REPRODUCTIVE BIOLOGY AND PHYSIOLOGY OF FEMALE GLASSY-WINGED SHARPSHOOTERS: MORPHOLOGY AND VITELLOGENESIS CYCLES

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ABSTRACT

Female *Homalodisca coagulata* (Say) were collected from October 2001 to February 2005 from citrus at the University of California, Riverside, Agricultural Operations (UCR, Ag. Ops.). Between five and twenty females per sampling date were dissected, and each was assigned an ovarian rank: previtellogenic, vitellogenic, or postvitellogenic. Ovarian ranking was used to characterize *H. coagulata* reproductive activity. Results of these dissections revealed consistent annual patterns in the proportion of previtellogenic females present in this field population. These patterns indicate that there are two distinct generations annually, with an occasional third generation. A step-wise regression model of *H. coagulata* vitellogenesis cycles in southern California was developed, which makes it possible to predict the appearance of the subsequent generation based on previous observed peaks in oviposition activity.

INTRODUCTION

The glassy-winged sharpshooter (GWSS), *H. coagulata* (Say), is a serious pest of many tree and vine crops (Turner and Pollard 1959, Nielson 1968). The GWSS is of primary concern to California growers because of its capacity to vector the bacterium, *Xylella fastidiosa* (*Xf*), which causes vascular disease in a number of crops, including grapes, citrus and almonds, as well as landscape plants including oleander and mulberries (Meadows 2001, Hopkins 1989, Purcell and Hopkins 1996). An adult GWSS need only acquire *Xf* once while feeding on an infected plant to then become a vector of *Xf* for the remainder of its life (Frazier 1965, Purcell 1979, Severin 1949).

Little is known about the reproductive biology of the GWSS. It has been reported that GWSS has two generations per year in Southern California (Blua et al. 1999). Oviposition occurs in late winter to early spring, and again in mid-to-late summer. Adult females can live several months and lay their eggs side by side in groups of about 10, ranging from 1 to 27 (Turner and Pollard 1959). The greenish, sausage-shaped eggs are inserted into the leaf epidermis of the host plants.

Our research is focused on the reproductive morphology and physiology of the GWSS. We are examining the seasonal differences in female GWSS reproduction between summer and overwintering populations by studying oögenesis cycles. This knowledge is important in determining how GWSS might choose plant hosts in the landscape, which host plants are particularly good for GWSS ovarian development and why they are good, and finally how control measures might best be implemented based upon season and stage of reproductive development. Better knowledge of reproductive biology might also lead to better decision support including improved choices and timing of chemical or non-chemical approaches to GWSS control.

OBJECTIVES

1. Collect and prepare GWSS specimens for studying the morphology and anatomy of females.
2. Study and describe the sensory structures located on the female ovipositor.
3. Characterize the reproductive cycle of female GWSS in Riverside, CA.
4. Study the effects of location on female GWSS reproductive cycle.
5. Study the effect of host plant type on female GWSS fecundity.

RESULTS

Objectives 1 and 2 have been reported in prior symposia. The results presented here address objective 3 of our *H. coagulata* research.

Female and male GWSS were collected from October 2001 to February 2005. Samples were taken on monthly, bimonthly or weekly intervals. Dissections of female specimens collected from citrus hosts at UCR, Ag. Ops. have revealed repeated patterns related to the proportion of previtellogenic females in the field (Figure 1). Based on our dissections, a step-wise regression model was developed to predict the appearance of previtellogenic females based on previous reproductive activity. Dissections of female *H. coagulata* showed that there were two distinct peaks of previtellogenic females each year on citrus at UCR, Ag. Ops., with a third peak occurring in both December 2002 and December 2004 (Figure 1). We define a peak in the proportion of previtellogenic females as the beginning of a generation. A peak in the proportion of previtellogenic females also occurred in October 2001. Peaks in the proportion of previtellogenic females were subsequently observed in July, October, and December 2002, in June and October 2003, and in June, October, and December 2004. We ceased sampling in February 2005. Egg-laying activity was greatest in March and August 2002, March and July 2003, and April and July 2004. Egg-laying activity began increasing again in February 2005 when collections were finally terminated.

