EFFECT OF CONSTANT TEMPERATURE ON GLASSY-WINGED SHARPSHOOTER LIFE CYCLE

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ABSTRACT

The glassy-winged sharpshooter (GWSS) is a vector of *Xylella fastidiosa (Xf)*, the causal agent of Pierce's disease of grapevine. It is the most common leafhopper associated with vineyards in Texas, with the exception of the High Plains. In the Hill Country grape growing region of Central Texas, the insect overwinters in the adult stage. The earliest egg masses are laid in February and March when relatively cool temperatures prevail. Our interest was to determine the effect of ten constant temperatures on GWSS egg development and the effect of exposure periods of 6 to 120 hours in duration to subfreezing temperatures. The effect of temperature on nymphal growth and development was also measured. However, adverse artificial rearing conditions in the growth incubators negatively affected nymphal development which was twice as long as expected in the optimal temperature range under natural conditions. We were unable to draw conclusions without modifying the rearing conditions. The study on the effect of temperature on adult survival is underway and results are not available for this report.

LAYPERSON SUMMARY

The glassy-winged sharpshooter (GWSS) is an insect pest which can transmit the bacterium responsible for Pierce's disease of grapevine. The insect and the disease are commonly associated with vineyards in Texas and are the main limiting factor to grape production in the State. We studied the effect of ten temperatures on the life cycle of GWSS and the effect of short exposure periods to subzero temperatures on the eggs. Tests using the adults are underway. The data generated by these studies are critical to optimizing rearing techniques and for developing control strategies for grape growers.

INTRODUCTION

Grapevine hybrids of *Vitis vinifera* which are traditionally associated with the highest quality wines are varieties susceptible to various degrees of damage by Pierce's disease (PD). This disease is an incurable, debilitating and often fatal bacterial infection caused by *Xylella fastidiosa (Xf)* and disseminated by xylem fluid-feeding insects such as the glassy-winged sharpshooter (GWSS). In Texas we also recorded an additional 28 xylem fluid-feeding species associated with vineyards (Lauzière et al 2008). Many of these insect pests can vector the bacterium (Mitchell et al in press). PD is the most important limiting factor to grape production in Texas (Texas Pierce's Disease Task Force 2004). Funded by the U.S. Department of Agriculture, a statewide research program was initiated in 2002 to study vectors in their natural habitat, their interaction with cultivated vines and other vegetation, and investigate their biology in order to develop pest and disease management strategies.

GWSS is native to the Gulf Coast states of the USA (Young 1968). Indigenous populations of GWSS depend on the insects' ability to survive under the environmental conditions prevailing in the different grape growing regions of Texas. Among abiotic factors, temperature plays a major role influencing an insect's life cycle. Temperature interacts jointly with other factors such as humidity, food availability and light and since temperature is easily measured and controlled, it is common practice to examine its influence upon species of economic importance (Howe 1967). Thorough knowledge of the effects of temperature on development and survival, among other aspects of the biology and behavior of GWSS, is also critical for developing and optimizing rearing techniques under carefully regulated environmental conditions and for conducting field research aimed at developing control strategies.

OBJECTIVES

1. Determine the effect of constant temperatures on the life cycle of GWSS (embryo, nymph and adult)
2. Determine the effect of subzero temperatures on embryos and adults

RESULTS AND DISCUSSION

These studies were conducted at the Texas AgriLife Pierce Disease Research and Education Program facility in Fredericksburg, TX. Containerized *Euonymus japonica* were grown in a greenhouse setting and placed into cages with reproductively mature GWSS. The plants were monitored daily for leaves bearing egg masses. These were left *in situ* and enclosed in an organza pouch fastened with twist-ties. The egg masses were incubated in a growth chamber at the following temperatures: 12, 15, 18, 21, 24, 27, 30, 32.5, 35, and 37.5°C. Development of the eggs was monitored twice daily and emergence of nymphs was recorded. Undeveloped eggs were dissected under a stereomicroscope after 21 days and the total number of eggs was recorded. Because of the non linearity of development rates (the reciprocal of the developmental period), only temperatures between 12 and 30˚C were used to compute the linear regression for embryonic development of GWSS. Nonlinearities of insect development at high temperatures justified the development of a nonlinear regression model. Therefore, embryonic development rate was fitted to the model of Logan et al. (1976). Embryonic survival was subjected to one-way analysis of variance (ANOVA) to test for temperature effect. When significant *F*-values were obtained, treatment means were discriminated using the Student Newman Keuls (SNK) test ($P < 0.01$).

