of the upper head, and a pale clypeus. Its prothoracic shield is brown with a central liplike undulation at its rear margin. The anal shield, barely visible, is pale brown with 12 to 16 dots of sclerotization.

Fourth Instar—The larva is 6 to 10 mm long and light brown to cinnamon brown, with small, ivory-colored setal areas. Its head, including the clypeus, is brown-black. The prothoracic shield is brown-black and has a straight rear margin. The anal shield is easily visible as ivory-colored dots in the shape of an anchor.

Fifth Instar—The larva (fig. 3) is 10 to 16 mm long and two toned. Its upper body is olive brown with conspicuous ivory-colored setal areas; its lower sides are light tan to pale orange. Its head is reddish brown or occasionally light chestnut brown, with two black triangles on each side of the upper head. The prothoracic shield is black and has a partial longitudinal split centrally located, at its base. The anal shield is orbicular and ivory colored, with uniformly distributed brown dots.

Sixth Instar—The larva (fig. 4) is 17 to 28 mm long and two toned; its upper body is olive brown or occasionally light reddish brown and rarely yellowish brown, with large, conspicuous ivory-colored setal areas. Its lower sides are pale yellow or pale orange. Its head and prothoracic shield are yellow brown to light chestnut brown with variable, small black markings; the prothoracic shield is divided by a median longitudinal line or split. The anal shield is large, orbicular, and ivory colored.

Adults have highly variable markings; one form is shown in figure 5.

Figure 3—Fifth instar *Choristoneura occidentalis*, 15 mm long.

Figure 4—Sixth instar *Choristoneura occidentalis*, 17 to 28 mm long.

Figure 5—*Choristoneura occidentalis* adult, wingspread 22 to 28 mm.

3



4



5



Achytonix epipaschia (Grote)
(Crumb 1956)

A. epipaschia is an occasional budworm associate throughout the Western United States.

Biology—Moths are in flight during late July in the Pacific Northwest; oviposition habits are not known. The small larva overwinters in a shelter spun in the foliage. Larvae in the spring are about 5 mm long and are found inside opening buds. Subsequent feeding pattern is similar to that of western spruce budworm, but the insect pupates about a week earlier.

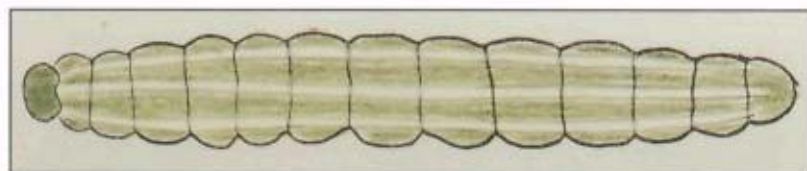
Synoptic Features—The small larva closely resembles that of western spruce budworm, except that setal areas are black and raised, three very

fine lines occur on the dorsum, and the anal shield is dark brown. Successive changes of body color as the larva molts are very pale olive green, apple green, and bright bluish green, with the white lines becoming more conspicuous. Figure 6 shows coloration and markings of the fully developed larva. The adult (fig. 7) is a medium-large (wingspread about 35 mm) gray moth with distinctive boomerang-shaped markings on the forewings.

Figure 6—*Achytonix epipaschia* larva, 18 to 22 mm long.

Figure 7—*Achytonix epipaschia* adult, wingspread about 35 mm.

6



7



***Acleris gloverana* (Walsingham),
western blackheaded budworm**

An important defoliator in its own right on the Pacific coast, *A. gloverana* is a common associate over much of the range of western spruce budworm. It has recently been found in the Southwestern United States (Stevens and others 1983). The adults of *A. gloverana* present a variety of color and marking patterns but the forewings always have raised patches of scales. Three typical forms are shown in figures 8, 9, and 10.



8

Biology—On the west coast, black-headed budworm adults fly 2 to 3 weeks after western spruce budworm. Oviposition is protracted; eggs are laid singly on needles, and the insect overwinters in this stage. The larva forms a silken tube in the opening buds, between and in alinement with the new needles. In late instars, it makes a shelter among damaged needles, where pupation occurs.



9

Figure 8—*Acleris gloverana* adult, wingspread about 18 mm.

Figure 9—*Acleris gloverana* adult, wingspread about 18 mm.

Figure 10—*Acleris gloverana* adult, wingspread about 18 mm.



10

Synoptic Features—The early instars have black heads and prothoracic shields, and lemon-yellow bodies (fig. 11). At the start of the last instar, the setal areas are prominent, although pale, and the body is a subdued yellow-green color; at this time, the larva resembles the Modoc budworm. Soon after, the setal areas fade, and the combination of chestnut-brown head, pale prothoracic shield, and grass-green body make the larva distinctive (fig. 12).

Figure 11—Early instar *Acleris gloverana*, length 10 mm.

Figure 12—Fully developed *Acleris gloverana* larva, length 12 to 16 mm.



11



12

***Anomogyna mustelina* (J. B. Smith)
(Crumb 1956)**

A. mustelina is a rare budworm associate in the Pacific Northwest, and is unknown elsewhere.

Biology—Overwintering occurs as an advanced instar. In spring, larvae are found in opening buds. They continue to feed on the new foliage for 2 to 3 weeks, then pupate. The pupal period lasts about 4 weeks. Otherwise, little is known about this species.

Synoptic Features—The larva is 25 to 30 mm long during its spring feeding. It has a pale-gray to pale-brown head and anal shield, and a yellow-brown thorax and abdomen with copious markings. Dorsal markings include small, reddish-brown dots and dashes running longitudinally and three thin, whitish-yellow longitudinal lines. The color of the anterior half of each segment is lighter than the posterior half, and sometimes the dorsum is suffused with pink. The pleural area is marked with a distinctive broad, whitish-yellow stripe; the venter is a pale olive green, suffused with pinkish brown.

***Archips* sp.**

An unidentified species of *Archips* was reared on several occasions from the foliage of Douglas-fir in the Pacific Northwest. Little is known about its life history and habits, except that the larva builds a silken tube or shelter from which it feeds. Fully developed larvae (length about 25 mm) have dark brown to black head capsules and prothoracic shields, with the remainder of the body yellow to grass green.

