LEAFHOPPER VECTORS OF PHONY PEACH DISEASE: FEEDING SITE PREFERENCE AND SURVIVAL ON INFECTED AND UNINFECTED PEACH, AND SEASONAL RESPONSE TO SELECTED HOST PLANTS[1]

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ABSTRACT

The feeding site acceptance and adult survival of 2 leafhoppers, *Homalodisca coagulata* (Say) and *H. insolita* (Walker), the vectors of phony peach disease (PPD), were determined on branches of uninfected and infected peach, *Prunus persica* L. Batsch 'Flordaking'. The seasonal use pattern of *H. coagulata* on 19 species of plants was also observed in the field during 1983 - 1985.

Although all sections of branches were used, both species of leafhopper accepted the terminal growth for feeding more frequently than older tissue on both infected and uninfected trees. Survival of field collected adults of the *H. insolita* was not different on infected or uninfected branches. However, percent survival of *H. coagulata* was significantly higher on uninfected peach branches.

Japanese plum, *P. salicina,* 'Santa Rosa'; citrus, *Citrus* sp. × *Poncirus* sp. hybrid; sumac, *Rhus* sp.; eastern baccharis, *Baccharis halimifolia* L., and crape myrtle, *Lagerstroemia indica* L. were food plants used most frequently by *H. coagulata* in the field. Fifteen other food plants were used to a lesser degree. Peach was only an occasional host. Vector abundance on particular food plants varied with species and time of year. The implications of these findings are discussed.

Key Words: Leafhopper vectors, phony peach disease, *Homalodisca insolita, Homalodisca coagulata,* feeding-site preference, peach, host selection.

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INTRODUCTION

Phony peach disease (PPD) is the most important production problem facing peach producers in the southeastern U.S. PPD first appeared in Georgia around 1900, and by 1933 it had spread from North Carolina to Texas (Hutchins 1933). Losses from the disease in Georgia alone in 1977 were estimated at $3.4 million (Ellis and Howell 1980). The causal agent of PPD is a fastidious xylem-limited bacterium (Hopkins et al. 1973) and is also the causal agent of plum leaf scald (PLS) (Kitajima et al. 1975; Davis et al. 1981; French 1982).

Approximately 18 - 24 months is required for symptom development. Infected trees initially appear more vigorous, with darker foliage, and profuse branching. As the symptoms progress branch internodes on infected trees become shortened, leaves become flattened and darker, and the trees are dwarfed. Infected trees flower earlier and hold their foliage longer in the fall. They also bear fewer, smaller, more colorful fruits that mature sooner than those of uninfected trees.

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Several species of leafhoppers, (Homoptera: Cicadellidae) are known to transmit the disease organism (Turner and Pollard 1959a). Turner and Pollard (1959b) studied the life histories of the vectors and suggested that *H. coagulata* (Say), *H. insolita* (Walker), *Oncometopia orbona* (F.) (previously *O. undata*), *Graphocephala versuta* (Say), and *Cuerna costalis* (F.) were principally responsible for the transmission and spread of the PPD agent. These vectors are common throughout the Southeast, and some species are responsible for transmitting at least two other xylem-limited bacteria: the causal agent of Pierce's disease of grapes (Adlerz and Hopkins 1979) and the causal agent of periwinkle wilt (McCoy et al. 1978).

Vector behavior, host selection, and use of host plants has received little attention. Ball (1979) found that populations of *H. insolita* peaked in March and again in August, while *H. coagulata* populations reached peak numbers in June - July in northern Florida. *Homalodisca coagulata* and *O. orbona* were considered the most important vectors by Turner and Pollard (1959b). Turner and Pollard (1959b) noted that *H. coagulata* used a variety of host plants through the season based on the "apparently temporarily satisfactory condition" of the individual plants. Adlerz (1980) recorded the incidence of *H. coagulata* and *O. nigricans* on wild host plants in central Florida by walking transects in several habitats and visually observing plants. He also found adult *H. coagulata* using a variety of plants through the season for feeding and oviposition. Adlerz (1980) suggested that common ragweed, mexicantea, sumac, goldenrod, and citrus were its primary hosts.

