LYGUS BUG ECOLOGY AND IMPLICATIONS FOR MANAGEMENT IN COTTON

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ABSTRACT

The western tarnished plant bug, *Lygus hesperus* Knight, is a key pest of several agricultural crops in California and particularly the San Joaquin Valley. In the Central Valley, this species is part of a pest complex with *L. elisus* Van Duzee, with *L. hesperus* populations, in most situations, comprising 96-99% of the individuals. Lygus bugs in California are major pests of cotton (causing flower bud abortion, death of plant terminals, staining of lint), fruit and vegetable crops (feeding results in a quality loss), and seed crops (feeding reduces seed set and yields). Numerous studies have been conducted on lygus bug biology over the last 50 years. Results of these studies form the basis for our present day understanding of lygus bugs and for much of the IPM schemes in place to manage this pest. Additional research on the biological traits of *Lygus* may help to strengthen IPM schemes for this important pest.

INTRODUCTION

Lygus hesperus Knight, the western tarnished plant bug (WTPB) and *Lygus lineolaris* (Palisot de Beauvois), the tarnished plant bug, are important pests of cotton and other crops in the western and southern/eastern U.S., respectively. Plant bugs in the family Miridae are important agricultural pests worldwide, especially *Lygus* which has at least 9 species of worldwide importance. *L. pratensis* and *L. rugulipennis* occupy similar ecological niches in Europe to *L. hesperus* and *L. lineolaris* in the US. The WTPB is economically important through reductions of crop yields and losses in crop quality. Yield reductions are the result of adult and nymphal bugs feeding of flower buds and flowers which either causes the flower to abort or disrupts the development of fruit from the flowers. Examples of losses in quality from feeding are the "blisters" on vegetables such as celery stalks, irregularly-shaped and "catfaced" lesions on strawberries, round pits on pome fruits, and small dead areas that often split as the fruit grows on stone fruits such as peaches and nectarines. WTPB feeding on seeds can reduce yields of seed crops (alfalfa, other legumes, vegetables) and quality of table market beans through pitting and blemishes. Another large economic cost of lygus bugs arises from the costs of control and from the increases in secondary pest populations due to the destruction of natural enemy populations. Some of the important predators in many agricultural systems are also true bugs and the insecticides targeted towards lygus bugs show little selectivity to these beneficials. A thorough understanding of WTPB biology is required to optimize IPM programs for this pest. A brief review of published results on lygus bug biology (life history, developmental rates, host plants, etc.) will be presented herein and some implications for managing this pest will be presented.

LIFE HISTORY

The WTPB enters a reproductive diapause in the fall. The diapause is facultative in that if the conditions required to induce the diapause are not given to the bugs (laboratory colony, for instance), they will continue in a reproductive state. Beards and Strong (1966) showed that WTPB adults were in a diapause state, i.e., not reproductive, by 15 Sept. Given the consistency

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of this date across several years of study, photoperiod, as with many insect species, is the environmental stimulus that induces the diapause. It is the nymphal stage, however, that responds to this stimulus. It appears that exposure of the nymphs to a photoperiod of less than 13 hours in mid-late August predisposes the adults developing from these nymphs to be in a diapause state. A portion of the adult population diapauses for only about 3 weeks and by mid-November about ½ of the population is reproductive. WTPB feed on alfalfa and weed host plants during warm periods from December to February. This period of diapause, i.e., late fall and early winter, may at first appear "counter-productive" to the insect's survival and fitness. Insects diapause often during periods of extreme unfavorable environmental conditions, often cold or heat (sometimes to drought), and the emergence from diapause in December would appear to be at the onset of the coldest period in the Central Valley. It has been hypothesized that the diapause may have evolved in response to the arid summer and fall conditions in the west, i.e., California's Mediterranean climate, and the subsequent lack of vegetation during this period (alfalfa production did not "fit into the picture" during this period of evolutionary time). With the onset of late fall and winter precipitation, vegetation would again be present to facilitate WTPB survival and ending the diapause would be advantageous. Eggs are deposited during the December to February period with eclosion occurring in late winter. An average of 200 eggs can be deposited over a 30 day period (Leigh 1963). Five to seven generations per year commonly occur in the Central Valley on alfalfa; one to two generations can occur on winter and spring host before movement to cotton and other "summer" crops. Three generations commonly occur per year on SJV cotton (Leigh et al. 1996). Adult WTPB are most active at dawn and dusk and move little at night; they can feed extensively at night (Sevacherian 1970).