Argyrotaenia spp.

Three species of *Argyrotaenia*, *A. dorsalana*, *A. provana*, and *A. klotsi*, are recognized budworm associates. *A. klotsi* is known only from the Southwestern United States; the others are distributed throughout the West.

Argyrotaenia dorsalana (Dyar) (Powell 1964a)

Biology—The life history of *A. dorsalana* is similar to that of western spruce budworm. Eggs are laid on the needles in small masses, and the hatching larvae overwinter on the branches. In spring, the larvae feed in opening buds as does western spruce budworm, mostly gouging the centers of the new needles. Later, they feed in a more exposed position than the western spruce budworm, often with the silken tube they use for shelter

completely outside the feeding area. Pupation, in the foliage, occurs slightly earlier than that of western spruce budworm.

Synoptic Features—Eggs are laid in masses in the same locations as those of western spruce budworm. Eggs of *A. dorsalana*, however, are smaller and their chorion has a finer texture; also, the egg masses have an orange-pink tint. The yellow-green body and pale yellow-brown head and prothoracic shield separate the early instars from all associates except other *Argyrotaenia* species. In late instars, appearance is somewhat variable, but the head is usually light tan, the prothoracic shield yellow to yellow green, and the body light olive green or pea green (fig. 13). The adults (figs. 14 and 15) are generally yellow-

13



ish, with highly variable amounts of brown markings on the forewings. Adult size varies considerably; ones we have reared have wingspreads from 16 to 24 mm.

***Argyrotaenia provana* (Kearfott)
(Powell 1964a)**

Biology—Life history information on *A. provana* is sketchy. Presumably the life history is similar to that of *A. dorsalana*, but events occur slightly later. After feeding, the larva enters a quiescent period for about 2 weeks before it pupates.

Synoptic Features—The earliest instars are unknown. Later, at a body length of 8 to 12 mm, the entire body of the larva—including the head, prothoracic shield, and anal shield—is emerald green. In the next instar, two narrow, yellowish, longitudinal stripes are superimposed on the dorsum, and a similar yellowish stripe on the pleural area, with the remainder of the body emerald green. In the last instar, the stripes are lost and the body color becomes subdued to a grass green. The full-grown larva is slightly larger than that of *A. dorsalana*. The adult (fig. 16) has gray-black forewings, with distinctive white patches, and has a wingspread of about 20 mm.

Figure 13—*Argyrotaenia dorsalana* larva, length 15 to 17 mm.

Figure 14—*Argyrotaenia dorsalana* adult, wingspread 16 to 24 mm.

Figure 15—*Argyrotaenia dorsalana* adult, wingspread 16 to 24 mm.

Figure 16—*Argyrotaenia provana* adult, wingspread about 20 mm.



14



15



16

***Argyrotaenia klotsi* Obraztsov
(Obraztsov 1961)**

Biology—The biology of this species is unknown but is likely similar to that of *A. dorsalana* and *A. provana*.

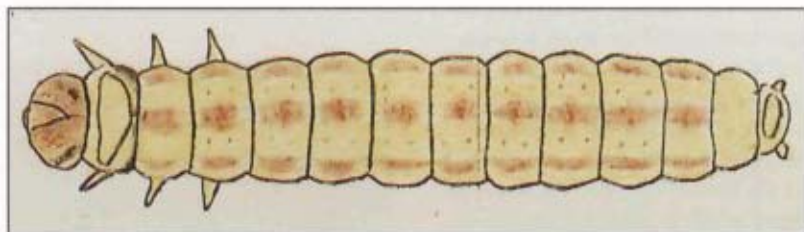
Synoptic Features—Small larvae are not known. Fully developed larvae (fig. 17) have brown head capsules with mottled black markings. Thoracic and abdominal segments are yellow green; broad brown dorsal and subdor-

sal lines run from the second thoracic to the penultimate abdominal segment. The adult (fig. 18), like that of *A. provana*, has gray-black forewings, but ornamented with yellow rather than white. It is about the same size as *A. provana*.

Figure 17—*Argyrotaenia klotsi* larva, length about 16 mm.

Figure 18—*Argyrotaenia klotsi* adult, wing-spread about 20 mm.

17



Chionodes spp.

At least three species of *Chionodes* are known associates of western spruce budworm. Of these, only *C. abella* Busck (fig. 19) is a described species (Busck 1903). It is found rarely in the Southwest, and its life history and habits are unknown. One undescribed species is known only from collections in southern Oregon.

The other (fig. 20) is common in the Northwest, and as far east as Montana. All are small moths, with wingspreads of about 12 mm.

Biology—These notes refer to the common undescribed species in the Northwest. Oviposition and overwintering habits are unknown. Larvae do not appear until the new shoots are well developed, which may suggest that early feeding is mainly in needles and staminate flowers. Fully developed larvae are present in shoots at the same time as full-grown western spruce budworm. Adults emerge in late summer.

Figure 19—*Chionodes abella* adult, wingspread about 12 mm.

Figure 20—*Chionodes* sp. adult, wingspread about 12 mm.



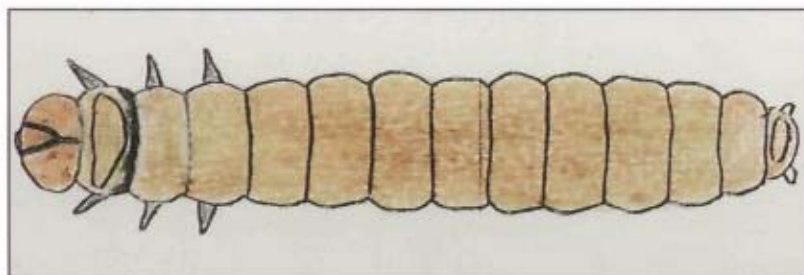
Synoptic Features—Larvae of the Northwestern species vary little between instars. The head and prothoracic shield are light chestnut brown, and the dorsum is marked with many alternating reddish-brown and white lines (fig. 21). The larva, slender in form, is extremely active when disturbed.

