

pupal development, could possibly play an important role in controlling the levels of spruce budworm populations. It is hoped that further field trials will establish the efficacy of *N. fumiferanae* as a biological control agent of the spruce budworm.—G. G. Wilson and W. J. Kaupp, Insect Pathology Research Institute, Sault Ste. Marie, Ont.

Effect of Insect Growth Regulators on the Survival of Douglas-fir Beetle Progeny.—Insect growth regulators (IGR) have shown promise at the operational level against mosquitoes and at the experimental level, under field conditions against insect pests of livestock and some forest defoliators (Staal, Annu. Rev. Entomol. 20:417-460, 1975). Scolytid and curculionid coleopterons were, however, considered to be insensitive to such materials (Slama, Annu. Rev. Biochem. 40:1079-1102, 1971). This report describes the effects of a variety of IGR, particularly ZR-515 (Zeocon Corp., Palo Alto, Calif.), on the development and mortality of Douglas-fir beetle broods [*Dendroctonus pseudotsugae* Hopk.].

For this study, the beetles were collected from the field after they had overwintered. The host material was presented to the beetles in the form of a 150-mm-dia bark and phloem slab in a plastic petri dish. The slab was clamped in the petri dish so that the phloem was held firmly against the bottom (Beanlands, Can. Entomol. 98:412-414, 1966). A pair of beetles was introduced into each petri dish. Dishes were kept at room temperature, and gallery length, number of eggs, number of larvae, and mortality of eggs and larvae were recorded periodically.

In preliminary tests, the following compounds at various doses up to 100 µg/insect were used by topical application to parent adults: (1) 4-ethylphenyl-6,7-epoxygeranyl ether (Pallos et al., Nature 232:486-487, 1971); (2) nonepoxy form of #1; (3) methylenedioxyphenyl-6,7-epoxygeranyl ether; (4) ethyl branches form of #3 at carbon 7 in the chain; (5) p-chlorophenyl-7-ethyl-6,7-epoxygeranyl ether (Bowers, Science 164:323-325, 1969); (6) methyl ester of cis-dihydro(+)-todomastic acid. The last compound occurs as free acid in some Douglas-fir trees and has shown morphogenetic activity against *Tenebrio molitor* L. (Rogers et al. Can. J. Chem. 52:1192-1199, 1974); (7) ZR-512; (8) ZR-515; (9) ZR-619; (10) ZR-777.

Only ZR-515 reduced hatching and affected larval development; consequently, this material only was used in further experiments, and was applied as follows: to the abdominal venter of parent adults at a rate of 50 µg/insect, or to the phloem as a 0.2% water emulsion to drip point. Untreated adults on phloem sprayed with water were used as controls. The dishes were examined every 2-3 days to record gallery length, numbers of eggs and larvae, and larval mortality.

The data (Table 1) were subjected to the t-test. Application of ZR-515 slightly increased egg production in beetles but the difference was not significant ($p > 0.1$). Gallery lengths showed no noticeable differences. Application of IGR to the phloem reduced the percentage hatch significantly ($p > 0.05$). However, topical treatment was not effective ($p > 0.1$). The exposure of the larvae to the treated phloem produced significantly high larval mortality ($p > 0.01$), compared with the check and topical treatment. Thus, the results reveal that the IGR is not transmitted to the egg and larval stages by the adults, which degrade it promptly, but that it must be continually available to the progeny to produce its effect. The IGR as used here appears to cause larval mortality, perhaps by blocking larval maturation. (See page 5).

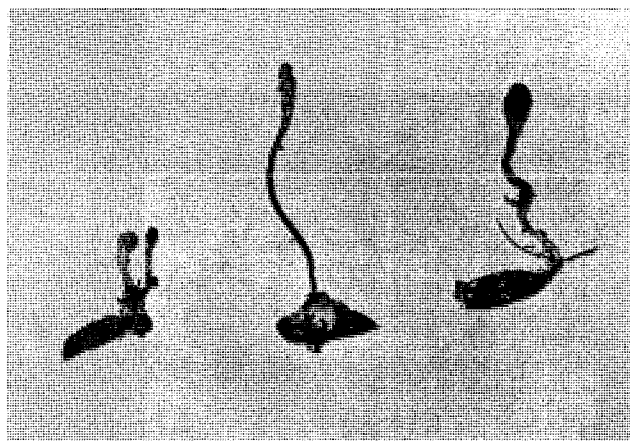
This report confirms Slama's contention (*op. cit.*, 1971) that bark beetles are generally insensitive to several IGR compounds. However, ZR-515 produced characteristic IGR-type results on Douglas-fir beetle progeny. As stated, ZR-515 must be applied to the host phloem to be effective and, since it is not systemic in action, its consideration for field use for

bark beetle control depends upon the development of practical means of delivering it to the phloem.—A. Ibaraki and T. S. Sahota, Pacific Forest Research Centre, Victoria, B.C.

Preliminary Tests with a Fungus to Control Insect Defoliators.—The fungus *Cordyceps militaris* (L.) Link, a natural control agent of the green-striped forest looper [*Melanolophia imitata* Wlk.], kills the insect in the pupal stage, thereby reducing its population. However, significant population control does not usually occur until the insect host, western hemlock [*Tsuga heterophylla* (Raf.) Sarg.], is severely defoliated. The possibility of artificially increasing parasitism with this fungus by spraying infestations of feeding late-instar loopers with a formulation of homogenized cultures was tested in the summer of 1970 in northern Vancouver Island, during a heavy infestation.

Mass cultures of *C. militaris* were made on 3% malt broth and incubated for 5-6 weeks at room temperature (Funk, Bi-mon. Res. Notes 29:25, 1973). The cultures were obtained from ascospores produced on a naturally-infected pupa of *Melanolophia*. Immediately before spraying, each fungus mat, consisting of hyphae and conidia, was homogenized in a Waring blender for 10 seconds and diluted with tap water (one mat from 500 ml broth was diluted to 2 litres). A mist blower was used to blow the suspension onto the infested trees; a check area was sprayed with water.

Four weeks after spraying, most loopers had pupated and 100% of 100 pupae dug from the duff were infected, as shown by the presence of fruiting bodies of *C. militaris* (Figure 1).



A few larvae, beaten from the foliage and caught on a sheet, were sluggish, discolored and partially necrotic. In the check area, only 30% of 62 pupae were infected. Sixty percent of a sample of 100 loopers, removed from the test area before spraying, pupated.

Similar tests were made on other species of Lepidoptera in succeeding years: the western hemlock looper [*Lambdina fiscellaria fiscellaria* Guen.] at Allouette Lake in 1971; the false hemlock looper [*Nepytia freemani* Monroe] at Port Renfrew in 1972, and the black-headed budworm [*Acleris gloverana* Powell] at Port Renfrew in 1972. In these tests, there was no indication of infection nor any reduction in numbers that could be attributed to the fungus.

The success in the infestation of *Melanolophia* on northern Vancouver Island was probably due to a cool, moist microclimate and the burrowing habit of the larvae prior to pupation in the duff, which would favor survival and growth of *C. militaris*. Further work is recommended in areas where favorable conditions exist.—S. Illytzyk and A. Funk, Pacific Forest Research Centre, Victoria, B.C.