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Biology and behavior of a larch bud moth, *Zeiraphera* sp., in Alaska

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Abstract

A possibly new species or subspecies of larch bud moth of the genus Zeiraphera, closely related to Z. improbana (Walker), was found associated with tamarack, Larix laricina (Du Roi) K. Koch, stands in interior Alaska. An outbreak occurred during 1975 and 1976 over an area of 240 000 ha (590,000 acres). Adult moths were mottled grayish in appearance. First instars emerged from the over-wintering egg stage from mid-late May and began feeding as soon as the tamarack buds began to unfold. Pupation, adult emergence, and oviposition occurred from mid-June to mid-July and there was one generation per year. Defoliated tamarack stands turned reddish-brown color by mid-June as partially defoliated needles turned brown, but stands refoliated by mid-July. Parasites and disease killed 99.6 percent of the pupal stage in 1976.

KEYWORDS: Larch bud moth, Zeiraphera sp., tamarack, Larix laricina, defoliation, biology and behavior, Alaska (interior).

Introduction

An unidentified species or subspecies of bud moth, Zeiraphera sp., completely defoliated 142 000 to 240 000 ha of tamarack Larix laricina (Du Roi) K. Koch, during 1975 and 1976 in the Tanana River drainage near Fairbanks, Alaska (Rush et al. 1977). The area infested extended from Tok (near the Canadian border) west to Nenana and from Fairbanks south to the Alaska Range (fig. 1). An infestation by Zeiraphera apparently occurred throughout the same area in 1958[2] as extensive areas of tamarack were heavily defoliated. In Alaska, tamarack occurs throughout the river basins between the Brooks Range on the north and the Alaska Range on the south and is especially abundant along the Yukon, Kuskokwim, and Tanana Rivers (fig. 1) (Viereck and Little 1975). During the same time period 70 percent of the tamarack trees in southeastern Yukon Territory were defoliated by Z. improbana (Walker) (Canadian Forestry Service 1976).

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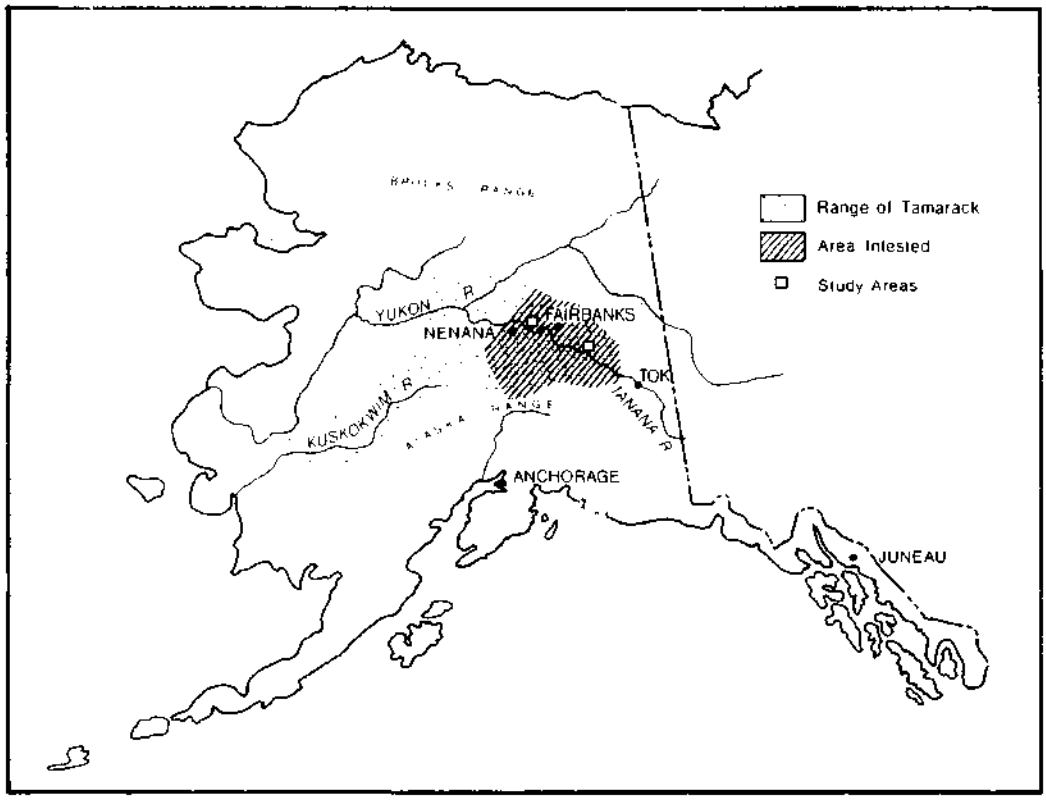

Figure 1.--Range of tamarack in Alaska and areas defoliated by larch bud moth, Zeiraphera *sp.*

Adult specimens reared during the 1975-1977 outbreak were identified by Dr. A. Mutuura, Biosystematics Research Institute, Ottawa, Ontario, as a possibly new species or subspecies of Zeiraphera closely related to *Z.* improbana (Walker) . Mutuura and Freeman (1966) previously described seven North American species of Zeiraphera, and *Z.* improbana was the only species that fed on tamarack.

