inhibitory effects of the chemical on the fungi were in direct proportion to the concentration. These effects were much greater against the phytopathogen than against the entomogenous fungi.

The concentrations of the chemicals used in these tests were higher than those to which these fungi would normally be exposed. In crop sprays, they would be dispersed as discrete droplets over a wide surface area. Our tests subjected the fungi to conditions found in a spray tank. Still, the results indicate that entomogenous fungi can be quite tolerant of the pesticides chlorothalonil, demeton, and the newer insect growth regulators.

REFERENCES CITED

Hall, I. M., and P. H. Dunn. 1959. The effect of certain insecticides and fungicides on fungi pathogenic to the spotted alfalfa aphid. J. Econ. Entomol. 52: 28–9.

Jaques, R. P., and N. A. Patterson. 1962. Control of the apple sucker, *Psylla mali* Schmidb., by the fungus *Entomophthora sphaerosperma* Fresen. Can. Entomol. 94: 818–25.

Nanne, H. W., and E. B. Radcliffe. 1971. Green peach aphid populations on potatoes enhanced by fungicides. J. Econ. Entomol. 64: 1569–70.

Patch, E. M. 1907. The potato plant louse. Maine Agric. Exp. Stn. Bull. 147: 235–57.

Shands, W. A., I. M. Hall, and G. W. Simpson. 1962. Entomophthoraceous fungi attacking the potato aphid in northeastern Maine in 1960. J. Econ. Entomol. 55: 174–9.

Shands, W. A., G. W. Simpson, and I. M. Hall. 1963. Importance of entomogenous fungi in controlling aphids on potatoes in northeastern Maine. Maine Agric. Exp. Stn. Bull. T6. 42 pp.

Shands, W. A., G. W. Simpson, I. M. Hall, and C. C. Gordon. 1972. Further evaluation of entomogenous fungi as a biological control agent of aphid control in northeastern Maine. Life Sci. Agric. Maine Exp. Stn. Tech. Bull. 58. 32 pp.

Shands, W. A., S. G. Thompson, G. W. Simpson, and H. E. Wave. 1958. Preliminary studies of entomogenous fungi for the control of potato-infesting aphids in Maine. J. Econ. Entomol. 51: 184–6.

Soper, R. S., and T. A. Bryan. 1974. Mammalian safety of the aphid-attacking fungus *Entomophthora* nr. *thaxteriana*. Environ. Entomol. 3: 346–7.

Wilding, N. 1972. The effect of systemic fungicides on the aphid pathogen, *Cephalosporium aphidicola*. Plant Pathol. 21: 137–9.

Development of *Pityophthorus confertus*[1]

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Pityophthorus confertus Swaine (Coleoptera: Scolytidae) infests many species of pine throughout the West. It commonly occurs in *Pinus contorta, P. ponderosa,* and *P. jeffreyi;* in addition, it has been taken from *P. edulis, P. monophylla, P. attenuata, P. coulteri,* and *P. lambertiana.* Contrary to published accounts of *P. confertus* being taken from fir trees (Blackman 1928, Chamberlin 1958), it occurs only in the pines.[3]

Members of the genus *Pityophthorus,* generally regarded as secondary, infest weakened trees or weakened parts of trees. *P. confertus* is commonly found in lodgepole pines that are infested by the mountain pine beetle, *Dendroctonus ponderosae* Hopkins. Some *Pityophthorus* sp. are considered beneficial because they kill suppressed limbs, which hastens pruning, and kill severely suppressed trees, which provides more growing space for other trees. However, these beetles occasionally are damaging; Salman (1938) reported top killing of thrifty ponderosa pine by *P. confertus* and *P. confinis* Le Conte. Although *P. confertus* is common, little is known about its biology; therefore, these studies were conducted to obtain some basic biological information.

Methods

Billets infested by *P. confertus* were cut in July 1970 from the upper boles of lodgepole pines killed by the mountain pine beetle the previous August on the Cache (now part of the Caribou) National Forest near Paris, Idaho. Billets were stored in the laboratory at 2°C. About 6 months later, they were removed from cold storage and *P. confertus* was allowed to complete development and to emerge in cages. Green billets, cut in October, then were placed in cages and exposed to attack. After an exposure of 4 days, the newly infested billets were placed in constant temperature cabinets set at 25°C and 30°C.

Twice each week, ca. 50 insects, in all stages of brood development, were counted from billets stored at each temperature. Larvae were collected and head capsules were measured to the nearest 0.02 mm. Information on oviposition behavior was obtained only at the lower temperature by recording the number of egg galleries extending from each nuptial chamber, the number of eggs laid per cm of gallery, and the length of individual galleries.

Rate of development was used to compare the response of the beetle to the 2 temperatures. Values assigned to the stages were (1) eggs, (2) first instar, (3) second instar, (4) pupa, and (5) adult. By using the values for stages present on the sample dates, development was correlated with time for each temperature.

Results and Discussion

The *P. confertus* male makes a nuptial chamber in the inner bark. Then, several females enter the chamber, mate, and construct egg galleries leading from the nuptial chamber. The number of galleries extending from nuptial chambers averaged 2.2 ($n = 11$; SD = 0.87). Seventeen days after billets were exposed to attack, the average length was 4.0 cm ($n = 11$; SD = 1.8) for all galleries. Apparently most galleries were completed because almost all females had abandoned them.

Eggs were laid in niches cut into the sides of galleries.

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[2] The first 2 authors conducted Science Fair projects on *Pityophthorus confertus* while students at North Ogden Junior High School. The 3rd author is Entomologist, USDA Forest Service, Intermountain Forest and Range Exper. Stn., Ogden, UT 84401.

