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NOTES ON THE BIOLOGY OF THE WESTERN SPRUCE BUDWORM, *CHORISTONEURA OCCIDENTALIS* (LEPIDOPTERA: TORTRICIDAE), IN NORTH CENTRAL WASHINGTON

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Abstract. Biology of the western spruce budworm, *Choristoneura occidentalis,* from Douglas-fir, was studied in the Okanogan National Forest in north central Washington. Larval head capsules were measured and mean values established for each of the 6 instars. Mean head values in the study area were equivalent to data from populations in Oregon, Montana, and Colorado, although biological events in Washington were slightly different. Oviposition, eclosion, and hibernacula formation occurred later in Washington than in Montana or Colorado. Needle-mining activity of the 2nd-instar larvae in the study area was comparable to that in Colorado, but a month longer than for those budworms in Montana. Twenty-five percent of field-collected budworm larvae were infested by 8 different parasite species; however, 95% of all parasitism involved only 2 species, *Glypta fumiferanae* and *Apanteles fumiferanae.*

Biology of the western spruce budworm, *Choristoneura occidentalis* Freeman, was studied in conjunction with a pesticide evaluation project conducted in the Winthrop Ranger District of the Okanogan National Forest, Washington, in 1975. Observations were made to confirm the presence of particular larval instars during a given sampling period. This confirmation allowed us to compare the life cycle of the localized budworm population on Douglas-fir in Okanogan County with published data on populations from Douglas-fir in Oregon (Bean & Batzer 1957), Colorado (McKnight 1967), and Montana (Johnson & Denton 1975). Budworm larvae were also reared to identify the different species of parasites.

MATERIALS AND METHODS

Foliage collections of Douglas-fir were made every 3rd day from 15 test plots north of Winthrop, Washington, on the Winthrop Ranger District, as well as other areas in Okanogan County, Washington. A portion of the larvae collected was preserved in alcohol. Two hundred larvae from each collection were separated into groups of 10 and placed into 20-mm Petri dishes containing modified spruce budworm diet (Lyon et al. 1972). Pupae were removed from these Petri dishes every 24 h and placed in 12 mm × 75 mm vials for adult moth or parasite emergence. Other species of lepidopterous larvae from the foliage collections were reared to adults for identification.

All larval head capsules from the preserved collections were measured with a

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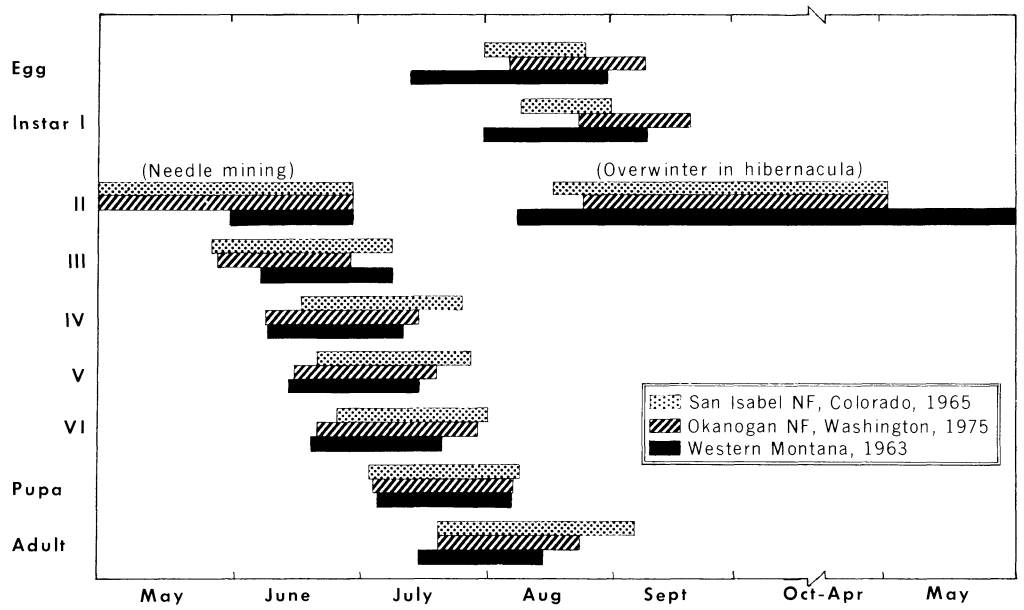

