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SEASONAL ACTIVITY OF ICHNEUMONID PUPAL PARASITOIDS OF *OPEROPHTERA* SPP. (LEPIDOPTERA:GEOMETRIDAE)

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ABSTRACT

Field placement of cocoons of *Operophtera* spp. was used to determine the timing of attack by pupal parasitoids of the winter moth, *Operophtera brumata* (L.), and the Bruce spanworm, *O. bruceata* (Hulst). *Coccygomimus hesperus* Tow. & Tow., the most abundant parasitoid recovered, attacked *Operophtera* pupae from early June until the end of August. At least two generations of *C. hesperus* occur each season. *Buathra dorsicarinata* (Pratt) was not recovered in numbers large enough to determine its timing of attack and no pupae parasitized by *Cratichneumon* sp. were recovered.

INTRODUCTION

Three native species of Ichneumonidae, *Coccygomimus hesperus* Tow. & Tow., *Buathra dorsicarinata* (Pratt) and an undescribed species of *Cratichneumon* are known to attack pupae of the introduced winter moth, *Operophtera brumata* (L.), and the native Bruce spanworm, *O. bruceata* (Hulst), on southern Vancouver Island (Humble in press). Over their range both *C. hesperus* and *B. dorsicarinata* have long flight seasons; the former is active from mid-May to late Dec., and the latter from mid-May to late Aug. (Townes and Townes 1960, 1962). In the Victoria area, the flight season for both species begins in mid-May. *Buathra dorsicarinata* flies until early Aug. (Humble in press), and *C. hesperus* until late Aug. (Humble unpub. data). The range and flight season of *Cratichneumon* sp. are unknown.

The timing of attack by these parasitoids on *Operophtera* pupae is unknown. Both winter moth and Bruce spanworm larvae mature between late May and early June, drop to the ground and pupate in silken cocoons. Pupae are present from mid-June to mid-Nov., and adults begin to emerge in early Nov. Although *Operophtera* pupae are present, they may not be suitable as hosts throughout the flight seasons of the parasitoids, since increasing host age can reduce the suitability of a host for parasitoid development (Schultz and Kok 1979). This study was carried out to determine the timing of attack by the pupal parasitoids on *Operophtera* pupae.

MATERIALS AND METHODS

Operophtera pupae were obtained by beating mature larvae from willow, broad-leaf maple and Garry oak on the University of Victoria campus. The larvae were provided with a substrate of moistened sand:vermiculite:peat moss (2:1:1) in screen-covered 25.4 cm plastic plant pots for pupation. The pots were held indoors at 15°C and 70% RH. The substrate was periodically sprayed with a 1% solution of sodium proprionate to inhibit the growth of mould (Maybee and Wylie 1961). Cocoons were sieved from the substrate as needed for field placement.

Pupae were placed in the field in four-mesh wire cages similar to those used by Price (1970) to prevent predation by small mammals or birds. Five cages were placed along the margins of a small (0.12 ha) stand of heavily defoliated willows growing in association with arbutus, Douglas fir, broad-leaf maple and red-osier dogwood. A thick shrub layer of snowberry, salmonberry, thimbleberry, Pacific blackberry, ocean spray and *Rosa* spp. was present along the margins of the stand.

Five cocoons were placed on the surface of the ground in each of the cages at the beginning of each weekly sample interval from 10 June to 17 Sept., and each two-week interval from 17 Sept. to 15 Oct., 1982. No cocoons were placed in the cages from 2-10 Sept. At the end of each sample interval the cocoons in each of the cages were replaced with fresh cocoons and individually reared at 20°C and 70% RH. The emergence date was recorded for each adult parasitoid. Developmental time from egg to adult parasitoid at 20°C was estimated by setting the midpoint of field exposure as the date of parasitism.

Emerged parasitoids were identified with the keys provided in Townes and Townes (1960), and compared with reference specimens. All non-emerged pupae were dissected for evidence of parasitism in June 1983. Exuviae of final-instar larvae of hymenopterous parasitoids were mounted on microscope slides for identification following the procedure of Finlayson (1960) and identified using keys provided by Gillespie and Finlayson (1981) and Humble (in press).

Some cocoons used for field placement were found to contain dead *Operophtera* larvae or larval-pupal parasitoids (puparia of *Cyzenis* (Diptera:Tachinidae) or final-instar larvae of *Triclistus* or *Agrypon* (Hymenoptera: Ichneumonidae)). None of the pupal parasitoids recovered are known hyperparasites (Carlson 1979; Humble in press; Townes and Townes 1960, 1962), therefore, the number of cocoons present during each sample interval was corrected to exclude those cocoons containing larval/pupal parasitoids. The G-test for goodness of fit (Sokal and Rohlf 1981) was applied to determine if the proportion of pupae parasitized by *C. hesperus* differed significantly between sample intervals.

RESULTS

A total of 375 *Operophtera* cocoons were placed in the field and all but five of the cocoons were recovered. The losses were probably due to predation by Carabidae. Twenty-three of the non-emerged cocoons contained the remains of dead host larvae or larval-pupal parasitoids.

