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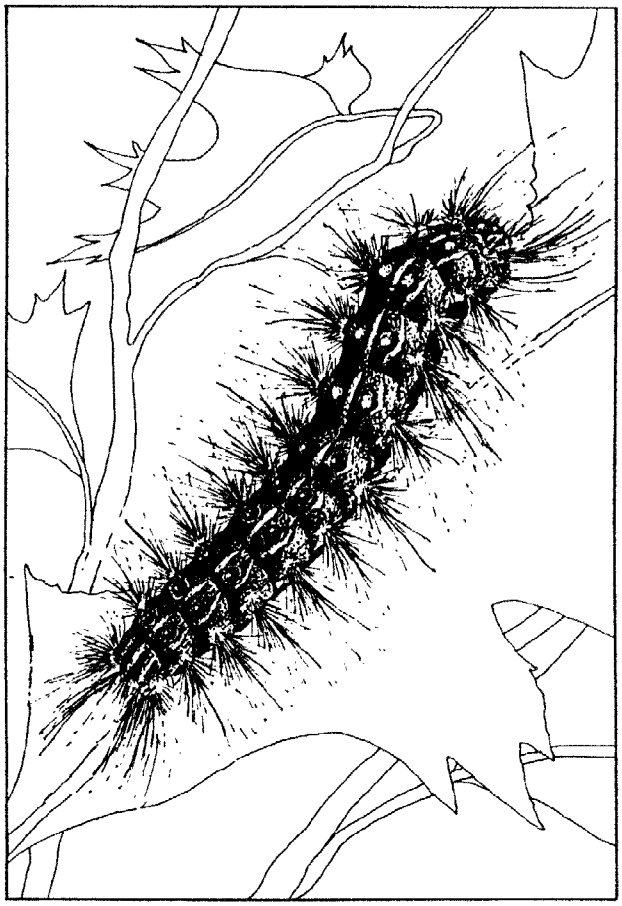
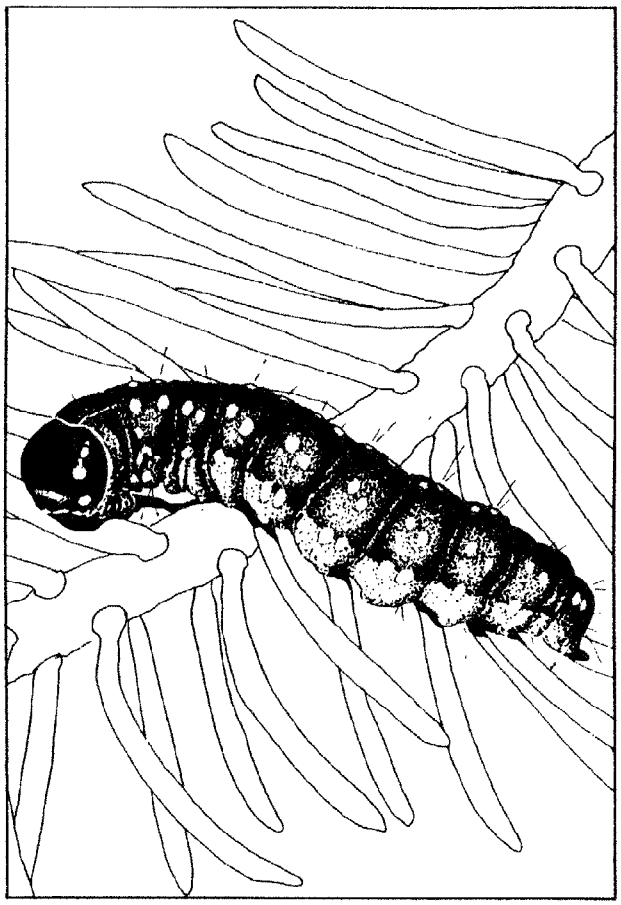
Forest Defoliator - Host Interactions: A Comparison between Gypsy Moth and Spruce Budworms





FOREWORD

The Canada/U.S. Spruce Budworms Program in cooperation with the Center for Biological Control of Northeastern Forest Insects and Diseases of the Northeastern Forest Experiment Station co-sponsored this Forest Defoliator-Host Interaction Workshop. This invitational workshop was limited to investigators of the spruce budworms and gypsy moth in the Forest Service, Canadian Forestry Service, and the University sector. The primary purpose of this workshop was to foster communication between researchers having a mutual interest and active research projects designed to understand the relationships between the host plant and forest defoliator feeding behavior, growth, and reproduction.

This Workshop was a follow-up to two previous meetings on host-insect interaction. In 1980, Dr. W. Mattson hosted a CANUSA-sponsored meeting at the North Central Forest Experiment Station, St. Paul, MN. This informal gathering brought together CANUSA Program investigators from the US and Canada for the purpose of sharing preliminary information and data on host-insect interactions. The second meeting took place in the fall of 1982. CANUSA(E) sponsored a Symposium on Spruce Budworm-Host Interaction at the Eastern Branch Meeting of the Entomological Society of America, Hartford, CT. The current Workshop developed from this Symposium. We found that participants were raising question concerning the similarity or differences between the spruce budworm and gypsy moth host interaction systems.

