EPIDEMIOLOGICAL ANALYSES OF GLASSY-WINGED SHARPSHOOTER AND PIERCE'S DISEASE DATA

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ABSTRACT
Analyses of spatiotemporal interactions between vector insects and pathogens are critical to understanding disease epidemiology. Sampling projects to assess *Xylella fastidiosa* (*Xf*) incidence in vineyards and sharpshooter trap catches from varying habitats were implemented in the Coachella Valley and lower San Joaquin Valley in California. Sampling was done at landscape and vineyard scales. Data from work in the Coachella Valley revealed low sharpshooter trap catches and two sharpshooter species had different spatial distributions at the landscape scale. Pierce's disease is relatively rare throughout the Coachella Valley and did not occur near patches where sharpshooters were trapped. Analyses of similar data from the lower San Joaquin Valley are currently underway.

INTRODUCTION
The progression of Pierce's disease (PD) across a landscape and in vineyards is dependent upon factors related specifically to four components: vector insects, *Xf* inducing PD, grapevines, and the environment. When conditions in all four of these areas are optimal, disease spread occurs. Conversely, sub-optimization within any of the four categories can slow or stop disease progress. The science of epidemiology seeks to determine how the four components interact, with the goal of creating long-term, sub-optimal conditions for disease spread. Achieving this goal will enable California producers to continue growing grapes in areas with PD and vector insects. Recently, the global positioning system, the geographic information system, and geostatistics have been applied to entomological and epidemiological studies. These technologies combined with advanced statistical methods can facilitate creation of insect and pathogen distribution maps and analyses of spatial distribution to understand epidemiology.

OBJECTIVES
1. Determine the spatial distribution of sharpshooter vectors and PD, and use these data to create statistical distribution maps.
2. Analyze spatial relationships between sharpshooter vectors and PD incidence.
3. Relate the epidemiology of *Xf* to environmental components, and identify characteristics of areas with varying PD incidences.

RESULTS
Sharpshooter Temporal and Spatial Distribution
Coachella Valley data from four years of sharpshooter monitoring were analyzed (2001-2004) to investigate dynamics of the temporal and spatial distributions of *Homalodisca coagulata* Say and *Homalodisca liturata* Ball and their spatial associations with the surrounding vegetation (Park et al. 2005a). Temporal trap catches of *H. liturata* and *H. coagulata* showed two peaks per year, and the peaks of the two species coincided (Figure 1).

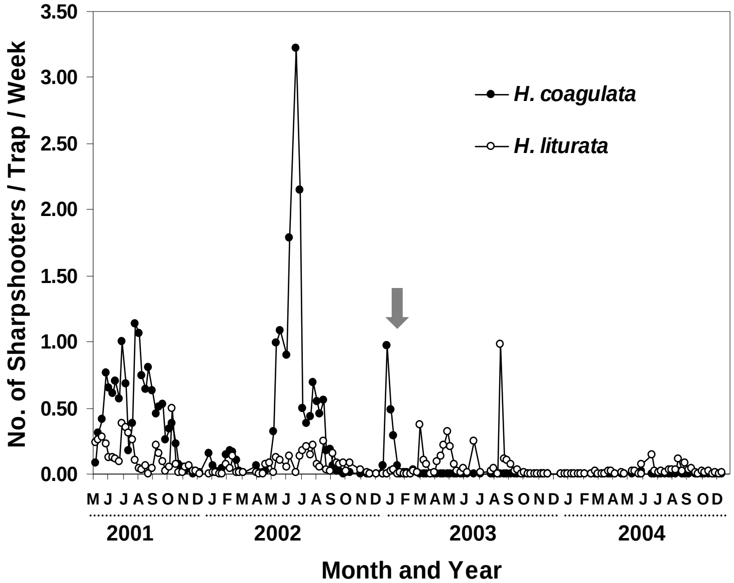

Figure 1. Trap catches of two sharpshooter species. Arrow indicates first application of insecticide to citrus.

A relatively new method, spatial analysis with distance indices (SADIE) (Perry 1995), was used to analyze sharpshooter spatial distribution. SADIE showed that spatial distributions of *H. coagulata* (Figure 2) and *H. liturata* (Figure 3) were significantly consistent between years (Index of Association [X] ranged from 0.310-0.685, $P \leq 0.001$), except for *H. coagulata* from 2003 vs. 2004. All patches (i.e. clusters of significantly high trap catches) of *H. coagulata* were located near citrus, and no patches were found in urban landscapes (Table 1). Major patches of *H. liturata* were located in desert saltbush scrub and urban areas where major gaps (i.e. clusters of significantly lower trap catches) of *H. coagulata* were located (Table 1), resulting in negative spatial association between the two species (Figures 2 and 3). Similar analyses for *H. coagulata* trap catches in Kern County are currently underway.