This paper reports research to determine the feeding site and survival of *H. coagulata* and *H. insolita* on infected and uninfected branches of peach and the food plant acceptance of *H. coagulata.*

METHODS AND MATERIALS

Feeding Site

Trees for the experiment were selected at random from a 1-ha block of seventh-leaf 'Flordaking' peach located on the University of Florida Agricultural Research and Education Center at Monticello. Infected trees were selected for typical PPD symptoms, and the disease was confirmed by serological (French et al. 1978) and cultural (Davis et al. 1981) methods. Branches on infected trees were ca. 75 cm long with 15 cm of new growth compared to uninfected tree branches which varied in length from 1.5 - 2.0 m.

Fourteen branches, 1 branch per tree, 3 infected and 11 uninfected were used for the study in 1983 and 20 branches, 10 in each category, were used in 1984. Each branch was divided into 30 cm sections and the sections were numbered and delineated by ribbon for later observation of leafhoppers. The quality of the branches was also recorded in 3 categories: 1) previous year's wood plus 30 cm of current year's wood, 2) current year's wood with hardening, brown bark, and 3) terminal of succulent, green tissue without brown bark. Previous observations of leafhopper behavior indicated these categories might be useful for further study. Infected branches were much shorter and did not have a section 2.

Screen-mesh cages 30 cm in diam. and slightly longer than the branch were placed loosely over each branch and closed with a drawstring to confine the leafhoppers. Ten to 20 leafhoppers collected from crape myrtle were introduced into each cage and allowed to choose feeding sites on the branches. Tests were

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run separately for *H. coagulata* and *H. insolita.* Leafhoppers survived less than 15 days in the cages, and new groups of leafhoppers were added 5 times each year at ca. 10-day intervals beginning 20 June. The number of leafhoppers introduced was constant within cages but varied by date.

Beginning one day after placement of the leafhoppers in the cages, each cage was observed; once in the mid morning and once in mid afternoon each day, until 5 or less leafhoppers remained alive. The number of leafhoppers feeding in each section was recorded during each observation period. Most leafhoppers observed were actively feeding. Feeding could not be confirmed for all leafhoppers. However, only leafhoppers oriented on the branches in the normal feeding posture were recorded. The branches used were unequal in length so the data were normalized for analysis into areas of unequal length based on the 3 categories of branch quality. The data were analyzed using analysis of variance procedures of the Statistical Analysis System (SAS 1984).

Vector Survival

Methods of caging and branch selection for this experiment were as described above but branches were not divided into sections. Leafhoppers were collected from the field and randomly assigned to the cages. The number of live and dead leafhoppers were recorded each day until all were dead in the cage. Cages were refilled 3 times at ca. 20-day intervals with 10 - 20 leafhoppers of each species (species were tested separately). Five cages each on infected and uninfected branches were used per species and numbers tested were constant within cages, but varied by date.

Response to Host Plants

Nineteen species of host plants that were suggested by Adlerz (1980), Turner and Pollard (1959b), or (Mizell, unpublished data) to be favored hosts were planted in a 0.1 ha block at Monticello. Four plants of each species were planted on a 4.5 × 4.5 m spacing in a completely random design in January 1983. The site was located in a corner of a 1.5-ha field surrounded by woods with a weedy border on all sides. Table 1 lists the species of plants used in the study.

Plants were obtained from several sources but the majority were removed from the surrounding woods and fields. Some plants (dogwood, crape myrtle, and peach) were grown in containers in the year prior to the experiment. Age of the plants was not controlled but an attempt was made to use plants of similar size. In some cases this was impossible due to dissimilar growth characteristics, and size differences became even more disparate over the course of the study. A rototiller was used to remove all competing ground vegetation during the study. Selected limbs on all plants were removed occasionally to facilitate leafhopper counting. No fertilizer was added.

