# SURVEY OF LYGUS (LYGUS HESPERUS KNIGHT) SUSCEPTIBILITY TO BIFENTHRIN (CAPTURE®) IN THE SAN JOAQUIN VALLEY OF CALIFORNIA

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## Abstract

A survey of the lygus bug (Lygus hesperus Knight) population in the San Joaquin Valley of California for susceptibility to bifenthrin was conducted using the glass vial technique. Lygus collected from alfalfa hay were found to be the most susceptible to bifenthrin while those taken from treated seed alfalfa and cotton were less susceptible. There was considerable variation in susceptibility in lygus collected from different crops, from the various geographic locations and different times during the season. These differences appear to be related to Capture Insecticide-Miticide and/or other pyrethroid use in the area being sampled. The data showed that lygus susceptibility to bifenthrin declines following a Capture application but recovers later in the season if the population is relatively susceptible at the time of treatment. Treatment of tolerant populations may only exacerbate control problems with a pyrethroid. These results suggests that if pyrethroid applications, including Capture, are restricted to once per season in a specific geographic area, susceptibility of lygus to Capture can be maintained. The data also suggest little long range lygus movement during the season.

## Introduction

The western tarnished plant bug, (Lygus hesperus Knight), commonly known as the lygus bug, is a significant pest on cotton in the desert southwest (Wene and Sheets 1994). It has periodically been a severe pest on the one million acres of cotton grown in the San Joaquin Valley of California. Lygus bugs can severely reduce cotton yields by causing square abortion, inhibition of seed development and lint stain (Godfrey et al., 1996).

A number of organophosphate and carbamate insecticides have been used over the past several years to control this insect. Unfortunately, lygus have become tolerant to these products after only a few years of use (Leigh et al 1976). This problem has been exacerbated by the frequent exposure of lygus populations to the various classes insecticides used in cotton and in other crops such as seed alfalfa.

Reprinted from the *Proceedings of the Beltwide Cotton Conference*
Volume 2:1074-1078 (1997)
National Cotton Council, Memphis TN

Bifenthrin (Capture) was first registered for use on cotton in California in 1991. It is a very effective insecticide with long residual activity and has been used primarily and extensively to control lygus on cotton and seed alfalfa. In 1995 there were reports that Capture was providing less than anticipated lygus control in some areas. Although Capture continued to provide good initial knockdown of lygus, anecdotal reports of reduced residual control surfaced. A reduction in residual activity may be indicative of a decline in pest susceptibility. However, it can also result from high population numbers, a high rate of immigration from alternate hosts, or agronomic practices which reduce the amount of compound being applied to the pest population.

Early in 1996, FMC initiated a program to determine if reduced susceptibility might be responsible for some of the performance problems reported. It was known that certain areas had historically received more exposure to pyrethroids than other areas. Alfalfa hay and seed are excellent host plants during the summer and are a convenient sites to collect adequate numbers of insects for testing.

Previous reports (Knabke and Staetz 1991, Dennehy and Russell 1996, Snodgrass and Scott 1996) have shown that the adult vial test (AVT) can be used to determine the susceptibility of various lygus populations to pyrethroids. In this study, population samples were taken from treated and untreated areas before and after Capture applications. This was done to understand how AVT results relate to actual control of field populations of lygus and because it is important to know how field applications affect the susceptibility of lygus populations throughout the season.

## Materials and Methods

### Collection of lygus - 1996; San Joaquin Valley

Lygus were collected from alfalfa seed and alfalfa hay, cotton, and weeds. Several of the sites were commercially grown alfalfa seed fields and were monitored throughout the spring and summer. Lygus adults were collected with sweep nets and placed into clear one gallon plastic jars. The adults were not anesthetized with $CO_2$ as in the 1991 study. Instead adults were placed directly into 20 ml glass scintillation vials by reaching into the plastic jar and tapping the lygus into the vials.

### Vial Treatment

Twenty milliliter glass scintillation vials were treated (Knabke and Staetz 1991) with five dosages of bifenthrin. Each vial received 0.5 ml of solution and was then placed onto a hot dog roller and rotated until dry at room temperature. The treatment rates were 0.3, 1.0, 3.0, 10.0 and 30.0 µg/vial. In addition, one or two small (2mm) ventilation holes were drilled into the vial caps. These holes prevented the buildup of moisture in the vials when they contained lygus.

