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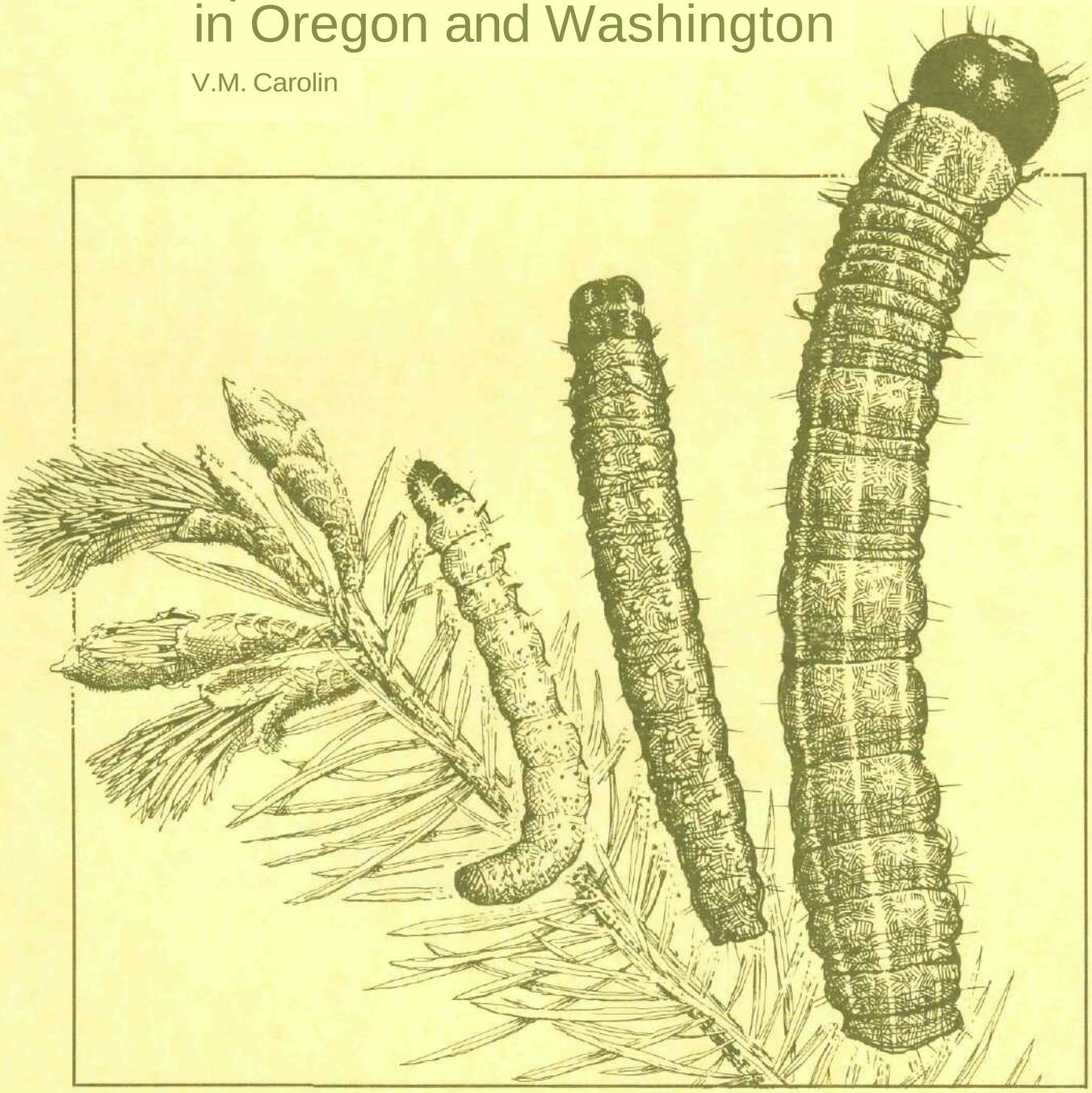
Larval Densities and Trends of Insect Species Associated With Spruce Budworms in Buds and Shoots in Oregon and Washington

V.M. Carolin



V. *M.* CAROLIN is consulting entomologist for the Pacific Northwest Forest and Range Experiment Station, Portland,, Oregon.

Larval Densities and Trends of Insect Species Associated With Spruce Budworms in Buds and Shoots in Oregon and Washington

by V. M. Carolin

Reference Abstract

Carolin, V. M.
1980. Larval densities and trends of insect species associated with spruce budworms in buds and shoots in Oregon and Washington. USD A For. Serv. Res. Pap. PNW-273, 18 p. Pac. Northwest For. and Range Exp. Station, Portland, Oregon.

Sampling studies on western spruce budworm and Modoc budworm disclosed a substantial number of associated insect species at the time larvae were in opening buds. About 20 species occur with sufficient regularity to justify identification by field crews.

Keywords: Insect populations, reproductive behavior (insect), western spruce budworm, identification (insect), *Choristoneura occidentalis*, Modoc budworm, *Choristoneura viridis.*

Research Summary

Research Paper PNW-273

1980

Densities and trends of insect species feeding in opening buds with the western spruce budworm, *Choristoneura occidentalis* Freeman, in Oregon and Washington, were analyzed for the period 1951 through 1962. During sampling at fixed plots for *C. occidentalis* in both sprayed and unsprayed areas, larvae of associated insect species were identified and quantified as numbers per one hundred 15-inch twigs. A similar but lesser effort was made in 1960-62 in unsprayed infestations of the Modoc budworm, *C. viridis* Freeman, in southern Oregon.

The various associated insect species and their frequencies on Douglas-fir, grand fir, and white fir are tabulated. Trends of six major associates at Douglas-fir and subalpine fir plots are shown graphically by study area; periods covered are 1951-59 for sprayed areas and 1955-58 for unsprayed areas. Major associates were: *Acleris gloverana* (Walsingham), *Argyrotaenia dorsalana* (Dyar), *Coleotechnites* sp., near *piceaella* (Kearfott), *Dioryctria reniculelloides* Mutuura and Munroe, *Griselda radicana* (Heinrich), and *Zeiraphera hesperiana* Mutuura and Freeman. Approximate trends in an infestation in the eastern Washington Cascades during 1960-62 and before spraying were deduced.

Indications as to preference of associated insect species for Douglas-fir and grand fir were obtained from two paired tree studies, one in northeast Oregon and one in the eastern Washington Cascades. Preference for Douglas-fir was shown by two associated species, and preference for grand fir by three associated species.

About 20 associated species occurred with sufficient frequency to justify their recognition as a routine part of sampling studies. Major peaks for most associates occurred in 1957 or 1958, along with the western spruce budworm.

Contents

Introduction

A new series of outbreaks by the western spruce budworm, *Choristoneura occidentalis* Freeman, have been underway in parts of the West. In 1973, infestations appeared to be increasing in Oregon, Washington, Arizona, New Mexico, and Colorado, although decreasing in the northern Rocky Mountains (Chansler and Toko 1975). As of 1973, the eastern counterpart — the spruce bud worm, *C. fumiferana* (Clemens) — had infested large areas in the State of Maine, eastern Canada, and the Lake States; and aerial control projects were underway. Concern over the prospects of widespread damage by these budworms led to the initiation in 1977 of a 6-year cooperative program between the United States and Canada, with a mission of developing management strategies for controlling these budworms, or learning to manage budworm-susceptible forests.

One of the program objectives is to develop and improve methods for assessing and predicting budworm population levels. Such determination requires that associated defoliators be recognized and that any peculiar relationships between spruce budworms and these associates be defined. Evaluation of control effectiveness also demands that associated defoliators be identified in both pre-control and post-control sampling. To this end, information on these associates needs to be made available to workers in the ongoing program.

One source of information is biological data obtained during a previous budworm outbreak in Oregon and Washington. The major outbreak, mostly in the Blue Mountains and Cascade Range, began in 1947 and ended in 1959, after 4.7 million acres were sprayed with DDT. A subsequent flare-up in the eastern Washington Cascades in 1959 was terminated in 1962 by aerial spraying. Also in 1959, the Modoc budworm, *C.viridis* Freeman, was found to be in epidemic status over a large area in southern Oregon and northern California. It reached a peak in 1960, then declined from natural causes.