The number of adult *H. coagulata* naturally infesting each plant was counted visually from May 1 to November 1 of 1983, 1984, and 1985. *Homalodisca insolita* or other known vectors were rarely observed. Observations were made from 1 to 3 times per week usually in mid to late afternoon. The mean number of *H. coagulata* observed per observation plant per day was converted to the percent of the total leafhoppers observed on each day to factor out daily and yearly differences in leafhopper abundance. The mean for the 3 yrs of data was calculated and percent observed was then grouped into 7-day intervals beginning on May 26.

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Table 1. Species of host plants used in evaluating acceptance by *Homalodisca coagulata* at Monticello, FL, in 1983, 1984, and 1985.

Family	Common Name	Genus and Species	Category*
Anacardiaceae	sumac	*Rhus* sp.	Cm
Caprifoliaceae	American elder	*Sambucus canadensis* (L.)	Oc
Celestraceae		*Euonymus* sp.	Oc
Compositae	common ragweed	*Ambrosia artemisiifolia* L.	Of
	eastern baccharis	*Baccharis halimifolia* L.	Cm
	goldenrod	*Solidago fistulosa* Mill.	Oc
	dogfennel	*Eupatorium capillifolium* (Lam.)	Of
Cornaceae	dogwood	*Cornus florida* (L.)	Oc
Leguminosae†	sicklepod	*Cassia obtusifolia*	Oc
Lythraceae	crape myrtle	*Lagerstroemia indica* (L.)	Cm
Myricaceae	wax myrtle	*Myrica cerifera* L.	Oc
Oleaceae	privet	*Ligustrum vulgare* L.	Of
Rosaceae	chickasaw plum	*Prunus augustifolia* Marsh	Of
	Japanese plum	*Prunus salicina* 'Santa Rosa' Lindl.	Cm
	blackberry	*Rubus* sp.	Oc
	black cherry	*Prunus serotina* Ehrh.	Oc
	peach	*Prunus persica* Latsch 'Flordaking'	Oc
Rutaceae	citrus-orange	*Citrus* sp. × *Poncirus* sp. hybrid	Cm
Vitaceae	wild grape	*Vitus* sp.	Oc

* Cm = commonly accepted host, Of = often accepted host, Oc = occasional or rare host of *Homalodisca coagulata*.
† Only observed during third year.

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RESULTS AND DISCUSSION

The mean number of *H. coagulata* and *H. insolita* observed on the normalized sections of uninfected peach branches were significantly different (Tables 2 and 3). More leafhoppers of both species were observed on the succulent growth of the terminals, section 3, than on the other sections. However, both species did feed on all 3 branch types. This is contrary to the field observations of Turner and Pollard (1959a) who suggested that the previous year's wood was the preferred feeding site. Feeding on succulent terminals was more pronounced for *H. insolita,* a predominantly grass feeder (Table 3). Similar results were found on the infected branches and the differences were even greater in favor of section 3, the succulent tissue of the terminals (Tables 2 and 3).

Table 2. Mean ± standard deviation number of *Homalodisca coagulata* (Say) observed in cages on different sections of branches of uninfected peach and branches on peach with severe symptoms of phony peach disease.

	Section*	$\bar{x} \pm$ SD	95% CL
	1	0.91 ± 1.28 B†	0.83 - 0.99
Uninfected	2	0.77 ± 1.09 C	0.71 - 0.83
Branch	3	1.43 ± 1.68 A	1.33 - 1.53
Infected	1 - 2	0.42 ± 0.73	0.32 - 0.52
Branch	3	1.54 ± 1.90	1.21 - 1.87

* Sections of branches were normalized by branch quality to give areas of 1 = previous year's wood, 2 = current year's wood-hardened bark and 3 = current year's wood-green bark and meristem area. Infected branches had no discernible section 2.

