REPRODUCTIVE BIOLOGY AND PHYSIOLOGY OF FEMALE GLASSY-WINGED SHARPSHOOTERS: EFFECT OF HOST PLANT TYPE ON FECUNDITY AND DEVELOPMENT

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ABSTRACT
Our study found that *Homalodisca coagulata* can successfully produce multiple generations when confined to a single host species: grape, citrus, or oleander, and that oviposition and development can occur successfully on any of these hosts. In 2002, more egg masses and adults were found on citrus than on grape or oleander. In 2004, there was no significant difference in the number of egg masses on the hosts, but more adults were produced on grape, than on citrus or oleander. Our study confirms that oleanders can serve as a reproductive host for *H. coagulata*. Oviposition on oleander was different than on grape and citrus, with most eggs being laid singly or in pairs in the epidermis on the underside of leaves. Because citrus and oleanders are commonly found in close proximity both to one another and to grapes in California, it is important to consider their contribution as sources of *H. coagulata* as it relates to Pierce's disease epidemiology.

INTRODUCTION
The glassy-winged sharpshooter (GWSS), *H. coagulata* (Say), was first detected in California in 1989 (Sorenson and Gill 1996) and quickly spread throughout the state (CDFA 2005). In California, *H. coagulata* movement patterns, breeding habitats and host preferences differ from native vectors of *Xylella fastidiosa* (Purcell 1999, Hopkins and Purcell 2002). *H. coagulata* has a wide host range, feeding on over 150 host plants ranging from herbaceous annuals to woody perennials (CDFA 2005).

H. coagulata belongs to the Proconiini tribe of the family Cicadellidae and is a xylem feeder (Nielson 1979). Xylem is a very dilute nutrient source and high volume feeding rates are required for survival and reproduction of insects. Florida studies indicate that nutritional requirements are different for nymphal and adult *H. coagulata* (e.g. Andersen et al. 1989, Andersen et al. 1992, Brodbeck et al. 1990, Brodbeck et al. 1993, Brodbeck et al. 1995, Brodbeck et al. 1996). These studies infer that regulation of consumption rates and assimilation efficiencies is necessary to accumulate nutrients required for development, suggesting that polyphagy is required for development. Field observations in California indicate a preference for different plant species at different times of the year, with choice observed to be linked to new vegetative growth of the preferred host plants (Daane and Johnson 2004).

In this study, we test the hypothesis that *H. coagulata* require multiple hosts to successfully produce additional generations by examining female fecundity and sex ratio of surviving adults of the subsequent generation when reared on a single host: grape (*Vitis vinifera* L.) (Vitidaceae), citrus (*Citrus sinensis* (L.) Osbeck.) (Rutaceae), or oleander (*Nerium oleandrum* L.) (Apocynaceae).

OBJECTIVES
1. Collect and prepare GWSS specimens for studying the morphology and anatomy of females.
2. Study and describe the sensory structures located on the female ovipositor.
3. Characterize the reproductive cycle of female GWSS in Riverside, CA..
4. Study the effects of location on female GWSS reproductive cycle.
5. Study the effect of host plant type on female GWSS fecundity.

RESULTS
The results presented here address objective 5 of our *H. coagulata* research.

Adult female and male *H. coagulata* collected from citrus hosts were confined to a single host, either grape, citrus or oleander, and their fecundity and success of progeny followed for a full generation. We made one infestation in 2002, while in 2004 we made four infestations. Females oviposited successfully and the resulting offspring developed to the adult stage on all three host plants. In addition, *H. coagulata* were successfully reared without reinfestation on all three host species from 3 March 2004 to 18 November 2004.

There was a significant difference in the mean number of egg masses for each of the host species in 2002 ($F_{2,40}$ = 21.54; P < 0.0001). Oviposition was greatest on citrus (mean $\pm$ SD number of egg masses = 52.20 $\pm$ 32.27; n = 15), followed by grape (20.54 $\pm$ 15.08; n = 13), and oleander (8.07 $\pm$ 7.18; n = 15) (Figure 1). The mean number of female nymphs maturing to the adult stage was significantly different between hosts in 2002 ($F_{2,41}$ = 8.64; P = 0.0007) (Figure 2). The mean number of females was significantly different between citrus and grape (P = 0.0005), but there was no significant difference between grape and oleander (P = 0.0690) or citrus and oleander (P = 0.1864) (Figure 2). The mean number of male nymphs maturing to the adult stage was significantly different between hosts in 2002 ($F_{2,41}$ = 9.96; P = 0.0003). The mean number of males was significantly different between citrus and grape (P = 0.0002), and grape and oleander (P = 0.0355), but there was no significant difference between citrus and oleander (P = 0.1876) (Figure 2).