Biological studies starting in 1950 gradually disclosed the identity of the principal associated defoliators; subsequently, information on recognition of principal associated defoliators was made available to survey and control personnel in the form of hand-colored larval diagrams.[1] A publication on the effects of DDT spraying on the western spruce budworm (Carolin and Coulter 1971) included evidence of differential survival between the budworm and its associates.

Untapped data on associated defoliators in the files of the Pacific Northwest Forest and Range Experiment Station have recently been synthesized and analyzed. Comparisons were made between the frequency of occurrence of various associates on three different tree species, between trends of common associates in sprayed and unsprayed areas, including relationship to budworm trends, and between various associates as to host preference.

[1] Unpublished report by V. M. Carolin and W. H. Klein, 1958, Pacific Northwest Forest and Range Experiment Station, Portland, Oregon.

Methods

Data Collection

Numbers of associated defoliators were recorded on foliage samples at spruce budworm study plots during the "larvae in the buds" stage, as defined by Carolin and Coulter (1972). Plot layout changed somewhat over the years, but sampling methods remained the same. The foliage sampling unit was the 15-in (38-cm) twig, removed from the lower half of the crowns of codominant firs by use of a six-section aluminum pole pruner, total length about 10.7 m (36 ft).

In 1951, 20 plots were established in areas sprayed with DDT either in 1949 or 1950, and three plots in unsprayed areas (Carolin and Wright 1953). Each plot had 10 subplots 100 m (about 330 ft) apart on a line; each subplot consisted of three sample trees. Ten 15 in (38-cm) twigs were cut from each sample tree; the total sample for the plot was 300 twigs. During 1952-54, the number of twigs per subplot was reduced to 10, taken from a variable number of sample trees. The total for the plot was 100 twigs. During this period, several of the plots in sprayed areas were decimated by logging, and two of the plots in unsprayed areas were scheduled for operational spraying in 1955.

In 1955 all plots retained in the sprayed areas, plus a replicate added in one area, and new plots in unsprayed areas were modified as to layout. Each plot now consisted of five subplots, still 100 m (330 ft) apart on a line, and each subplot consisted of five numbered trees from each of which four 15-in (38-cm) twigs were removed. In unsprayed areas, the tree sample was reduced to two twigs for very high budworm populations or when staminate flower production was heavy. Density was still expressed as number of larvae per 100 twigs.

Starting in 1959, when studies initiated in 1951 were phased out, all new plots installed were 10-tree or larger clusters. Number of twigs taken per tree ranged from two in very high populations to six in low popu lations. Larval density was now expressed both on a 100-twig basis arid a 1,000-bud basis.

During the examination of twig samples, larvae of unknown or uncertain identity were examined under a hand lens and given a temporary name, often a nickname, under which numbers were recorded. Sample specimens were then placed in rearing. Large numbers of a single species were reared in glass-topped boxes on developing shoots supplied with water. Small numbers, usually one to four larvae, were reared in powderboxes with short twig sections bearing new foliage. All rearings were labelled as to temporary name of the insect, plot at which collected, tree species, and collection date. The material was examined periodically, foliage replaced, and changes in the appearance of the larvae noted. Material from plots sampled early in the season was reared in transit; most rearing was done at a field laboratory.

Adult specimens were mounted and labelled with pertinent information. Most were assigned to numbered collections under the Hopkins U.S. System; solitary specimens from a sampled locality were sometimes given a Miscellaneous Number. Specimens were then sent to the Insect Identification and Parasite Introduction Branch, Agricultural Research Service,[2] for determination. These determinations were later tied in with the temporary insect names in our field notes.

Occurrence of Associated Defoliators by Tree Species

Sampling records obtained when larvae were in the opening buds provided the main basis for comparing the occurrence of various associated defoliators among tree species. During the early studies in 1951-54, two different tree species were sampled at most plots. Starting in 1955 only one tree species was sampled at each plot, except for comparisons of densities of associated insects on paired tree species.

[2] The present name is the Insect Identification and Beneficial Insect Introduction Institute (SEA).

In sprayed areas during 1951-54, 76 records were obtained at plots having a mix of Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) and grand fir (*Abies grandis* (Dougl.) Lindl.), and four records at a plot having mostly subalpine fir (*Abies lasiocarpa* (Hook.) Nutt.) with some Engelmann spruce *{Picea engelmannii* Parry). During 1955-59, 44 records were obtained at plots in which only Douglas-fir was sampled, and 10 records at plots in which only subalpine fir was sampled.

In unsprayed areas in northeastern Oregon during 1951-54, 12 records were obtained at plots having a variable mix of Douglas-fir and grand fir sample trees; no host associations were shown for 1953. Then, during 1955-59, 20 records were obtained at plots in which only Douglas-fir was sampled, and 1 record obtained for a paired Douglas-fir and grand fir plot. In an unsprayed infestation in the eastern Washington Cascades during 1960-62, four records were obtained for Douglas-fir plots, five for grand fir plots, and one for a paired Douglas-fir and grand fir plot.

In an unsprayed area in southern Oregon during 1960-62, during a study of the Modoc budworm, 14 plot records were obtained in white fir *{Abies concolor* (Gord. and Glend.) Lindl.) stands.

After 1962, supplemental information on associated defoliators was obtained from the following sources: (1) beating plots in eastern Oregon; (2) studies in western Oregon on insects other than one of the spruce budworms, but in which one of the budworms was an associate; (3) collections of opportunity.

Based on plot records and supplemental information, lists of species of associated defoliators were prepared for three tree species — *A. grandis, A. concolor,* and *P. menziesii* - and an index developed to show the relative frequency at which these defoliators were found. Terms to indicate relative frequency were: common - occurring in nearly all plots every year; occasional - occurring in about half the plots every year; sporadic - not found for a period of years, but in other years found in most plots; and rare - found only in one or two plots or locations in 1 or 2 years.

Trends of Associated Species

SPRAYED AREAS

Of the initial 20 plots established in sprayed areas, 10 were retained throughout the period of study (1951-59), and all were in Oregon. Distribution of the 10 plots by study areas was: Eugene (western foothills of the Cascades) — 3; Mount Hood (eastern slope of the Cascades in the Mount Hood National Forest)-2; south Umatilla (southern part of the Umatilla National Forest, in the Blue Mountains) — 2; La Grande (Wallowa-Whitman National Forest, in the Blue Mountains) — 2; and north Umatilla (northern part of the Umatilla National Forest, in the Blue Mountains)— 1, with a replicate added in 1955. One of the Eugene plots was logged and not sampled in 1959 but is included in the record series. One of the Mount Hood plots was resprayed in 1952 but was retained.

Except for the north Umatilla area, sample trees during 1951-54 in the retained plots were mainly Douglas-fir, with a sprinkling of grand fir. In the north Umatilla area, sample trees during this period were primarily subalpine fir but included a few Engelmann spruce. Starting in 1955, sampling was restricted to Douglas-fir in four study areas and to subalpine fir in the north Umatilla area.

Trends for each associated defoliator were analyzed by (1) transferring the number of larvae per 100 twigs for each year to a summary sheet for the period 1951-59, (2) averaging these densities for plots in the same area, and (3) plotting the average density in . each year over that year. Trends were compared for each major associate by area and for all major associates over the period 1951-59.

UNSPRAYED AREAS

Northeast Oregon. - Plots used in the Blue Mountains from 1951 through 1954 suffered various mishaps, including spraying and partial logging. In addition, records on associated defoliators and host relationships were often lacking. No reasonable analysis as to trends was possible.

Three new plots were established in 1955, and only Douglas-fir trees were sampled. The one remaining unsprayed plot was revamped so that only Douglas-fir was sampled. After sampling in 1957, this plot was discontinued because spruce budworm populations had dropped to a low level. A fifth plot was added this year. Three of the four plots remaining in 1958 were sprayed operationally that year, after plots were sampled. The fourth plot was sampled again in 1959, after which studies in the Blue Mountains were terminated.