These Proceedings resulted from a three-day Workshop held in April 1983 at the Park Plaza Hotel, New Haven, CT. The structure of the Workshop allowed each participant a period for a presentation followed by lengthy discussion. These discussions were lively, friendly technical exchanges clarifying or elaborating on points raised by the speaker. Frequently, these exchanges were thought-provoking and often provided avenues for further detailed discussions and in some cases, future cooperative efforts.

The papers that make up these Proceedings were submitted at the Workshop as camera-ready copy. As a result, the participants did not have the benefit of reappraising their work in light of the discussions that followed their presentations or other ideas that developed at the Workshop.

Since the Workshop was planned late in the life of the CANUSA Program, we asked each investigator to be especially aware of the implications of these interactions on population dynamics of the insect in relation to forest management potential. When possible, we also asked that future research needs and direction be mentioned.

As technical coordinators for this Proceedings, it was our task to arrange and more effectively focus material so that papers provide a smooth transition of ideas and research activities on insect-host interactions for the spruce budworms and gypsy moth.

Lastly, we would like to acknowledge the support and confidence expressed by the following:

Denver P. Burns, Director, Northeastern Forest Experiment Station

Melvin E. McKnight, Program Leader, CANUSA

William E. Wallner, Director's Representative, Hamden, CT

August 1983 Robert L. Talerico, Broomall, PA

COVER SKETCH

Left, gypsy moth larva; right, spruce budworm larva.

PROCEEDINGS,

forest defoliator--host interactions:

A comparison between gypsy moth and spruce budworms

New Haven, Connecticut, April 5-7, 1983

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Sponsored jointly by the
Canada/United States Spruce Budworms Program
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CONTENTS

WESTERN LARCH AS A HOST OF THE WESTERN SPRUCE BUDWORM: A COMPARISON OF CAGED LARVAE ON SUSCEPTIBLE CONIFERS 1/ 2/

Roy C. Beckwith

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Caged field studies indicate that the foliage of western larch is apparently less suitable to western spruce budworm larval development than the foliage of Douglas-fir, subalpine fir, and Engelmann spruce.

Western larch, Larix occidentalis Nutt., is sometimes listed as a major host of the western spruce budworm, Choristoneura occidentalis Freeman, (Furniss and Carolin 1977). Clearly, budworm larvae feed on larch and produce damage (Fellin and Schmidt 1967; Schmidt and Fellin 1973). However, numbers of eggs on larch are usually low suggesting that populations on this species stem partly from incidental oviposition but mostly from passive dispersal in the 1st and 2nd instars (Wissenbach 1982). Also, our observations have indicated, that although larch may support large numbers of early instars, few seem to survive to the pupal stage.

Large larvae from a laboratory colony were caged in the field on several of the listed host species to check the relative suitability of western larch as a host. Data were collected on survival and pupal weight when feeding was completed; this note reflects the results of that study.

Methods

Two field sites in north-central Washington were chosen to obtain four host species representing different genera. One site (B. S. Place) contained Douglas-fir, Pseudotsuga menziesii var. glauca (Beissn.) Franco, and larch; the other site (Twisp River) contained Douglas-fir, subalpine fir, Abies lasiocarpa (Hook.) Nutt., and Engelmann spruce, Picea engelmannii Parry ex Engelm. Douglas-fir was tested on both sites to be sure there were no major differences between sites.

At each site, five open-grown trees per species of approximately the same height (4-5 m) were selected for testing. Fine-mesh nylon bags were placed around 45-cm tips of four branches per tree about 2 m from the ground. To monitor temperature, one tree per species had thermocouples on the under-surface of branches within the nylon bags and on uncovered branches.

The nylon bags were stocked with laboratory-reared western spruce budworm. 3/ The overwintering larvae had been exposed to cold temperatures to break diapause and timed to reach the 5th instar at about the same time as the field population. The test larvae were fed a standard budworm diet until they molted to the 5th instar, at which time they were randomly assigned to a specific nylon bag. Only five larvae were placed in each bag to ensure adequate current foliage to complete development. All cages at one field site were fully stocked within 2 days. Enough 5th instars were available at the proper time to infest five trees of Douglas-fir and Engelmann spruce at Twisp River; subalpine fir at Twisp River and the tree species at B. S. Place had four trees stocked with larvae.