Baltensweiler et al. (1977) summarized the results of 26 years of research on the population dynamics of *Z.* diniana in Europe. The biology and behavior of the Alaskan species are quite similar to *Z.* diniana except for host plants. The Alaska Zeiraphera feeds predominantly on I., laricina whereas *Z.* diniana feeds on several different coniferous hosts.

This paper describes the life cycle and behavior of an unidentified species of Zeiraphera in tamarack stands of interior Alaska.

Methods

The study was conducted in two areas of heavy infestation located in the Tanana River drainage. Single sample plots were established in May 1975 in the Bonanza Creek Experimental Forest located 40 km west of Fairbanks and near Delta Junction located 134 km east of Fairbanks (fig. 1). The study sample plots contained open-grown, mixed species of tamarack and black spruce, Picea mariana (Mill.) B.S.P. The dominant and codominant trees ranged from ca. 6 to 9 m in height and ca. 6.5- to 15.2-cm d.b.h. Each of the two sample plots contained 100 trees which were marked and numbered with plastic tags. Branch samples were collected weekly from 10 randomly selected trees in each plot in order to estimate larval development and density from egg eclosion to pupation. All larvae were collected and counted on a 63-cm-long branch which was collected from the south side of the midcrown level. Preliminary sampling indicated no significant difference in egg or larval density in relation to crown level or direction. Larval density was expressed in terms of number per 0.64 m^2 (1,000 in^2) of branch area.

Branches were clipped with a pole pruner equipped with *a* muslin basket lined with a plastic bag which in turn held the clippel branch. The plastic bag with branch was sealed and transpoited the laboratory for processing. In addition, 200 larvae were collected each week and measurements made by ocular micrometer of body length and width and head capsule width. Other exlemal characteristics such as color were examined.

Pupal development was measured by trapping last instars as they dropped from the trees. Wire screen traps (50- x 50- x 7.5-cm) were partially filled with peat moss covered with a 2. 35-cm- thick layer of sphagnum moss and placed on the ground beneath intested larch. Escape of larvae from the traps was prevented by coating the upper surface of the wooden trap frame with Tanglefoot.[3] Pupal density was expressed as number per square meter, A wire screen cover was placed over the pupal trap following pupation in order to live trap emerging adult moths and parasites. Moth density and sex ratio were thus obtained. Pairs of adults were caged separately in plastic screen sleeve cages placed over the terminal 38 cm of uninfested tamarack branches. Mating and ovipositional behavior were observed and oviposition data recorded. Half of the sleeve cages were removed following oviposition in order to measure egg predation and parasitism.

All samples of larvae and pupae from the weekly collections were reared in the laboratory in order to collect emerging parasites. Diseased specimens were sent to specialists for identification.

[3]Mention of products, trade names, or companies does not imply endorsement by the U.S. Department of Agriculture.

Description of Stages

Adults: Moths of both sexes have a grayish-black head, thorax, and abdomen with scattered patches of brown. Forewings are mottled grayish with patches of white, brown, and black scales. Hindwings are light gray with a fuscous fringe on the posterior edge. Adults are 7.3±0.31 mm in length (range 6.2-10.8 mm) with a wingspread of 14.2±0.6 mm (range 12.3-17.2 mm).

Egg: Eggs are oblong, ca. 0.35-0.60 mm in length and 0.15-0.25 mm in width. Color varied from whitish-orange immediately after oviposition, changing with age to a dullish reddish brown.

Larvae: Body and head capsule measurements and color variations are described for each instar in table 1. The thoracic legs of each instar are brown, but the head and body color varies. Newly emerged larvae are pale green with black heads and transform through successive instars to a fifth instar characterized by a brown head and yellowish green body with light brown dorsal and lateral spots.

