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Comparative Toxicity of Acephate, Diflubenzuron, and Malathion to Larvae of the Larch Casebearer, *Coleophora laricella* (Lepidoptera: Coleophoridae) and Adults of Its Parasites, *Chrysocharis laricinellae*[1] and *Dicladocerus nearcticus*[1,2]

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ABSTRACT

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Fourth-instar larch casebearer, *Coleophora laricella* (Hübner), was significantly less susceptible to acephate and malathion than were adults of its parasites, *Chrysocharis laricinellae* (Ratz.) and *Dicladocerus nearcticus* Yoshimoto ($P < 0.01$). The parasites were more tolerant ($P < 0.01$) than the hosts to diflubenzuron. Malathion was equally toxic to both parasite species. *D. nearcticus* appeared to be the more tolerant of the parasites to both acephate and diflubenzuron.

Larch casebearer, *Coleophora laricella* (Hbn.), a pest of western larch, *Larix occidentalis* Nutt., is currently the object of a biological control program throughout the range of larch in Idaho, Montana, Washington, and Oregon. Parasites introduced into the area have included seven European and Japanese species (Denton 1972, Ryan and Denton 1973, Bousfield et al. 1974, Ryan et al. 1975, 1977). Two species, *Agathis pumila* (Ratz.) and *Chrysocharis laricinellae* (Ratz.), are now well established; a third, *Elachertus argissa* (Walk.), has been recovered in limited numbers. At times, the native species, *Spilochalcis albifrons* (Walsh) and *Dicladocerus nearcticus* Yshm., reach moderate parasitization levels (Bousfield and Lood 1973).

Chemical control of the casebearer has been attempted. Although laboratory (Lyon and May 1970, Page et al. 1980) and field tests (Denton and Tunnock 1968, Washburn et al. 1977, Hard et al. 1979) were done, little effort was directed at assessing the effects of chemicals on the parasites of this pest. Exceptions are the work of Skuhravy (1973, 1976) with juvenoids and Hard et al. (1979) with Orthene. Neither investigator, however, quantified the effects of the chemicals on parasites. *C. laricinellae* and *D. nearcticus*, which are currently the most abundant species attacking the casebearing stage of their host, would inadvertently be treated as adults during chemical control. *C. laricinellae* is present in the adult stage during both spring and fall casebearing periods (Ryan 1980). *D. nearcticus* is also present as adults during the spring period, but it is not known whether adults of that species are present during the fall casebearing period as well.

This paper reports the results of laboratory tests to determine the percent mortality of these parasites, as adults, resulting from dosages of acephate, diflubenzuron, and malathion that produced 50 to 90% mortality against casebearing larvae of their host.

Materials and Methods

Insects

Overwintering 3rd-instar larch casebearers from a field population in eastern Oregon were reactivated by being placed in containers (Lyon and May 1970) with cut larch foliage at 20°C under a long-day photoperiod (LD 18:6) (Ryan 1979).

Adults emerging from a laboratory culture of *C. laricinellae* or from field-collected material for *D. nearcticus* were shipped from Corvallis, Oreg., to Berkeley, Calif., in April, May, and June 1980. The parasites were transferred from their shipping containers (large vials containing excelsior impregnated with a 1:1 solution of honey and water) to 473-ml cardboard holding cages (Ryan 1980) until needed for testing.

Trees

Bareroot western larch seedlings were potted in 1-gal (ca. 3.8-liter) containers during winter 1979–1980. A long-day photoperiod was used to induce foliation.

Chemicals

Field formulations of acephate (Orthene 75S), technical malathion, and the insect growth regulator, diflubenzuron (Dimilin 25WP), were freshly prepared as wt/vol concentrations of the active ingredient for each replication of the test. Aniline blue dye (for acephate and diflubenzuron) and oil red dye (for malathion) were added at 1.0% to colorimetrically confirm deposit estimates (Rayner 1956).

Bioassay: Larch Casebearer

To determine insecticide dosages for testing against the parasites, we first assessed the LD_{50} and LD_{90} dosages of three candidate chemicals to 4th-instar casebearing larvae established on potted larch trees. Insecticide dosages were applied to each treatment group (20 4th-instar casebearing larvae per seedling) with the Moellman spray chamber

[1]Hymenoptera: Eulophidae.
[2]This publication reports research involving pesticides. It does not contain recommendations for their uses nor does it imply that any uses discussed here have been registered. All uses of pesticides must be registered by appropriate State or Federal Agencies before they can be recommended. Received for publication 28 May 1981.
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(Robertson et al. 1979) during a total exposure of 60 sec. Parameters of spray application were: 0.25-ml delivery volume expelled through the nozzle at 704 g/cm^2 pressure and an average spray deposit volume of 9.35 liters per ha. The LD_{50}s and LD_{90}s were determined by spraying three trees with each of eight dosages. Control trees were sprayed with dye and water.