Budworms in bagged branches were examined and temperatures from thermocouples recorded at 2- to 3- day intervals. Pupae were removed, sexed, and weighed to the nearest milligram within 72 hours of pupation. Pupal weight and survival were used to determine the adequacy of each host as a food source. Weights of naturally occurring pupae from Douglas-fir at B. S. Place were compared with those of pupae bagged on Douglas-fir at that site. Weights of only those pupae that successfully produced adults were used in the analyses. The data were analyzed by ANOVA; differences were tested by a Duncan's multiple range test (1955) incorporating Kramer's (1956) modification for unequal sample size.

1/ Lepidoptera: Tortricidae.

2/ The research reported here was financed in part by the Canadian/United States Spruce Budworms Program - West.

3/ Supplied by Dr. M. Martignoni, Forestry Science Laboratory, Corvallis, Oregon.

Results

All individuals that survived to the pupal stage and emerged were pooled for each host in the analysis because survival and pupal weights were not significantly different between branches or trees.

Survival ranged from 49% on larch to 88% on Douglas-fir at Twisp River (Table 1). Survival on larch was clearly much lower than on the other species. The same pattern occurred when comparing pupal weights from the four hosts. Male and female pupae were significantly lighter on larch than on the other species (Table 2). The heaviest males were obtained from Douglas-fir at B. S. Place; the heaviest females were also obtained from Douglas-fir at B. S. Place, but they were not significantly heavier than those on Douglas-fir at Twisp River. In general, the bagged pupae on Douglas-fir were heavier than those collected from the natural population.

Table 1. Percent survival to adults of western spruce budworm reared on various hosts in north-central Washington, 1981.

Location	Host	Number Started	Number Adults	Percent Survival
Twisp River	Douglas-fir	100	88	88
	Subalpine Fir	80	67	83
	Spruce	100	82	82
B. S. Place	Douglas-fir	80	67	83
	Larch	80	39	49

Table 2. Pupal weights of western spruce budworm reared on different hosts in north-central Washington in 1981.

Location	Host	Males n	Males $\bar{x}$ (mg)[a/]	Males S.E.	Females n	Females $\bar{x}$ (mg)[a/]	Females S.E.
Twisp River	Douglas-fir	50	90.2 b	1.70	38	121.6 ab	4.75
	Subalpine Fir	35	76.4 c	2.13	32	91.3 d	2.92
	Spruce	45	80.8 c	3.10	37	108.3 bc	4.29
B. S. Place	Douglas-fir	46	103.9 a	2.70	21	135.5 a	5.45
	Larch	17	41.5 d	2.67	22	43.2 e	3.49
	Natural	26	81.6 bc	2.43	33	104.5 cd	2.73

[a/] Any two means by sex not having a common letter are significantly different at the .01 probability level.

Discussion

Reduced pupal weights and poor survival (49%) of western spruce budworm reared on larch may indicate that the foliage does not provide late instars with proper nutrition for normal development, or the foliage may contain materials that produce an antibiosis in the insect. Ryan (1979) found that survival and growth of the larch casebearer, Coleophora laricella (Hbn.), were associated with the stage of foliage growth. Under the conditions of the 1981 experiment, the

laboratory stock may not have adapted as well to the larch foliage as to that of the other species. The report by Fellin and Schmidt (1967) of severe defoliation of larch does not mention when the damage occurred. The defoliation may have been caused by early larval feeding from high populations after spring dispersal (Beckwith and Burnell 1982). The rough bark of larch provides an excellent substrate for overwintering larvae that land on the trees during fall dispersal; large populations would thus be in place on the tree when the larvae emerge in the spring. Larch foliage breaks in the spring much earlier than Douglas-fir or true fir, thus new growth is available for early emerging larvae. The disappearance of larger larvae from larch could result from excessive predation, off-tree dispersal because of inadequate foliar nutrition, or both (Beckwith and Burnell 1982). Spur-shoot foliage apparently offers inadequate protection for large larvae. Preliminary work in 1980 also suggested that the foliage did not provide proper nutrition to produce pupae of normal size; however, larvae may still feed on the foliage as Chew (1980) found that larvae do not necessarily reject plants that fail to support larval growth in favor of those that do.

Why the natural pupae collected from Douglas-fir were significantly lighter than the caged insects on Douglas-fir is not clear. Feeding in the natural population may have been interrupted by predators, parasitoids or excessive wind movement. The experimental larvae may have been protected from these factors by the nylon mesh cages. The slightly different temperatures in the cages probably would not account for increased pupal weight; air temperatures in the cages were only 1 to 2°C higher when the cages were in the sun and equal to or slightly lower in shade. The artificial diet fed the first three instars of the test may have given them a growth advantage over the natural population. Also, the laboratory population may have larger pupae because of genetic differences.

A phytophagous insect must be able to complete its life cycle solely upon a plant species and be normal in all respects for that plant species to be considered a major host. An antibiosis response (delayed development, small size, or reduced fecundity) would indicate that the plant is marginal as a host (Painter 1968). Foliage of western larch is apparently less suitable to budworm development than foliage of Douglas-fir, true firs, and Engelmann spruce.

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