**Bioassay**

Five to ten adults were placed in each vial with five vials being used for each test rate. After three hours the number of alive, dead, or moribund insects was recorded (Knabke and Staetz 1991; Dennehy and Russell 1966; and Snodgrass and Scott 1966). Individuals that were unable to move were counted as dead; those which were capable of uncoordinated movement were recorded as moribund; and those which could move normally were considered to be alive.

The results were analyzed by calculating the percent mortality ([dead + moribund / total] x 100) at each dosage. Treatment mortality was corrected for deaths which occurred in the control group using Abbott's (1925) formula. The corrected data for each site were subjected to probit analysis (SAS Institute 1989) for estimation of LC50 and LC90 values and 95 percent confidence limits.

**Field Testing - 1991; Imperial Valley, CA/Gila Valley, AZ**

In 1991, field tests were conducted in a low pyrethroid use area (Holtville, CA - host: alfalfa hay) and a high pyrethroid use area (Gila Valley, AZ - host: alfalfa seed). The field tests used various treatments of Capture 2 EC Insecticide sprayed onto replicated plots (four) 16 feet x 40 to 60 feet. The applications were made with a 16 foot wide plot sprayer fitted with 8001 flat fan nozzles applied at 35 psi and 22 gpa. The plots were sampled by taking seven sweeps per plot with a standard sweep net. On the day of, or within five days of the start of the field tests, several AVT tests (Knabke and Staetz, 1991) were conducted at each site.

## Results and Discussion

In 1996, seventy-three separate bioassays were conducted during the period of April 11 to August 21. Lygus were collected from alfalfa seed (47), alfalfa hay (18), cotton (6), and weeds (2). Overall there was a considerable range of LC values between crops. Values tended to be lowest for lygus collected early in the season from alfalfa hay and highest for those collected later in the season from cotton (Table 1).

**Alfalfa hay**

The data from alfalfa hay (San Joaquin Valley, 1996) are straightforward. LC values from alfalfa hay (Table 2) were quite low (LC50 values - 0.1 to 0.4 $\mu$g/vial) with the LC values from some sites nearly as low as the very susceptible lygus (mean LC50 0.2 $\mu$g/vial) collected from Holtville, CA in 1991 (Table 3). Although the chemical use history of each of these fields is not known, alfalfa hay in these areas is generally not directly sprayed with any pyrethroid (only permethrin is registered for use on alfalfa hay in California).

Lygus adults collected from alfalfa hay tended to be more susceptible than those collected from seed alfalfa or cotton (Table 1). Lygus adults were collected from three alfalfa hay fields near Corcoran on August 15. As shown in Figure 1, the LC90 values were < 5 $\mu$g / vial. Low LC values were also observed at three alfalfa hay locations near Dos Palos which were sampled about the first of June and again on August 20. The lygus in these alfalfa fields were very susceptible early in the season and even more susceptible in late August (Figure 2) with the LC90 values below 1 $\mu$g / vial. Conversely, the LC90's of lygus collected from seed alfalfa at several locations near San Joaquin ranged from about 5 to 15 $\mu$g / vial and the LC90 for lygus from cotton was greater than 25 $\mu$g / vial (Figure 3).

**Weeds**

Lygus were collected from weed hosts in proximity to a seed alfalfa field in a high pyrethroid use area to evaluate the relative susceptibility of an overwintering population. One weed site near San Joaquin, CA indicated these lygus were relatively tolerant to bifenthrin (Table 4).

The fields in the San Joaquin area have received frequent applications of Capture and other pyrethroids since they became available for commercial use on cotton and alfalfa seed. On the same day, adults collected near Clovis, CA (about 35 miles west of the first site), were about twice as susceptible to bifenthrin as those from the San Joaquin area. The Clovis area is primarily a pasture and fruit production area where pyrethroids are seldom used. These results suggested there could be rather large differences in lygus susceptibility over relatively short distances and correlated with pesticide use in the area.