Pupae: Pupae are dull brown and are found in cocoons constructed from forest floor materials such as peat, moss, bark scales, and bits of other plant material. Pupae are ll.l±0.5 mm in length (range 9.5-12.6 mm) and 2.1±0.1 mm in width (range 1.9-2.3 mm). Sexes can be separated according to location of the genital opening. Females have the opening ventrally on the eighth abdominal segment, whereas for males it occurs ventrally on the ninth segment.

Table 1—External measurements (mm) and color phases of larch bud moth, Zeiraphera sp., larvae collected from tamarack, Fairbanks, Alaska

Instar	I	II	III	IV	V
No. measured	200	250	350	325	340
Length:					
Mean	3.5	7.4	9.4	9.9	10.3
Range	2.8-4.2	5.3-9.2	8.2-10.7	7.0-11.5	8.7-12.8
Body width:					
Mean	0.51	0.72	1.12	1.18	1.75
Range	.47-.55	.66-.77	.82-1.23	.90-1.32	1.48-2.04
Head width:					
Mean	.50	.83	1.11	1.22	1.32
Range	.46-.54	.76-.96	1.06-1.16	1.18-1.26	1.28-1.40
Color:					
Head	black	black	brownish-black	dark brown	brown
Body	pale green	pale green	green	yellowish-green	yellowish-green

Life History and Behavior

The seasonal development of the larch bud moth in Alaska is shown in fig. 2. The bud moth is univoltine with an egg diapause. The factors responsible for the induction of diapause are unknown; however, diapause was terminated when temperatures reached 10°C. Overwintering eggs successfully survived temperatures as low as -52°C, which often occur in interior Alaska.

Adults emerged from late June until late July with peak flight occurring when cumulative degree days reached ca. 500° above a 5°C threshold usually in early July. Moth emergence occurred in the early morning between 0300 h and 0500 h when light intensity was ca. 700 lux and when daily temperatures were at a minimum (mean of 10°C in June and July). Flight and mating occurred at twilight (2250-0150 h). Twilight is that period when the sun is not more than 6° below the horizon (Johnson and Hartman 1969). At latitudes north of 60-l/2°N, evening twilight overlaps morning twilight during the summer. In the study areas there was ca. 3 h of twilight from late June to late July. The light intensity during this twilight period ranged from 13.5 lux at 2250 h and 0150 h to 8.6 lux at 2400 h.

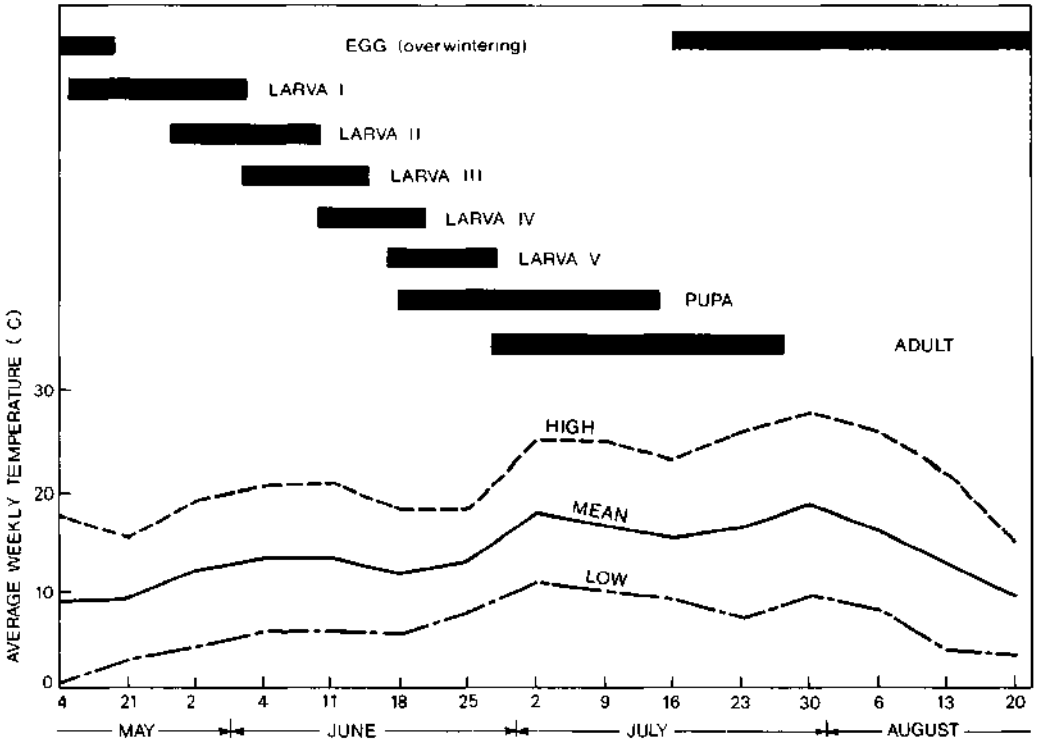

Figure 2.—Seasonal development of the larch bud moth, Zeiraphera *sp., with daily temperatures in interior Alaska.*