Eastern Washington Cascades. — In 1960, four 10-tree cluster plots were established in the eastern Washington Cascades on part of the Yakima Indian Reservation near Goldendale. Two were in Douglas-fir stands and two were in grand fir stands. All four plots were sampled both in 1960 and 1961; the 1961 record for one of the grand fir plots was lost. A fifth plot was established in 1961, with grand fir being sampled. In 1962, just before operational spraying, one of the original grand fir plots was sampled, and at the edge of the plot newly installed in 1961, paired Douglas-fir and grand fir trees were sampled. Because of the short duration of study, possible trends of associated defoliators were approximated from a tabulation which listed larval densities by plot and year.

Southern Oregon. - Also in 1960, a study on the Modoc budworm used four 10-tree clusters of white fir in each of two subareas: the North Warner Mountains and the Gearhart Mountains. In 1961 half of the plots in each subarea were again sampled. In 1962 only one of the original plots was sampled. Possible trends of associates were approximated by a simple tabulation of replicated plots, showing larval densities by plot and year.

Host Preference

Preference of some associated defoliators between Douglas-fir and grand fir was tested in 1959 at a paired tree plot in northeast Oregon near Halfway. Ten pairs of these two tree species were sampled by taking six 15-in (38-cm) twigs per tree; all opening buds or new shoots were counted on each 15-in twig. Larval densities were expressed both as larvae per 100 twigs and larvae per 1,000 opening buds. Densities of seven associates occurring at a density of at least seven larvae per 100 twigs were compared between the two tree species. In this same season, a follow-up was made when some of the associates were still feeding at the time spruce budworm larvae were full-grown. Four twigs were cut per tree and density expressed on a 100-twig basis.

Preference for either Douglas-fir or grand fir was again tested in 1962 in a paired plot comparison in the eastern Washington Cascades near Goldendale. Five pairs of trees were sampled, and we took only four twigs per tree because of very high numbers of western spruce budworm. Numbers of opening buds on each twig were again counted. Larval densities were expressed on the same two bases as at the Halfway plot.

In our studies on the Modoc budworm in southern Oregon, no paired tree comparisons were possible. The host tree species was exclusively white fir; no Douglas-fir occurred in the two subareas in which studies were conducted.

Results

Occurrence of Associated Defoliators by Tree Species

Most of the defoliators associated with western spruce bud worm on Douglas-fir were also associated with this species on grand fir and with the Modoc budworm on white fir (tables 1-3). Some species not recorded on grand fir and white fir in our study areas are listed in *Western Forest Insects* (Furniss and Carolin 1977) as occurring on these hosts or on "true firs."

COMMON AND OCCASIONAL ASSOCIATES

Associates common on all three tree species were *Argyrotaenia dorsalana* (Dyar), *Dioryctria reniculelloides* Mutuura and Munroe, and *Griselda radicana* (Heinrich). *Acleris gloverana* (Walsingham) was common on these three hosts from 1957 through 1960 but was sporadic from 1951 to 1956. A gelechiid, *Coleotechnites* near *piceaella* (Kearfott), was common on Douglas-fir but was rare or occasional on the two true firs. Another gelechiid, in the *Chionodes-Telphusa* complex, was common on grand fir and white fir but only occasional on Douglas-fir. An olethreutid, *Zeiraphera hesperiana* Mutuura and Freeman, was the most common associate on Douglas-fir; a different and unidentified species of *Zeiraphera* was common on grand fir and occasional on white fir.

A diprionid sawfly, *Neodiprion* sp., was occasionally found in small loosely knit colonies on the new shoots of Douglas-fir; larvae start to feed as soon as the bud cap is off. A webspinning sawfly, *Acantholyda* sp. (Pamphiliidae), was occasional on grand fir, common on white fir, but rare on Douglas-fir. One or more xyelid sawflies in the genus *Pleroneura* were found on true firs, and most commonly on white fir. The larvae of three species of *Pleroneura* on white fir in California cannot be separated morphologically (Ohmart and Dahlsten 1977).

RARE AND SPORADICALLY OCCURRING ASSOCIATES

A new and apparently rare species of *Choristoneura* was collected as small larvae on both Douglas-fir and grand fir at two study plots in the Cascades. Adult specimens are at the U.S. National Museum.

Loopers feeding on new growth were generally rare. The two species found most often were *Eupithecia annulata* (Hulst) and *Enypia* sp. near *griseata* Grossbeck; both were on Douglas-fir, grand fir, and white fir. Three loopers which occur in coastal forests and interior wet belt forests were recorded in other studies. The western hemlock looper, *Lambdina fiscellaria lugubrosa* (Hulst), was collected from grand fir during a spruce budworm damage study in the Snake River area of Oregon. It is an occasional associate of *C. occidentalis* in the northern Rocky Mountains. The phantom hemlock looper, *Nepytia phantasmaria* (Strecker), was accompanied by *C. occidentalis* in a small outbreak on Douglas-fir in parklike settings near Portland, Oregon, during 1964-65. The greenstriped forest looper, *Melanolophia imitata* (Walker), occurs mostly in coastal areas, with a species of *Choristoneura* sometimes present; it was commonly found in beatings of Douglas-fir in the northern Rocky Mountains (Volker 1978).

Several noctuids occurred rarely or sporadically. The two species found most often were *Achytonix epipaschia* (Grote) and *Xylomyges simplex* (Walker), on Douglas-fir and white fir.

Trends of Associated Species

SPRAYED AREAS

Long-term trends were evident in most study areas for six associated species: *Acleris gloverana, Argyrotaenia dorsalana, Coleotechnites* near *piceaella, Dioryctria reniculelloides, Griselda radicana,* and *Zeiraphera hesperiana* (figs. 1-6). In addition, *Achytonix epipaschia* and *Xylomyges simplex* (Noctuidae) and a combination of all loopers (Geometridae) showed increases from obscurity from 1957 through 1959, without a clear indication of trend. Not recorded in these sprayed areas during the period of study was the Douglas-fir tussock moth, *Orgyia pseudotsugata.*

Table 1 — Defoliators associated with western spruce budworm in opening buds and new shoots on Douglas-fir in Oregon and Washington

Order, family, and species	Locality	Occurrence
HYMENOPTERA		
Diprionidae		
Neodiprion sp.	E. Oreg. and Wash.	Occasional
Pamphiliidae		
Acantholyda sp.	E. Oreg. and Wash.	Rare
LEPIDOPTERA		
Gelechiidae		
Chionodes spp.	Oreg. and Wash.	Occasional
Coleotechnites sp. near *piceaella* (Kearfott)	Oreg. and Wash.	Common
Coleotechnites sp.	Eugene, Oreg.	Rare
Geometridae		
Enypia sp. near *griseata* Grossbeck	E. Oreg. and Wash.	Rare
Eupithecia annulata (Hulst)	Oreg. and Wash.	Occasional
Lambdina fiscellaria lugubrosa (Hulst)	N.E. Oreg. and S.W. Wash.	Sporadic
Melanolophia imitata (Walker)	S.W. Wash.	Sporadic
Nepytia phantasmaria (Strecker)	W. Oreg.	Sporadic
Stenoporpia n. sp.	Eugene, Oreg.	Rare
Lymantriidae		
Orgyia pseudotsugata (McDunnough)	E. Oreg. and Wash.	Sporadic
Noctuidae		
Achytonix epipaschia (Grote)	Oreg. and Wash.	Sporadic
Anomogyna mustelina Smith	E. Oreg.	Rare
Xylomyges simplex (Walker)	Oreg. and Wash.	Sporadic
Olethreutidae[1]		
Griselda radicana (Heinrich)	Oreg. and Wash.	Common
Zeiraphera hesperiana Mutuura and Freeman	Oreg. and Wash.	Common
Plutellidae		
Ypsolopha (Abebaea) sp., prob. *cervella* (Walsingham)	Eugene, Oreg.	Rare
Pyralidae		
Dioryctria abietivorella (Grote)	Eugene, Oreg.	Rare
Dioryctria reniculelloides Mutuura and Munroe	Oreg. and Wash.	Common
Tortricidae		
Acleris gloverana (Walsingham)	Oreg. and Wash.	Sporadic/common
Archips sp.	Eugene, Oreg.	Rare
Archips sp.	Baker, Oreg.	Rare
Argyrotaenia dorsalana (Dyar)	Oreg. and Wash.	Occasional-common
Argyrotaenia provana (Kearfott)	Oreg.	Rare
Choristoneura rosaceana (Harris)	W. Oreg.	Sporadic
Choristoneura n. sp.	Eugene, Oreg. and Goldendale, Wash.	Rare
Clepsis persicana (Fitch)	Baker, Oreg.	Rare
Walshiidae		
Periploca sp.	Baker, Oreg.	Rare

[1]Sometimes considered a subfamily, Oiethreutinae, in the Tortricidae.