† Means not followed by same letter are significantly different as determined by Duncan's new multiple-range test, $\alpha = 0.05$.

Table 3. Mean ± standard deviation number of *Homalodisca insolita* (Walker) observed in cages on different sections of branches of uninfected peach and branches of peach with severe symptoms of phony peach diseases.

	Section*	$\bar{x} \pm$ SD	95% CL
	1	0.31 ± 0.71 B†	0.23 - 0.38
Uninfected	2	0.19 ± 0.51 B	0.16 - 0.23
Branch	3	0.90 ± 1.21 A	0.76 - 1.04
Infected	1 - 2	0.06 ± 0.27 B	0.02 - 0.10
Branch	3	1.02 ± 1.50 A	0.75 - 1.29

* Sections of branches were normalized by length to give areas of 1 = previous year's wood, 2 = current year's wood-hardened bark, and 3 = green bark and meristem area. Infected branches had no discernible section 2.

† Means not followed by same letter are significantly different as determined by Duncan's new multiple range test, $\alpha = 0.05$.

Maximum survival time for both *H. insolita* and *H. coagulata* in the cages on peach was approximately the same, i.e., 12 days. Percent survival, however, on individual days was higher for *H. coagulata* (Fig. 1). No difference in percent survival of *H. insolita* was found between infected and uninfected branches (Fig. 1).

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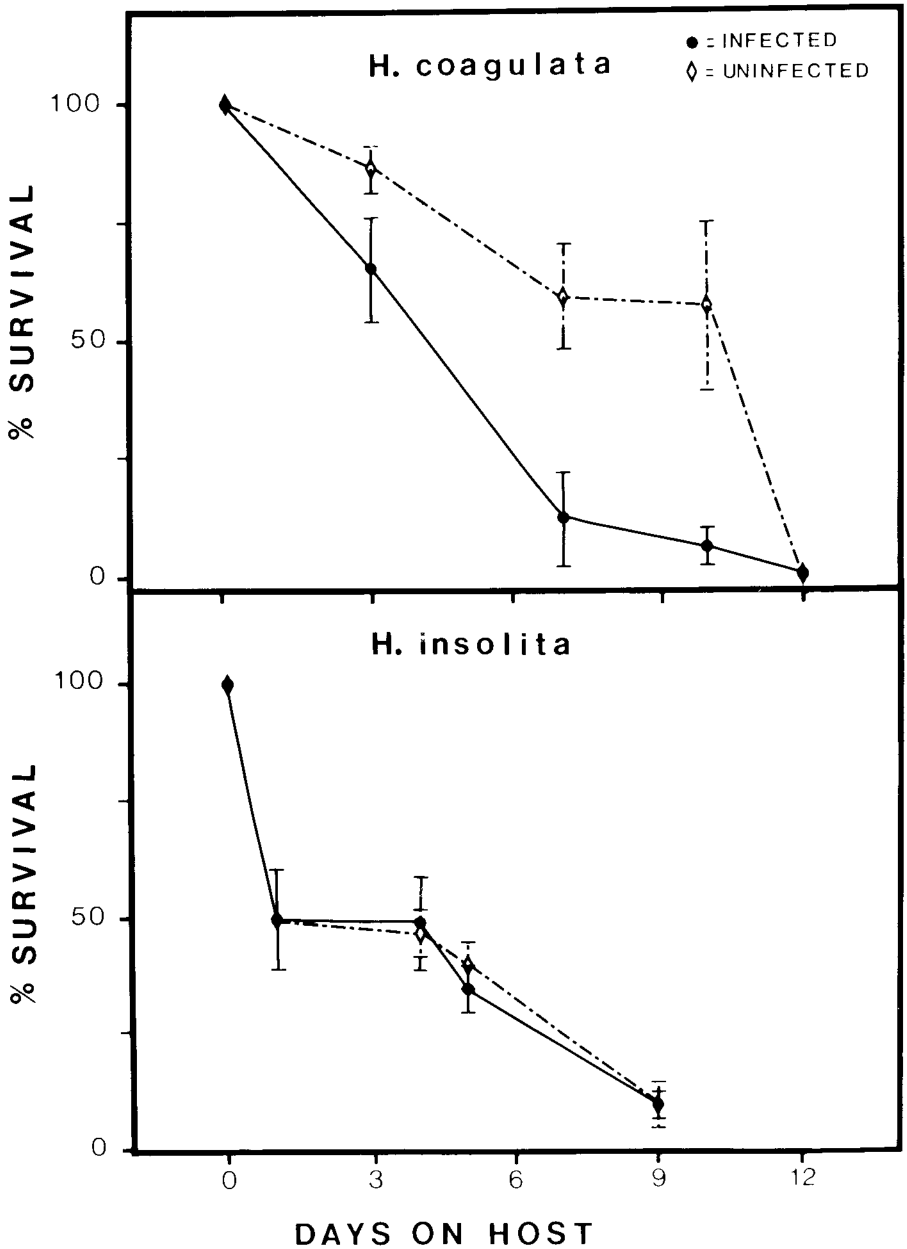