**Cotton**

Generally, it was difficult to collect enough lygus from cotton to do a complete test. Consequently some of the field collections made in 1996 were from sites where reduced control was suspected. However, even at these locations previous insecticide use was found to be important. A low level of lygus control was suspected at Mendota, CA, but the adults were found to be generally susceptible to bifenthrin (Table 5). Two fields in a heavy pyrethroid use area near Helm, CA, were sampled in late July. One field had not been treated while the second field had been treated with Capture the previous day. The few remaining adults collected from the treated field were less susceptible than those from the untreated field (Table 5).

The San Joaquin cotton site was contiguous to a commercial alfalfa seed field that was drying down. As a consequence the adults were moving from the alfalfa field to the adjacent cotton field. This population had been sprayed with Capture in the alfalfa field and were tolerant to bifenthrin (Table 5). These test results show that pesticide applications made to one crop can have direct consequences to the susceptibility of lygus populations found in adjacent host crops.

**Alfalfa Seed**

Most of the data were obtained from alfalfa seed fields. This crop was chosen for several reasons: These areas are fertile breeding sites for lygus; these fields provide a stable host crop for lygus collections until seed harvest; and Capture has been used extensively since 1991. Therefore, lygus population susceptibility to bifenthrin could be followed throughout the season permitting the gathering of susceptibility data before and after Capture applications.

In three of the five alfalfa seed fields monitored, a decrease in lygus susceptibility was noted at the first sampling after application followed by a progressive increase in susceptibility. This phenomenon was most clearly demonstrated at the Kettleman City and Stratford locations. As shown in Figure 4, the LC90 increased from about 2 $\mu$g / vial on May 23 to about 18 $\mu$g / vial on June 25 following a treatment on June 7. By July 18 the LC90 was again less than 5 $\mu$g / vial. Another example of this phenomenon was observed with lygus collected from a field that was located near Stratford. Fortunately it was possible to sample this field five times: once at the end of May, two days after a Capture application and then three more times at roughly two week intervals. In this instance there was a sharp decline in susceptibility (LC90 increased from <2 $\mu$g / vial before treatment to about 20 $\mu$g / vial after treatment) followed by a gradual increase in susceptibility through August 1 (Figure 5).

At another location, Lanare, CA, lygus susceptibility was substantially higher ten days following a Capture application. However, eight days later the alfalfa seed field was sampled again and the lygus were nearly as susceptible as before the Capture treatment (Figure 6).

The results from Corcoran, CA (Figure 7) indicate a similar trend in reduced susceptibility following treatment, however, sampling was not continued. Thus a reversion to increased susceptibility was not determined. The results from Alpaugh, CA (Figure 8) did not follow the reversion pattern observed in the first three locations.

The rapid cycling in susceptibility would suggest a second Capture treatment could be made, however, recent commercial experience indicates marginal control can occur following a second application.

**Diagnostic Dose**

In 1991 vial and field tests were conducted in Arizona and California with lygus collected from alfalfa hay (CA) and alfalfa seed fields (AZ) that were adjacent to cotton fields that had been treated with pyrethroids. The lygus from Holtville, CA were found to be very susceptible (Table 6) while those from Arizona were not susceptible to bifenthrin (Table 7). The data show that a diagnostic rate of about 5 $\mu$g / vial can identify bifenthrin-susceptible and non-susceptible lygus populations (Table 8). More work is required in California to identify a specific rate, or rates, which can identify potential problem fields. This year's data suggests that a rate of 3 $\mu$g / vial (Table 9) will identify susceptible populations while 10 or 30 $\mu$g / vial will identify populations which can still be controlled with bifenthrin but with reduced residual activity.

## Conclusions

There is considerable variation in the susceptibility of Lygus hesperus to bifenthrin in the San Joaquin Valley of California. The susceptibility of a lygus population appears to depend on both the host crop and the locale of the population. This variability is most likely due to the previous use history of Capture and other pyrethroids in the area. The differences in susceptibility can be substantial over relatively short distances which suggests that there may not be much long range movement of lygus during the season.

