KEYS TO MANAGEMENT OF GLASSY-WINGED SHARPSHOOTER: INTERACTIONS BETWEEN HOST PLANTS, MALNUTRITION, AND NATURAL ENEMIES

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INTRODUCTION

Leafhopper vectors of *Xylella fastidiosa* (including GWSS) behave very differently than most herbivorous insects. GWSS has evolved many unusual adaptations that enable subsistence on xylem fluid. Adult GWSS may feed on hundreds of different host species, are long lived and exceptionally mobile and fecund. Nutrition affects GWSS female fecundity and longevity, and malnutrition is a primary source of mortality of immatures. We have established that adults prefer to feed on xylem fluid with specific chemical characteristics (high amide concentrations). Nymphs develop more successfully on xylem fluid with low amide concentrations and proportionally higher concentrations of many of the more dilute amino acids that are deemed essential for the development of most insects. We have also established the physiological basis for this phenomenon: adults can more efficiently use nitrogen and carbon from high amide concentrations than can young developing nymphs cannot. Given the pivotal status of host plant nutrition on GWSS behavior and survival, we are investigating GWSS behavior and that of its parasitoids in field and laboratory experiments to elucidate how the underlying feeding and oviposition behavioral mechanisms relate to host plant quality. The behaviors involved in host selection can be divided into two extremes. In the first, selection takes place after insects contact the host, the second extreme implies that the insect perceives plant characteristics at a distance and select hosts based on these perceptions. These two extremes can be described as host-plant recognition and host-plant finding. Host plant recognition is less well known in the literature, but our research is addressing behaviors involved in both categories.

OBJECTIVES

1. Determine the effects of host plant assemblages and host plant chemistry on distribution, performance and behavior of *Homalodisca coagulata,* glassy-winged sharpshooter (GWSS) and its natural enemies.
2. Determine the relationship of host plant xylem chemistry on host selection, feeding and ovipositional behavior of GWSS and its parasites.
    a. assess host plant acceptance and subsequent feeding rate, host plant selection and acceptance for oviposition and the survival and performance of early and late instar nymphs as a function of host plant species.
    b. quantify the impact of these plant variables on the behavior and parasitism rate of eggs by *Gonatocerus ashmeadi*.

RESULTS AND CONCLUSIONS

We examined GWSS host utilization with a series of choice and no-choice tests in cages containing example hosts most relevant to California (Navel orange, Spanish Pink lemon, and *Vitis* sp. - > Chardonnay = grapes). Glabrous soybean as a standard was also included as soy is one of the few hosts on which immature GWSS consistently develop. Cages with adult GWSS (two types run separately - diapausing (late autumn), and reproducing (mid-summer)), and one plant of all 4 species or with 4 plants of each species separately were used to assess host selection, consumption rates, oviposition, nymphal development, growth and survivorship. In choice-tests, Navel oranges were consistently the preferred hosts, 40-65% of GWSS remained on Navel when examined for 10-22 day intervals. Selection of other hosts was dependent on time of year; Spanish Lemon was selected moderately by diapausing insects (25-40%) and *Vitis* and soy were not preferred (<20%). Reproductively-active GWSS also preferred Navel 45-65%, followed by soy (20-30%), with *Vitis* and Lemon lowest (<20%). Despite high selection of Navel (and lemon by diapausing leafhoppers), the two citrus hosts consistently had the lowest consumption rates by adult GWSS. Consumption rates were consistently 1-2 mL/day on *Citrus* while they were 4-7 mL/day on the less preferred *Vitis* and soybean. Consumption was not significantly different between diapausing and reproducing GWSS suggesting that diapausing GWSS are still active in accumulating nutrients, albeit for storage of nutrients for successful overwintering rather than egg production. Navel oranges received the highest rates of oviposition, with *Vitis* also receiving moderate levels of egg deposition. Lemon and soy received very little oviposition. Neonate nymphs (less than 24 hrs) introduced from neutral hosts quickly rejected both *Vitis* and Lemon (<5% remained on hosts after 5 days), and were only able to develop to second instar on Lemon and fourth instar on grape. In contrast, roughly 30% of neonates placed on Navel remained for 5 days; however, these developed slowly and all perished before completion of the second instar. On the soy standard, ca. 35% successfully developed to adults. Preferential selection of Navel thus appears related to reproductive behavior (including oviposition and development of very young nymphs) rather than consumption rates. Navel selection occurred by diapausing as well as reproducing GWSS, indicating that generalized cues in Navel may be operative even when GWSS is not seeking ovipositional sites. We noted a decrease in preference (60 to 40%) for Navel over time by diapausing