The larva of *C. abella* (fig. 22) is uniformly brown, with the head and anal segments having a somewhat rosy cast. Thoracic legs and the posterior dorsal part of the first thoracic segment are black.



Figure 21—*Chionodes* sp. larva, length about 10 mm.

Figure 22—*Chionodes abella* larva, length about 10 mm.



***Choristoneura retiniana*
(Walsingham) (= *C. viridis*
Freeman), Modoc budworm**

C. retiniana is common in California and southern Oregon; scattered populations are also found within other parts of the range of western spruce budworm.⁶

Biology—White fir is the principal host. Oviposition and overwintering habits are similar to those of western spruce budworm, but overwintering sites appear to be mainly on foliated parts of branches. In spring, some needle-mining occurs. The feeding habit in opening buds and elongating shoots is similar to that of western spruce budworm. In high populations, larvae appear to drop on silken threads to a greater extent than do those of western spruce budworm.

Synoptic Features—Small larvae feeding in opening buds are yellow. In the third instar, the head and prothoracic shield are a medium brown; body length is 3 to 5 mm. In the fourth instar, the head and prothoracic shield are dark brown to black, and body length is 5 to 8 mm. Larger larvae feeding on elongating shoots are greenish. In the fifth instar, the body is usually yellow-lime but may be much darker. The head is brown with dark triangles as in the western spruce budworm, the prothoracic shield

black, and setal areas pale yellow and conspicuous. In the sixth and extra instars, the body is grass green. The head is light tan, the prothoracic shield yellow brown, setal areas pale yellow and elliptical (smaller than those of western spruce budworm), and the anal shield pale yellow brown and oblong-circular. Length at maturity is around 20 mm.

The yellow, bud-feeding larvae are sometimes confused with those of *Acleris gloverana*. In casual observation, large larvae can be confused with various green-bodied associates.

⁶Powell, J. A.; DeBenedictis, J. A. Taxonomic relationships and pheromone isolation among western spruce budworm populations. CANUSA-West final report: 1982. 41 p. [Available from USDA Forest Service, Pacific Northwest Forest and Range Experiment Station, P.O. Box 3890, Portland, OR 97208.]

***Choristoneura* n. sp.**

This rare species from the Pacific Northwest has likely been lumped with the western spruce budworm during field examination of foliage. Larvae collected from the southern Willamette Valley of Oregon and the eastern Cascades of Washington in the 1950's and 1960's were reared to adults that were identified by a specialist at the U.S. National Museum.

Biology—Oviposition and overwintering habits are probably similar to those of western spruce budworm, but the larva may feed before overwintering. When found in opening buds, the larva is somewhat larger than that of western spruce budworm, but their subsequent feeding habits appear identical. The new species ceases feeding and pupates about 2 weeks earlier than western spruce budworm, however.

Synoptic Features—When the larva is 8 to 10 mm long, the head is orange brown, the prothoracic shield light brown and margined on the sides and rear by a broad black line; the anal plate is large, ivory-colored, and circular. The dorsum is reddish brown, with prominent roundish ivory-colored setal areas and two pale longitudinal lines, and the pleural area bears a broad yellow stripe. Later, when the larva is 12 to 15 mm long, the head and anal plate become light chestnut brown, and the pale lines disappear. The very dark adult is much smaller than that of western spruce budworm.

***Coleotechnites* spp.**

At least two undescribed species of *Coleotechnites* are budworm associates.

Biology—Few details are known of the life history or the habits of these species, but they are probably similar to those of the closely related *C. piceaella* (Kearfott), an associate of *Choristoneura fumiferana* in the Eastern United States. *Coleotechnites piceaella* lays eggs between old bud scales and in similar protected locations late in summer. The small larva of this and the common Northwestern species mines needles and overwinters in a needle or a mass of mined needles. In spring, as buds open, the larva spins a silken tube from the twig to the base of the bud, and feeds from the tube into the bud.

Synoptic Features—The larva (fig. 23) varies in color from pinkish brown to yellowish brown; the head, collar-like prothoracic shield, and anal plate are light brown. Setal bases are small, but dark and conspicuous. The larva is very active. At maturity it is 7 to 8 mm long. Adults (fig. 24) are small, fragile moths with heavily fringed wings; wingspread is about 10 mm.

***Dioryctria* spp. (Mutuura & Munroe 1973)**

The spruce coneworm, *Dioryctria reniculelloides* Mutuura & Munroe, has long been recognized as a western spruce budworm associate, at times being about as numerous as budworms themselves. Recently, *D. pseudotsugella* Munroe has been identified as another associate of western spruce budworm (Stevens and others 1983). The two species are difficult to distinguish in the larval and adult stages, so we choose here to consider them a single entity. Other as yet undescribed species may also be involved. The following sections on life history and synoptic features were prepared for *D. reniculelloides*, but probably serve reasonably well for *D. pseudotsugella*.

Biology—Eggs are laid on the bark of limbs. After hatching, the small larva overwinters in some of the same

places as the western spruce budworm. In spring, it sometimes mines needles. Normally it feeds in opening buds much as does the western spruce budworm, and as the shoot elongates, feeding and webbing are also similar. Pupation is slightly later than that of the western spruce budworm in the Pacific Northwest, and 7 to 10 days earlier than western spruce budworm in the northern Rocky Mountains.

Synoptic Features—During needle-mining and bud-feeding, the larva resembles the western spruce budworm in form, but the body is reddish brown to almost black with 8 to 10 interrupted longitudinal white lines and a distinctive white "eyespot" on each side of the eighth abdominal segment. The frass, expelled into the

23

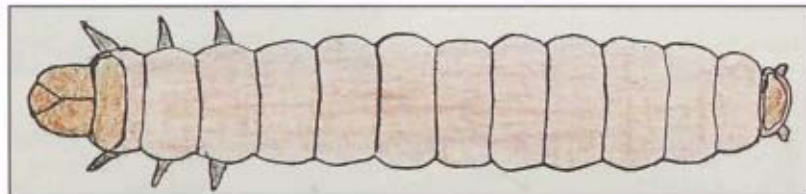


Figure 23—*Coleotechnites* sp. larva, length about 8 mm.