Insecticide applications can decrease the overall susceptibility of the lygus population in an area over a short time period although there tends to be a reversion to susceptibility in the weeks following the treatment. However, this also suggests that repeated applications of pyrethroids in a limited area can result in a substantial loss of susceptibility. It is not clear whether full reversion to susceptibility will occur following several applications to the same population in a crop season. In addition, treatment of tolerant populations will only result in the selection of more tolerant individuals which will result in an increased loss of susceptibility.

The variability in bifenthrin susceptibility over time and geography indicates that in order to obtain a complete picture of the bifenthrin susceptibility of a lygus population in a particular area, susceptibility monitoring must be conducted at the local field level and population samples be taken at several locations throughout the season.

The results further suggest that only one pyrethroid application be made to a given lygus population per year timed in a window to protect the critical fruit formation period.

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Table 1. Mean LC values* (3h) for adult lygus collected from the host plants shown in the SJV, 1996.

| | µg / vial | | | |
|---|---|---|---|---|
| Host | LC50 | range | LC90 | range |
| Alfalfa hay | 0.5 | 0.1 - 0.9 | 2.3 | 0.4 - 5.1 |
| Alfalfa seed | 2.3 | 0.1 - 7.4 | 8.7 | 1.0 - 35.1 |
| Cotton | 3.9 | 1.0 - 8.1 | 16.7 | 4.4 - 28.6 |
| Weeds | 2.9 | 1.7 - 4.1 | 10.8 | 5.8 - 15.9 |

*Mortality data are based on 3h exposure to bifenthrin in coated 20 ml glass scintillation vials. Analyses were based on five rates with 25 to 50 lygus per rate; data were corrected for check mortality with Abbott's formula.

Table 2. LC values* for adult Lygus hesperus collected from alfalfa hay near the towns indicated.

| | | µg / vial | | | | | |
|---|---|---|---|---|---|---|---|
| Location | Date | LC50 | (95% C.I.) | | LC90 | (95% C.I.) | |
| Tranquility | 5/20 | 0.7 | 0.4 | 1.1 | 6.1 | 3.6 | 14.6 |
| Tranquility | 5/22 | 0.6 | 0.5 | 0.8 | 1.6 | 1.2 | 2.3 |
| Dos Palos | 5/29 | 0.3 | | | 0.5 | | |
| Dos Palos | 5/29 | 0.4 | 0.2 | 0.8 | 3.2 | 1.5 | 6.6 |
| Dos Palos | 6/6 | 1.1 | 0.8 | 1.5 | 3.5 | 2.2 | 5.5 |
| Tulare | 6/24 | 0.5 | 0.3 | 0.6 | 1.3 | 0.9 | 2.1 |
| Visalia | 6/24 | 0.3 | 0.2 | 0.4 | 0.7 | 0.5 | 1.5 |
| Visalia | 6/24 | 0.3 | 0.1 | 0.4 | 1.1 | 0.7 | 2.7 |
| Delano | 7/1 | 0.5 | 0.3 | 0.6 | 1.7 | 1.2 | 3.5 |
| Shafter | 7/1 | 0.3 | 0.2 | 0.4 | 1.1 | 0.7 | 2.4 |
| Firebaugh | 7/9 | 0.1 | 0.0 | 0.2 | 0.9 | 0.4 | 2.5 |
| Firebaugh | 7/9 | 0.4 | 0.3 | 0.8 | 4.6 | 2.3 | 9.1 |
| Corcoran | 8/15 | 1.1 | 0.7 | 1.5 | 5.1 | 3.4 | 9.9 |
| Corcoran | 8/15 | 1.1 | 0.2 | 3.1 | 3.8 | 1.7 | 28.6 |
| Corcoran | 8/15 | 0.8 | 0.6 | 1.1 | 3.2 | 2.0 | 5.2 |
| Dos Palos | 8/20 | 0.3 | 0.1 | 0.4 | 1.0 | 0.7 | 2.7 |
| Dos Palos | 8/20 | 0.3 | | | 0.4 | | |
| Firebaugh | 8/20 | 0.4 | 0.3 | 0.6 | 0.9 | 0.7 | 1.6 |

*Mortality data are based on 3h exposure to bifenthrin in coated 20 ml glass scintillation vials. Analyses were based on five rates with 25 to 50 lygus per rate; data were corrected for check mortality with Abbott's formula.