Thirty-four of the pupae were parasitized by *C. hesperus* and two were parasitized by *B. dorsicarinata*. No pupae parasitized by *Cratichneumon* sp. were recovered. The proportion of cocoons parasitized per sample interval by the two species is shown in Fig. 1. *Coccygomimus hesperus* attacked *Operophtera* pupae from early June through to the end of Aug., while *B. dorsicarinata* was recovered only during the 12-19 Aug. sample interval.

The proportion of pupae parasitized by *C. hesperus* differed significantly between sample intervals ($0.01 < P < 0.025$). The highest level of parasitism by *C. hesperus* occurred 2.5 to 3 weeks after the *Operophtera* larvae had spun down from the willows to pupate. A second smaller increase in the level of parasitism occurred near the end of the field activity of *C. hesperus* (Fig. 1).

Twelve male and twenty female *C. hesperus* emerged. The mean developmental times and 95% confidence limits for male and female *C. hesperus* at 20°C were 24.2 ± 2.9 days and 26.8 ± 1.9 days respectively.

DISCUSSION

Coccygomimus hesperus attacked *Operophtera* pupae for three months following host pupation. Both the bimodal distribution of parasitism by *C. hesperus* over time and its short developmental time show that at least two generations occur during its flight season. Similarly, winter moth pupae in

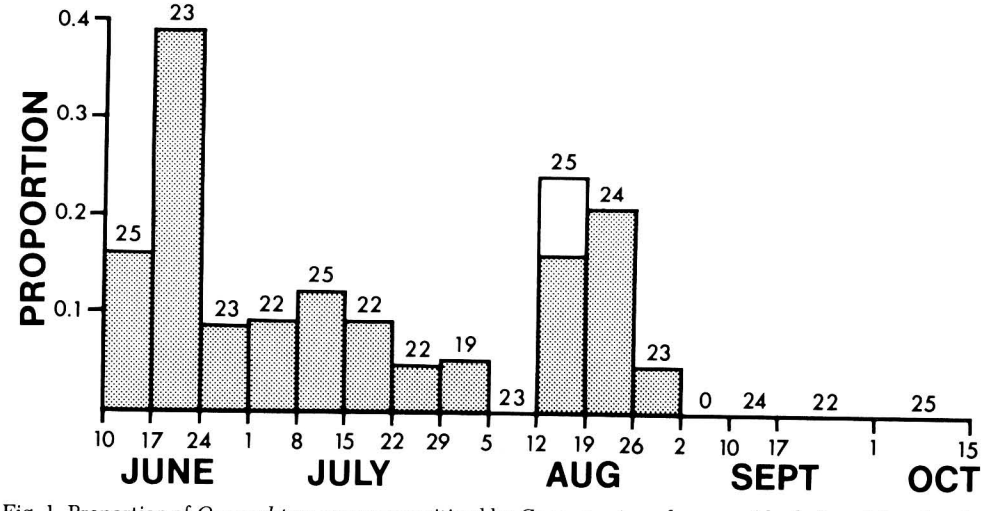

Fig. 1. Proportion of *Operophtera* pupae parasitized by *Coccygomimus hesperus* (shaded) and *Buathra dorsicarinata* (unshaded) during each sample interval. Sample size given for each interval is the number of cocoons containing *Operophtera* pupae or pupal parasitoids.

Europe were attacked by up to three generations of *C. contemplator* (Mueller) (Sechser 1970).

C. hesperus parasitized about 1.2% of the *Operophtera* pupae recovered from soil samples taken after the flight seasons of the pupal parasitoids had ended (Humble in press). However, because more than one generation of *C. hesperus* occurs, sampling at the end of the season only would underestimate the frequency of attack by this species.

Recovery of only two pupae parasitized by *B. dorsicarinata* with cocoon plants was surprising, as it was the most abundant parasitoid of *Operophtera* pupae recovered from soil samples during the winter of 1980-81 (Humble in press). The cocoon-plant recoveries indicate a short period of attack in mid-Aug. However, both its long flight season and abundance in previous years suggest that the cocoon-plants may not have sampled its field activity adequately.

Although *Operophtera* pupae parasitized by *Cratichneumon* sp. had previously been recovered from soil samples taken at the same site used in this study (Humble in press), *Cratichneumon* sp. was not recovered with cocoon plants. Most members of the subfamily to which *Cratichneumon* belongs (Ichneumoninae) oviposit into the host larva, but some species, such as *Cratichneumon nigritarius* (F.) oviposit only into newly-formed pupae of the host (Heinrich 1960). Since *Cratichneumon* sp. has not been reared from pupae of *Operophtera* spp. collected as mature larvae (Gillespie and Finlayson 1981), it seems likely that it also needs newly-formed pupae for oviposition. The *Operophtera* pupae used for cocoon plants were not placed in the field until well after pupation had occurred in order to avoid damaging the unsclerotized, newly-formed pupae during sorting and handling. Thus host material suitable for oviposition may not have been available to females of *Cratichneumon* sp.

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