Life History of Chaetorellia succinea: Laboratory and Field Studies in North America

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Introduction: Yellow starthistle (YST), Centaurea solstitialis, is one of the most important invasive weeds in the Western U.S. (fig. 1). Several natural enemies were imported for biological control of YST in California. Many of these insects have been studied in Europe and in U.S. quarantines, however, the accidentally introduced fly Chaetorella succinea (fig. 2A & B) has not been adequately studied and little life history information is available despite its increasing impact on this weed. Understanding its developmental biology is important as it is currently not in synchrony with the target host plant (fig. 3). In this poster, we provide a summary of biological studies conducted both in the laboratory and in the field that were aimed at providing information on its phenology and development under California and Oregon field conditions.

Methods: Laboratory studies- Natural diapausing larvae were collected from multiple field sites in mid-winter and returned to the laboratory where they were placed in temperature and light controlled incubators (fig. 4 A & B). Five temperatures (10, 15, 20, 25 & 30 °C) were used in combination with two light conditions, long (15hr/d) and short (12 hr/d) light cycles. Since the larvae and pupae can not be seen inside of the seed heads or hybridraca (only emerging flies can be detected), additional larvae were dissected from the seed heads and hybridraca, and held naked within glass screw vials where they were monitored daily for pupation (naked larvae only) and adult emergence (all samples). Similar developmental studies were conducted on eggs, larvae and adults on living plants (fig. 5) to measure within-season population parameters, however, these results are not presented here.

Results: Laboratory studies- Post-diapause development of larvae and pupae took different amounts of time at the different incubation temperatures (fig. 7). These data were used to calculate both the mean and variance of the temperature-dependent developmental rate functions and to estimate a developmental base temperature (9 °C), that allowed a predictive model to be developed (fig. 8 A & B). Cumulative emergence curves for each temperature (fig. 9 A) show the overall effect of temperature on the combined overwintering larval and pupal development. Placement of these same data on a degree-day scale (base 9.0 °C), suggests that the model accurately describes the laboratory data. Similar results were obtained when the model was used to independently collected field trapping data (fig. 11).

Methods: Field studies- Emergence traps (fig. 6) were placed into the field just prior to the initiation of fly emergence at multiple field sites in California and Oregon. Traps were monitored frequently for insect emergence and counts were recorded for both male and female flies. In parallel with the collection of trap data, weekly sweepnet samples of fly abundance were collected along with detailed host plant samples and background environmental conditions (not presented here). Data was collected not only on C. succinea but also on Urophora sirunaseva, another important natural enemy of YST.

Results: Field studies- Extensive collections of both C. succinea and U. sirunaseva were achieved at all sites, however, both species were not always present at all locations. Chaetorella succinea was found to be most prevalent and emerged significantly earlier than U. sirunaseva. In both species, the males were the first to emerge, however, there was substantial overlap in timing of emergence across sex (fig. 10 A). Non-linear regression was used to estimate logistical patterns of cumulative emergence for both Julian days and degree days. When the analysis was controlled for both geographic location and trap placement within a site, differences in emergence times between males and females were statistically significant. Future models will need to separate the sexes and estimate local variability in emergence caused by microclimatic conditions. Likewise, adult longevity needs to be studied and incorporated into this evaluation.

Summary: A combination of laboratory and field studies on the developmental biology of Tephritid natural enemies of YST, have provided useful predictive models of fly emergence in the spring. This information is being linked with other data on the within-season biology to help develop management strategies for these natural enemies and to assist biological control scientists in making decisions about our ability to predict and potentially alter the synchrony of these agents using additional European germ plasm.