EPIDEMIOLOGY OF PIERCE'S DISEASE IN THE CENTRAL SAN JOAQUIN VALLEY OF CALIFORNIA: FACTORS AFFECTING PATHOGEN DISTRIBUTION AND MOVEMENT

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ABSTRACT
The overall goal of this project is enhance our present understanding of the epidemiology of Pierce's disease (PD) in the central San Joaquin Valley (SJV) of California by elucidating factors that influence its geographical distribution and movement. The objective of this research will be to characterize the seasonal abundance and dispersal biology of the glassy-winged sharpshooter (GWSS), a primary vector of *Xylella fastidiosa (Xf*), to identify where the vector(s) acquire the pathogen, to determine when vectors move into vineyards and transmit the pathogen to grapes, and to genetically characterize the populations of *Xf* isolated from GWSS collected in different perennial cultivated and non-cultivated plant species compared to strains present in PD- affected vineyards. Based on preliminary results of seasonal plant utilization by GWSS, we conclude that host plant species can significantly influence GWSS population biology. GWSS adult, nymph, and egg mass densities varied among perennial, cultivated crop plant species and non-cultivated weed species examined in this study including sweet cherry, navel, lemon, olive, avocado, plum, pomegranate, pistachio, and grape. Temporal patterns of GWSS capture, representing dispersal activity of both overwintered and first generation adult GWSS, varied among the perennial crop species examined. Moreover, patterns of adult GWSS capture among the distances sampled along linear transects extending into perennial crops were dissimilar among perennial crops.

INTRODUCTION
The glassy winged sharpshooter (GWSS, *Homalodisca coagulata*) was introduced into Southern California around 1990 and first identified in 1994 (1). This sharpshooter has continued to expand its range in the state and is expected to affect the overall increase in plant diseases caused by *Xylella fastidiosa* (*Xf*) (5). *Xylella fastidiosa* has an extensive and diverse host range including many common cultivated crop and ornamental plant species as well as numerous, non-cultivated, wild host species. *Xylella fastidiosa* strains have a complex pathogenic relationship with a diverse host range including monocots and dicots (7). Analyses of the genetic diversity of *Xf* have elucidated differences between many of the strains and a conclusion emerging from some studies is that strains of *Xylella* cluster within groups based upon host association. Knowledge of the genetic diversity of strains that comprise the population of *Xf* in the central San Joaquin Valley (SJV) of California will help in devising effective strategies for managing Pierce's disease (PD), as well as other diseases caused by this bacterium.

X. fastidiosa is transmitted by xylem feeding sharpshooters (Cicadellidae) and spittlebugs (Cercopidae) (4). In California, there are at least 20 species capable of transmitting the pathogen (2), although only four species are considered to be epidemiologically important for PD in grapes (6). Knowledge of which vector species transmit *Xf* in the central SJV, where they acquire the pathogen, when they move into vineyards, and when they spread the pathogen to grapes is critical to understanding and managing the spread of PD in this area. This overall goal of this project is to further our understanding of the epidemiology of PD in the central SJV of California with a focus on the identification of factors that influence its geographical distribution and movement.

OBJECTIVES
1. Identify and characterize the seasonal abundance and dispersal biology of GWSS, a primary vector of *Xylella fastidiosa*, and their patterns of host plant utilization within and among perennial, cultivated and non-cultivated plant species in agricultural production systems.
2. Compare the genetic structure of *Xylella fastidiosa* strains isolated from GWSS in different perennial, cultivated and non-cultivated plant species to those strains present in PD-affected vineyards.