Fig. 1. Percent survival of field collected *H. coagulata* and *H. insolita* on phony peach infected and uninfected peach.

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However, percent survival of *H. coagulata* was higher on uninfected branches than on infected branches (Fig. 1). This data, coupled with results from the feeding site data of Tables 2 and 3 suggests that *H. coagulata* feeds more often on and survives better on succulent terminal growth. Moreover, when *H. coagulata* and *H. insolita* feed on peach, they will feed predominantly on trees which do not display disease symptoms.

Observation of *H. coagulata* on 19 species of host plants including PLS infected and uninfected Japanese plum allowed separation of host plants into 3 groups: commonly accepted (Miller and Strickler 1984) (usually 25% or more of total observed), often accepted (usually 10 - 25%), and occasionally accepted (usually < 10%) hosts (Figs. 2, 3, and 4). Commonly accepted hosts were crape myrtle, eastern baccharis, Japanese plum, sumac, and citrus, *Citus* sp. × *Poncirus* sp. hybrid. Often accepted hosts were common ragweed, dogfennel, chickasaw plum, PLS-infected Japanese plum and common privet. Peach and all other host plants in the test were only occasionally accepted by *H. coagulata* in this choice situation.

Several patterns in leafhopper feeding were observed. Crape myrtle was by far the most commonly accepted host of *H. coagulata* (Fig. 2). Thirty percent or more of leafhoppers observed were found on crape myrtle throughout the season. Uninfected Japanese plum was the second most accepted host and uninfected trees were favored over infected trees (Fig. 2). *Homalodisca coagulata* were observed on uninfected plum throughout the season but increased in mid to late season. Eastern baccharis was the third most accepted host and peak numbers were observed in early and late season (Fig. 2). Sumac also ranked high but peak numbers of *H. coagulata* were observed, only in early season (Fig. 2). In contrast, peak vector response to chickasaw plum was observed in late season (Fig. 3).

The third group of host species, occasional hosts, contained peach (Fig. 4). This result supports the findings from the feeding site preference and percent survival tests discussed above. Peach does not appear to be commonly accepted by *H. coagulata* in contrast to the observations of Turner and Pollard (1959b). Indeed only 5% of *H. coagulata* were ever observed on peach (Fig. 4). Of course this may differ in an orchard situation where peach is the only host available. However, it is doubtful that peach, especially those trees with PPD symptoms, will attract and sustain high numbers of *H. coagulata.*

Low levels of feeding on peach and the fact that the bacteria, when present in the tops of peach branches, is present in low numbers (Hutchins et al. 1953; Wells et al. 1980; French 1972) suggest that *H. coagulata* may not often acquire the bacteria from peach with visual symptoms of PPD. This in turn casts doubt on the need to rogue infected trees (current management recommendations) exhibiting strong PPD symptoms and suggests that other plants are more important in the disease epidemiology. An example is chickasaw plum (Bruer et al. 1951; Cochran et al. 1951; Kenknight et al. 1951) which is known to harbor the PPD causal agent (Hutchins and Rue 1949; Kenknight 1961) and in this test was used by *H. coagulata* throughout the season.