Table 2 — Defoliators associated with western spruce budworm in opening buds and new shoots on grand fir in Oregon and Washington

Order, family, and species	Locality	Occurrence
HYMENOPTERA		
Pamphiliidae		
Acantholyda sp.	E. Oreg. and Wash.	Occasional
Xyelidae		
Pleroneura spp.	Oreg. and Wash.	Rare/occasional
LEPIDOPTERA		
Gelechiidae		
Chionodes sp.	E. Oreg. and Wash.	Occasional
Coleotechnites sp. near *piceaella* (Kearfott)	Oreg. and Wash.	Rare
Telphusa sp.	Oreg. and Wash.	Rare
Geometridae		
Enypia sp. near *griseata* Grossbeck	E. Oreg.	Rare
Eupithecia annulata (Hulst)	Oreg. and Wash.	Rare
Gabriola sp. near *minima* (Hulst)[1]	E. Oreg.	Rare
Lambdina fiscellaria lugubrosa (Hulst)	N.E. Oreg.	Rare
Lymantriidae		
Orgyia pseudotsugata (McDunnough)	E. Oreg. and Wash.	Sporadic
Noctuidae		
Anomogyna sp.	E. Oreg.	Rare
Syngrapha sp.	E. Oreg.	Rare
Olethreutidae[2]		
Griselda radicana (Heinrich)	Oreg. and Wash.	Common
Zeiraphera improbana (Walker)	E. Oreg.	Rare
Zeiraphera sp.	E. Oreg. and Wash.	Common
Pyralidae		
Dioryctria reniculelloides Mutuura and Munroe	Oreg. and Wash.	Common
Tortricidae		
Acleris gloverana (Walsingham)	Oreg. and Wash.	Sporadic/common
Argyrotaenia dorsalana (Dyar)	Oreg. and Wash.	Occasional-common
Choristoneura n. sp.	Goldendale, Wash.	Rare

[1]This species was found on subalpine fir, but presumably occurs on grand fir.
[2]Sometimes considered a subfamily, Olethreutinae, in the Tortricidae

Table 3 — Defoliators associated with Modoc budworm in opening buds and new shoots on white fir in southern Oregon

Order, family, and species	Occurrence
HYMENOPTERA	
Pamphiliidae	
Acantholyda sp.	Common
Xyelidae	
Pleroneura spp.	Common
LEPIDOPTERA	
Gelechiidae	
Chionodes sp.	Common
Coleotechnites sp. near *piceaella* (Kearfott)	Occasional
Telphusa sp.	Rare
Geometridae	
Enypia sp. near *griseata* Grossbeck	Rare
Lymantriidae	
Orgyia pseudotsugata (McDunnough)	Rare
Noctuidae	
Achytonix epipaschia (Grote)	Occasional
LEPIDOPTERA (continued)	
Noctuidae (continued)	
Syngrapha sp.	Rare
Xylomyges simplex (Walker)	Occasional
Olethreutidae[1]	
Griselda radicana (Heinrich)	Common
Zeiraphera sp.	Occasional
Pyralidae	
Dioryctria reniculelloides Mutuura and Munroe	Common
Tortricidae	
Acleris gloverana (Walsingham)	Sporadic/common
Archips sp.	Rare
Argyrotaenia dorsalana (Dyar)	Occasional-common

[1]Sometimes considered a subfamily, Olethreutinae, in the Tortricidae.

Major peaks for the six principal associated species, with the possible exception of *Acleris glovemna,* were in 1957 or 1958; peaks for the western spruce budworm in these same sprayed areas have been reported for these same 2 years (Carolin and Coulter 1971; also see table 4, appendix). At the nine Douglas-fir plots, the greatest increase in numbers of all associates (excluding colonies of *Neodiprion* sp.) occurred between 1956 and 1957: 385 to 627 specimens, or an increase of 63 percent. Between 1957 and 1958, a decrease of 27 percent took place; At the two subalpine fir plots, the greatest percentage increase was 209 percent between 1956 and 1957, starting from a low density. It was followed by a 129-percent increase in 1958,'and a 12-perc^nt decrease in 1959.

Zeiraphera hesperiana was the most abundant species in these plots. Its density before, spraying was not recorded hut may have been substantial. It reached low ebb in all five sprayed areas during 19 53 and 1954, then increased to either a peak or plateau in 1957. Thereafter, three areas showed about the same densities through 1959; two others showed a sharp decrease in 1959 (fig. 1). The highest densities by far were in the Eugene area: 52-53 larvae per 100 twigs in 1957 and 1958.

Acleris gloverana was not recorded at the Douglas-fir plots from 1951 to 1955. Several larvae were found during 1956 to 1959, with the highest density at a single plot being six larvae per 100 twigs. An increase was evident but the data failed to show year-to-year trends for individual areas. At the subalpine fir plots, trends were distinct; Starting in 1955, density increased steadily and reached a peak in 1958 at one plot, and in 1959 at the other plot (fig. 2). During these peaks, damage to foliage was readily visible from the ground. This flare-up followed by 1 year an extensive outbreak *of, Acleris gloverana* on 237,000 acres of Western hemlock and true fir in western Washington

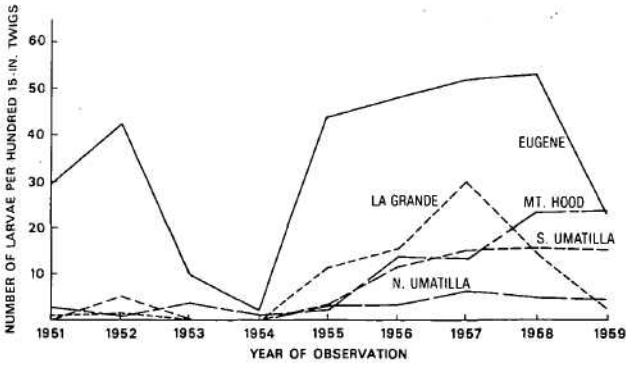


Figure 1. — Trends in density of Zeiraphera hesperiana *larvae on Douglas-fir and subalpine fir in sprayed areas.*

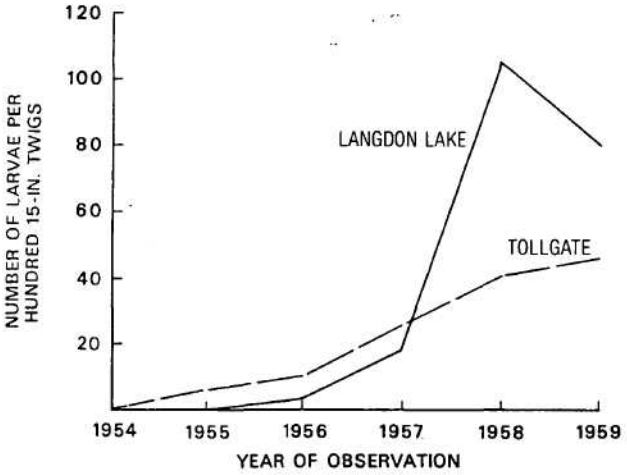


Figure 2. — Trends in density of Acleris gloverana *larvae on subalpine fir in two sprayed plots.*

Argyrotaenia dorsalana was at a very low level from 1951 to 1954. In 1951 it was recorded at only two plots. During 1952-54, some of the associated larvae were not identified, and *A. dorsalana* may have been overlooked. Starting in 1955, this species was found in all four Douglas-fir areas, but not in the subalpine fir area. A number of larvae were reared each year to assess variation; very few were found to be *A. provana.* Entries on the field forms were corrected for this incidence. From 1955 to 1959, *A. dorsalana* was found at average densities up to 3.5 larvae per 100 twigs. Although these are low densities, the two areas in the Blue Mountains (La Grande and south Umatilla), both sprayed in 1950, appear to show similar trends, with an early peak in 1955 and then peaking either in 1957 or 1958. The Mount Hood area showed a peak in 1958, and the Eugene area showed a strong upswing in 1959, possibly reaching a peak (fig. 3).