An inverse relationship between the peaks in the proportion of previtellogenic females and vitellogenic (egg-laying) females occurred in each year (Figure 2). In June, the proportion of vitellogenic females declined as the proportion of previtellogenic females increased. This decline was followed by a sharp increase in vitellogenic activity, resulting in the greatest annual levels of egg production, presumably from the first adult generation. In October, vitellogenic activity decreased, as the proportion of previtellogenic females increased, marking the appearance of the second generation. We also observed this period to coincide with the highest annual levels of egg parasitism. Vitellogenic activity remained low during the winter, until temperatures began to increase in spring. The annual cycle was then repeated, with the initiation of egg production beginning again in February.

Our dissections showed that egg laying activity occurred at some level throughout the year in the study population of *H. coagulata*. Egg-laying activity was not observed in November 2001, but some egg-laying was recorded in January 2002. The proportion of vitellogenic females remained between five and ten percent during winter 2002-2003. Egg-laying was not recorded in December 2003, but increased through the spring of 2004. The percentage of previtellogenic females remained at or above five percent during winter 2004-2005. The proportion of vitellogenic females present during winter appeared to be related to higher minimum temperatures in a given year. These results suggest that although vitellogenic activity decreases in December, there is not a clear reproductive diapause in the population of GWSS in Riverside, California. The majority of the female GWSS that overwinter are postvitellogenic, suggesting that they have matured and oviposited before entering a reproductive rest period.

CONCLUSIONS

In summary, the ovarian ranking method that we developed appears to be reliable for characterizing *H. coagulata* reproductive activity. Applying this method to our dissection data indicates that two to three generations occur each year in southern California citrus. Adult peak densities typically occur in June and October, and again in December in years when there occurs third generation. Periods of greatest egg production occur in March and July. A model based on our 3.5 year study of ovarian development predicts peaks in previtellogenic females based on oviposition activity four months previous to time *t*. Based on reproductive development times from our dissections and knowledge that most Cicadellidae begin egg production about seven days post-eclosion (Nielson 1968, Nielson and Toles 1968, Raine 1960, Stoner and Gustin 1967, Tonks 1960), we conclude that the interval from a peak in egg production to the appearance of the next generation of young adults is between three and four months. A stepwise regression-based model resulting from analysis of our dissection data indicates that vitellogenic activity, four months prior, has the most significant effect on the proportion of previtellogenic females at time *t*. A lag time of four months between peaks in vitellogenic females and peaks in previtellogenic females is consistent with our observation that *H. coagulata* have three generations per year, which correspond to three peaks in the proportion of previtellogenic females. The level of oviposition activity in February and June appears to be the most important in the model to predict the appearance of peaks in previtellogenic females. There is also a less significant effect of the amount of oviposition activity in the month of April.

Our study of the oögenesis cycle has defined the timing and number of generations of GWSS in California. Clarification of the timing of reproductive events including peak periods of egg production and mating activity, can improve the timing of control activities, particularly applications of insecticides with ovicidal action and releases of egg parasitoids.