Ragweed and dogfennel are perennial weeds which were only used in late season by *H. coagulata* when these species are maturing. Citrus and privet were species also used more often in late season. All other species of food plants always had < 1% of the observed *H. coagulata. Euonymus* sp. plants used in the study were small and did not grow well. In other situations we have observed this

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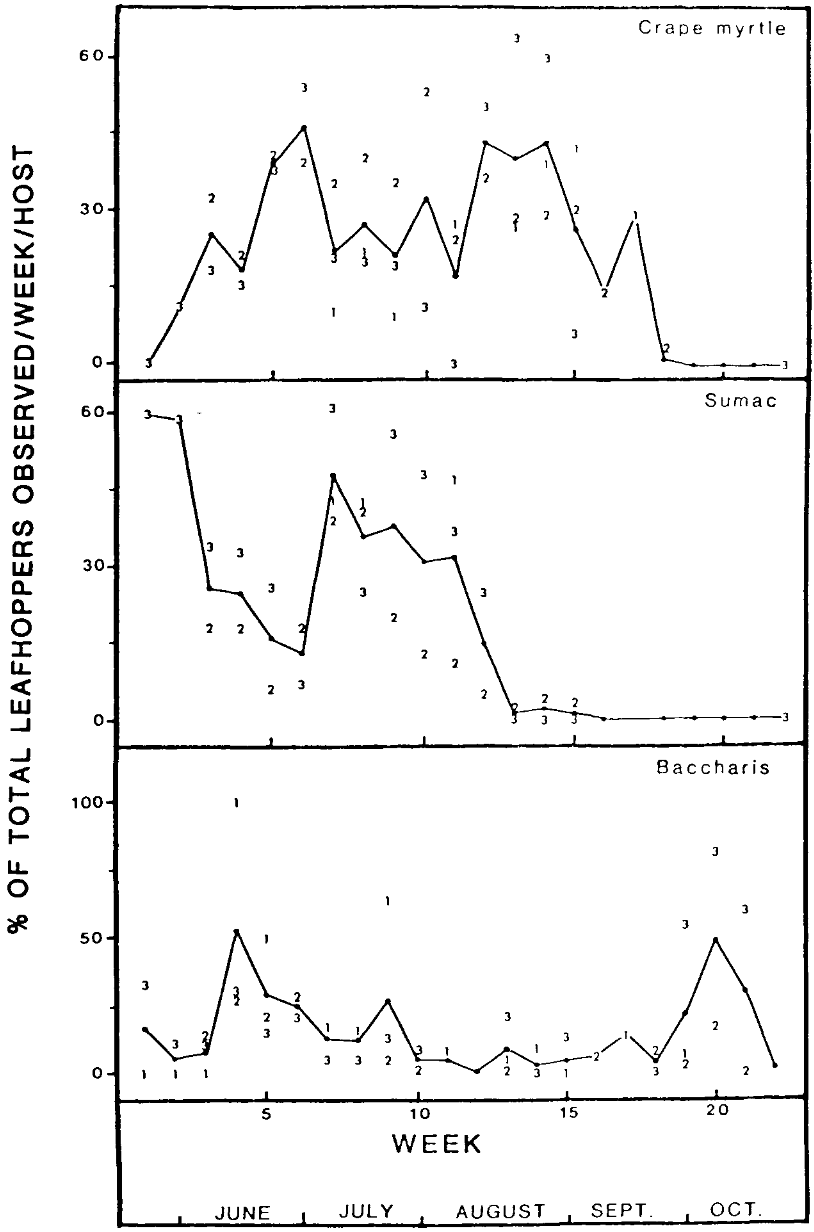

Fig. 2. Seasonal abundance of *Homalodisca coagulata* on selected host species in the field. Solid line is the mean percent observed on each host species as a percent of the total observed at each time period. The numbers indicate year observed: 1 = 1983, 2 = 1984, 3 = 1985. Missing numbers are equal to mean.

