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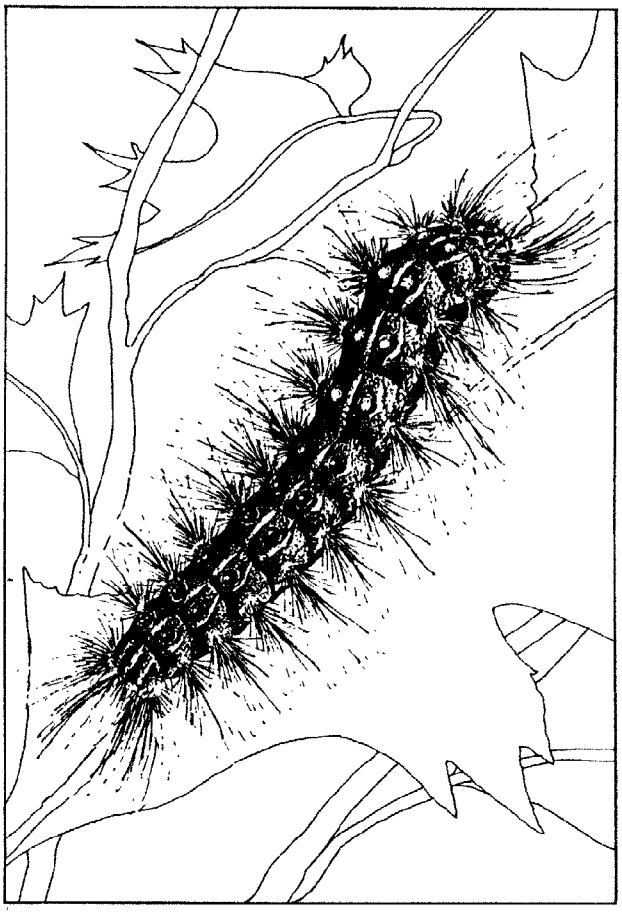
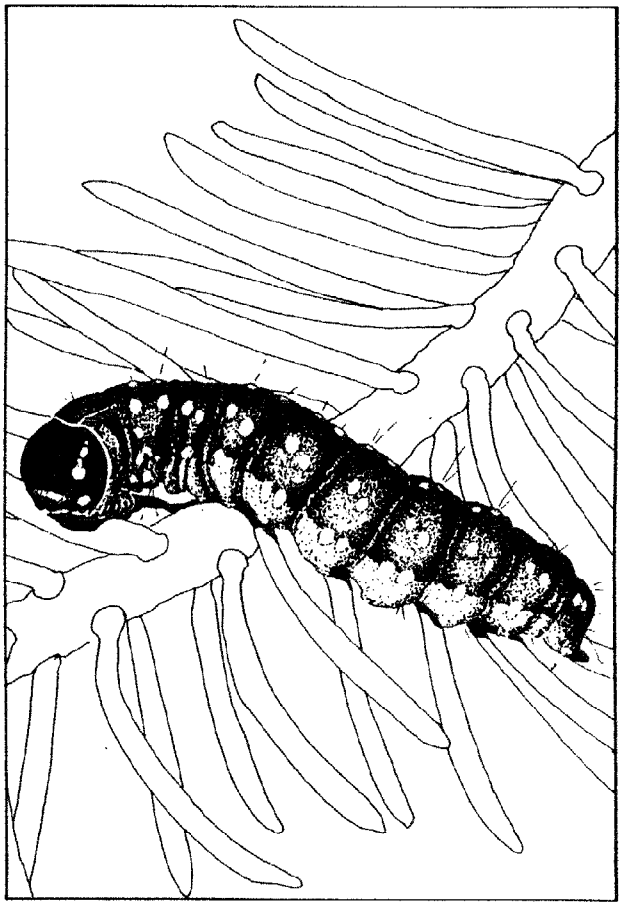
Proceedings

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
Northeastern Forest Experiment Station

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DOUGLAS-FIR PROGENY TESTING FOR RESISTANCE TO WESTERN SPRUCE BUDWORM

Geral I. McDonald

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Ample evidence exists that inland populations of Douglas-fir suffer varying amounts of defoliation by western spruce budworm (Johnson and Denton 1975; Williams 1967; McDonald 1981). Such variation in plant insect association can be the result of the plant escaping attack in time and place to actual confrontation between plant and insect (Harris 1980). Co-evolved genetic interaction between insect and plant is usually involved in initiation and preservation of plant polymorphisms, whether they be morphological or chemical responses (Gilbert 1982; Berenbaum 1983). Since western spruce budworm (Choristoneura occidentalis Freeman) is a native insect, there are three reasons for wanting to know more about the genetic nature of the Douglas-fir-budworm interaction. First, genetic interaction may hold the key to understanding budworm populations release and crash (Lorimer 1982). Second, a co-evolved and dynamically balanced genetic interaction may be keeping damage to levels biologically tolerable to Douglas-fir, which, if preserved, will provide the foundation for additional silvicultural and chemical controls (Browning 1980). The third reason is the possibility of actively breeding for unnatural levels of resistance for use in reforestation (Lamb and Aldwinckle 1980).