Table 3. LC values* for adult Lygus hesperus collected in California and Arizona in 1991.

| Site | Date (1991) | No. tests | Mean value - ug / vial LC50 | LC90 |
|---|---|---|---|---|
| Holtville, CA | 7/19 | 2 | 0.20 | 0.60 |
| Gila Valley, AZ | 7/25, 7/29 | 3 | 3.81 | 17.0 |

*Mortality data are based on 3h exposure to bifenthrin in coated 20 ml glass scintillation vials. Analyses were based on five rates with 25 to 50 lygus per rate; data were corrected for check mortality with Abbott's formula.

Table 4. LC values* for adult Lygus hesperus collected from weeds located in two distinct California areas on April 11, 1996.

| | µg / vial | | | | | |
|---|---|---|---|---|---|---|
| Location | LC50 | (95% C.I.) | | LC90 | (95% C.I.) | |
| Clovis | 1.7 | 1.2 | 2.4 | 5.8 | 3.8 | 11.8 |
| San Joaquin | 4.1 | 2.9 | 5.8 | 15.9 | 10.4 | 30.9 |

*Mortality data are based on 3h exposure to bifenthrin in coated 20 ml glass scintillation vials. Analyses were based on five rates with 25 to 50 lygus per rate; data were corrected for check mortality with Abbott's formula.

Table 5. LC values* for adult Lygus hesperus collected from cotton in the San Joaquin Valley, CA in 1996.

| | | µ / vial | | | | | |
|---|---|---|---|---|---|---|---|
| Location | Date | LC50 | (95% C.I.) | | LC90 | (95% C.I.) | |
| Mendota | 6/21 | 1.0 | 0.1 | 3.0 | 6.2 | 2.2 | 16.1 |
| Helm | 7/25 | 1.1 | 0.7 | 1.5 | 4.4 | 2.9 | 9.0 |
| Helm | 7/26 | 8.1 | 5.6 | 11.6 | 28.6 | 18.2 | 71.1 |
| San Joaquin | 8/13 | 5.3 | 0.4 | 63.4 | 27.7 | 7.3 | 50.3 |
| Visalia | 8/21 | (<3.0) | | | | | |

*Mortality data are based on 3h exposure to bifenthrin in coated 20 ml glass scintillation vials. Analyses were based on five rates with 25 to 50 lygus per rate; data were corrected for check mortality with Abbott's formula.

Table 6. Effect of Captureâ 2EC on Lygus hesperus on alfalfa hay at Holtville, CA in 1991.

| | | % Control | | | | | |
|---|---|---|---|---|---|---|---|
| | | Adults | | | Nymphs | | |
| Treatment | lb. ai/A | 1 DAT | 2 DAT | 6 DAT | 1 DAT | 2 DAT | 6 DAT |
| Capture 2EC | 0.01 | 98 | 51 | 28 | 94 | 90 | 86 |
| Capture 2EC | 0.02 | 88 | 58 | 50 | 98 | 98 | 97 |
| Capture 2EC | 0.03 | 100 | 87 | 30 | 100 | 99 | 99 |
| Capture 2EC | 0.05 | 96 | 95 | 67 | 97 | 99 | 100 |
| Capture 2EC | 0.1 | 100 | 100 | 67 | 97 | 100 | 99 |
| No. per 7 sweeps | | 12.5 | 13.8 | 25.3 | 29 | 48.5 | 91.3 |

Table 7. Effect of Captureâ 2EC on Lygus hesperus on alfalfa hay at Gila Valley, AZ in 1991.

| | | % Control | | | |
|---|---|---|---|---|---|
| | | Adults | | Nymphs | |
| Treatment | lb. ai/AC | 1 DAT | 5 DAT | 1 DAT | 5 DAT |
| Capture 2EC | 0.01 | 62 | 0 | 69 | 46 |
| Capture 2EC | 0.03 | 84 | 0 | 77 | 62 |
| Capture 2EC | 0.05 | 91 | 3 | 82 | 76 |
| Capture 2EC | 0.1 | 93 | 0 | 95 | 89 |
| Capture 2EC | 0.2 | 98 | 0 | 95 | 88 |
| No. per 7 sweeps | | 142.3 | 59.3 | 51.5 | 62.3 |