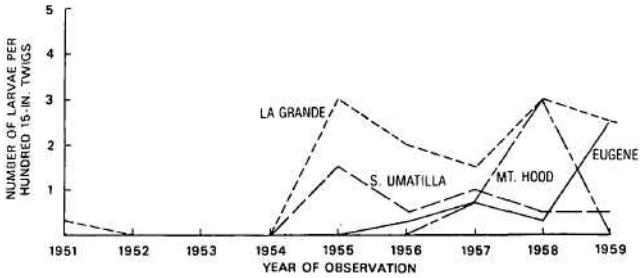


Figure 3. — Trends in density of Argyrotaenia dorsalana *larvae on Douglas-fir in sprayed areas.*

Coleotechnites near *piceaella* oscillated at a low population density in the Douglas-fir areas during 1951-56. All areas showed a strong increase in 1957; and three of these showed population peaks in 1958, followed by a decline in 1959 (fig. 4). The peak in the Eugene area was a year later. Only one specimen of *Coleotechnites* was found in the subalpine fir area, and it is possible that this was not the same species.

Dioryctria reniculelloides, the spruce coneworm, was found in all five sprayed areas and in all plots but one in 1951. During 1952-54, it was at a very low density in all plots, followed by a resurgence in two of the Douglas-fir areas in 1955. In 1957 it showed a strong peak in three of the Douglas-fir areas, and a strong decline thereafter (fig. 5). No trend was evident in the fourth Douglas-fir area, Mount Hood, nor in the subalpine fir (north Umatilla) area; only one specimen was found in each of these two areas during 1955-59.

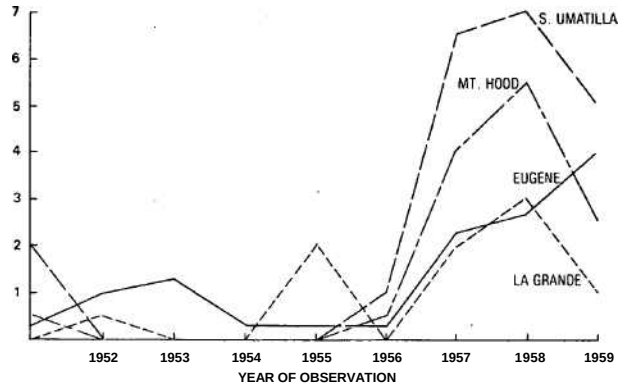


Figure 4. — Trends in density of Coleotechnites *sp. near* piceaella *larvae on Douglas-fir in sprayed areas.*

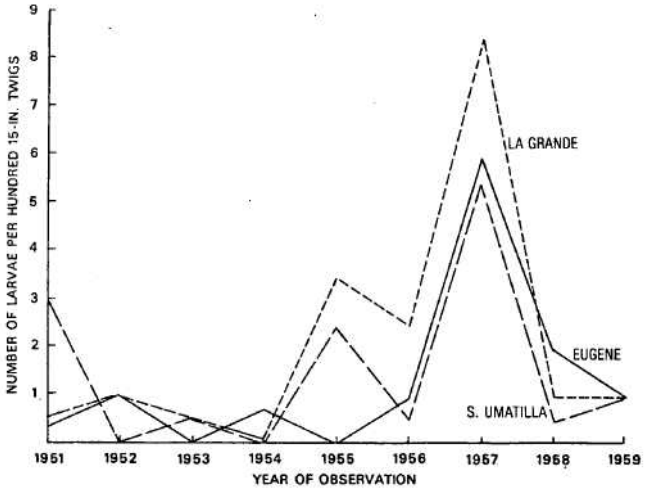


Figure 5. — Trends in density of* Dioryctria reniculelloides *larvae on Douglas-fir in sprayed areas.

Griselda radicana, the spruce tip moth, was one of the two most common associates of the spruce budworm in these sprayed areas. Its numbers oscillated at a low level in all areas until 1955, when it showed a strong increase in the La Grande area. Subsequently, this species showed peaks in 1957 in three of the Douglas-fir areas and in the subalpine fir area, with the La Grande area showing the strongest peak (fig. 6). The fourth Douglas-fir area, Mount Hood, which showed low densities throughout the study period, showed a small peak in 1958, which may be an artifact of sampling.

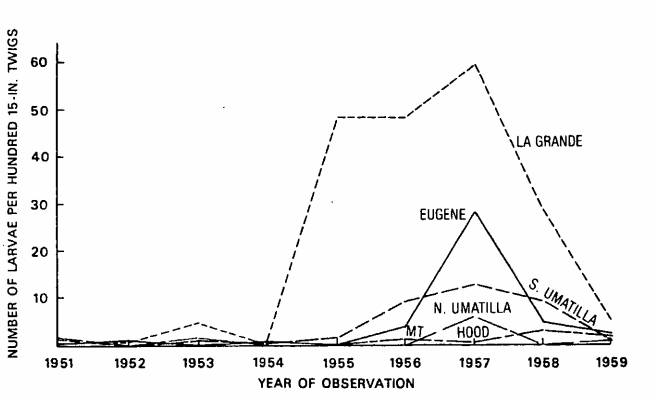


Figure 6. — Trends in density of* Griselda radicana *larvae on Douglas-fir and subalpine fir in sprayed areas.

Achytonix epipaschia and *Xylomyges simplex,* two noctuids of potential significance in western forests, were not recorded in these sprayed areas until 1957. During 1957-59 both species were found in the Eugene and Mount Hood areas at average densities up to 3.5 larvae per 100 twigs, and *A. epipaschia* in the south Umatilla area at average densities up to 3.0 per 100 twigs. Neither species was recorded in the La Grande study area, but *A. epipaschia* was recorded in the north Umatilla subalpine fir area in 1958. In 1964 these species caused noticeable defoliation on Douglas-fir on 8,400 acres in western Oregon (Orr et al. 1965).[3]

[3] Both noctuid species were found in this infestation, although only *Xylomyges, simplex,* is/mentioned in the report., Specimens were identified by V. M. Carolin.

Loopers (Geometridae) on opening buds and new shoots were mostly rare — one specimen in 1951 and none for 1952-55. Subsequent recoveries in number of specimens found at the 11 plots were: 1956 — 2, 1957-13, 1958-4, and 1959-3. The species found most often was *Eupithecia annulata,* which commences feeding on the opening bud in the conceal ment of the bud sheath. It was found in three of the sprayed areas.

UNSPRAYED AREAS

Northeast Oregon. — Trends of major associated species from 1955 to 1958 were similar to those shown in the sprayed areas, particularly those in northeast Oregon, for the same period. Only one of the six species showing discernible trends in the sprayed areas — *Coleotechnites* near *piceaella* — failed to occur with sufficient frequency to provide a comparison.

Major peaks for five associates were in 1957 or 1958, as in the sprayed areas. The total numbers of speci mens of all associates at four plots increased from 324 to 1,005 between the years 1956 and 1957 – a 210-percent increase. The number of specimens then decreased 44 percent between 1957 and 1958.

Zeiraphera hesperiana was the most abundant associated species. In 15 of the 16 plot years represented by these four plots, its density was 2 to 16 percent of that of the western spruce budworm. In the remaining plot year, 1957 at Chesnimnus, its density was 68 percent of that of a declining spruce budworm population. The highest density of Z. *hesperiana* was in the Dale (south Umatilla) plot in 1957 - 206 larvae per 100 twigs amidst a very high spruce budworm population.

An upswing starting in 1955, as in the sprayed areas, was followed by a peak in 1957 at all plots (fig. 7). A similar peak was shown in the La Grande sprayed area in 1957, while a plateau was shown for the south Umatilla sprayed area during 1957-59.