Alternating with tree sprays, dye deposit samples were taken on 9-cm-diameter filter papers. The dye was eluted and quantified in a Spectronic 20 colorimeter, and standard curves were used to estimate average dosage of insecticide deposited.

Mortality was observed at 7 days posttreatment for acephate and malathion. The insecticidal action of diflubenzuron is slower than conventional chemicals; therefore, the bioassay was extended to 21 days. The data were analyzed with the probit option of the computer program, POLO (Russell et al. 1977).

Parasites

C. laricinellae and *D. nearcticus* adults were anesthetized with CO_2, transferred to glass petri dish bottoms (100 by 20 mm) lined with filter paper, and exposed for 60 sec to the LD_{50} and LD_{90} casebearer dosages in the Moellman spray chamber. A minimum of 10 adults were sprayed for each dosage and replication. The parasites were transferred to holding cages with food (honey and water), and mortality was observed daily for 7 days. Control groups were untreated.

Proportions of parasites killed by the respective LD_{50} and LD_{90} casebearer dosages were corrected for control mortality by Abbott's formula before computing the binomial confidence bands for the proportions (Steel and Torrie 1960). The confidence limits were used to test the two-tailed hypothesis that parasite mortality was equal to host mortality ($P = 0.01$).

Results and Discussion

A comparison of the LD_{50}s indicates that acephate (6.1 g/ha) was 71 times more toxic than diflubenzuron (433 g/ha) and 3 times more toxic than malathion to 4th-instar casebearers. Malathion was not tested against this casebearer population, but was tested against an earlier population (M. Page, unpublished data), at which time it was found to have an LD_{50} of 17.6 g/ha. Malathion appears to be 24 times more toxic than diflubenzuron. The LD_{90} for acephate was 105 g/ha. Because of formulation difficulties, the highest concentration of diflubenzuron (726 g/ha) that could be applied in a homogeneous suspension resulted in only 63% mortality. Control mortalities were: acephate, 27%, and diflubenzuron, 23%.

Adults of *C. laricinellae* and *D. nearcticus* were significantly more susceptible ($P < 0.01$) than were 4th-instar larch casebearers to acephate and malathion (Table 1). At the LD_{50} dosage, acephate killed 97% of *C. laricinellae* and 80% of *D. nearcticus* adults. Malathion killed 83% of the adults of both species exposed to the estimated LD_{50}. The parasites were more tolerant than the hosts to diflubenzuron ($P < 0.01$). Insect growth regulators as a class of chemicals are normally nontoxic to adult insects. However, 26% of *C. laricinellae* and 10% of *D. nearcticus* adults were killed by the LD_{50} dosage.

Local suppression of casebearers is possible with a spring application of malathion (Denton and Tunnock 1968), or a fall application of acephate (Hard et al. 1979). Our results suggest that field treatment with either of these would kill a higher proportion of adults of the two parasites, *C. laricinellae* and *D. nearcticus,* than of the target insect and may be counterproductive to long-term management of larch casebearer populations.

Greater tolerance of adult parasites to diflubenzuron, however, may be desirable for population management of casebearers. Skuhravy (1973) showed a significant reduction in the next casebearer population after a 92 to 96% control of 4th-instar casebearers with an insect growth regulator. He was unable, however, to quantify the effects of the chemical on the host parasites. These facts and our

Table 1.–Comparative effects of acephate, diflubenzuron, and malathion to casebearing host larvae and to adult *C. laricinellae* and *D. nearcticus* in the laboratory

Chemical	Dosage for 4th-instar host (g/ha)	7-day parasite mortality: *C. laricinellae* *n*	*C. laricinellae* %	*D. nearcticus* *n*	*D. nearcticus* %
Acephate[a]	Control	78	9.0	22	0
LD_{50}	6.1	224	96.9	60	80.0
LD_{90}	105.0	168	100.0	–	–
Dimilin[a]	Control	37	10.8	20	5.0
LD_{50}	433.0	183	26.2	60	10.0
LD_{63}	726.0[b]	40	57.5	–	–
Malathion[a]	Control	52	11.5	10	0
LD_{50}	17.6[c]	168	83.3	30	83.3[d]

[a]Mortality obtained in the host control groups was 27% for acephate, 23% for dimilin, and 14% for malathion.
[b]Formulation limitations of the 25% WP precluded the ascertainment of an LD_{90} dosage.
[c]Dosage used in an earlier study (M. Page, unpublished data).
[d]Only one replication.

laboratory results suggest that an effective chitin inhibitor may be the population control tool to satisfy both biological and chemical control specialists, i.e., those persons involved in integrated pest management.

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