STATUS OF BOLLWORM, HELICOVERPA ZEA, SUSCEPTIBLILTY TO PYRETHROIDS: IRAC-US 1998 UPDATE

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Abstract

In 1998, IRAC-US sponsored a bollworm monitoring program to determine if a widespread change in the susceptibility of the bollworm to the pyrethroid insecticides is occurring. Bollworm moths were collected and tested in Alabama, Arkansas, Georgia, Louisiana, Mississippi, Missouri, North Carolina, South Carolina and Texas. Over 10,200 moths were bioassayed from June through October 1998. Survival at the 5 µg/vial dose of cypermethrin ranged from a low of 0% to a high of 21.2% in Louisiana during June. Louisiana (June and July), Alabama (July) and North Carolina (September) were the only collection locations to exceed 10% survival at the 5 µg/vial dose. Survival at the 10 µg/vial dose of cypermethrin ranged from 0% to a high of 4.9% in Alabama during July. Alabama (July), Louisiana (July) and North Carolina (September) were the only three collections to exceed 2% survival at the 10 µg/vial dose. The increasing tolerance of the bollworm to the pyrethroids demonstrated in this study, suggest that maintaining the effectiveness of the pyrethroids against the bollworm should become a higher priority in future resistance management plans.

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Introduction

The bollworm, *Helicoverpa zea*, is one of the most important pests of cotton and it has been documented to have developed resistance to several classes of insecticides (Sparks 1981). Several studies in recent years have reported bollworm populations that have developed tolerance or resistance to the pyrethroid insecticides (Abd-Elghafar et al. 1993, Kanga et al. 1996, Brown et al. 1998, Walker et al. 1998). In 1996 neurophysiological assays found a low frequency of pyrethroid target-site resistant bollworms in Louisiana (Holloway et al. 1997). Also, a long term monitoring program in Louisiana seems to indicate a gradual change in the susceptibility of bollworm to the pyrethroid insecticides (Bagwell et al. 1998).

The Insecticide Resistance Action Committee - United States (IRAC-US) is an inter-company committee dedicated to prolonging the effectiveness of insecticides and acaricides by countering resistance problems. The IRAC-US committee increases awareness of resistance through various educational programs and sponsors research to promote the prevention or management of insecticide resistance. During our 1998 meeting to review research proposals submitted for funding, we reviewed several proposals to evaluate various aspects of bollworm resistance to the pyrethroids. Since there was a high level of concern across the cotton belt about possible bollworm resistance to pyrethroids, IRAC-US thought it would be prudent to first find out if there was a widespread change in the bollworm susceptibility to the pyrethroids. The committee cooperated with university researchers to develop an extensive monitoring program in 1998. The purpose of this paper is to report the results of the 1998 bollworm monitoring program.

Materials and Methods

Wire cone traps (Harstack et al. 1979) baited with artificial sex pheromone lures (Hendricks et al. 1987) were used to collect bollworm male moths from June through October. Moths were collected from cotton growing regions in Alabama, Arkansas, Georgia, Louisiana, Mississippi, Missouri, North Carolina, South Carolina and Texas. Multiple collection locations were used in six of the eight participating states.

All of the vials used for testing were produced at a central location and then shipped to each participating state for testing. The interior of glass scintillation vials (20 ml) were coated with cypermethrin (5 μg/vial or 10 μg/vial). A discriminating dose has not been determined for the bollworm. However, Kanga et al. 1996, suggested 2.5 μg/vial as a possible discriminating dose for cypermethrin

to bollworm. Without a definitive discriminating dose we chose to error on the high side when choosing doses to evaluate. The 5 μg/vial dose of cypermethrin was chosen as the low dose for this monitoring program because historical data exists for this dose against the bollworm (Bagwell et al. 1998). The 10 μg/vial dose of cypermethrin was chosen as the high dose because it is considered lethal to homozygous pyrethroid susceptible tobacco budworm, *Heliothis virescens*, moths as well as moths heterozygous for pyrethroid resistance (Plapp et al. 1987). Bollworm individuals surviving the 10 μg/vial dose also should be resistant to pyrethroids. Vials were stored in a dark area to prevent photodegradation of the pyrethroid insecticide. Acetone-treated vials were used to check for moth natural mortality.