24



Figure 24—*Coleotechnites* sp. adult, wingspread about 10 mm.

webbing during bud-mining, is yellowish and a good clue to the identity of the hidden miner. In later instars, the brightly colored dorsum and undulating subdorsal lines make the larva easy to distinguish, at least to genus. Figure 25 shows a typical larva; figures 26 and 27 show variations. The pupae are dark brown to black; the moths (figs. 28 and 29) have gray forewings (wingspread about 20 to 25 mm) with distinctive whitish transverse bands and are not likely to be confused with other budworm associates.

Figure 25—*Dioryctria* sp. larva, length 18 to 24 mm.

Figure 26—*Dioryctria* sp. larva, length 18 to 24 mm.

Figure 27—*Dioryctria* sp. larva, length 18 to 24 mm.

Figure 28—*Dioryctria reniculelloides* adult, wingspread 20 to 25 mm.

Figure 29—*Dioryctria pseudotsugella* adult, wingspread 20 to 25 mm.



25



26



***Egira simplex* (Walker)
(Hardy 1962)**

E. simplex (fig. 30) is a large noctuid that is widely distributed throughout the West, and is an occasional budworm associate. It is found in older literature under the name *Xylomyges simplex*.

Biology—In early spring, the adult deposits groups of eggs on foliage of both conifers and hardwoods. On Douglas-fir, the young larva penetrates the opening bud and feeds much like the western spruce budworm; as the shoot elongates, the larva feeds from an external silken shelter much like that of western spruce budworm. It pupates 1 to 2 weeks later than the western spruce budworm and overwinters in that stage.

Synoptic Features—In its early feeding, the small larva (4 to 6 mm long)

resembles the western spruce budworm in its orange-brown coloration and dark-brown head. The last abdominal segment is almost completely black, however, and the setal areas are black. In subsequent instars, the dorsum is marked with three white or whitish-yellow lines on a light olive-green background and, later, on a brighter green background. The head, prothoracic shield, setal bases, and anal shield remain dark brown or black (fig. 31). At maturity, the larva is 30 to 35 mm long, strikingly large and stocky. Life stages, including each instar, are described in detail by Hardy (1962).

Figure 30—*Egira simplex* adult, wingspread 40 mm.





Figure 31—Early-instar *Egira simplex* larva,
15 mm long.

***Enypia griseata* Grossbeck (Evans 1960)**

E. griseata has been reared as a budworm associate from the Southwestern United States, and adults identified as "*Enypia* sp. nr. *griseata*" have been reared from the Pacific Northwest. Other species of *Enypia* are known from Douglas-fir and true firs (Evans 1960) and may also appear as western spruce budworm associates. The following material relates to *E. griseata*.

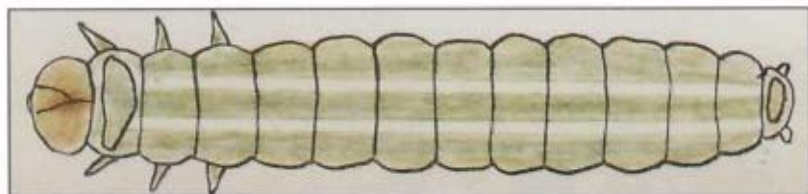
Biology—The pearly eggs are laid singly or in twos on needles. The larva overwinters, usually in the fourth instar. Pupation is in the foliage. Adults may be found throughout the summer.

Synoptic Features—The head and prothoracic shield of the small larva are pale green-brown; the body is gen-

erally gray-green, with several greenish longitudinal lines. The fully developed larva (fig. 32) is green, with two pairs of conspicuous, near-white lines; the head is pale russet-green, with darker epicranial markings. Length is 20 to 25 mm. The adult (fig. 33) is a large, generally gray moth, with a wingspread of about 35 mm. The wings of the commonly reared species in the Pacific Northwest have a dusting of whitish scales superimposed on the gray. Evans (1960) includes photographs of the adults of many species.

Figure 32—*Enypia griseata* larva, 20 to 25 mm long.

Figure 33—*Enypia griseata* adult, wingspread about 35 mm.



32



33

Epinotia radicana (Heinrich),
spruce tip moth (Blais 1961, Powell
1964b, Brown 1983)

34



Figure 34—*Epinotia radicana* larva, 9 to 12 mm long.

E. radicana, known until recently as *Griselda radicana*, is transcontinental and an associate of both the western and the eastern spruce budworms.

Biology—Eggs are laid singly at the base of needles. They overwinter and hatch in the spring; the small larvae enter the opening buds, feeding mainly at the top. The larvae cease feeding about the same time as, or slightly later than, the western spruce budworm, then go into a quiescent period for 3 to 4 weeks in dead needles and other debris before pupating. Emergence is in late summer.

Synoptic Features—Early instars are pale yellow. The first instar is slender, but in later stages (figs. 34 and 35) the larvae grow stouter, and pinkish to red-brown longitudinal lines appear. In early feeding, the bud cap is tied with silk, like a hat, to the opening bud. During the quiescent period before pupation, the larva becomes whitish and unmarked. The adult (fig. 36) is small (wingspread about 12 to 16 mm) with gray forewings having distinctive rusty-colored basal sections.



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Figure 35—*Epinotia radicana* larva, 9 to 12 mm long.

Figure 36—*Epinotia radicana* adult, wingspread 12 to 16 mm.

***Eupithecia* spp. (MacKay 1951,
McDunnough 1949, Ross and Evans
1956)**

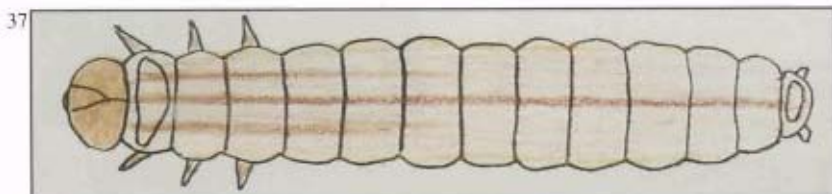
Many members of the genus *Eupithecia* feed on foliage of conifers. *E. annulata* (Hulst) is common in the Pacific Northwest and the northern Rockies, and *E. catalinata* McDunnough has been reared from the Southwestern United States. The following material pertains to *E. annulata*.