DEVELOPMENTAL RATES

Several studies have been conducted on WTPB development in response to temperature including detailed laboratory developmental studies and field studies utilizing intensive sampling and population age distribution census. Several other studies monitored development of WTPB at a single temperature regime (and on various hosts for instance) and can be used for comparison with the full developmental response curve from green beans. On green beans, lower and upper developmental thresholds of 46.4^0F and 104^0F, respectively, were determined (Champlain and Butler 1967). Egg and nymphal development required ~260 and 510 degree-days, respectively (~770 degree-days for egg to adult). Pickel et al. (1990) found somewhat lower values on strawberries with 252 degree-days for egg eclosion and 371 degree-days for nymphal development (623 egg to new adult). This study derived a lower developmental threshold of 54 ^{0}F. This higher threshold could account somewhat for the variance in degree-day values although the host plant is undoubtedly also important. Sevacherian et al. (1977) studied the development of lygus bugs on safflower and utilized these data to generate an IPM approach in this crop. With a lower threshold of 52 ^{0}F, 668.6 degree-days were required for 50-70% of the population to reach the 3rd to 5th instar. Although it is difficult to compare with the other studies, if one infers that the average development is to the mid 4th instar, at least another 100 units would be required to reach adulthood. Therefore, WTPB development on safflower appears to be similar to that on green beans (about 800 degree-days) and somewhat slower than that on strawberry (623 degree-days). Leigh (1963) reported that WTPB required 7 days (=200 degree-days at 52^0F base) and ~13.5 days (~370 degree-days) for eclosion and the nymphal development to new adults, respectively, on green beans. The 570 degree-days (oviposition to new adult) is lower than that found by Champlain and Butler albeit they used a different lower threshold. Cave and Gutierrez (1983) found a trend for faster nymphal development of WTPB on alfalfa (228 degree-days), compared with cotton (303 degree-days on squares and 342 degree-days on terminals). They used a 53.4^{0}F lower threshold for development in this field study in which Lygus from a laboratory colony were placed into field cages. Barlow et al. (1999) reported on the development of WTPB on alfalfa and weeds under late winter/spring conditions. Adult WTPB longevity was comparable on wild oats, annual bluegrass, chickweed, Shephard's purse, and groundsel to data reported from green beans (Leigh [1963]) at ~40 days. However, adult longevity on alfalfa was 81 days, twice that on green beans. Cave and Gutierrez (1983) showed survival of WTPB on alfalfa in the 40 day range under "summer" conditions. Developmental times (degree-days) of WTPB nymphs on these spring annual weeds ranged from 576 on wild oats to 671 on chickweed (54^{0}F base temperature) (Barlow et al. 1999). Development was slower on alfalfa at 1020 degree-days. The reason for the slow development on alfalfa relative to other studies, i.e., Cave and Gutierrez (1983), is unknown. Several researchers have speculated on the need for flowers (pollen and nectar) to enhance WTPB development. In the Barlow, Godfrey, Norris study, several of the winter annual weeds flowered more readily than alfalfa during the lygus bug developmental period and this could have influenced the results. Shepherd's purse was the best host in terms of building WPTB numbers through the one generation of the study in an environmental chamber. Populations increased 9-fold on this weed species; numbers were roughly maintained at constant levels on common groundsel and annual bluegrass. Wild oats, alfalfa, and common chickweed allowed only a few WTPB to develop from the egg to adult stage, but some development did occur. Foxtail barley was not an acceptable developmental host.