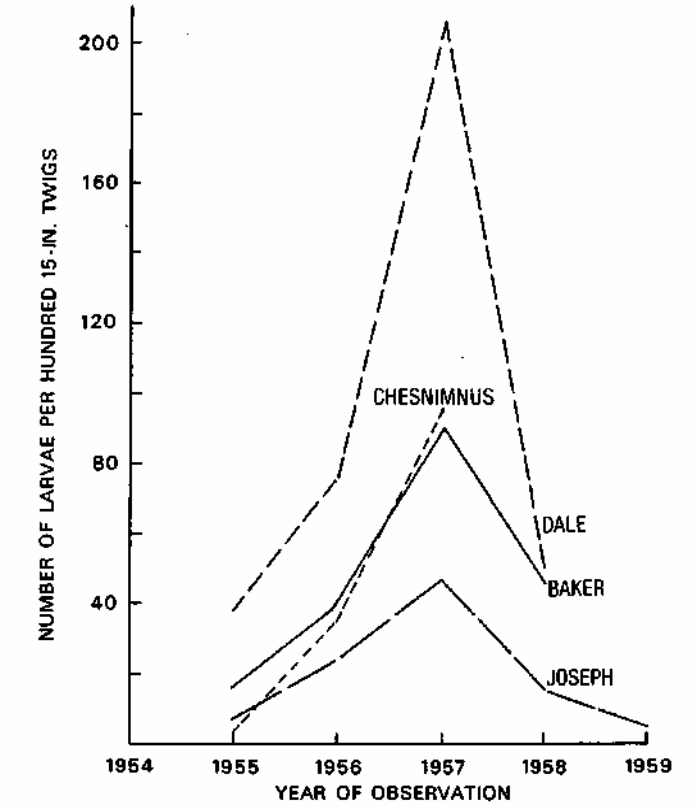


Figure* 7. — *Trends in density of* Zeiraphera hesperiana *larvae on Douglas-fir in unsprayed areas.

Acleris gloverana began an upward trend at two plots each in 1956 and 1957. Possible peaks were shown at the Baker and Dale plots in 1958 (fig. 8); collection of further data under existing conditions was terminated by operational spraying. At the Joseph plot in an area left unsprayed, a slow increase at a low level continued through 1959. At the Chesnimnus plot a small increase at a low level occurred in 1957; but this plot was dropped in 1958.

These four unsprayed Douglas-fir plots showed substantially higher densities of *A. gloverana* than were found in the four sprayed Douglas-fir plots in northeastern Oregon (south Umatilla and La Grande areas). Densities in the unsprayed plots were as high as 30 larvae per 100 twigs.

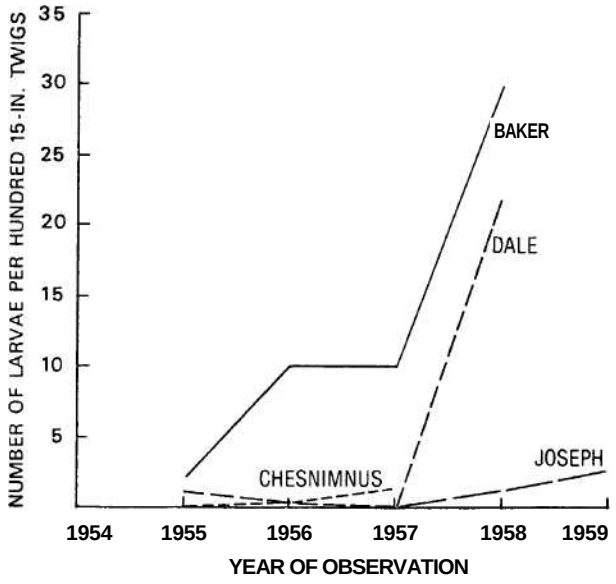


Figure** 8. — **Trends in density of** **Acleris gloverana** **larvae on Douglas-fir in unsprayed areas.

Argyrotaenia dorsalana showed a steady increase at two plots from 1956 to 1958; at the Joseph plot, left unsprayed, a decrease took place in 1959 (fig. 9). At a third plot, it oscillated at a low plateau during 1956-58; and at a fourth plot, it was at a very low density with no trend discernible. The overall pattern is much the same as in the sprayed plots in northeastern Oregon, except that no peak was evident in 1955.

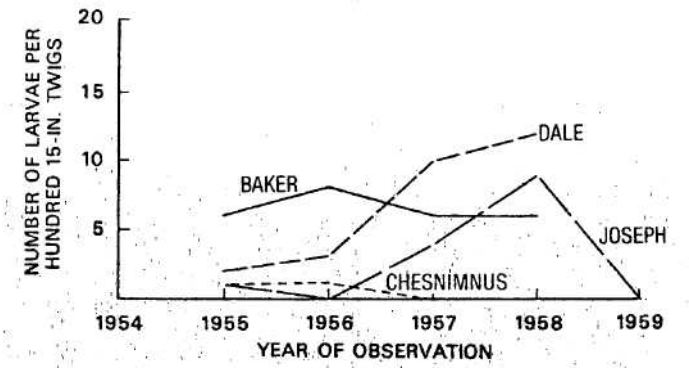


Figure 9. — Trends in density of** **Argyrotaenia dorsalana** **larvae on Douglas-fir in unsprayed areas.

Dioryctria reniculelloides showed strong peaks at three plots in 1957, then declined in 1958 (fig. 10), as in the sprayed areas. A slight resurgence was shown in 1959 at one of these unsprayed plots. No trend was evident at a fourth plot having a very low density. Highest density of *D. reniculelloides* was at the Dale (south Umatilla) plot in 1957 - 158 larvae per 100 twigs, amidst a very high spruce budworm population.

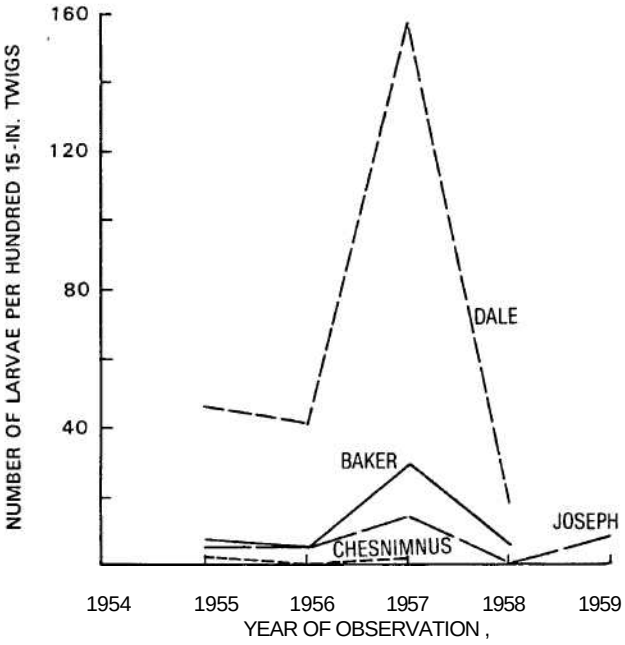


Figure 10. — Trends in density of** **Dioryctria reniculelloides** **larvae on Douglas-fir in unsprayed areas.

Griselda radicana was second only to *Zeirnphera hesperiana* in abundance, as it was in the sprayed areas. It showed an increase in density between 1955 and 1956, followed by peaks either in 1957 or 1958 (fig. 11). Only the Baker plot showed a sharp peak in 1957 as in the sprayed areas. At the Joseph plot, left unsprayed, a decrease in density took place in 1959. Highest density of *G. radicana* was 131 larvae per 100 twigs, recorded at the Joseph plot in 1958.

Some other species or species groups were more numerous in some years than in others, but trends at individual plots were unclear. The principal gelechiids, *Coleotechnites* near *piceaella* and species in the genus

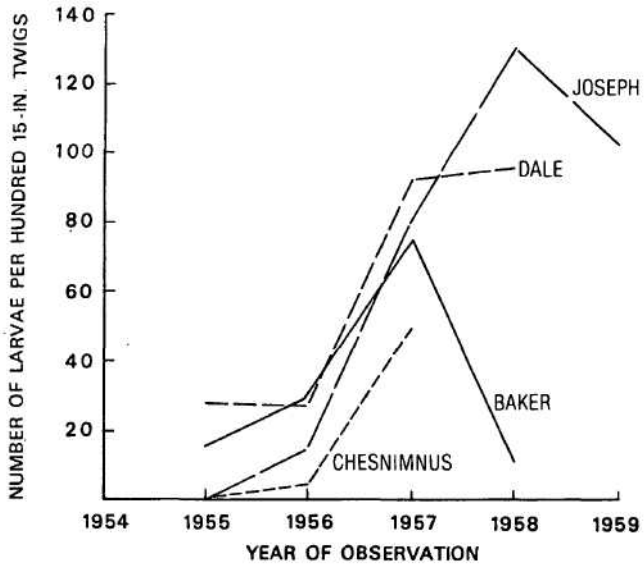


Figure 11. — Trends in density of* Griselda radicana *larvae on Douglas-fir in unsprayed areas.