RESULTS
The seasonal plant host utilization of GWSS within and among a variety of perennial, cultivated crop plants including sweet cherry, navel, lemon, olive, avocado, plum, pomegranate, pistachio, and grape are being sampled in GWSS-infested areas at each of three locations for each crop type in Tulare County in central California. Additionally, non-cultivated annual and perennial weed species occurring within and surrounding GWSS-infested perennial tree crops were sampled for GWSS

populations. Host utilization was assessed monthly at each of three locations for each crop type based on sweep/beat-net sampling for adult and immature GWSS and visual inspections for GWSS egg masses through the interval May to October, 2003. Based on preliminary results, host plant species can influence GWSS population biology. The largest mean number of adult GWSS (Figure 1a) were collected from citrus (navel and lemon), pomegranate, olive, avocado, and non-crop weed species whereas mean nymphal population densities (Figure 1b) were greatest from citrus and pomegranate with fewer nymphs collected from cherry, plum, and non-crop weed species. Non-crop plant species upon which adult GWSS were collected included red-root pigweed, prickly lettuce, annual sowthistle, little mallow, lambsquarters, field bindweed, blue morning glory, curly dock, evening primrose, johnsongrass, and ground cherry. The greatest mean number of GWSS egg masses (Figure 1c) was collected from citrus, pomegranate, and cherry whereas no egg masses were collected from non-crop weed species. The absence of detectable GWSS life stages in grapes and pistachio are not a true reflection of host utilization in these studies, as the only available experimental locations for these crops were just outside of the active GWSS-infested area.

Seasonal dispersal of adult GWSS was monitored within and among the variety of previously indicated perennial crop plant species. Beginning March, 2003, yellow sticky traps (approx.15 X 30 cm) were suspended 2 m above the ground between tree canopies along 4 linear transects (20 per crop type) at distances of 0, 5, 10, 50, and 100 m at each of 3 experimental locations for each crop sampled. All traps were collected and replaced weekly to capture adults dispersing within and moving among different crop types and the surrounding vegetation. Through October, 2003, a total of 27,264 adult GWSS, 18 green sharpshooters (GSS, *Draeculacephala minerva*), and 588 unidentified spittlebugs (Cercopidae) were captured on yellow sticky cards. Temporal patterns of GWSS capture, represented by plotting mean proportions of adult GWSS captured over time, were similar in citrus and pomegranate (Figure 2a) throughout the sampling interval (March – August) representing dispersal of both overwintered and first generation adult GWSS. Seasonal patterns of GWSS capture in olive, avocado, and plum were dissimilar to that of either citrus or pomegranate with only minor dispersal of overwintered adult GWSS in the early season and a delay of approximately 8-12 days in the periods of peak capture of first generation adult GWSS (Figure 2b). Patterns of adult GWSS capture among the distances sampled along linear transects also varied among the crop types examined throughout the emergence of first generation adult GWSS. Specifically, uniform mean trap captures across all distances were observed within GWSS-reproductive hosts navel and lemon compared to avocado and olive where highest mean trap captures were detected along only the margins of crops and declined with distance into the field.

In addition, to maximize our ability to identify actual vectors of *Xf*, the presence of the pathogen in a subsample of vectors captured on yellow cards from perennial and non-crop species will be determined initially through PCR (3). Based on genomic information, strain specific primers will subsequently be used to investigate the pathotype profile. Research has yet to begin on this objective to identify the incidence and pathotype profile of *Xf* infectious GWSS collected at different times throughout the season and from different specific habitats or perennial crop plant types.

CONCLUSIONS

We believe that this project will generate significant new information regarding the epidemiology of Pierce's disease in the central SJV of California and in providing practical guidance towards management of this pathosystem. This information may be useful in understanding the epidemiology of other economically important diseases caused by *Xf*. Both objectives address gaps in our present understanding that must be filled in order to develop PD and GWSS management strategies. This research will expand on previous work by documenting the relative importance of potential vector species that transmit *Xf* in the central SJV, where they acquire the pathogen, when they move into vineyards, and when they spread the pathogen to susceptible crops in the agricultural landscape of the central San Joaquin Valley of California. Knowledge of the genetic diversity of strains that comprise the population of *Xf* in detected from potentially infectious GWSS will help in devising effective strategies for managing Pierce's disease , as well as other diseases caused by this bacterium.