[3] Letter dated May 4, 1973, from Stephen L. Wood, Dept. of Zool., Brigham Young Univ., Provo, Utah.

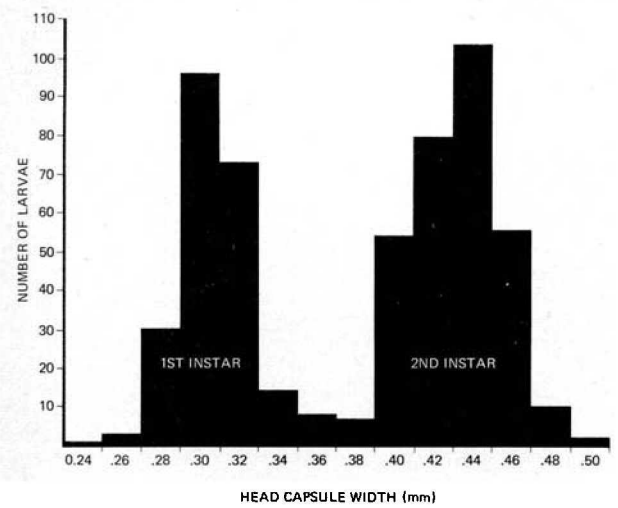

FIG. 1.—Distribution of larval head capsule measurements of *Pityophthorus confertus*. Larvae reared at 25° and 30°C were combined.

Niches were spaced an average 2.7 mm apart ($n = 69$; SD = 1.0). *P. confertus* oviposited an average of 3.7 eggs per cm of gallery ($n = 46$; SD = 1.8). Eggs were most abundant (average 5.4, range 0–8) in the 4th cm of gallery.

Only 2 larval instars were apparent from head capsule measurements (Fig. 1). Head capsules of larvae reared at the 2 temperatures differed significantly (*t-test*) at the 0.05 level for first instars (mean 25°C = 0.304 mm, SD = 0.017, $n = 131$; mean at 30°C = 0.310 mm, SD = 0.023, $n = 98$) and at the 0.001 level for 2nd instars (mean at 25°C = 0.439 mm, SD = 0.021, $n = 150$; mean at 30°C = 0.424 mm, SD = 0.023, $n = 166$). Because of the large number of observations, we were able to detect small, but consistent, differences in head capsule widths. However, the differences were extremely small and were not consistent within temperature; first instars were smaller at 25°C than at 30°C, but 2nd instars were larger. No explanation for these differences is offered.

Brood held at 25°C required ca. 6 days longer to complete development than brood held at 30°C. Because the difference in development for any given length of time is ca. 6 days longer at 25°C than at 30°C, slopes of regression lines are not significantly different. The difference appears to be primarily related to rate of embryogenesis. Data were not obtained on rate of embryogenesis. Once the egg hatches, development proceeds at about the same rate for the 2 temperatures. The similar rates of development after hatching also indicate that development probably would not increase much at temperatures exceeding 25°C. Regression statistics at 25°C are $\hat{Y} = 0.7 + 0.075x$, $r^2 = 0.75$, $s_{y.x} = 0.59$; and at 30°C are $\hat{Y} = 1.23 + 0.073x$, $r^2 = 0.71$, $s_{y.x} = 0.61$, where $\hat{Y}$ = expected development and x = number of days. Development from time parent females infested the billets until the population consisted almost entirely of brood adults took about 52–58 days. The sex ratio (females to males) was 1.07:1 ($n = 120$) at 25°C and 0.85:1 ($n = 202$) at 30°C. The sexes can be distinguished by the denser and longer hairs on the frons of the female, a characteristic reported for several species of *Pityophthorus* (Blackman 1928).

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REFERENCES CITED

Blackman, M. W. 1928. The genus *Pityophthorus* Eichh. in North America. N. Y. State Univ. Coll. For. Syracuse Univ. Tech. Publ. 25: 1–159.

Chamberlin, W. J. 1958. The Scolytoidea of the northwest, Oregon, Washington, Idaho, and British Columbia. Oreg. State Coll. Stud. Entomol. 2. 208 pp.

Salman, K. A. 1938. An unusual type of top kill of ponderosa pine. J. Econ. Entomol. 31: 613–6.

Dispersal of the Adult Cabbage Maggot, *Hylemya brassicae*[1,2]

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Information on the dispersal of the adult cabbage maggot, *Hylemya brassicae* (Bouché), is scanty. Based on the relative amount of damage caused to crops located at various points from the source of infestation, Read (1958) concluded that the flies travelled short distances, mainly in the downwind direction. Mowat and Coaker (1968) assessed dispersal of a wild, dieldrin-resistant strain of the cabbage maggot from a large farm by determining the distribution of resistant flies in the surrounding areas over 3 years. They showed the fly had little innate tendency to disperse. Hawkes (1972) estimated that the rate of dispersal of ^{32}P-marked cabbage maggot adults released in a cabbage plot ranged from 8–20 m per day. The farthest point at which marked flies were recaptured was 58.2 m from the release point. Hawkes concluded that in the presence of the hedge and host crops, *H. brassicae* dispersed only through "trivial" movements and that wind direction did not affect the direction of dispersal. Reviewing the studies at the National Vegetable Research Station, Wellesbourne, England, Coaker and Finch (1971) suggested populations in brassica crops more than 800 m apart would be unlikely to intermix during the 2–3-week period of adult survival.

[1] Diptera: Anthomyiidae.

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