Table 1. Percentage occurrence of patches and gaps of *H. coagulata* and *H. liturata* in each type of surrounding vegetation from 2001-2004 combined data

Types of surrounding environment	*H. coagulata* Patch ($n^a = 11$)	*H. coagulata* Gap ($n^b = 154$)	*H. liturata* Patch ($n^a = 15$)	*H. liturata* Gap ($n^b = 234$)
Urban landscape	0.0%	26.1%	80.0%	14.7%
Desert saltbush scrub	36.4%	56.5%	86.7%	45.7%
Desert	27.3%	27.2%	26.7%	24.1%
Citrus	100.0%	19.6%	33.3%	34.5%
Grape	90.9%	27.2%	6.7%	41.4%

[a] Total number of sample locations (i.e. sum of each year's sample locations) included within patches.
[b] Total number of sample locations (i.e. sum of each year's sample locations) included within gaps.

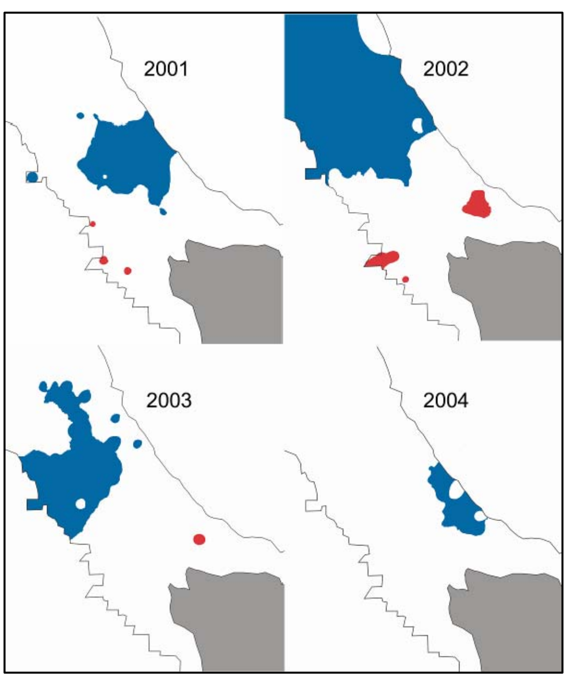

Figure 2. *H. coagulata* patches (red) and gaps (blue) in the Coachella Valley.

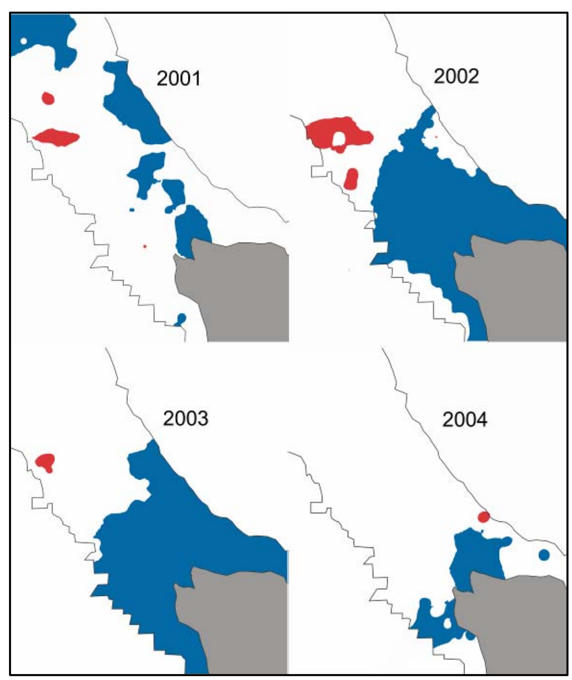

Figure 3. *H. liturata* patches (red) and gaps (blue) in the Coachella Valley.