Chionodes, were most common in 1957 and 1958. *Achytonix epipaschia* and *Xylomyges simplex,* two noctuids recorded in the sprayed areas during 1957-59, were found in the unsprayed plots only in 1957 and 1958, and at low densities. Loopers (Geometridae) were recorded only in 1957 and 1958, and at very low densities.

Eastern Washington Cascades. - The duration of the study in this area was too short for determining trends of most budworm associates. Trends were apparent, however, for *Acleris gloverana* occurring on Douglas-fir and grand fir, and two species of *Zeiraphera,* one on Douglas-fir and the other on grand fir.

A flare-up of *Acleris gloverana* on 24,500 acres (9 915 ha) in the Yakima Indian Reservation had been recorded in 1957 (Whiteside 1958), and it persisted in mixture with the western spruce budworm on 9,960 acres (4 030 ha) in 1959 (Buckhorn and Orr 1959). At one grand fir plot in this area, sampled from 1960 through 1962, a density of 25 larvae per 100 twigs was found in 1960. Then, in 1961 and 1962, *A. gloverana* was not recovered at this plot. It was found at a very low density in one of three other plots sampled in 1961 and on grand fir in a paired plot in 1962.

Both species of *Zeiraphera* were recorded at moderate densities in 1960, ranging from 23 to 45 per 100 twigs at two Douglas-fir plots and from 95 to 118 per 100 twigs at two grand fir plots. In 1961 on Douglas-fir, *Z. hesperiana* showed little change. At the grand fir plot sampled for 3 years, the unidentified species *of Zeiraphera* dropped from 95 larvae per 100 twigs to 5 in 1961 and was recorded at 13 per 100 twigs in 1962. It was not recorded at the paired plot in 1962.

Southern Oregon. — In both subareas, the larval densities of most associated Lepidoptera showed strong reductions from 1960 to 1961 (table 5, appendix). In the north Warner Mountains, plots resampled in 1961 showed sharp reductions in the density of *Dioryctria reniculelloides,* the most abundant associate in 1960. In the Gearhart Mountains, plots resampled in 1961 showed a persistence *of Acleris gloverana* at a low level, a small reduction in *D. reniculelloides,* and a slight increase in a species of *Acantholyda.* At the one plot resampled in this subarea in 1962, there was no change in the density of *Acleris,* a further reduction in *Dioryctria,* a further increase in *Acantholyda,* and a small eruption of *Pleroneura* species.

Host Preference

NORTHEAST OREGON

At the Halfway plot, with larvae per 100 twigs used as a measure of density, the paired tree comparison showed the following: (1) no preference between Douglas-fir and grand fir by *Argyrotaenia dorsalana* and *Dioryctria reniculelloides;* (2) a strong preference for Douglas-fir by *Griselda radicana* and *Zeiraphera hesperiana;* (3) a strong preference for grand fir by *Acleris gloverana, Chionodes-Telphusa* spp., and *Zeiraphera* species. With larvae per 1,000 opening buds used as a measure of density, the same pattern was shown except that the preferences of *A. gloverana* and *Zeiraphera* sp. for grand fir were of less intensity.

Discussion

The subdued ratings resulted from the contrasting number of new shoots per twig on the two tree species, averaging 19.7 on Douglas-fir, and 45.7 on grand fir. The presence of *Zeiraphera* sp. on the Douglas-fir trees was unusual and probably caused by wind-drift of small larvae from the grand fir trees. Larval densities were as follows:

Insect species	Douglas-fir	Grand fir	Douglas-fir	Grand fir
	- Per 100 twigs -		*- Per 1,000 buds -*	
Acleris gloverana	60	163	30	36
Argyrotaenia dorsalana	7	7	4	2
Chionodes-Telphusa spp.	0	22	0	5
Dioryctria reniculelloides	9	8	5	2
Griselda radicana	85	7	43	2
Zeiraphera hesperiana	48	2	25	1
Zeiraphera sp.	11	68	6	15

Information obtained during the follow-up, when almost half of the spruce budworm population had pupated, was limited to three associates. The *Zeiraphera* larvae had long since left the trees to pupate in the litter; and the *Argyrotaenia* larvae had also pupated, presumably on the trees, but were not found on the twig samples. *Dioryctria reniculelloides* was evident at a very low density on grand fir and was not found on Douglas-fir. *Griselda radicana* was three times as numerous on Douglas-fir as on grand fir, and *Acleris gloverana* and the species of *Chionodes-Telphusa* were found at much higher densities on grand fir.

EASTERN WASHINGTON CASCADES

Excluding colonies of *Neodiprion* sp. found only on the new shoots of Douglas-fir, only eight species of associated defoliators were found during the sampling of the paired trees. Most were represented by only one or two specimens on the 20 twigs cut per tree species. The only clear preference shown was by one or more species in the *Chionodes-Telphusa* complex., Larval density was 30 per 100, twigs on grand fir; no larvae were found on Douglas-fir.

This particular year, 1962, appeared to be the culmination of a decline in associated defoliators, in this area; however, the western spruce budworm, of main interest in the test (Carolin and Coulter 1975), was On a steady upward trend (table 6, appendix).

In studies based on sampling foliage for a particular insect, the number of other species occurring in immature stages poses a problem in recognition. Especially with Lepidoptera, the coloration and markings of most larvae of the various species change drastically from the time they are in the opening buds until they are full-grown larvae. The early instars are a problem because their small size makes it difficult to see important morphological features. A hand lens must be used frequently, and rearing is essential in cases of doubt. Insects being reared should be re-checked under a microscope for features that may have been overlooked with a hand lens. A key to small larvae associated with spruce budworms in opening buds and new shoots is now available (Carolin and Stevens 1979).

The listing of budworm associates by tree species suggests that a few associates are restricted to one or two tree species. It also indicates a different frequency of occurrence of some associates on different tree species. The limited tests on host preference show that, even when frequency is the same, larval density of some associates may be greater on one tree species than another. Thus, if associated defoliators are the subject of specific studies (i.e., finding alternate hosts of budworm parasites; obtaining material for taxonomic study), information on frequency of occurrence and density on particular hosts is of particular value.

Examination of trends of associated species during 1955-59 suggests a strong climatic influence at work between 1956 and 1957, facilitating the strong upward surge, in both sprayed and unsprayed areas, of nearly all associated defoliators along with the western spruce budworm. One must assume that favorable conditions for both survival and reproduction occurred from summer of 1956 through spring of 1957. Less favorable conditions then occurred in 1957-58 and in 1958-59. Slight differences in years of peaking, followed by a decline, might be due to the influence of geographic location; but without local meteorological data, this could not be proven.

Conclusions

Trends shown by major associates were remarkably consistent between areas in some cases, and no more variable than one might expect in other cases. *Dioryctria reniculelloides* peaked in all sprayed and unsprayed areas in 1957, then declined sharply. In northeast Oregon *Zeiraphera hesperiana* peaked in both sprayed and unsprayed areas in 1957. In sprayed areas, *Griselda radicana* peaked in 1957, with lower peaks in northeast Oregon; in unsprayed areas in northeast Oregon, it peaked either in 1957 or 1958. *Acleris gloverana,* an insect which is more at home in northwestern Oregon and western Washington, peaked later than the other associates by a year or two in all areas. Subsequent studies in eastern Washington indicate a collapse of A *gloverana* in 1960.

Trends in the Eugene area (the western foothills of the Cascades in west-central Oregon) were slightly different for some associates. Peaks for *Zeiraphera hesperiana, Coleotechnites* near *piceaella,* and *Argyotaenia dorsalana* were all in 1958, a year later than in most other areas. One might expect some differences in this area from geographic moderation of climatic influences.