GWSS, suggesting that leafhoppers were very gradually shifting to better feeding hosts; for reproductively active GWSS, choice of Navel actually increased with time.

Field evaluation of Vitis selection by GWSS:

We examined seasonal trends in GWSS abundance on 12 cultivars of *Vitis*. These included the economically important *Vitis vinifera* (cv. Chardonnay, Chenin Blanc and Exotic), and rootstock species including *V. champinii* (cvs. Dog Ridge and Ramsey), *V. rupestris* (cvs. St. George and Constancia), and *V. simpsoni* (cv. Pixialla). We also examined 4 Southeastern muscadine genotypes from *V. rotundifolia* (cvs. Carlos, Noble, Early Fry, Regale). Vines (4-8 per genotype) were counted at least once a week from late May until the present (late October). GWSS populations on *Vitis* peaked in June with abundances being greater on *V. champinii*, *V. rupestris*, and *V. simpsoni* (13-18 adult GWSS per vine). Abundances were significantly lower on *V. vinifera* (7.5 per vine) and *V. rotundifolia* was significantly lower than all other species (2.2 per vine). Populations on *Vitis* declined in mid-summer but these trends in selection continued until August, at which time GWSS counts on *V. vinifera* rose to approximate those found on *V. champinii*, *V. rupestris*, and *V. simpsoni*. Increased selection of *V. vinifera* persisted until late season, when GWSS populations in Florida decline. Selection of muscadine grapes *V. rotundifolia* was always significantly less than all other *Vitis* species. High suitability of *V. champinii, V. rupestris,* and *V. simpsoni* for GWSS may be of interest as these species are often used as rootstocks. We have previously established that rootstocks largely determine xylem composition, and have shown in Florida that selection of rootstock can be used to alter the preference of GWSS for cultivars of *Prunus*. Rootstocks may be a tool for establishing grapes less suitable for GWSS.

One of our primary objectives is to identify plant nutritional variables that may be operational in determining host acceptance, consumption rates, ovipositional preference, etc. Choice experiments were repeated using important host plants from the leafhoppers home range including yaupon holly, burford holly, crape myrtle and soy. Preliminary results of chemical analyses from both sets of choice experiments indicate general trends we have found on Florida hosts previously. Specifically, Navel has proportionally very low amide concentrations. This is consistent with what we have found for other hosts that are poor feeding hosts, but good ovipositional hosts. In a field experiment we evaluated GWSS oviposition rate in response to plant nutritional quality. There were some significant differences in host acceptance and oviposition rate. We also examined oviposition in no-choice experiments (cages with 4 plants of one host species rather a mix of four host species). There were some significant differences in host acceptance and consumption rates indicating that feeding history should be considered in future experiments and can impact GWSS host selection. Completion of our analyses and further experimentation should delineate chemical cues related to ovipositional selection.

Understanding the determinant mechanisms involved in parasitoid plant and host egg finding and recognition (selection and acceptance) is also an objective. We conducted experiments in the field and laboratory to elucidate the cues produced by the plant, the vector or its eggs that parasitoids may be exploiting. We have ostensibly eliminated many possibilities including components of GWSS excreta, but to date we have not positively identified any specific cues directing parasitoid behavior. More candidate cues both chemical and visual need to be evaluated while this work continues.

Understanding the mechanisms involved in adult GWSS host plant finding and recognition is also the subject of several experiments. We have determined that the host plant appears to provide cues that GWSS may recognize in the air prior to landing. Other results suggest that host acceptance is determined by taste at the xylem tissue level. We are presently validating experimental methodologies to further tests hypotheses generated from current field results.

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