FIG. 1. Life cycle of the western spruce budworm on Douglas-fir trees at the Winthrop Ranger District, Okanogan National Forest, Washington, 1975; the San Carlos District, San Isabel National Forest, Colorado, 1965; and in western Montana, 1963.

stereoscopic dissecting microscope equipped with an ocular micrometer. Head capsule width for 1st-instar larvae was measured immediately after eclosion. A growth ratio was computed for the 1974–75 generation based upon head capsule widths.

RESULTS AND DISCUSSION

Life history

As noted by McKnight (1967), the life cycle of the western spruce budworm is similar to that of other *Choristoneura* that defoliate coniferous trees. McKnight suggested that differences in species of *Choristoneura* between localities can be attributed to climatological influences rather than differences in biology, except for *Choristoneura biennis* Freeman, which has a 2-year life cycle. Data from the present study seem to support this contention. The following detailed comparison of life cycle information for the western spruce budworm on Douglas-fir is based upon the 1975 data from this study on the Winthrop Ranger District, Washington, data reported by McKnight (1967) on the San Isabel National Forest, Colorado, and information provided by Johnson & Denton (1975) for western Montana (FIG. 1).

Adult emergence in the Winthrop Ranger District extended from the 3rd week of July through the 3rd week of August; oviposition started in the 2nd week of August and continued to mid-September. Eclosion began in the 1st week of August and instar I was present until the 2nd week of September. Hibernacula formation and

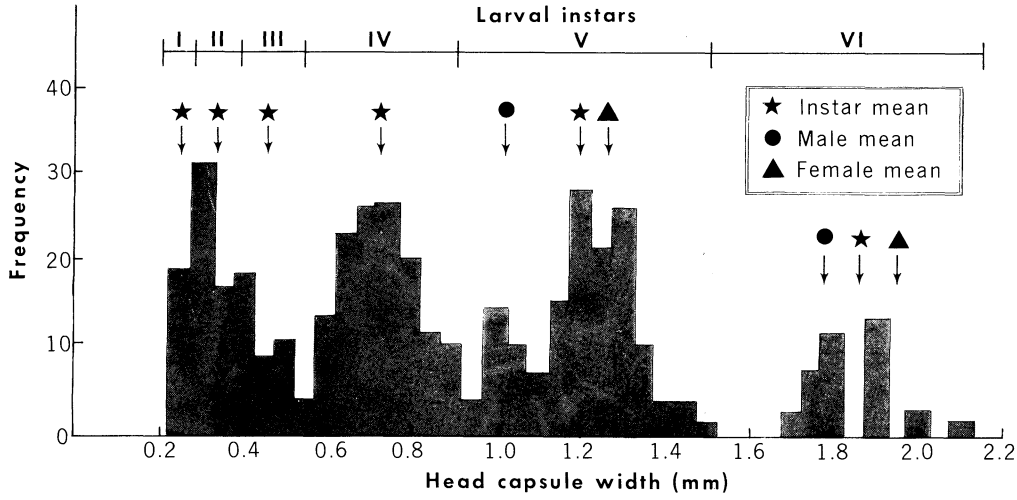

FIG. 2. Histogram of *Choristoneura occidentalis* head capsule measurements, Okanogan National Forest, 1975.

needle mining activity are both accomplished in instar II. Hibernacula formation started in mid-August and continued until late April. Needle mining activity began when diapause ended in early May and continued through late June. Larval development after instar III took place from late May to late July. Sixth-instar larvae pupated from the 1st week of July to the 2nd week of August.

Biology of the western spruce budworm feeding on Douglas-fir was different between populations in Montana, Colorado, and Washington. Adult emergence and flight period for Colorado (McKnight 1967) began 1 week later than in Montana (Johnson & Denton 1975) and continued 2½ weeks longer than in Washington. Eggs

TABLE 1. Head capsule measurements of the western spruce budworm (*C. occidentalis*) collected in Oregon, Colorado, and Washington.