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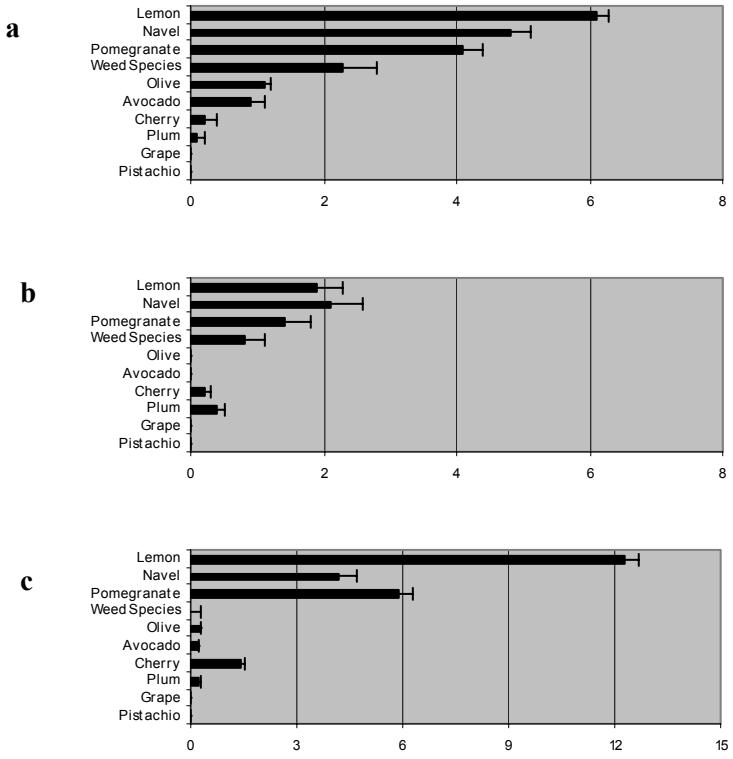

Figure 1. Mean (±SEM) number of adult (a), nymphal (b), and egg mass lifestages (c)of GWSS collected through sweep and beat-net sampling through the sampling interval May-September, 2003 at experimental locations in Tulare County, California.

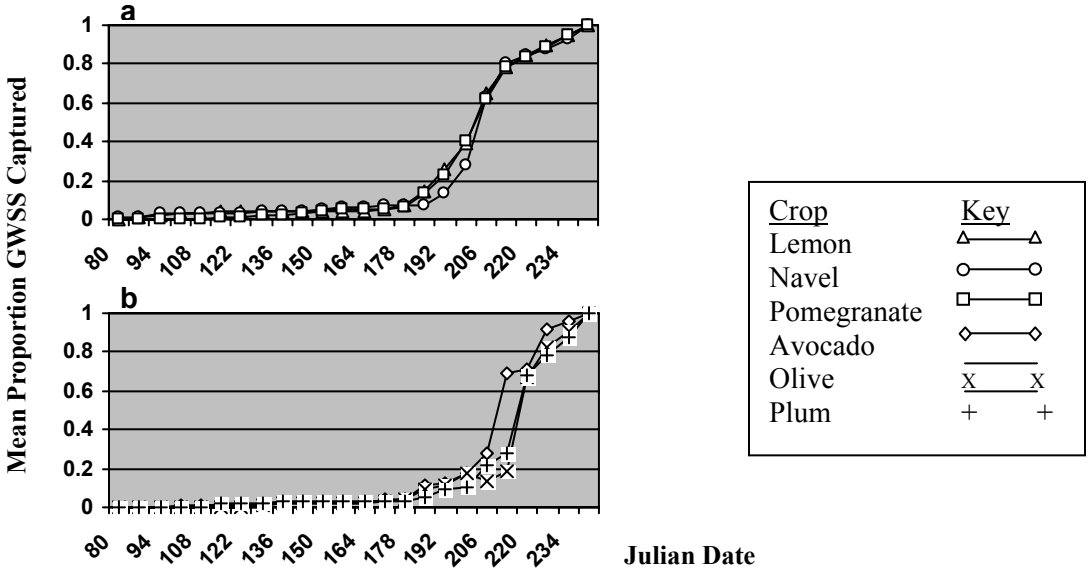

Figure 2. Mean proportion of adult GWSS captured on yellow sticky cards March-August, 2003 in navel, lemon, and pomegranate (a) as well as avocado, olive, and plum (b). Temporal patterns of capture represent both early-season dispersal of overwintering adults and 1st generation adult GWSS.