The apparent downward trend of lepidopterous associates in the eastern Washington Cascades during 1960-62 may represent a continuation of the general trend shown in northeast Oregon. The lack of sampling data for unsprayed conditions in both areas in 1959 eliminates the basis for a conclusion. On the other hand, southern Oregon probably represents a different universe.

The similarity in trends between sprayed and unsprayed areas after 1954 might seem to indicate that the effects of the 1949 and 1950 spraying had largely dissipated; however during 1955-59 (tables 4, 6, appendix), densities of the common associates, with the exception of *Coleotechnites* near *piceaella,* were substantially higher in the unsprayed areas.

In mixed fir types, the selection of Douglas-fir over grand or white fir as a standard tree species for sampling western spruce budworm is advantageous in determining trends of its associates. In unsprayed areas, the greater susceptibility of grand and white fir to bud-killing (Carolin and Coulter 1975) results in a reduction of the food supply; this sets up a competitive situation between the budworm and its associates and between associates. Trends could be determined for categories of tree damage, but would require a substantially stepped-up sampling effort.

The larvae of a number of defoliators feed in association with spruce budworms in opening buds and new shoots of Douglas-fir, grand fir, and white fir. In Oregon and Washington, about 20 species that are common, occasional, or sporadic on one or more of these hosts should be recognized during sampling for spruce budworms.

Trends of major associates can be determined by recording their numbers during sampling at fixed plots for spruce budworms at the larvae-in-opening-buds stage. Observers should learn to recognize larvae of the most common species in their study areas and should rear any species of uncertain identity.

Strong oscillations in the densities of the various associates appear to be controlled by the same major factor or set of factors that control densities of spruce budworms in these same areas. If so, annual sampling of host trees for associates, in stands away from typical spruce budworm outbreak areas, could have considerable value in predicting trends of spruce budworms.

Literature Cited

Buckhorn, W. J., and P. W. Orr.
1959. Forest insect conditions in the Pacific Northwest during 1959. USDA For. Serv., 37 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Carolin, V. M., and W. K. Coulter.
1971. Trends of western spruce budworm and associated insects in Pacific Northwest forests sprayed with DDT. J. Econ. Entomol. 64 (1):291-29-7.

Carolin, V. M., and W. K. Coulter.
1972. Sampling populations of western spruce budworm and predicting defoliation of Douglas-fir in eastern Oregon. USDA For. Serv. Res. Pap. PNW-149, 38 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Carolin, V. M., and W. K. Coulter.
1975. Comparison of western spruce budworm populations and damage on grand fir and Douglas-fir trees. USDA For. Serv. Res. Pap. PNW-195, 16 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Carolin, V. M., and K. H. Wright.
1953. Studies of the biology and control of the spruce budworm in Oregon and Washington. USDA Bur. Entomol. and Plant Quar. Spec. Rep., 30 p. For. Insect and Disease Invest., Portland, Oreg.

Carolin, V. M., Jr., and Robert E. Stevens.
1979. Key to small lepidopterous larvae in opening buds and new shoots of Douglas-fir and true firs. USDA For. Serv. Res. Note RM-365, 4 p. Rocky Mountain For. and Range Exp. Stn., Fort Collins, Colo.

Chansler, John F., and Harvey V. Toko.
1975. Forest insect and disease conditions in the United States, 1973. USDA For. Serv., 55 p. Washington, D.C.

Furniss, R. L., and V, M. Carolin.
1977. Western forest insects. U.S. Dep. Agric. Misc. Publ. 1339, 654 p.

Ohmart, C. P., and D. L. Dahlsten.
1977. Biological studies of bud mining sawflies, *Pleroneura* spp. (Hymenoptera:Xyelidae), on white fir in the central Sierra Nevada of California. I. Life cycles, niche utilization, and interaction between larval feeding and tree growth. Can. Entomol. 109 (7): 1001-1007.

Orr, P. W., L. F. Pettinger, and R. E. Dolph.
1965. Forest insect conditions in the Pacific Northwest during 1964. USDA For. Serv., 90 p. Pac. Northwest Reg., Portland, Oreg.

Volker, Kurt Carl.
1978. Ecology of parasites and predators of the Douglas-fir tussock moth in the Pacific Northwest. Ph.D. thesis. Univ. Idaho, Moscow, 92 p.

Whiteside, J. M.
1958. Forest insect conditions in the Pacific Northwest during 1957. USDA For, Serv., 49 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Appendix

Table 4 — Comparison of average larval densities of western spruce budworm and associated defoliators in Oregon and Washington infestations (In number of larvae per one hundred 15-inch twigs)

Study area and tree species	1951	1952	1953	1954	1955	1956	1957	1958	1959
				SPRAYED AREAS					
Eugene – Douglas-fir:									
Western spruce budworm	0.3	2	8	24	6	7	16	13	7
Associated defoliators	31	49	12	4	45	55	98	63	33.5
Mount Hood – Douglas-fir:									
Western spruce budworm	13	28	1	0	7	6	15	12.5	0.5
Associated defoliators	5.5	13.5	7.5	1.5	4	15.5	21	40	33
South Umatilla – Douglas-fir:									
Western spruce budworm	4.5	0.5	5	10	17.5	11	19	7	6.5
Associated defoliators	9.5	15.5	1.5	1.5	11	25	43	38	26
La Grande – Douglas-fir:									
Western spruce budworm	20	26	24	16.5	39	12.5	14	8.5	6
Associated defoliators	3.5	14.5	9	0	73	69.5	102.5	54.5	16
North Umatilla – subalpine fir:									
Western spruce budworm	5	4	0	0	2.5	2.5	4.5	0.5	1
Associated defoliators	1	6	4	3	6.5	11	34	78.5	69

Table 5 - Comparison of average larval densities of Modoc budworm and associated defoliators in southern Oregon infestations (In number of larvae per one hundred 15-inch twigs)

Study area and tree species	1959	1960	1961	1962
North Warner Mountains – white fir:				
Modoc budworm	—	1322	401	—
Associated defoliators	—	174	26	—
Gearhart Mountains – white fir:				
Modoc budworm	—	621	236	110
Associated defoliators	—	95	60	127

Table 6— Comparison of average larval densities of western spruce budworm and associated defoliators in Oregon and Washington infestations (In number of larvae per one hundred 15-inch twigs)

Study area and tree species	1955	1956	1957	1958	1959	1960	1961	1962
UNSPRAYED AREAS, N. E. OREGON								
Baker – Douglas-fir:								
Western spruce budworm	281	227	597	310	—	—	—	—
Associated defoliators	53	92	215	105	—	—	—	—
Chesnimnus – Douglas-fir:								
Western spruce budworm	177	190	141	—	—	—	—	—
Associated defoliators	7	40	147	—	—	—	—	—
Dale – Douglas-fir:								
Western spruce budworm	851	1700	2186	324	—	—	—	—
Associated defoliators	123	149	490	208	—	—	—	—
Dixie – Douglas-fir:[1]								
Western spruce budworm	—	—	1010	385	—	—	—	—
Associated defoliators	—	—	13	26	—	—	—	—
Joseph – Douglas-fir:								
Western spruce budworm	309	224	433	224	88	—	—	—
Associated defoliators	13	43	152	166	122	—	—	—
UNSPRAYED AREAS, E. WASHINGTON								
Goldendale – Douglas-fir:								
Western spruce budworm	—	—	—	—	—	365	428	—
Associated defoliators	—	—	—	—	—	51	46	—
Goldendale – grand fir:								
Western spruce budworm	—	—	—	—	—	215	1206	1382
Associated defoliators	—	—	—	—	—	151	29	25

[1] Trees with severe damage.

Carolin, V. M.
1980. Larval densities and trends of insect species associated with spruce budworms in buds and shoots in Oregon and Washington. USDA For. Serv. Res. Pap. PNW-273, 18 p. Pac. Northwest For. and Range Exp. Station, Portland, Oregon.

Sampling studies on western spruce budworm and Modoc budworm disclosed a substantial number of associated insect species at the time larvae were in opening buds. About 20 species occur with sufficient regularity to justify identi fication by field crews.

Keywords: Insect populations, reproductive behavior (insect), western spruce budworm, iden tification (insect), *Choristoneura occidentalis* Modoc budworm, *Choristoneura viridis.*

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