Table 8. Comparison of 3h mortality of Lygus hesperus in bifenthrin coated 20 ml glass scintillation vials (5 $\mu$g / vial) and percent control in the field for Captureâ applied at 0.05 lb. a.i./acre.

| | Pct Mortality | Pct Control 6 DAT | |
|---|---|---|---|
| Location | @ 5 m /vial | Nymphs | Adults |
| Holtville, CA | 100 | 97 | 67 |
| Gila Valley, AZ | 50 | 76 | 3 |

Table 9. Mean percent mortality (3h) of Lygus hesperus collected from the crops shown in bifenthrin coated 20 ml glass scintillation vials.

| | Percent Lygus hesperus mortality | | | |
|---|---|---|---|---|
| $\mu$g/vial | Hay | Seed | Cotton | Weeds |
| 30.0 | 99.8 | 99.4 | 97.4 | 100.0 |
| 10.0 | 98.1 | 88.7 | 75.3 | 86.0 |
| 3.0 | 94.0 | 70.0 | 61.0 | 56.0 |
| 1.0 | 77.0 | 33.0 | 34.0 | 30.0 |
| 0.3 | 38.9 | 8.9 | 13.3 | 3.0 |

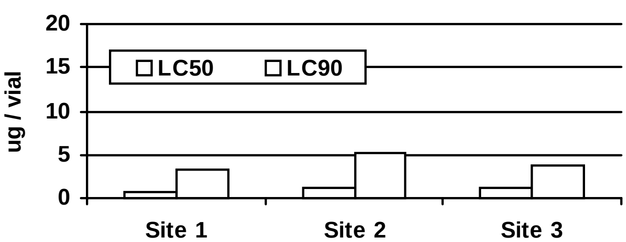


Figure 1. Susceptibility of adult Lygus hesperus collected in alfalfa hay at three locations approximately one mile apart at Corcoran, CA on August 15, 1996.

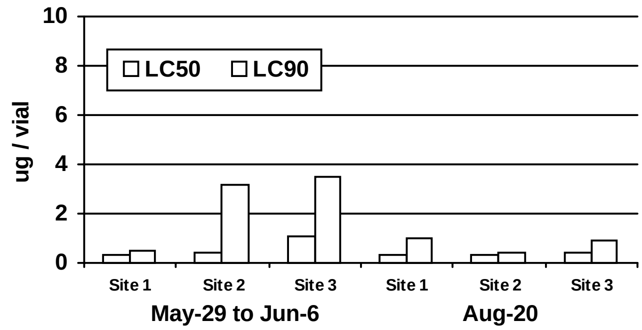


Figure 2. Bifenthrin susceptibility of adult Lygus hesperus collected in alfalfa hay at three locations at Dos Palos, CA about June 1 and again at the same sites on August 20, 1996.

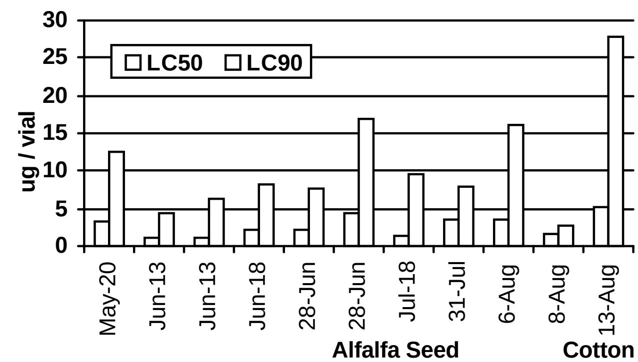


Figure 3. Bifenthrin susceptibility of adult Lygus hesperus collected in alfalfa seed and cotton at several locations at San Joaquin, CA between May 20 and August 13, 1996.