	WASHINGTON*			COLORADO**			OREGON***
INSTAR	No. larvae	Mean width (mm)	Standard error	No. larvae	Mean width (mm)	Standard error	Mean width (mm)
I	32	0.27	0.0018				
II	45	0.34	0.0045	689	0.34	0.0010	0.35
III	31	0.46	0.0072	898	0.44	0.0010	0.48
IV	138	0.73	0.0076	333	0.67	0.0029	0.76
V	154	1.20	0.0106	665	1.17	0.0072	1.26
VI	36	1.86	0.0200	692	1.86	0.0047	2.02

* Winthrop Ranger District, Okanogan National Forest, 1975.
** San Carlos District, San Isabel National Forest, 1965 (McKnight 1967).
*** Eastern Oregon, 1948 (Bean & Batzer 1957).

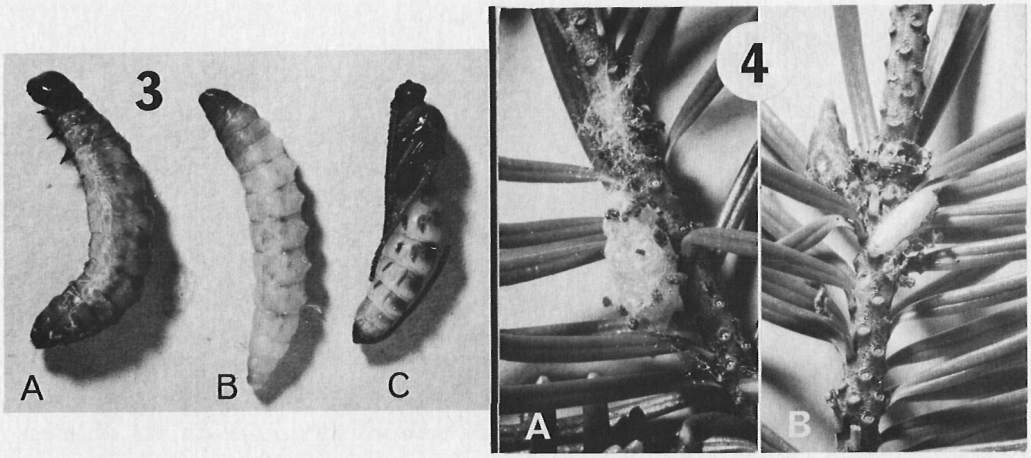

FIG. 3–4. **3.** Larvae and pupa of *Glypta fumiferanae*: A, 4th stage larva inside the western spruce budworm larval skin after the host has been consumed; B, 4th stage emerged from host (note characteristic dark area around head); C, ♀ pupa removed from the cocoon. **4.** Cocoons of the western spruce budworm parasites: A, *Glypta fumiferanae*; B, *Apanteles fumiferanae.*

from all 3 locations were deposited during the same period. The initial oviposition in Montana occurred 15 days earlier than in Colorado. Eclosion began on August 1 in Montana, whereas instar I in Colorado was found only during the last 3 weeks of August. Hibernation began during August at all 3 locations. Emergence from the hibernacula and length of time in the needle mining stage were comparable for Washington and Colorado populations. In Montana, hibernation extended through May, with needle mining activity only in June. In general, duration of instars IV, V, and VI was the same, but occurred 7 days later in Colorado (McKnight 1967). Time spent in the pupal stage coincided for all 3 locations.

Head capsule width has long been used as a criterion to distinguish larval instars (Dyar 1890). Using larval collections obtained on different dates throughout 1974–