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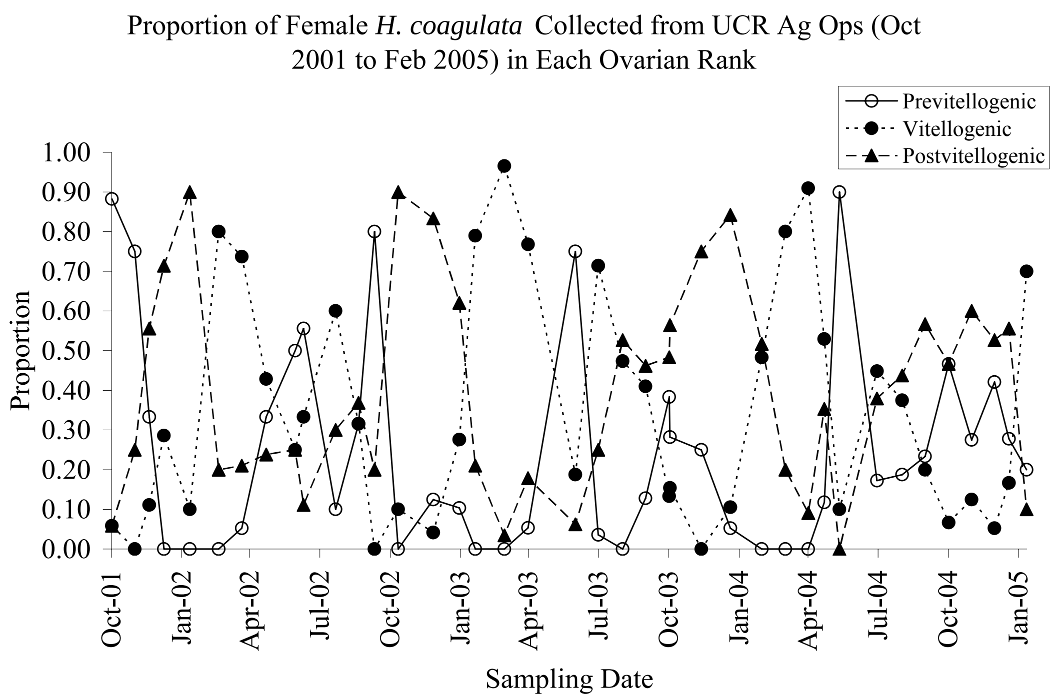

Figure 1. Proportion of female *H. coagulata* in each ovarian rank collected and dissected per month from citrus at the University of California, Riverside Agricultural Operations from October 2001 to February 2005. Previtellogenic females have not yet ovulated. Vitellogenic females have mature or maturing eggs in their ovarioles. Postvitellogenic females have ovulated and have a corpus luteum in their ovarioles.

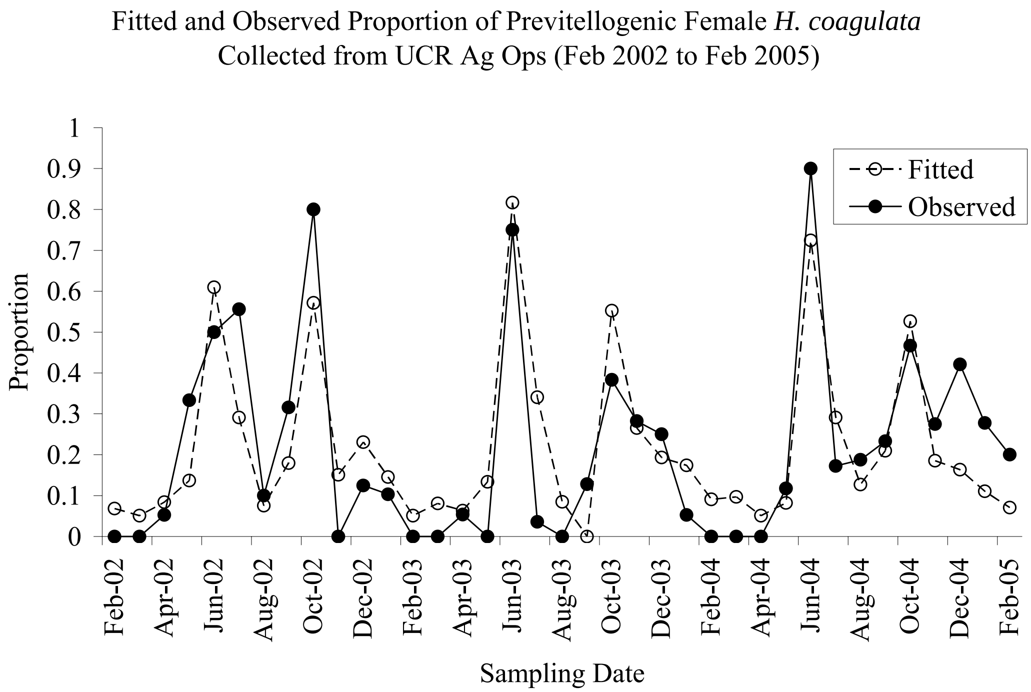

Figure 2. Step-wise regression model of the proportion of previtellogenic female *H. coagulata* per sample date: fitted values are indicated by the dashed line, and observed values are indicated by the solid line.

Section 3: Pathogen Biology and Ecology