

REPRODUCTIVE COMPATIBILITY WITHIN AND AMONG SPRUCE BUDWORM (LEPIDOPTERA: TORTRICIDAE) POPULATIONS

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ABSTRACT

Spruce budworm moths collected as larvae from two species of host trees in four populations were mated in single pairs in two years. In 1980 but not 1981, more of the intra-population matings than the inter-population matings were fertile. Host tree origin was not a significant factor in the level of sterility.

Incompatibility is the lack of offspring or the reduced fitness of offspring from crosses between strains of the same species. Although common in insects, the manifestations and underlying mechanisms of incompatibility are many and varied. Examples range from embryo mortality because of cytoplasmic incompatibility in the mosquito, *Culex pipiens* L. (Diptera: Culicidae) (Laven 1959) to complex genomic and cytoplasmic disturbance of F_1 reproductive ability in the fruit fly, *Drosophila melanogaster* L. (Diptera: Drosophilidae) (Kidwell et al. 1977). Intraspecific incompatibility has also been documented for Lepidoptera (Oliver 1979), but not all species exhibit this phenomenon (Robinson and Proverbs 1973). No information concerning the presence or absence of incompatibility is available for the economically important spruce budworm, *Choristoneura fumiferana* (Clemens), despite the relevance of this information to questions about outbreak origins, migration, local adaptation, and the genetic relatedness of different populations. In this paper we report that spruce budworm populations were not consistently compatible as measured by the frequency of fertile matings.

MATERIALS AND METHODS

Late instar spruce budworm larvae were collected from balsam fir, *Abies balsamea* (L.) Mill., and white spruce, *Picea glauca* (Moench) Voss., from a population in each of four localities in June of 1980 (St. Louis Co., Minnesota; Forest Co., Wisconsin; Coos Co., New Hampshire; Johnson Twp., Ontario). In June of 1981 collections were limited to Minnesota (MN) and New Hampshire (NH). Each larva was placed in a small plastic container with diet (McMorran 1965) until pupation. We crossed individuals that came from the same population, and individuals from different populations. We also established crosses in which both the male and female came from the same host tree species, and crosses in which the male came from one host species and the female came from the other host species. On the day of emergence, single male and female adults were placed together in pint paper cups covered by petri dish lids, with oviposition sites of white spruce shoots. Foliage was checked for eggs 3–5 days after crosses were established and again after moths were dead (6–12 days). Needles with attached egg masses were removed, placed in petri dishes, and sealed with parafilm to which a gauze square was attached (Grisdale 1970). Each dish was placed in a sleeve of black paper with a hole cut above the gauze square, at room temperature under direct fluorescent lighting. The hatching, spinning, and molting process took 10–15 days. If no larvae were observed after 3 weeks, the egg masses were discarded.

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Matings were scored as fertile if eggs were laid and they hatched. Sterile crosses produced no eggs or eggs that did not hatch. In 1981 we dissected females that did not lay eggs to check for spermatophore transfer. Proportions of fertile matings were compared among all categories by χ^2 tests.

RESULTS

Moths collected as larvae from host trees of the same species did not differ significantly in frequency of fertile matings (Table 1) from moths collected as larvae from different host tree species. An average of 60% ($n = 248$) of the crosses produced hatching eggs.

Moths from different populations were more incompatible than moths from the same population in 1980. Sixty-five percent of the crosses involving individuals from the same population were fertile, while only 52% of the inter-population crosses were fertile ($n = 248$, $\chi^2 = 4.56$, $P < 0.05$).

In 1981, crosses from only two populations were compared (Table 2). Although there was variability in the frequency of fertile matings, ranging from 52% to 68%, intra- and inter-population matings were not significantly different (Table 2). The biggest difference was between the crosses MN x NH and NH x MN, 68% and 52%, respectively.

DISCUSSION

Spruce budworm populations differ in frequencies of morphological (Harvey 1977; Stehr 1955, 1959; Lorimer 1982), physiological (Stock and Robertson 1980, Campbell 1962), and electrophoretically detectable (Willhite 1979) traits. Differences among populations may represent selection by and adaptation to local forest conditions. For example, chemical composition of host species from the midwestern and eastern U.S. differ markedly (Wilkinson et al. 1971, Zavarin and Snajberk 1972), and surviving larvae from these localities would have utilized different diets of host tissue. However, in this study, matings of moths originating from spruce and fir within a population were as fertile as matings of moths from the same host species, even though balsam fir and white spruce are chemically distinct.