We also studied the effect of freezing temperatures (-0.9± 0.21°C) on GWSS eggs exposed for 0, 6, 24, 48, 72 and 120 consecutive hours. After each specified time period, the plants bearing egg masses were transferred into a second growth chamber held at a constant 25°C and the eggs were monitored daily for nymphal emergence. Mortality was assessed as described above, 21 days after the mean emergence period when the eggs were assumed to be non-viable. We used a one-way ANOVA to estimate the effect of the exposure period on development time and survival. When significant *F*-values were obtained, treatment means were discriminated using the SNK test ($P < 0.01$).

Embryonic development of GWSS was successful to nymphal emergence between 15 and 35°C. Ultimate embryonic survival varied with temperature ($F = 3.09$; df = 7, 156; $P = 0.004$). The proportion of egg hatching was not significantly different for temperatures between 18 and 35°C and averaged 74.2% ± 2.9. At 15°C, percent survival was significantly lower with 43.8% ± 8.8 of the embryos developing into nymphs. Embryos continuously exposed to 12 or 37.5°C did not develop. The lower embryonic development threshold was calculated using a linear regression over the 15-30°C range and was estimated at 12.1°C. Using the Logan model and all temperatures tested, we determined that the optimal development temperature for GWSS eggs is 30.6°C. Embryonic development time decreased linearly between 15 and 30°C, ranging from 22.7 to 4.7 days.

Exposure to freezing temperatures delayed embryonic development for all exposure periods as compared to unexposed egg masses ($F = 201.17$; df = 4, 384; $P < 0.0001$). Eggs exposed to freezing temperatures for 6 and 24 hours required about nine days to complete their development, whereas embryogenesis of eggs treated for 48 hours and 72 hours took 11.8 and 13.2 days, respectively. Lethal effects occurred when eggs were kept below freezing for a consecutive 120 hours. This was also the only treatment which affected the plant. Percent survival was significantly different among the 24-120-hour exposure periods ($F = 16.99$; df = 5, 113; $P = 0.001$) with 26.6% survival measured after a 24-hour exposure down to 0% survival at 120 hours.

Nymphal development of GWSS fed black-eyed pea plants was studied by M. Sétamou at Weslaco in a similar fashion under controlled constant temperatures of 18, 21, 24, 27, 30, 34°C. In the optimal temperature range, development to adulthood required 45 days. In a previous study, nymphs reared by Lauzière and Sétamou (2009) at 25°C developed in 29.8 ± 0.7 days. We are critical of the data obtained from the temperature study and are concerned that food and light may have deeply affected the development of the nymphs reared under artificial light without sun light. Steps are being taken to correct our methodology so that we may draw conclusions that are more applicable to insect populations under natural conditions.

Temperature data summarized for the Hill Country of Central Texas indicated that the coldest months are usually December, January and February, with average temperatures of 8.8 to 15.1°C for the years 2003 to 2008. The warmest months are usually July and August which ranged 26.8 to 30.9°C in 2003-2008. During the past six years, the coldest year was 2004. Data from a previous study indicated that during the winter of 2004, temperatures in the vineyards remained below 0°C for a total of 100-140 hours (Lauzière et al. 2008). The winter of 2005 was not as cold as it was the previous winter, however, temperatures remained below zero for a total of 200-240 hours. On average, in this region, temperatures remain below zero for 8.6 ± 7.7 consecutive hours at a time and minimal temperatures of -2.8 ± 2.23°C (range -13.5-0.16°C) are recorded. It would be interesting to study this insect's development under cyclical temperature fluctuations in the low to freezing temperature range.

CONCLUSIONS

These studies showed that temperature had a strong influence on growth and development of GWSS. Embryonic development times decreased with increasing temperatures whereas mortality increased with increasing temperatures. For rearing purposes, temperatures of 28-30°C are optimum for the eggs and will yield the highest percentage of emerging nymphs.

Field data from 2005-2008 indicated that GWSS females actively produced eggs from February to September, with highest egg loads observed in March (13.8 ± 7.2 eggs/female; n = 155; (Lauzière 2008). During these months in Central Texas, relatively cool temperatures are usually observed which will affect glassy-winged sharpshooter development. However, the data suggest that egg development is possible and is correlated by field observations of the first generation of adults in early April.

Bioclimatic studies on insect hosts and their natural enemies can help explain their geographic distribution and also provide insight into the potential physiological limitations for their spread into other regions, either naturally or through unintentional translocations.

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