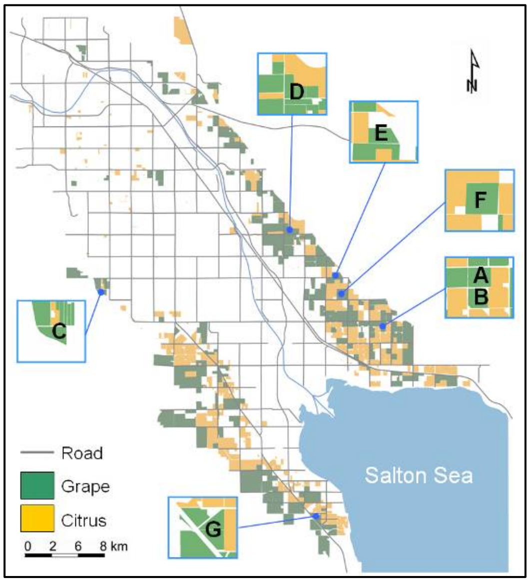

Figure 4. Locations of vineyards with PD identified in surveys from 2001-2004. A total of 13 diseased grapevines were identified; two in vineyard A (2002), one in vineyard B (2002), four in vineyard C (2003), one in vineyard D (2003), one in vineyard E (2004), two in vineyard F (2004), and two in vineyard G (2004).

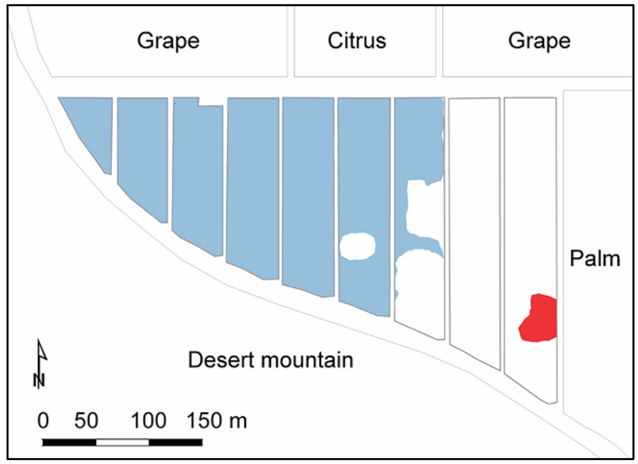

Figure 5. Spatial distribution of grapevines with PD in vineyard C. Red area indicates a significantly high cluster of PD incidence (patch) and the blue area indicates an area with significantly low PD incidence (gap).

Pierce's Disease Spatial Distribution at the Landscape and Vineyard Scale
The spatial distribution of PD in the Coachella Valley was analyzed at two spatial scales, landscape and vineyard, with data collected from 2001–2004 (Park et al. 2005b). At the landscape scale, seven vineyards were identified (A–G) with diseased grapevines (Figure 4). A total of 13 diseased grapevines were identified from seven vineyards during the landscape-scale survey. For these seven vineyards, the mean distance between a citrus orchard and the closest diseased grapevine in the vineyards was 143 m (Figure 4). PD was found in three varieties, Perlette, Flame, and Superior Seedless.

One vineyard, vineyard C, was further studied to characterize the vineyard-scale spatial distribution of PD because it had high disease incidence (3.8%) compared with the other vineyards. This vineyard was relatively flat with 2 m of maximum elevation difference, and it was surrounded by palm trees to the east, citrus and grapes to the north and arid mountains with desert saltbush scrub to the west and south (Figure 5). Geostatistical analysis showed that a power model fit the semivariogram for PD distribution in the vineyard, indicating strong aggregation of PD. SADIE also showed that the distribution pattern of PD in the vineyard was aggregated ($I_a = 2.12$, $P = 0.013$) with a significant patch (area of 1680 m^2) in the eastern edge of the vineyard (Figure 5). Similar analyses are currently underway for PD distribution in Kern County at the landscape and vineyard scales.

Spatial Relationship Between Sharpshooters and PD Distribution
In the Coachella Valley, no vineyard with PD (Figure 4) overlapped with any sharpshooter patches (Figures 2 and 3), indicating no spatial relationship between sharpshooters and PD at the landscape scale. While possible associations may exist at a scale finer than we examined, we believe that PD distribution may be related to vector species other than *H. coagulata*. We have documented *Xf* transmission with a desert cicada species, and there are several other sharpshooter species present in the Coachella Valley that may be involved with spreading this bacterium. In Kern County, we have acquired data from sticky traps that were placed in vineyards with PD. We have begun analyzing these data and we are hopeful that relationships between disease distribution and *H. coagulata* distribution will be elucidated through this process.

CONCLUSIONS
- *H. coagulata* and *H. liturata* trap catches were spatially consistent between years.
- *H. coagulata* and *H. liturata* spatial relationships with surrounding vegetation imply that areawide management targeting specific habitat types may be possible by identifying sharpshooter patches and gaps in space and time.
- Overall, PD incidence in the Coachella Valley was low and infected vineyards were distributed throughout the area.
- PD was aggregated within one vineyard in the Coachella Valley.
- There was no spatial relationship between sharpshooter trap catches and PD incidence at the landscape scale in the Coachella Valley.
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FUNDING AGENCIES

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