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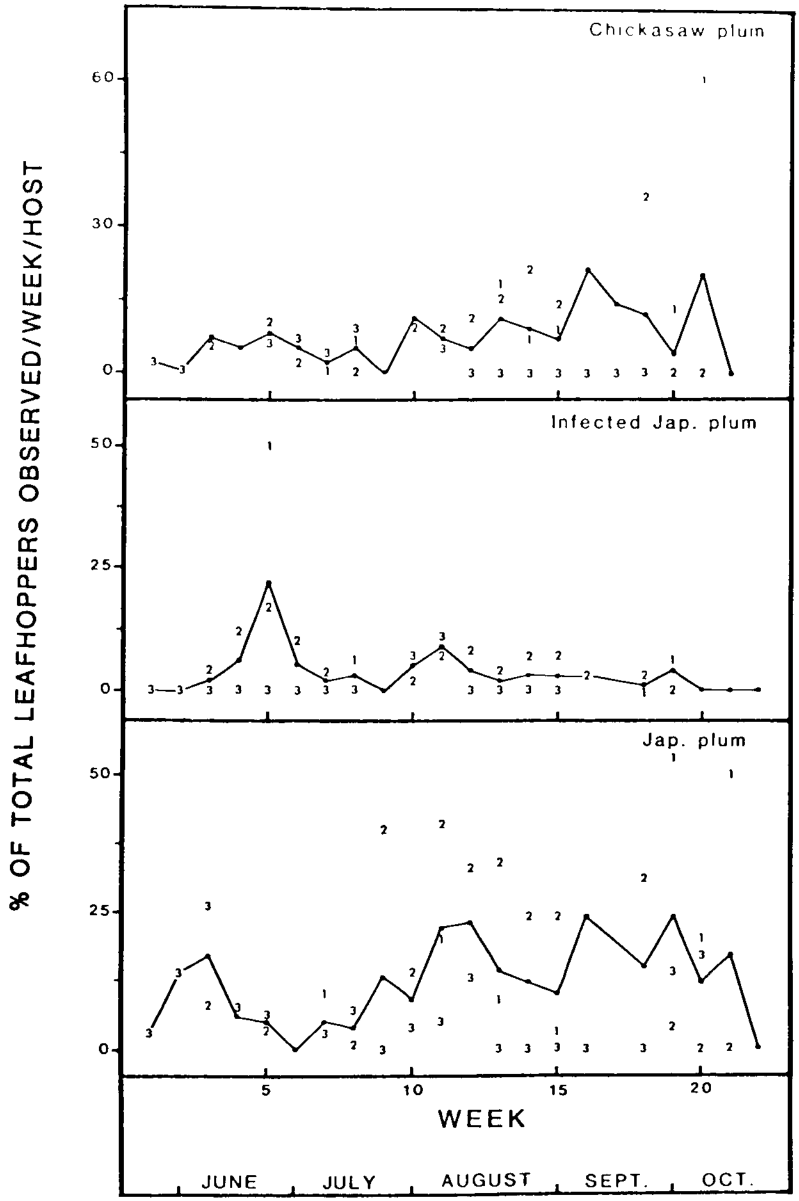