The reduction in fertile matings among insects collected from different populations in 1980 was not repeatable in 1981. Perhaps the two populations chosen for the experiment in 1981 were more compatible than other combinations of the four populations studied in 1980.

Table 1. Fertile matings among moths collected as larvae from balsam fir and white spruce in 1980.

Cross ($\text{♀} \times \text{♂}$)	n	Fertile matings (%)
spruce \times spruce	59	58
fir \times fir	52	58
Total, same species	111	58
spruce \times fir	89	61
fir \times spruce	48	62
Total, different species	137	61

Table 2. Fertile matings among moths collected from Minnesota (MN) and New Hampshire (NH) in 1981.

Cross (♀ × ♂)	n	Matings (%)	Fertile matings (%)
MN × MN	36	72	53
NH × NH	55	69	60
Total, intra-population	91	70	58
MN × NH	47	77	68
NH × MN	27	63	52
Total, inter-population	74	72	62

In summary, in one year we found a small reduction in reproductive compatibility among spruce budworm from different populations, measured by mating success in the laboratory.

ACKNOWLEDGMENTS

We thank Karen Hosfield for laboratory assistance and Drs. George Harvey and William Mattson for comments on an earlier draft. This study was partially funded by the Canada-United States Spruce Budworm Program (CANUSA-E).

LITERATURE CITED

- Campbell, I. M. 1962. Reproductive capacity in the genus *Choristoneura* Led. (Lepidoptera: Tortricidae). I. Quantitative inheritance and genes as controllers of rates. Canadian J. Genet. Cytol. 4:272-288.
- Grisdale, D. 1970. An improved laboratory method for rearing large numbers of spruce budworm, *Choristoneura fumiferana* (Lepidoptera: Tortricidae). Canadian Entomol. 102:1111-1117.
- Harvey, G. T. 1977. Mean weight and rearing performance of successive egg clusters of eastern spruce budworm (Lepidoptera: Tortricidae). Canadian Entomol. 109:487-496.
- Kidwell, M. G., J. F. Kidwell, and J. A. Sved. 1977. Hybrid dysgenesis in *Drosophila melanogaster*: A syndrome of aberrant traits including mutation, sterility and male recombination. Genetics 86:813-833.
- Laven, H. 1959. Speciation by cytoplasmic isolation in the *Culex pipiens* complex. Cold Spr. Harb. Symp. Quant. Biol. 24:166-173.
- Lorimer, N. 1982. Morphological variation by population, host, and sex in spruce budworm. Environ. Entomol. 11:493-496.
- McMorran, A. 1965. A synthetic diet for the spruce budworm, *Choristoneura fumiferana* (Clem.) (Lepidoptera: Tortricidae). Canadian Entomol. 97:58-62.
- Oliver, C. G. 1979. Genetic differentiation and hybrid viability within and between some Lepidoptera species. Amer. Natur. 114:681-694.
- Robinson, A. S., and M. D. Proverbs. 1973. Hybridization between geographical races of the codling moth (Lepidoptera: Olethreutidae). Canadian Entomol. 105:289-290.
- Stehr, G. 1955. Brown female—a sex-linked and sex-limited character in the spruce budworm. J. Hered. 46:263-266.
- _____. 1959. Hemolymph polymorphism in a moth and the nature of sex-controlled inheritance. Evolution 13:537-560.

- Stock, M. W., and J. L. Robertson. 1980. Inter- and intraspecific variation in selected *Choristoneura* species (Lepidoptera: Tortricidae): A toxicological and genetic survey. *Canadian Entomol.* 112:1019-1027.
- Willhite, E. A. 1979. Genetics of outbreaking western spruce budworm, *Choristoneura occidentalis* Freeman (Lepidoptera: Tortricidae), populations in Idaho and Montana. M.S. thesis, Univ. Idaho.
- Wilkinson, R. C., J. W. Hanover, and R. H. Flake. 1971. Genetic variation in monoterpene composition of white spruce. *For. Sci.* 17:83-90.
- Zavarin, E., and K. Snajberk. 1972. Geographical variability of monoterpenes from *Abies balsamea* and *A. fraseri*. *Phytochemistry* 11:1407-1421.