Mating occurred in previously defoliated trees which usually began to refoliate by mid-July. Adult females were capable of oviposition immediately after mating without a pre-oviposition period as was found with the spear-marked black moth, Rheumaptera hastata (L.), in Alaska (Werner 1977). Eggs were laid singly beneath bark scales, on cones, and in the axes of tree branchlets. An average of 160 eggs was laid per female over a period of 4 days.

First instars emerged in mid-May when the cumulative degree day temperature reached ca. 100° above the 5°C threshold. Larval emergence coincided with tamarack bud break, and thereafter larval development was closely related to host phenology. First instars fed within the newly developed needle clusters. Second, third, and fourth instars fed within a tubelike structure constructed from the needle clusters. Larval development began in mid-May and extended to mid-July. Fifth instars and occasionally fourth instars lived within finely webbed tunnels constructed along the branch axis. Fifth instars were often found outside of the webbed tunnels feeding on needles. Feeding by all instars except the first occurred during the twilight hours (2250-0150 h). First instar feeding occurred throughout all hours of the day.

When the fifth instars had completed feeding, they dropped to the ground on silken threads and constructed cocoons from pieces of moss, dead larch needles, or any other organic matter on the forest floor. The larvae did not burrow but followed natural channels in the peat soil which normally occurs beneath tamarack trees. Larvae preferred moist soil for pupation, and 80 percent of the cocoons were found within the upper 3 cm of the soil surface. Pupation began in late June and was completed by mid-July.

Natural Enemies

The impact of abiotic and biotic mortality agents on the density of the various stages of Zeiraphera sp. is shown in table 2. Rapid decreases in temperature during April 1976, i.e., from 0° to 30°C in 24 h, killed ca. 32 percent of the overwintering egg stage. Predation by lacewing larvae, Chrysopa sp., accounted for 2.4-percent reduction of the egg population following oviposition in July 1975 and the onset of winter in early October 1975. Predation by Chrysopa sp. and ants, Formica sp., reduced first-, second-, and third-instar populations by ca. 8 percent in 1975 and 9 percent in 1976. Bird predation removed 3 percent of the fourth instars and 10 percent of the fifth instars during the summers of 1975 and 1976. Slate-colored juncos, Junco hyemalis, redpolls, Acanthis sp., and chickadees, Parus sp., were observed feeding on larvae and adults.

Table 2 -Seasonal density and mortality of *Zeiraphera* populations on heavy defoliation sites

Insect stage	Mean density[1]		Percent mortality	
	1975	1976	1975	1976
Egg (Sept.)	209±12.6	—	--	2.4
Egg (May)	—	123±10.2	31.6	—
Larvae I	112±8.5	94±9.6	1.3	2.1
Larva II	102±8.9	88±10.2	3.2	2.6
Larva III	75±6.3	68±8.4	3.8	3.2
Larva IV	72±4.5	63±5.6	4.9	12.2
Larva V	60±3.6	51±2.4	45.2	76.3
Pupa	89±1.3	43±1.7	62.3	99.6

[1]Egg and larval density per 0.64 m^2 branch area. Pupal density per square meter of litter.

Parasitism accounted for 16-percent reduction of fifth instars in 1975 and 30 percent in 1976. The greatest impact of parasitoids was on the pupal stage with a 55-percent reduction in 1975 and a 90-percent reduction in 1976. Three species of braconids, *Meteorus nive itarsis* (Cress.), *Apanteles* sp., and *Agathis* sp. were reared from fifth instars. The following ichneumonids were reared from fifth-instar larvae: *Glypta* sp. and *Elachertus* sp.

Ichneumonid pupal parasitoids were *Coccygomimus pedalis* (Cress.), *Mesochorus* sp., *Itoplectis quadricingulatus* (Prov.), *Gelis* sp., and *Mastrus annulicornis* (Thorn.). One tachnid *Actia* sp. was reared from late-instar larvae.

A granulosis virus contributed to a 24- to 31-percent decline of fifth instars in 1975 and 1976 and ca. 8-percent decline of pupae in both years. Dead and dying larvae were found in the webbed shelters along tamarack branches and hanging from foliage where they died while spinning to the ground to pupate.

Acknowledgment

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