Male moths were removed from the traps early in the morning to prevent desiccation. Only moths that appeared to be young and healthy were used in these tests. One moth was placed in each vial and held at room temperature for 24 hours. Mortality was determined by removing the moths from the vials and tossing them into the air. If the moth was unable to fly or could fly only a short distance (< 3 meters), it was recorded as dead. All data were corrected for control mortality using Abbott's (1925) formula.

Results and Discussion

From June to September 10,235 male bollworm moths were evaluated from nine states for pyrethroid resistance using the adult vial test at a dose of 5 or 10 µg/vial of cypermethrin (Table 1). Survival at the 5 µg/vial dose of cypermethrin by state (Table 2) ranged from 0-21.2%, 0-12.9, 0.7-15.1 and 4.4-13.7 in June, July, August and September, respectively. Louisiana (June and July), Alabama (July) and North Carolina (September) were the only collection locations to exceed 10% survival at the 5 µg/vial dose. Survival at the 10 µg/vial dose of cypermethrin by state (Table 3) ranged from 0-1.8%, 0-4.9, 0-1.2 and 0-3.0 in June, July, August and September, respectively. Alabama (July), Louisiana (July) and North Carolina (September) were the only three collection locations to exceeded 2% survival at the 10 µg/vial dose.

Alabama

In July and August 769 male moths were evaluate from three counties. The highest level of survival at the 5 µg/vial dose was observed in July with 10.8% survival. At 10 µg/vial the highest survival was observed in July with 4.9%.

Arkansas

In June and July 668 male moths were evaluated from two counties. The highest survival at the 5 µg/vial dose was observed in June with 8.2%. At 10 µg/vial the highest survival was observed in June with 1.8% survival.

Georgia

In July and August 795 male moths were evaluated from one county. The highest survival at the 5 µg/vial dose was observed in June with 4.6%. At 10 µg/vial the highest survival was observed in July with 1%.

Louisiana

In June, July and August 608 male moths were evaluated from 13 parishes. The highest survival at the 5 µg/vial dose was in June with 21.2%. At 10 µg/vial the highest survival was observed in July with 3.8%.

Mississippi

In June, July and August 1,399 male moths were evaluated from one county. The highest level of survival at the 5 µg/vial dose was observed in August with 0.7%. No survival was observed at the 10 µg/vial dose.

Missouri

In August and September 239 male moths were evaluated from one county. The highest level of survival at the 5 µg/vial dose was observed in August with 15.1%. No survival was observed at the 10 µg/vial dose.

North Carolina

In July, August and September 1,012 male moths were evaluated from three counties. The highest level of survival at the 5 µg/vial dose was observed in September with 13.7%. At the 10 µg/vial dose the highest survival was also observed in September with 3.0%.

South Carolina

In June, July, August and September 3,760 male moths were evaluated from 14 counties. The highest level of survival at the 5 µg/vial dose was observed in June and September with 4.4%. At the 10 µg/vial dose the highest survival was also observed in July with 1.4%.

Texas

In June, July and August 958 male moths were evaluated from two counties. The highest level of survival at the 5 µg/vial dose was observed in July with 1.9%. At the 10 µg/vial dose the highest survival was observed in August with 0.4%.

Conclusions

Two of collection locations, Louisiana (June) and Missouri (August), had survival greater than 15% at the 5 µg/vial dose which was higher than all of the collections tested in Louisiana from 1988 to 1997 (Bagwell et al. 1998). This increasing level of survival at the indicates that bollworm populations have an increasing level of tolerance to the pyrethroids. No testing of bollworms has been reported at the 10 µg/vial dose of cypermethrin. In this study eleven of twenty-three collection locations tested had survival at the 10 µg/vial dose. Survival at this high dose would further indicate a change in the response of the bollworm to the

pyrethroids. The indication of changing tolerance in the bollworm to the pyrethroid insecticides warrants further monitoring.

Resistance management plans have generally focused on maintaining the effectiveness of the pyrethroids against the tobacco budworm. However, reports of bollworm field control failures with the pyrethroid insecticides (Walker et al. 1997) and the increasing tolerance of the bollworm to the pyrethroids demonstrated in this study, suggest that maintaining the effectiveness of the pyrethroid insecticides against the bollworm should become a higher priority in future resistance management plans.

