3. Biological Control

COLPOCLYPEUS FLORUS PARASITISM OF LEAFROLLERS

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In recent years, the acreage on which mating disruption for control of codling moth is implemented has increased dramatically. Two species of leafroller, *Pandemis pyrusana* (PLR) and *Choristoneura rosaceana* (OBLR), have caused the highest level of crop loss, in many cases exceeding that of codling moth, in apple orchards using codling moth mating disruption in Washington. Any pheromone-based codling moth management program must account for and plan to mitigate leafroller populations. While *Bacillus thuringiensis*, Lorsban, and Penncap-M are useful at present, continued reliance on them may result in rapid development of resistance. An alternative to using insecticides is biological control. Currently we are conducting research on several parasitoids which attack leafrollers and are attempting to achieve biological control using conservation of native parasitoids, classical biological control and augmentative releases.

Rearing of parasites: Rearing of *C. florus* was improved to 55-65% in 1996 from the 5-10% efficiency observed in 1995 with nearly 15,000 wasps produced per week at peak rearing in July. However, although numerous techniques to facilitate mass rearing were attempted, none were successful so rearing large numbers for augmentative releases was laborious and expensive. About 52,000 females were released in 1996 at a labor cost of $13,300 (rearing supplies and host rearing not included). Techniques attempted for mass rearing included using larger multi-host containers with several *C. florus* as well as large multi-cell grids with a single leafroller and *C. florus* per cell. No parasitism was observed in the large containers, and only 8% parasitism was observed in the multi-cell container. The use of plastic straws as artificial retreats to improve parasitoid efficiency was also tried with similar results. There are several behavioral characteristics of the *C. florus* - host interaction which make mass rearing difficult. First, *C. florus* stings the host and then waits while the host undergoes a behavioral change and starts spinning large quantities of silk; thus, the parasitoid may remain with the host for from 18 h to about 3 d. The extended period that the female remains with the host precludes many of the exposure techniques used in mass rearing other species of parasitoid.

Alternate hosts for *C. florus*: In 1966 studies were begun by a graduate student, Chris Nobbs, to locate potential alternate hosts for overwintering and summer population growth by *C. florus*. Several leafrollers were discovered in alfalfa and weeds in central Washington. *Clepsis pallorana*, a leafroller common in alfalfa in the Columbia Basin, was collected, a colony was established and preliminary studies conducted to determine its suitability as a host of *C. florus*. Laboratory evaluations have indicated that it is as suitable as OBLR (Table 1). Preliminary field cage studies were conducted to determine if *C. florus* will parasitize *C. pallorana* in alfalfa in the presence of OBLR infested apple trees. Results indicate that while OBLR in apples appear preferred, *C. pallorana* was attacked successfully in alfalfa. Two other as yet unidentified leafrollers were collected from alfalfa and weeds in the Leavenworth and Chelan areas. One of these appeared to enter a summer aestivation state, and evaluations were not completed against these potential hosts although we hope to examine at least one of them in 1997.

Table 1. Comparison of *Clepsis pallorana* and OBLR as hosts for *C. florus*.

Host species	Percent attacked	% Producing progeny	# Progeny produced	Sex ratio (% male)	Development time (days)	Parasitism in field cages
Clepsis pallorana	92.0	77.5	14.0	8.1	14.3	16.5
OBLR	96.0	60.0	11.0	5.7	14.3	85.7

Diapause induction in *C. florus*: A study was conducted to determine the critical daylength and temperatures which predispose *C. florus* to enter diapause. Freshly hatched *C. florus* were placed at one of 8 temperatures and 4 daylengths. Development was monitored and diapausing larvae noted. Results indicated that diapause was primarily induced by exposure to very cool temperatures (below about 13°C) although there was an interaction with daylength with individuals entering diapause at slightly warmer temperatures when the daylength was short.

Field releases of *C. florus*: Augmentative releases were made at 8 locations in the spring of 1996 and 8 locations against the summer leafroller generation. Release rates were set at either 1000 or 5000 per acre (except one location in summer with 500 and 2500/acre) with plot size ranging from a tenth of an acre to one acre. Changes in leafroller phenology due to a cool spring and extensive use of Bts made timing of releases extremely difficult; probably half of releases were made before the leafrollers reached the appropriate stage. At several locations where Bts were used, evaluation was difficult because a large proportion of the leafrollers collected subsequently died from Bt intoxication (Appendix). At four release sites leafroller densities were too low to get an adequate evaluation, although parasitism at two of these sites was 100% in the release blocks. Despite the difficulties, several sites showed promise. Parasitism in Brewster and Milton-Freewater was good, and at Parker parasitism was higher than expected with an earlier than optimal release date. Also, after spring releases, *C. florus* was recovered from several other sites within the Parker areawide project, and we have hopes for establishment there. Releases were also made in Bellingham and Olympia in an attempt to establish *C. florus* west of the Cascade range as a control for both native and exotic leafrollers in apples.

Parasitoid survey: Surveys for parasitoids of leafrollers were conducted at all *C. florus* release locations as well as orchards in Mattawa, TFREC and Milton-Freewater, OR. As observed in 1995, the important parasitoids varied between locations and in 1996 were observed to contribute to significant mortality in two locations, although one location was different than in 1995. The most important parasitoid in the spring at some orchards was an *Enytis* sp. At one of these locations (Brewster) a significant amount of mortality was attributable to a previously undiscovered parasitoid species in addition to tachinids and *C. florus* which has been identified as a *Sympiesis* sp. *Sympiesis* appears to behave similarly to *C. florus* but is larger, and the females are darker with a metallic green thorax and black abdomen. This parasitoid was also recovered at three other locations [Bridgeport (SARE), Howard Flat-Areawide, and TFREC] in low numbers and may be an example of a parasitoid coming back as we reduce pesticide application in some areas. In 1996, tachinids caused significant mortality at Brewster (>80% parasitism of pupae) and at the Parker areawide site as well as The Dalles. In Milton-Freewater, parasitism was higher in wild and unsprayed sites than at commercial orchards. Parasitism at TFREC was again high in the second generation, approaching 100% leafroller mortality with high rates of parasitism by *C. florus* and *Apanteles* sp.