All investigations of genetics must begin with some observable difference in the target populations. Budworm feeding differences are readily apparent in western conifer populations (Williams 1967; McDonald 1981). These differences could be caused by factors ranging from asynchronous phenology (Manley and Fowler 1969) to a complex interaction of pheromones, mating, egg oviposition, and larval feeding preference (McDonald 1981). The first step to unlocking these secrets is progeny testing (McDonald 1982). Such tests have shown the presence of independent genetic components for larval feeding (family heritability = 0.43) and oviposition levels (stand differences) on 2-year-old Douglas-fir (McDonald, in press). One must conclude that some level of genetic interaction for one or both of these traits is functioning. More importantly, these traits may be reciprocally related to geographic variation of budworm populations as delineated by Willhite and Stock (1983) and discussed by McDonald (in press). Such geographic association could materially change seed and breeding zone requirements for inland Douglas-fir.

Since ecological adaptation has a genetic basis in Douglas-fir (Rehfeldt 1979), genotypes were expected to express consistent long-term growth patterns in response to their adapted environments. Patterns of radial stem growth were studied and found to be associated with a tree's ability to accommodate budworm outbreaks. The patterns of radial growth of dead or heavily defoliated Douglas-fir varied greatly, whereas paired, non-defoliated trees showed much more consistent growth patterns from year to year.

Literature Cited

Berenbaum, M. R. Coumarins and caterpillars: a case for coevolution. Evolution. 7:163-179; 1983.

Browning, J. A. Genetic protective mechanisms of plant-pathogen population: their coevolution and use in breeding for resistance. In: Biology and breeding for resistance to arthropods and pathogens in agricultural plants. College Station, TX: Texas A & M University; 1980: 52-75.

Gilbert, L. E. The coevolution of a butterfly and a vine. Scientific American. 24(2): 110-121; 1982.

Harris, M. K. Arthropod-plant interaction related to agriculture, emphasizing host plant resistance. In: Biology and breeding for resistance to arthropods and pathogens in agricultural plants. College Station, TX: Texas A & M University; 1980: 23-51.

Johnson, P. C.; Denton, R. E. Outbreaks of the western spruce budworm in the American Northern Rocky Mountain area from 1922 through 1971. General Technical Report INT-20. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Forest and Range Experiment Station; 1975. 144 p.

Lamb, R. D.; Aldwinckle, H. S. Breeding for disease and insect resistance in tree crops. In: Biology and breeding for resistance to arthropods and pathogens in agricultural plants. College Station, TX: Texas A & M University; 1980: 546-560.

Lorimer, N. Pest outbreaks as a function of variability in pests and plants, pages 287-294. In: Resistance to diseases and pests in forest trees; Pudoc Waginengen; 1982: 503 p.

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Lorimer, N. Pest outbreaks as a function of variability in pests and plants, pages 287-294. In: Resistance to diseases and pests in forest trees; Pudoc Waginengen; 1982: 503 p.

Manley, A. M.; Fowler, D. P. Spruce budworm defoliation in relation to introgression in red and black spruce. Forest Sci. 15: 365-366; 1969.

McDonald, G. I. Differential defoliation of neighboringDouglas-fir trees by western spruce budworm. Res. Note INT-306. Ogden, Ut: U.S. Department of Agri-culture, Forest Service, Intermountain Forest and Range Experiment Station: 1981. 10 p.

McDonald, G. I. Progeny testing of Douglas-fir seedlings for resistance to western spruce budworm; pages 460-465. In: Resistance to diseases and pests in forest trees. Pudoc Wageningen. 1982.

McDonald, G. I. Heritability of feeding preference in Douglas-fir seedlings fed to western spruce budworm. IUFRO Workshop on host-insect interaction. Banff, Canada, September 1983. In press.

Rehfeldt, G. E. Ecological adaptation in Douglas-fir (Pseudotsuga menziesii var. glauca) populations. 1. North Idaho and and northeast Washington. Heredity. 43: 383-314; 1979.

Williams, C. B., Jr. Spruce budworm damage symptoms related to radial growth of grand fir, Douglas-fir, and Engelmann spruce. Forest Sci. 13:274-285; 1967.

Willhite, E. A.; Stock, M. W. Genetic variation among western spruce budworm (Chonistoneura occidentalis) (Lepidoptera:tentricidae outbreaks in Idaho and Montana. Can. Ent. 115: 41-45; 1983.