There was no significant difference in the mean number of egg masses between host species in 2004 ($F_{2,39}$ = 1.16; P = 0.3250) (Figure 1). The mean number of female nymphs maturing to the adult stage was significantly different between hosts in 2004 ($F_{2,43}$ = 5.08; P = 0.0104). The mean number of females was significantly different between citrus and grape (P = 0.0115), and grape and oleander (P = 0.0450), but there was no significant difference between citrus and oleander (P = 0.8379) (Figure 2). The mean number of male nymphs maturing to the adult stage was significantly different between hosts in 2004 ($F_{2,43}$ = 3.24; P = 0.0489) (Figure 2), but mean separation did not reveal significant differences between hosts.

The mean $\pm$ SD number of egg masses was greatest on citrus in the spring generation of 2004 (23.67 $\pm$ 21.57; n = 6), on grape in the summer generation (first infestation) (18.83 $\pm$ 8.35; n = 6), and oleander in the summer generation (second infestation) (27.67 $\pm$ 46.20; n = 3) (Figure 1). It is interesting to note that egg masses are typically much smaller on oleander (one to two eggs per egg mass) than on citrus or grape (10+ eggs per egg mass). The greatest nymphal survival was observed on grape for the first two infestations, and the survival of nymphs on all host species was low in the third infestation (Figure 2).

CONCLUSIONS

Multiple generations of *H. coagulata* are possible when confined to grape, citrus or oleander, indicating that a compulsory movement of adults between hosts is not necessary to maintain a population. Nymphal survival and female fecundity were greatest on grapes relative to citrus and oleander in the summer generation (first infestation) of 2004. This observation is consistent with field observations by Hix (2002) that adult *H. coagulata* enter vineyards, often after exiting citrus groves, in May and June and can complete a generation in grapes during July and August. *H. coagulata* typically leave vineyards in the winter, and are thought to be sustained on citrus and other non-deciduous hosts including ornamentals such as oleanders.

In southern California, *H. coagulata* are observed on citrus year around where they produce two to three generations per year (Hummel et al. 2005). Proximity of citrus groves near vineyards has proven significant in the epidemiology of some Pierce's Disease epidemics (Perring et al. 2001). In our study, fecundity was greatest on citrus in 2002, but this was not the case for all studies conducted in 2004. The inconsistency may be due to differences in host quality. Even though all plants were uniformly irrigated and fertilized, there may have been inherent seasonal differences in plant physiology. Anderson et al. (1992) suggested that high amide concentrations in host plants may be responsible for oviposition preference by *H. coagulata*, but these were not measured in our study.

Our study confirms that oleander can serve as a reproductive host for *H. coagulata* and support multiple generations. This is significant as oleanders are often found in association with grape and other agricultural crops as well as in landscape situations. Nymphal survival on oleander was relatively high, and multiple generations of *H. coagulata* were produced on oleander alone. Oviposition was different on oleander than on grape and citrus, with most eggs being laid singly or in pairs in the epidermis on the underside of oleander leaves.

Results of our study refute our original hypothesis that *H. coagulata* require multiple hosts to successfully produce additional generations.