Biology—Oviposition occurs in early spring, but the sites are unknown. The small larva feeds on the new needles of opening buds under cover of the bud scales. As it grows, the larva continues to feed on the new needles, gouging out rectangular patches near the middle of a needle. It pupates in early summer, with a few crinkly strands of silk holding the tail end of the pupa. The pupa overwinters.

Synoptic Features—When about 6 mm long, the larva has a yellow body, with the head, pleural areas, and anal shield brown. The prothoracic shield is light brown and paler in the center. The fully developed larva (fig. 37), about 22 mm long, has a pale brown head; the dorsum is reddish or yellowish brown with three longitudinal lines; the pleural area may have a yellowish stripe. The adult of *E. annulata* (fig. 38) is an indistinctly marked moth, with a wing-spread of 20 to 24 mm. *E. catalinata* is similar in size and is similarly marked.

Figure 37—*Eupithecia annulata* larva, about 22 mm long.

Figure 38—*Eupithecia annulata* adult, wing-spread 20 to 24 mm.



Lambdina fiscellaria lugubrosa
(Hulst), western hemlock looper

Biology—Single eggs are laid in early fall on lichens, moss, and roughened bark. Eggs overwinter and hatch in spring. Newly emerged larvae feed on needles of opening buds and later instars feed on old needles. Pupation occurs both on and off the tree in various kinds of natural debris.

Synoptic Features—Eggs are spherical and grayish. The first instar has a distinctive black head, and each of the first five abdominal segments has a transverse whitish-yellow band followed by a dark-brown band. In subsequent instars, the head gradually becomes paler but with dark streaking and mottling and round black dots; the dorsum is pale brown or pale green, with the setal bases appearing as four dark dots on each segment. A maze of white and dark lines occurs in the pleural area. In the last instar (fig. 39), the head is whitish, with light-brown mottling and eight large dots; the dorsum ranges from a very light

yellowish brown or pinkish brown to a light gray. A white subdorsal stripe is subtended by a broken black line, with the maze of fine lines below. The mature larva is 25 to 30 mm long. The adult (fig. 40) is tan, with a wingspread of about 35 mm.

Figure 39—*Lambdina fiscellaria lugubrosa* larva, 18 to 30 mm long.

Figure 40—*Lambdina fiscellaria lugubrosa* adult, wingspread about 35 mm.



39



40

Melanolophia imitata (Walker),
greenstriped forest looper (Evans
1962)

The greenstriped forest looper, common along the Pacific coast, feeds on a variety of conifers.

Biology—In early spring, the adult deposits small, barrel-shaped eggs on tree limbs and boles. After the eggs hatch, larvae move to the foliage and feed on both new and old needles, with 1-year-old foliage preferred. In September, the mature larva drops to

the ground, pupates in the duff, and overwinters.

Synoptic Features—In all stages, the larva has a green head with no markings, and a green body; the dorsum is marked with a pair of whitish longitudinal lines. The last instar (fig. 41) is apple green, 30 to 37 mm long, with the white dorsal lines prominent and a fainter yellow stripe in the pleural area. Although commonly a coastal species, it has recently been found in beatings of Douglas-fir in the northern Rocky Mountains (Volker 1978). The adults (fig. 42) vary in wingspread from 20 to over 35 mm.



Figure 41—*Melanolophia imitata* larva, 30 to 37 mm long.

Figure 42—*Melanolophia imitata* adult, wingspread 20 to 35 mm.



***Nematocampa limbata* (Haworth),
filament bearer**

The filament bearer, a transcontinental species, is an occasional budworm associate in the Pacific Northwest and the northern Rockies. In the older literature this insect is listed as *Nematocampa filamentaria*.

Biology—In northern Idaho in 1976, Markin (unpublished) found development of *N. limbata* lagging significantly behind that of western spruce budworm; early instars were seen in late June, and the larvae finished feeding in late July. Adults appeared in early to mid-August. Eggs failed to

hatch by fall; the species apparently overwinters in this stage. Early instars fed mostly on new foliage, but later stages fed more or less indiscriminately, cleaning up needles unclaimed by western spruce budworms.

Synoptic Features—The knobbed dorsal projections on the fully developed larva (fig. 43) readily identify the species. The larva is up to 20 mm long; and the medium-sized adult (fig. 44) is tan and has a wingspread of about 20 mm.

Figure 43—*Nematocampa limbata* larva, 20 mm long.

Figure 44—*Nematocampa limbata* adult, wing spread about 20 mm.



43



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***Nepytia phantasmaria* (Strecker),
phantom hemlock looper (Wickman
and Hunt 1969)**

This species has been associated with low populations of western spruce budworm on Douglas-fir in the Willamette Valley of Oregon. Its usual host in coastal Oregon and British Columbia is western hemlock, but it has also caused serious damage to white fir in northern California.

Biology—In late September and October, the eggs are laid singly or in small clusters on the underside of conifer needles; they overwinter and hatch about the time buds are opening. The small larva feeds at first on new needles, then moves to old needles during its third or fourth instar. It molts into a fifth instar and continues to feed until early September; then, it attaches itself by a few silken strands to needles and pupates.

Synoptic Features—First and second instars are pale green with two faint white longitudinal stripes on the dorsum. Third and fourth instars have green heads with black dots; the body is green with two white dorsal stripes. The appearance changes little in the fifth and final instar (fig. 45), when it reaches a length of 25 to 35 mm. The adult (fig. 46) has a wingspread of about 25 mm.



45



46

Figure 45—*Nepytia phantasmaria* larva, 25 to 35 mm long.

Figure 46—*Nepytia phantasmaria* adult, wingspread 25 to 30 mm.

