ARE GLASSY-WINGED SHARPSHOOTER (GWSS) POPULATIONS REGULATED IN CALIFORNIA? LONG-TERM PHENOLOGICAL STUDIES FOR GWSS IN AN ORGANIC LEMON ORCHARD

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ABSTRACT
Glassy-winged sharpshooter (GWSS) population densities have been steadily declining over a 7.5 year period in organic lemons grown in an experimental study plot at UC Riverside Agricultural Operations. Peak adult GWSS populations in September 2009 were just 16% of those observed around August 2002. It is uncertain if egg parasitism, which has consistently averaged ~25% per year of GWSS egg masses is responsible for the observed decline. Density-dependent analyses of time series data are planned once data sets are large enough to provide greater insight into factors (i.e., parasitism [density-dependent mortality] or weather [density-independent mortality]) affecting GWSS population dynamics.

LAYPERSON SUMMARY
Glassy-winged sharpshooter (GWSS) populations in an organic lemon orchard in Riverside, southern California have been declining steadily since 2002. In September 2009, GWSS densities at their peak were only 16% of those observed at a similar peak in August 2002. This downward trend seems to have occurred in most of southern California but there are occasionally flare ups of GWSS as populations undergo localized outbreaks. The exact reasons for the significant decline in GWSS population densities is unknown, but could be due to the activity of natural enemies like egg parasitoids, or the weather, especially winter conditions, could be responsible. Consequently, the goal of this study is to figure out why GWSS populations have largely collapsed in southern California.

INTRODUCTION
Data collected from bi-weekly monitoring over the last 7.5 years from organic commercially-managed lemons at Agricultural Operations (Ag. Ops.), UC Riverside indicates that glassy-winged sharpshooter (GWSS) populations are declining steadily each year (**Figure 1**). It is uncertain whether parasitism of GWSS eggs by mymarid parasitoids is responsible for this downward population trend (**Figure 2**). In California, there is a guild of natural enemies attacking GWSS. The dominant parasitoid attacking GWSS in California is *Gonatacerus ashmeadi* followed by *G. morrilli*. *G. triguttatus* from Texas and *G. fasciatus* from Louisiana have been released in California, but widespread establishment and proliferation has not occurred. Other minor parasitoid species include *G. novofasciatus*, *Ufens* sp., and *Zagella* sp. Together, this guild of parasitoids provides an average of ~25% parasitism of GWSS eggs over the entire 7.5 yrs that this study site has been monitored. There are at least four possible reasons for low seasonal parasitism levels in California: (1) Competitive exclusion amongst members of the GWSS parasitoid guild is reducing effective biological control. (2) An extremely aggressive and efficacious natural enemy that can outcompete *G. ashmeadi* and completely dominate the system year round to the almost total exclusion of all current parasitoids has not been established in California and is needed for successful biological control of GWSS (this would require exploitation of non-GWSS hosts during long periods of host egg unavailability over winter). (3) The absence of resource subsidies such as nectar provided by flowering plants in agroecosystems may limit parasitoid efficacy because longevity and fecundity is significantly reduced when parasitoids can not access carbohydrates. Understory management may be an important cultural strategy to benefit GWSS parasitoids if it can be demonstrated not to enhance GWSS and *Xylella* populations. (4) Climate, in particular, prolonged cool periods over winter when GWSS eggs are unavailable probably has a severe affect on parasitoid reproductive success and the ability of *G. ashmeadi* and populations of other parasitoids to propagate through the winter. Long-term phenology studies which generate data similar to the project reported on here, can be used to tease out density-dependent and density-independent factors affecting population dynamics to elucidate factors affecting GWSS population growth.

OBJECTIVE
This project has one objective:
1. Conduct bi-weekly surveys of GWSS eggs, nymphs, and adults, and associated rearing of parasitoids from harvested egg masses from organic lemons at Ag. Ops., UC Riverside. These data will be analyzed to determine if density-dependent (e.g., natural enemies) or density-independent (e.g., winter temperatures and rainfall) influence observed GWSS population trends at the study site at UC Riverside.