Few studies have been conducted examining WTPB movement, host choice, feeding, and life history traits among several plant hosts. Given the high mobility of this pest and the multiple available hosts during the season, this would appear to be an important area of research. Cave and Gutierrez (1983) compared survivorship and fecundity of WTPB in cotton to cotton (bugs produced on cotton and placed on cotton for the next generation), alfalfa to alfalfa, and alfalfa to cotton scenarios. Adult females remaining on cotton produced eggs about 1 day quicker than those originating on alfalfa and moving over to cotton; continuous production on alfalfa allowed adult females to oviposit in 10 days (1 day quicker than continuous rearing on cotton). The number of eggs deposited was greatest in the cotton to cotton system, intermediate in the alfalfa to alfalfa and lowest in the alfalfa switching to cotton system. Al-Munshi et al. (1982) found that WTPB adults survived longer on green beans and wheat than on mustard which was better than tomato. The longevity of adults transferred among these hosts was also quantified. Barlow et al. (1999) in a choice test compared the acceptability of wild oats, annual bluegrass, chickweed, Shepherd's purse, groundsel, foxtail barley, and alfalfa as hosts and ovipositional substrates for WTPB. Using visual observations, adults spent the most "time" on Shepherd's purse and groundsel and the least time on foxtail barley. Alfalfa was intermediate in terms of acceptance. Oviposition occurred on all hosts with annual bluegrass, Shepherd's purse, and groundsel having moderate numbers of eggs deposited; inexplicably, the highest number of eggs was deposited in foxtail barley which was not a host for WTPB nymphal development.

Lygus bug movement among different host plants in the field has not been expensively studied. The cultural control tactic of interplanting alfalfa strips within cotton fields to attract and retain WTPB in the alfalfa (Stern 1969, Stern et al. 1967) indicates that alfalfa may be a preferred host. The finding by Leigh et al. (1974) that higher numbers of WTPB were found in cotton with higher plant densities and more frequent irrigation indicates that micro-habitat may be important. Overall, factors which increased the density of the plant canopy facilitated higher lygus numbers in this study. Therefore, WTPB selection of alfalfa may be related more to the plant canopy (thick, lush growth) than the specific host plant.

HOST PLANTS

The western tarnished plant bug has a wide host range; however, the reported host range is not a wide as *L. lineolaris*. Scott (1977) reported over 100 plant species as host for WTPB in 24 plant families. By comparison, Young (1986) reported more than 385 plant species in 55 families as tarnished plant bug hosts. The breakdown by common plant families is below.

Table 1. Percentage of hosts reported by family(from Goodell 1998).

Plant Family	*L. lineolaris* [a]	*L. hesperus* [b]
Asteraceae	26.17	23.42
Fabaceae	11.01	15.32
Brassicaceae	7.70	6.31
Graminae	5.23	7.20
Chenopodiaceae	3.31	6.31
Plantaginaceae	1.10	7.21
Rosaceae	5.79	5.00
others	39.69	29.00

[a] Young, 1986
[b] Scott, 1977

Much of the literature on WTPB hosts is clouded by the lack of reporting whether the plant species is a reproductive host or if the insect was just found feeding on the plant. In addition, reproduction on many weedy host plants has not been studied. The five weeds shown to be hosts by Barlow et al. (1999) were all new hosts compared with the Scott (1977) list and one of these hosts was shown to be a good host for reproduction. Al-Munshi et al. (1982) in a laboratory study added wheat to the WTPB host list. The importance of weeds for promoting WTPB populations is unclear. Barlow (1997) found more WTPB in an alfalfa stand infested with broadleaf weeds compared with non-weedy alfalfa. Conversely, grassy weeds in an alfalfa field appeared to deter lygus bug population build-up relative to pure alfalfa. The role of specific weed hosts in increasing WTPB field populations, and subsequent damage potential to cotton due to population level or feeding propensity, is unknown. Certainly, winter and early spring weeds act as a reservoir for WTPB and provide a link to "summer" crops in the Central Valley. The relative importance of alfalfa versus valley basin weeds versus Foothill weeds for providing this link and hosts for early build-up is unknown.

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