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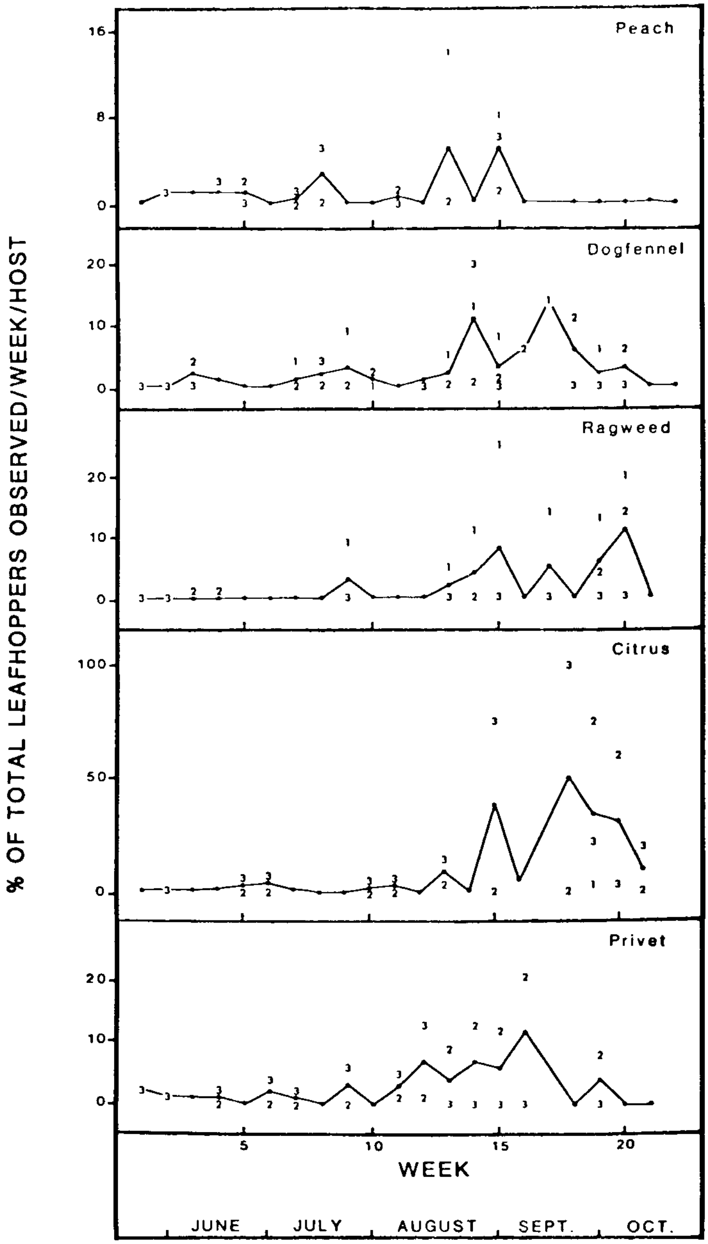

Fig. 4. Seasonal abundance of *Homalodisca coagulata* on selected host species in the field. Solid line is the mean percent observed on each host species as a percent of the total observed at each time period. The numbers indicate year observed: 1 = 1983, 2 = 1984, 3 = 1985. Missing numbers are equal to mean.

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species to be an important ovipositional plant for *H. coagulata* (Mizell 1982, unpublished data).

Data from this study lead to the conclusion that many species of plants are more often accepted than peach for feeding by the primary vector of PPD, *H. coagulata.* Feeding-site studies and survival tests further support this observation because no leafhopper of either species survived more than 12 days on peach alone. The observed patterns of leafhopper feeding on host species and literature cited previously suggest that, while *H. coagulata* does have a few accepted hosts on which it feeds throughout the season, many different plant species are used and in fact may be required. Moreover, the suitability of the myriad of potential hosts appeared to have changed seasonally, and may change daily.

Only a few of the food plants in the experiment (dogfennel, ragweed) are found commonly in peach orchards, but most others may be found in the orchard borders. Searching by the vector for acceptable host plants at different times of the season may result in many trips to and from peach orchards. This would increase the chances for acquisition and transmission of the disease. Further study of the underlying physical and chemical determinants concerning host finding, host selection, host acceptance, and host suitability by the vectors is in progress.

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