Orgyia pseudotsugata
(McDunnough), Douglas-fir tussock
moth (Brookes and others 1978)

47



The Douglas-fir tussock moth ranks with western spruce budworm as one of the most important forest defoliators in Western North America, and is a potential budworm associate.

Biology—Eggs masses overwinter and eggs hatch in May and June; young larvae usually feed on newly expanding foliage of Douglas-fir and true firs. Later instars feed on both old and new foliage; then, most pupate in stout cocoons on foliage where they have been feeding. Females are wingless and mate on their cocoons.



Figure 47—Early instar *Orgyia pseudotsugata*, about 15 mm long.

Figure 48—Fifth instar *Orgyia pseudotsugata*, about 25 mm long.

Synoptic Features—This is one of the few western spruce budworm larval associates that are hairy, and thus readily distinguishable. The tussock moth has a variety of hairy projections in the different instars (figs. 47 and 48). The instars are described in detail by Beckwith (1978).

Stenoporpia sp.

An undetermined species of the looper genus *Stenoporpia* has been reared from Douglas-fir in the Pacific Northwest. The fully developed larva (about 30 mm long) has a light-brown head, orange-red-brown dorsum, and yellowish pleural and ventral areas.

Syngrapha spp., false loopers
(Eichlin and Cunningham 1978,
McGuffin 1954)

Moths of this genus are occasionally reared as associates of western spruce budworm, but they are relatively unknown to most forest entomologists. We have reared *S. angulidens* (J. B. Smith) occasionally in the Southwest; *S. celsa* (Hy. Edwards) is well known from the Pacific region.

Biology—The eggs are laid singly, and members of the genus overwinter as small larvae.

Synoptic Features—Full-grown larvae are green, with a white or dark green stripe in the pleural area, and up to 25 mm long; they have only three pairs of abdominal prolegs. The adults (figs. 49 and 50) are medium-sized (wingspread 25 to 30 mm), heavy-bodied, distinctively marked moths.



Figure 49—*Syngrapha angulidenx* adult, wingspread 25 to 30 mm.

Figure 50—*Syngrapha celsa* adult, wingspread 25 to 30 mm.

Telphusa sedulitella (Busck)

Ypsolopha spp.

Y. nella (Busck) is a common associate of western spruce budworm on white fir in the central Rockies and the Southwestern United States (Stevens and others 1983), and a species identified as *Ypsolopha* prob. *cerrella* (Walsingham) has been reared from Douglas-fir in the Pacific Northwest. The following material refers to *Y. nella*.

T. sedulitella is a relatively rare associate of western spruce budworm in the Pacific Northwest.

Biology—In spring, the larva is found in an intermediate stage, feeding in opening buds of grand fir. It continues its feeding in elongating shoots and pupates 1 to 2 weeks before western spruce budworm. Emergence is in early July.

Synoptic Features—When first found in opening buds, the slender larva has a yellowish chestnut-brown head, prothoracic shield, and anal shield, and a pale dorsum marked with five, brown, longitudinal lines. In the next instar, the lines become lavender brown. In the final instar, the head and prothoracic shield are chestnut brown, the prothoracic shield tinged with black at the rear, and the dorsum pale yellow and now marked with seven, reddish-brown, longitudinal lines. A similar line occurs below the lateral midline, and the venter is pale yellow. The mature larva is 9 to 10 mm long. The adult (fig. 51) is a small, slender moth with narrow dark-brown wings marked with silver.

Biology—Relatively little is known of the life history of this species. Larvae appear in late spring to early summer and pupate in the foliage, about the same time as the budworm.

Synoptic Features—Larvae and adults are both highly distinctive, as are the larval feeding characteristics. Color varies considerably within and between instars, but all stages have conspicuous black setae borne on black setal bases (fig. 52). Background colors on the dorsum range from gray to green to purple; all instars have a series of longitudinal dorsal lines. The adults have wingspreads of about 20 mm; their abdomens and hindwings are gray. The forewings are narrow, brown, and often ornamented with a darker longitudinal line. Figures 53 and 54 show typical markings. Larvae web the outer ends of the needles together into a tent, within which they feed. As the needles elongate, the tent becomes more globular than spindle-shaped, and is a readily seen indicator of *Ypsolopha*.

Figure 51—*Telphusa sedulitella* adult, wing-spread about 10 mm.



Figure 52—*Ypsolopha nella* larva, 9 to 14 mm long.

Figure 53—*Ypsolopha nella* adult, wingspread 20 mm.

Figure 54—*Ypsolopha nella* adult, wingspread 20 mm.

Zeiraphera spp.

Z. hesperiana Mutuura & Freeman has long been considered an associate of western spruce budworm in the Pacific Northwest and the northern Rockies (Carolin 1980, Markin 1982), and adults identified as *Z. hesperiana* have recently been reared from the Southwestern United States (Stevens and others 1983). *Z. pacifica* Freeman also appears to be a common associate in Idaho.

Biology—Eggs of *Z. hesperiana* are laid singly on bare portions of limbs during midsummer, and overwinter. In spring, eggs hatch, and the young larvae feed completely concealed in the opening buds. Early feeding encircles the base of the new shoot. As the shoot develops, the larva and the effects of its feeding gradually become visible. In the Northwest, the larva drops to the ground to pupate in the litter about the time the larvae of western spruce budworm are entering the last instar. The life history of *Z. pacifica* has not been intensively studied; presumably, it is similar to *Z. hesperiana*. Damage caused by *Z. pacifica* is noted by Condrashoff (1966).

Synoptic Features—Eggs are small, yellow, and spiny surfaced. The larva of *Z. hesperiana* resembles the western spruce budworm slightly when small, but the body is dirty whitish-brown or pale yellow. The setal bases are conspicuously black, and three small sclerotized areas occur on the dorsum of the penultimate segment. Later, the larva becomes brownish yellow, and in the last two stages has

a broad brown dorsal stripe (fig. 55). The larva is generally sluggish. Adult *Zeiraphera* moths are distinctively marked and readily separable from any other common budworm associates by the presence of a prominent saddle-like, white to brownish-white patch located on the forewings when the moth is at rest.