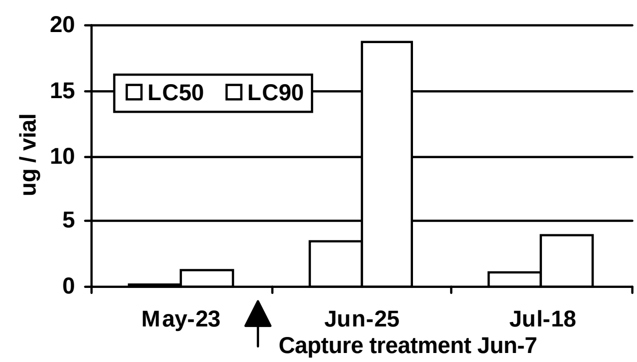


Figure 4. Change in bifenthrin susceptibility of a Lygus hesperus population at Kettleman City, CA following a Capture® application to seed alfalfa.

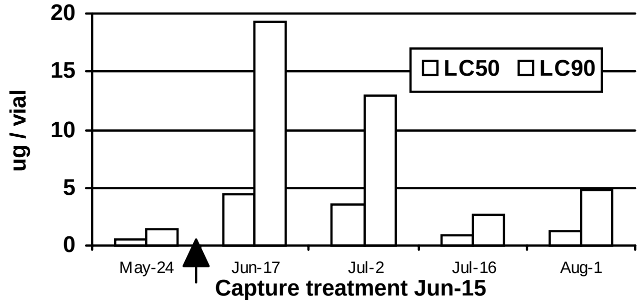


Figure 5. Change in bifenthrin susceptibility of a Lygus hesperus population at Stratford, CA following a Capture® application to seed alfalfa.

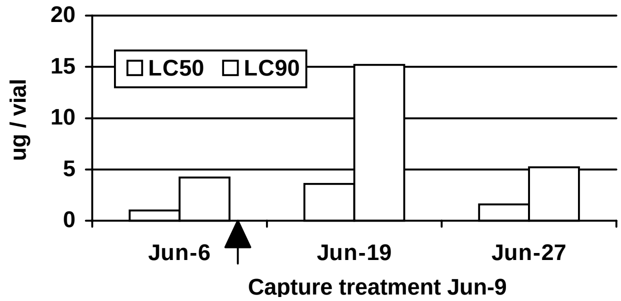


Figure 6. Change in bifenthrin susceptibility of a Lygus hesperus population at Lanare, CA following a Capture® application to seed alfalfa.

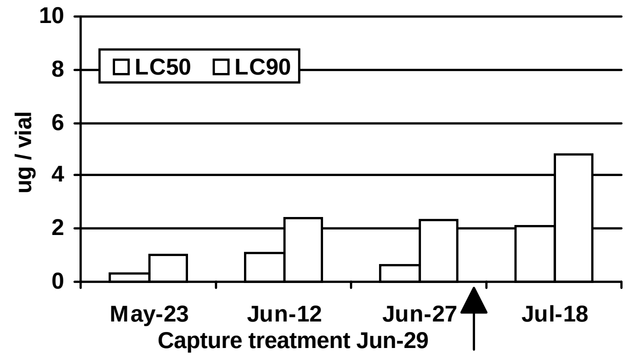


Figure 7. Change in bifenthrin susceptibility of a Lygus hesperus population at Corcoran, CA following a Capture® application to seed alfalfa.

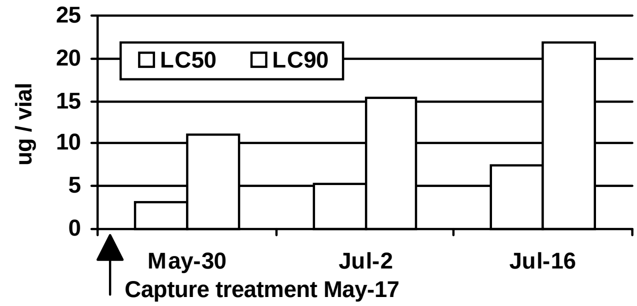


Figure 8. Change in bifenthrin susceptibility of a Lygus hesperus population at Alpaugh, CA following a Capture® application to seed alfalfa.