RESULTS
The population monitoring study and measures of percentage parasitism clearly indicate that GWSS densities have continued to decline steadily at the long-term monitoring plot (**Figure 1**) and percentage parasitism have remained relatively constant

over this time period (**Figure 2**). Detection of density-dependent mortality from sequential census data such as that presented here is notoriously difficult and the results of analytical models differ in outcomes depending on assumptions made even when dummy data sets have been constructed to show density-dependent mortality. One of the major problems with these types of analyses is serial correlation, where densities at N_t directly influence the population at N_{t+1}. Recent developments in analyses of time series data, such as those we are collecting for GWSS are now providing much more robust tests that overcome autocorrelation problems. The Partial Rate Correlation Function (PRCF) is a relatively new statistical procedure specifically designed for time series analysis of biological populations to detect density dependent feed back. Literature searches so far indicate that PRCF is the best of the extant techniques for analyzing long-term population counts. Consequently, census data collected from GWSS monitoring will be subjected to PRCF once we have data for a minimum of 10 consecutive years to determine if density-dependent or density-independent feedback is responsible for observed fluctuations from generation to generation. Detection of density-dependent mortality will indicate that populations are being regulated, and could suggest that natural enemy populations are responsible. Currently, our data set is too short to determine if parasitoid activity is providing density-dependent mortality and is subsequently responsible for decreasing GWSS densities at the study site.

CONCLUSIONS

GWSS populations appear to be showing a steady annual decrease in numbers in an organic lemon orchard at UC Riverside. Percentage parasitism of GWSS eggs by mymarid parasitoids, in particular, *G. ashmeadi*, has remained relatively constant from year to year at ~25%. It is unknown if this level of parasitism is sufficient to have caused the steady decline in GWSS numbers observed over the past 7.5 years or whether climatic variables such as wet winters (e.g., 2006), or very cold and dry winters (e.g., 2007) suppressed GWSS population growth while warmer than normal spring periods (e.g., 2008) accounts for observed rebounds in GWSS populations.

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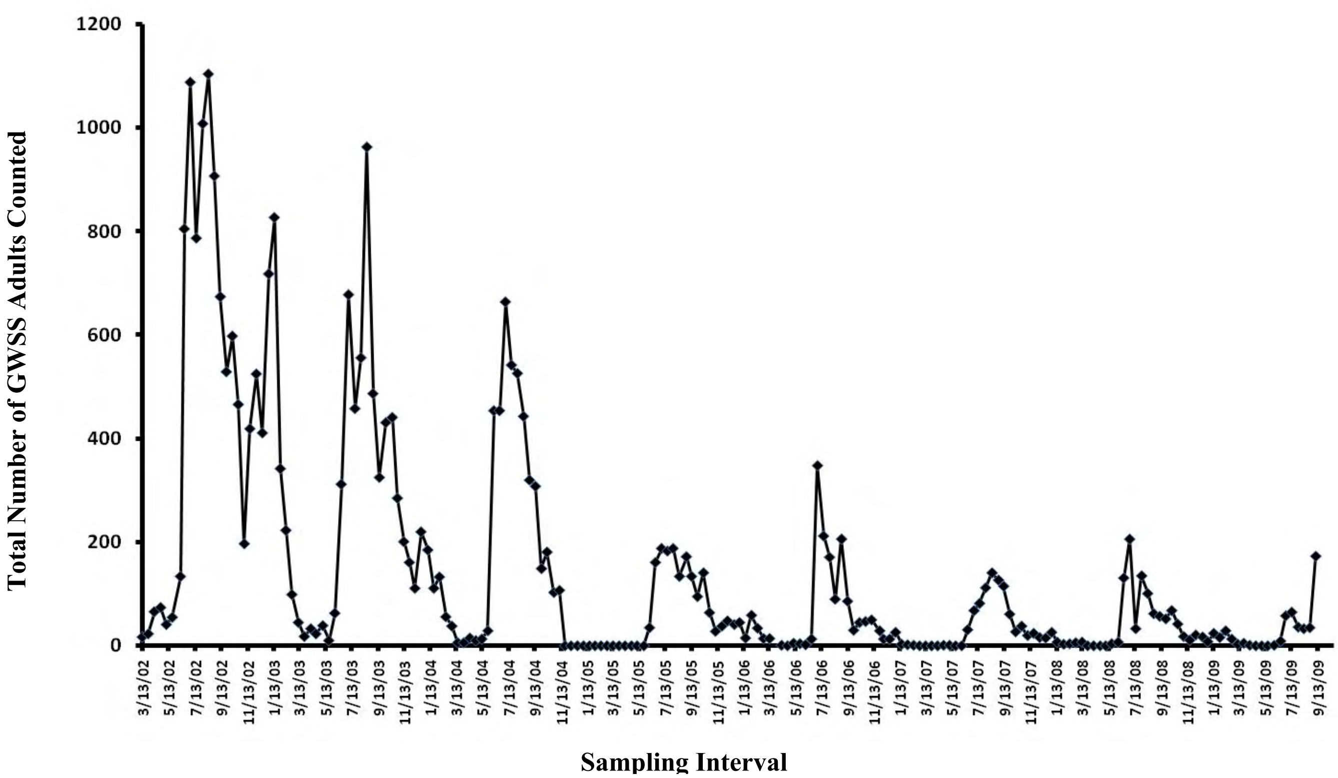

Figure 1. Phenology of adult GWSS in organic Eureka lemons. Data are total counts from timed five minute surveys made every two weeks of 10 mature lemon trees at UC Riverside Ag. Ops.