Adults identified as *Z. hesperiana* (fig. 56) are generally larger than those of *Z. pacifica* (fig. 57) (wing-spreads 15 to 20 mm vs. 10 to 12 mm), but the species appear similar otherwise. In Idaho, sympatric populations of what appear to be both species tend to be host-specific—*Z. hesperiana* on Douglas-fir, *Z. pacifica* on true fir. In Idaho, at least, larvae are separable; *Z. pacifica* is smaller, flattened dorsoventrally, and has a uniformly pale, off-white thorax abdomen. Both have tan head and capsules.

Figure 55—*Zeiraphera hesperiana* larva, 12 to 15 mm long.

Figure 56—*Zeiraphera hesperiana* adult, wing-spread 15 to 20 mm.

Figure 57—*Zeiraphera pacifica* adult, wing-spread 12 to 15 mm.



Role of Associates in the Habitat

Although the role of individual budworm associates in the habitat is fairly well known, the interaction among them is not. A synthesis of available information is presented below.

Host Preference

Studies in Oregon and Washington by Carolin (1980) showed that most of the defoliators associated with western spruce budworm on Douglas-fir were also found on grand fir and with the Modoc budworm on white fir. In northeast Oregon, sampling of paired Douglas-fir and grand fir trees showed: no preference between the two tree species by *Argyrotaenia dorsalana* and *Dioryctria* sp., probably *reniculelloides*; a strong preference for Douglas-fir by *Epinotia radicana* and *Zeiraphera hesperiana*; and, a strong preference for grand fir by *Acleris gloverana*, *Chionodes-Telphusa* species, and a then-unidentified *Zeiraphera* species, possibly *Z. pacifica*. In similar studies in the eastern Washington Cascades, a preference for grand fir by the *Chionodes-Telphusa* complex was again shown; populations of other associates were too low for comparison. Surveys in northeast Oregon in 1956 revealed a spot infestation by *Acleris gloverana* on subalpine fir, with light but visible defoliation (Whiteside 1957), suggesting a general affinity of this species for true firs in areas away from the insect's usual coastal habitat.

Indications of host preference by other associates are strictly observational. In an outbreak in northern Idaho and western Montana during 1937, the western hemlock looper showed a preference for true firs, but several intermixed species, including Douglas-fir, were also fed upon (Evenden 1938). Two noctuids, *Achytonix epipaschia* and *Egira simplex*, listed by Carolin (1980) as sporadic on Douglas-fir and rare on grand fir, caused noticeable defoliation in 1964 on Douglas-fir on 8,400 acres (3 360 ha) in western Oregon (Orr and others 1965). After an analytical review of records, Beckwith (1978) concluded that apparent host preference by the Douglas-fir tussock moth between Douglas-fir and grand fir was inconsistent, differing among forest areas.

Life History

The amount of damage associates may add to that caused by western spruce budworm is affected by the timing of larval feeding and larval development relative to bud-opening and shoot development and to feeding site. Abundance is also a factor; Markin (1982) describes an insecticide field test against western spruce budworm on Douglas-fir in southeast Idaho in which associates constituted 52 percent of all larvae found on foliage samples.

A few associates have life histories similar to that of western spruce budworm. At least one and possibly two *Dioryctria* species fit the budworm pattern closely, but with variations shown in relative time of pupation. Three species of *Argyrotaenia* have life histories similar to that of western spruce budworm, with pupation ranging from slightly before to slightly after that of the budworm. One noctuid, *Achytonix epipaschia*, also has a similar life history, but with slightly earlier pupation. All other associates for which we have life history information differ in phenology from that of western spruce budworm in one or more respects. Simplified comparisons between the phenology of western spruce budworm and selected associated species are made in table 2.

Table 2—Synopsis of life histories of some lepidopterous associates, compared with western spruce budworm

Species	Oviposition	Eclosion	Start of feeding	Pupation
<i>Choristoneura occidentalis</i>	Mid to late summer	Mid to late summer	Spring	Midsummer
<i>Achytonix epipaschia</i>	Midsummer	Mid to late summer	Spring	Midsummer
<i>Acleris gloverana</i>	Late summer	Spring	Spring	Late summer
<i>Argyrotaenia</i> spp.	Mid to late summer	Mid to late summer	Spring	Midsummer
<i>Chionodes</i> sp. A	Spring	Late summer	Summer	Spring ¹
<i>Chionodes</i> other spp.	?	?	Spring	Midsummer
<i>Coleotechnites</i> sp., nr. <i>piceaella</i>	Mid to late summer	Late summer	Late summer	Late spring ¹
<i>Dioryctria</i> spp.	Mid to late summer	Mid to late summer	Spring	Midsummer
<i>Egira simplex</i>	Spring	Spring	Spring	Mid to late summer
<i>Eupithecia annulata</i>	Spring	Spring	Spring	Early summer
<i>Epinotia radicana</i>	Late summer	Spring	Spring	Late summer ²
<i>Lambdina fiscellaria lugubrosa</i>	Early fall	Spring	Spring	Late summer
<i>Melanolophia imitata</i>	Spring	Spring	Spring	Late summer
<i>Nematocampa limbata</i>	Mid to late summer	Spring (?)	Late spring	Midsummer
<i>Nepytia phantasmaria</i>	Early fall	Spring	Spring	Late summer

¹Of the following year.

²Larva undergoes a 3- to 4-week nonfeeding period before pupating.

Table 2—Continued

Species	Oviposition	Eclosion	Start of feeding	Pupation
<i>Orgyia pseudotsugata</i>	Late summer	Spring	Spring	Late summer
<i>Syngrapha</i> spp.	Midsummer	Midsummer	Late summer	Early summer ¹
<i>Telphusa sedulitella</i>	Mid to late summer	Mid to late summer	?	Midsummer
<i>Zeiraphera hesperiana</i>	Midsummer	Spring	Spring	Early summer

¹Of the following year.