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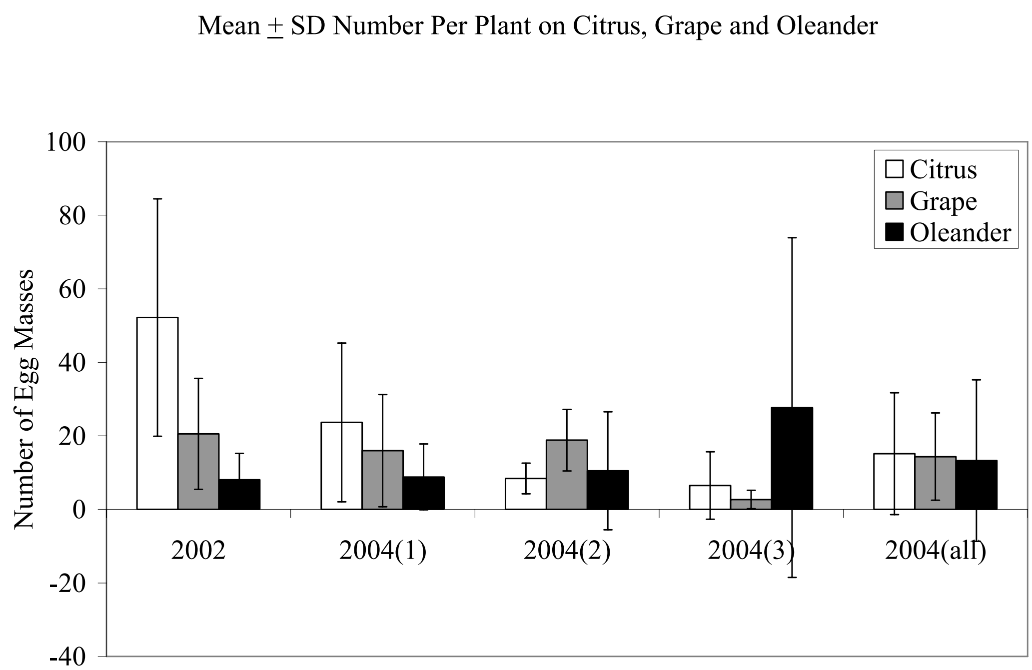

Figure 1. Mean ± SD number of egg masses per plant produced on citrus, grape, and oleander in 2002 and 2004; 2004(1): the spring generation of 2004; 2004(2): the summer generation (first infestation) of 2004; 2004(3): the summer generation (second infestation) of 2004; 2004(all): the mean for the three infestations of 2004.

Mean ± SD Number Per Plant on Citrus, Grape and Oleander

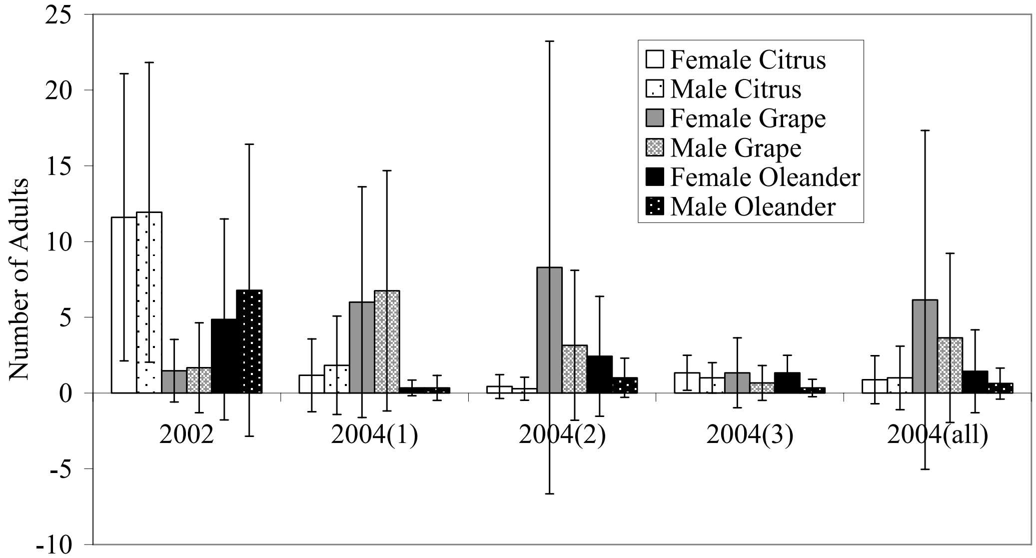

Figure 2. Mean ± SD number of progeny per plant successfully maturing to the adult stage on citrus, grape and oleander in 2002 and 2004; 2004(1): the spring generation of 2004; 2004(2): the summer generation (first infestation) of 2004; 2004(3): the summer generation (second infestation) of 2004; 2004(all): the mean for the three infestations of 2004.