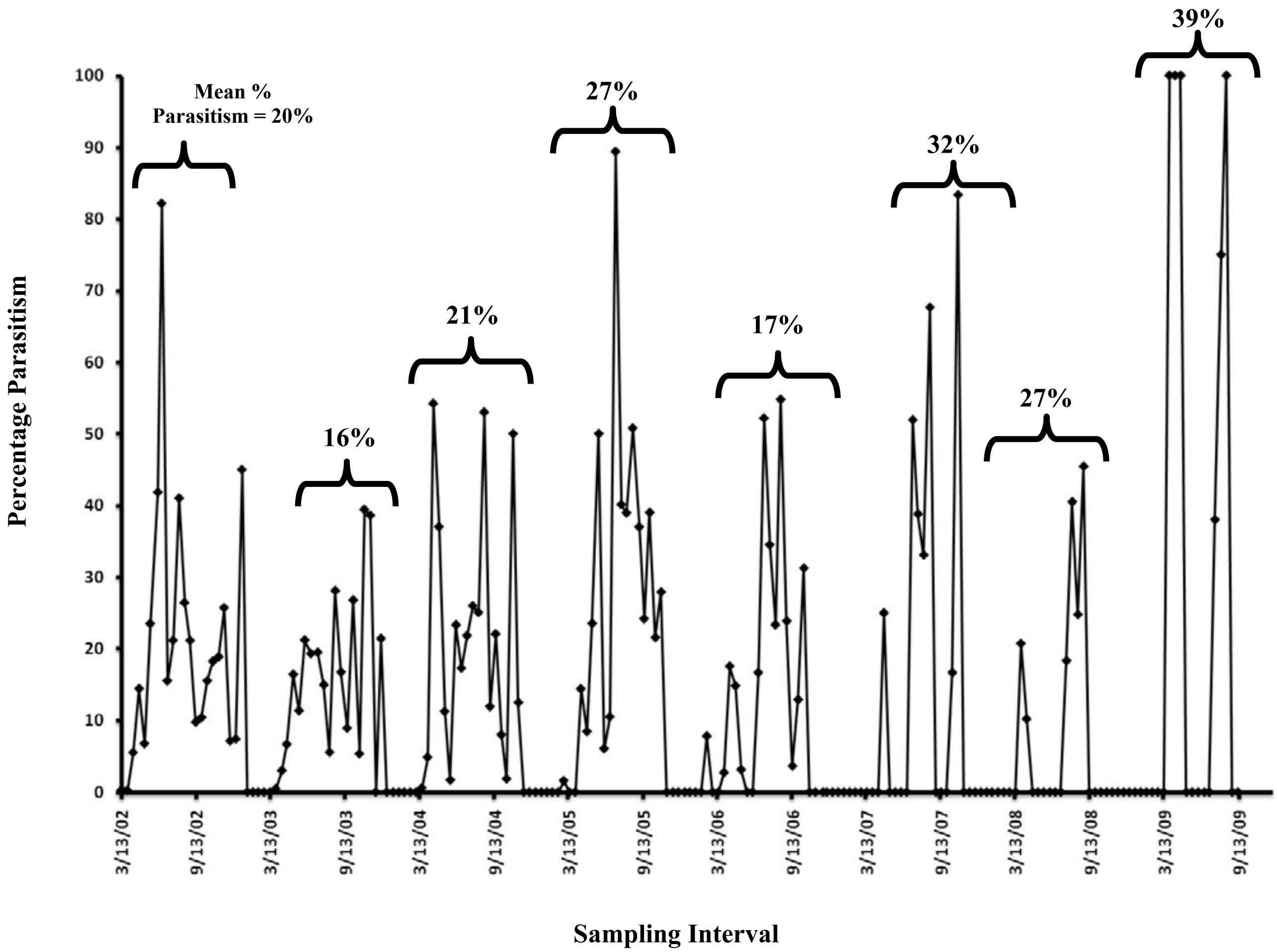

Figure 2. Percentage parasitism estimates of GWSS eggs in Eureka lemons. GWSS egg masses are collected from timed five minute surveys made every two weeks of 10 mature lemon trees at UC Riverside Ag. Ops. Harvested leaves are returned to the laboratory, the number of eggs per egg mass are counted and parasitoid emergence and species identity is determined. Percentage parasitism of GWSS eggs across all years has averaged ~ 25%.