Despite differences in life histories, most associates feed in buds as early instars, like the western spruce budworm. A few associates in buds are advanced instars, however; they have obviously fed in the previous fall, on trees either host or nonhost for western spruce budworm, and wintered as larvae. During bud-feeding, two noctuids, *Syngrapha* sp. nr. *celsa* and *Anomogyna mustelina*, and the loopers, *Stenoporpia* sp., and one or more species of *Enypia* are larvae 20 to 25 mm long. Their feeding is concluded in about 2 weeks. The common species of *Ypsolopha* in the Southwest, and a rare species in the Pacific Northwest, are first found on new growth as intermediate instars. The larvae of *Coleotechnites* sp. nr. *piceaella*, a small gelechiid, are mainly in their last stages at the time of budfeeding, and pupate in about 2 weeks. With the possible exception of *Ypsolopha nella*, these species have little impact on the production of new foliage.

Of early instars in opening buds, only *Zeiraphera hesperiana*, the *Zeiraphera* on true firs, and *Eupithecia annulata* (and possibly *E. catalinata*) cease feeding noticeably earlier than western spruce budworm. The *Zeiraphera* larvae cease feeding about the time western spruce budworm is entering its last larval stage, dropping to the ground to pupate; *E. annulata* pupates shortly thereafter. Because of its frequent abundance, *Z. hesperiana* may have a significant impact on production of new foliage, but would not be recorded in late larval samples for western spruce budworm. Three loopers of sporadic occurrence, *Lambdina fiscellaria lugubrosa*, *Melanolophia imitata*, and *Nepytia phantasmaria*, are found in freshly flushed buds but feed late into the growing season and more on old than new needle growth. *Acleris gloverana* also feeds later, pupating about the time western spruce budworm is laying eggs.

Feeding Sites

Variation in bud-feeding sites of associates provides a potential for serious bud damage, particularly if this feeding adds to that of western spruce budworm. A few associates, such as *Achytonix epipaschia* and *Egira simplex*, feed much as does western spruce budworm. Others usually occupy a different part of the bud.

Zeiraphera hesperiana tunnels around the base of the bud, rarely touching the shoot axis. *Dioryctria* spp. tend to bore directly into the center of the bud and damage the shoot axis; western spruce budworm is located in this area too, but usually has a meandering mine near the shoot axis. *Epinotia radicana* usually is at the tip of the opening bud, webbing the bud cap to the tip. *Acleris gloverana* and *Ypsolopha* spp. build tubes made of needles. *Argyrotaenia* spp. usually feed only part way into the bud, keeping their bodies in an external silken tube. The various loopers are mostly external feeders and can be characterized as needle-gougers.

Competition between associates and western spruce budworm and among associates is probably ameliorated by the variation in feeding sites. Sample counts for western spruce budworm and associates in Oregon and Washington (Carolin 1980) show that (1) when little previous bud damage has occurred, both western spruce budworm and associates can be abundant; and (2) when previous bud damage has reduced the food supply, abundance of associates is sharply reduced. The preponderance of associates over western spruce budworm described by Markin (1982) may demonstrate the effect of little previous damage to buds. Some direct competition between western spruce budworm and associates is evident. *Dioryctria reniculelloides* larvae are known to prey on western spruce budworm pupae (McKnight 1971), and mature larvae of *Epinotia radicana* have been observed feeding on fresh western spruce budworm pupae (Carolin, unpublished). Other instances of predation no doubt go unobserved, and are indicated only by dead western spruce budworm found inside the buds. No predation among the various associates is known to us, but it probably occurs to a minor extent.

Abundance

In unsprayed infestations of western spruce budworm in Oregon and Washington during 1955–58, associates feeding in opening buds of Douglas-fir constituted 3 to 28 percent of the total larval population on samples at the different plots (Carolin 1980). During insecticide tests against western spruce budworm on Douglas-fir in southeast Idaho in 1976, associates found on all samples for all sampling intervals represented 52 percent of all larvae recorded (Markin 1982). In similar tests in western Montana in 1981, associates made up 27 percent of all larvae found (Markin, unpublished).

In Oregon and Washington infestations, Carolin (1980) listed six species as being relatively abundant: *Acleris gloverana*, *Argyrotaenia dorsalana*, *Coleotechnites* sp. nr. *piceaella*, *Dioryctria reniculelloides*, *Epinotia radicana*, and *Zeiraphera hesperiana*. In unsprayed Douglas-fir plots, *Z. hesperiana* was the most abundant species, with up to 206 larvae per 100 15-inch (37.5-cm) twigs. *Epinotia radicana* was next in abundance, with up to 131 larvae per 100 twigs, and *D. reniculelloides*, although low in density at three plots, reached 158 larvae per 100 twigs at a fourth plot. *Acleris gloverana* attained a density of 30 larvae per 100 twigs on Douglas-fir plots, and over 100 larvae per 100 twigs at a subalpine fir plot sprayed several years before.

In southeast Idaho, of the total defoliator population, associates were represented as follows: *D. reniculelloides*, 18 percent; *Z. hesperiana*, 17 percent; *Nematocampa limbata*, 8 percent; *E. radicana* 2 percent; *A. gloverana*, 1 percent; and unidentified larvae, 7 percent (Markin 1982). Both *D. reniculelloides* and *Z. hesperiana* occurred at densities as high as 6 larvae per 100 buds, and *N. limbata* as high as 2.6 larvae per 100 buds at one of the sampling intervals. In the western Montana tests (Markin, unpublished), *D. reniculelloides* represented 16 percent, *A. gloverana* 7 percent, *E. radicana* 5 percent, and *Z. hesperiana* 1 percent of all larvae found.

Because these records were obtained in different years, no valid comparison can be made between forest regions represented. These associates have been shown to oscillate in density over a period of years (Carolin 1980), but *Zeiraphera hesperiana*, *Dioryctria reniculelloides*, *Epinotia radicana*, and *Argyrotaenia dorsalana* are clearly among the major associates of western spruce budworm.

Additional Research Needed

Although some facts about budworm associates are known, clearly much remains to be learned. For some areas, even such basic information as the composition of the associate complex is unknown. Data on life histories and habits are sketchy for many of the associates. We urge entomologists to collect and rear associates and to make their findings known. Only in this way will these important information gaps be filled.

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