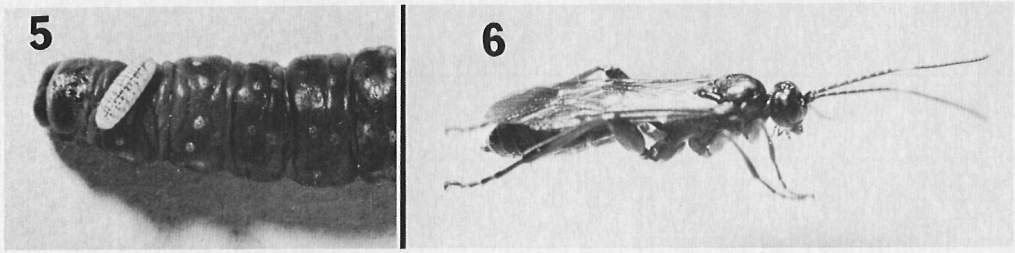

FIG. 5–6. **5.** Larva of the ichneumonid parasite *Phytodietus fumiferanae* attached to the 2nd thoracic segment of a western spruce budworm larva. **6.** The ichneumonid parasite *Phaeogenes maculicornis hariolus.*

TABLE 2. Parasites successfully reared from 4927 *C. occidentalis* larvae collected from the Winthrop Ranger District study area in 1975.

SPECIES	INSTAR KILLED	RELATIVE ABUNDANCE*
Hymenoptera		
Braconidae		
Apanteles fumiferanae	IV, V	Abundant
Ichneumonidae		
Glypta fumiferanae	V, VI	Abundant
Glypta sp.	VI	Rare
Phaeogenes maculicornis hariolus	Pupa	Rare
Phytodietus fumiferanae	VI	Rare
Tranosema rostrale rostrale	V, VI	Rare
Diptera		
Tachinidae		
Ceromasia auricaudata	Pupa	Rare
Madremyia saundersii	VI, Pupa	Common

* Relative abundance is defined as rare = occasional occurrence, common = reared from most collections, and abundant = greater than 5% parasitism.

75, measurements of head capsule widths indicated that there were 6 larval instars (FIG. 2) with mean head capsule widths (in mm) for each of the 6 instars as follows: 0.27, 0.34, 0.46, 0.73, 1.20, and 1.86 (TABLE 1). The mean capsule widths for both sexes were different in the last 2 instars (FIG. 2). The male head capsule width for instars V and VI averaged 1.02 mm and 1.77 mm, respectively; whereas female head capsule measurements averaged 1.26 mm and 1.95 mm, respectively. The average ratio of increase between mean values for each instar was 1.48. Head capsule samples from northern Washington, southern Colorado, and eastern Oregon were almost identical (TABLE 1). The largest difference in mean head capsule widths occurred in stadia VI. Measurements from all 3 locations were not significantly different.

Parasites

In 1975, 25.9% of field-collected larvae on the study plots were parasitized (TABLE 2). Among the parasites reared, *Glypta fumiferanae* (Viereck) was the predominant parasite (FIG. 3 & 4a). *Apanteles fumiferanae* Viereck (FIG. 4b) was the 2nd most abundant, followed by *Madremyia saundersii* (Williston) and *Ceromasia auricaudata* Townsend. Both *G. fumiferanae* and *A. fumiferanae* were considered 2 of the 4 most important hymenopterous budworm parasites by Carolin & Coulter (1959); the other 2 were *Phytodietus fumiferanae* Rohwer (FIG. 5) and *Phaeogenes maculicornis hariolus* (Cresson) (FIG. 6). The results in TABLE 2 indicate a difference in parasite biology. *Glypta* and *Apanteles,* which attack the host in the first 2 instars, were more plentiful than *Phaeogenes maculicornis hariolus* and *Phytodietus fumiferanae,* which attack late stage larvae and pupae. A higher incidence of parasitism would have been recorded if more budworms were collected during the pupal stage.

Associated defoliators

Throughout the summer, larval collections from Douglas-fir in the study area provided material for rearing several other Lepidoptera species. Defoliators associated with the western spruce budworm were Geometridae—*Enypia venata* (Grote), *Enypia* sp., *Stenoporpia satisfacta* (Barnes & McDunnough); Tortricidae—*Acleris variana* (Fernald), *Argyrotaenia dorsalana* (Dyar), *Choristoneura retiniana* (Walsingham); Phycitidae—*Dioryctria pseudotsugella* Munroe; and Olethreutidae—*Griselda* nr *radicana* (Walsingham). *Acleris variana* and *Griselda radicana* Walsingham have also been associated with the spruce budworm *C. fumiferana* (Clemens), in New Brunswick balsam fir-spruce type forests (Miller 1950).

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