Acknowledgments

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Table 1. Responses of bollworm male moths to cypermethrin during 1998.

Location (County/Parish)	Date	% Survival (No.Tested) 5ug	% Survival (No. Tested) 10ug
ALABAMA			
Macon (EVSRS)	July 7	0.0 (3)	0.0 (3)
Macon (EVSRS)	July 8	0.0 (2)	0.0 (3)
Macon (EVSRS)	July 13	22.3 (12)	0.0 (12)
Macon (EVSRS)	July15	0.0 (3)	0.0 (4)
Macon (EVSRS)	July 17	14.3 (15)	28.6 (15)
Macon (EVSRS)	July 21	25.0 (5)	0.0 (5)
Macon (EVSRS)	July 23	41.6 (6)	0.0 (5)
Macon (EVSRS)	July 27	0.0 (4)	0.0 (5)
Macon (EVSRS)	July 28	0.0 (6)	0.0 (5)
Limestone	July 28	0.0 (5)	0.0 (6)
Limestone	July 29	0.0 (16)	0.0 (14)
Limestone	July 30	8.0 (12)	0.0 (9)
Macon (EVSRS)	July 31	0.0 (2)	0.0 (3)
Limestone	July 31	25.0 (4)	0.0 (4)
Henry (WREC)	August 3	0.0 (10)	0.0 (10)
Henry (WREC)	August 4	0.0 (40)	0.0 (40)
Henry (WREC)	August 5	6.4 (33)	0.0 (33)
Macon (EVSRS)	August 5	20.0 (5)	0.0 (5)
Limestone	August 6	0.0 (8)	0.0 (8)
Henry (WREC)	August 6	3.6 (30)	0.0 (30)
Macon (EVSRS)	August 12	23.0 (12)	0.0 (11)
Limestone	August 13	0.0 (23)	0.0 (18)
Limestone	August 14	0.0 (29)	0.0 (20)
Limestone	August 15	6.5 (32)	0.0 (21)
Limestone	August 18	0.0 (40)	0.0 (40)
Limestone	August 19	8.9 (13)	0.0 (14)
Limestone	August 20	13.0 (8)	0.0 (8)
Henry (WREC)	August 20	0.0 (20)	0.0 (20)
ARKANSAS			
Jefferson	June 11	0.0 (5)	0.0 (5)
Jefferson	June 12	0.0 (8)	0.0 (8)
Lonoke	June 17	0.0 (10)	0.0 (10)

Table 1. Continued

Location (County/Parish)	Date	% Survival (No.Tested) 5ug	% Survival (No. Tested) 10ug
Jefferson	June 18	0.0 (10)	0.0 (10)
Lonoke	June 18	0.0 (20)	0.0 (20)
Lonoke	June 18	0.0 (20)	0.0 (20)
Lonoke	June 23	0.0 (8)	0.0 (8)
Lonoke	June 23	16.7 (10)	33.3 (10)
Lonoke	June 23	0.0 (8)	0.0 (8)
Lonoke	June 24	20.0 (10)	0.0 (10)
Lonoke	June 24	10.0 (10)	10.0 (10)
Lonoke	June 24	20.0 (10)	0.0 (10)
Lonoke	June 25	0.0 (10)	0.0 (10)
Lonoke	June 25	14.3 (10)	0.0 (10)
Lonoke	June 25	0.0 (10)	0.0 (10)
Lonoke	June 26	0.0 (10)	0.0 (10)
Lonoke	June 26	10.0 (10)	0.0 (10)
Lonoke	June 26	0.0 (10)	0.0 (10)
Lonoke	June 29	0.0 (2)	0.0 (2)
Lonoke	June 29	66.7 (10)	0.0 (10)
Lonoke	June 29	0.0 (2)	0.0 (2)
Lonoke	June 30	0.0 (3)	0.0 (3)
Lonoke	July 1	10.0 (10)	0.0 (10)
Lonoke	July 6	0.0 (10)	0.0 (10)
Lonoke	July 7	10.0 (10)	0.0 (10)
Lonoke	July 9	0.0 (10)	0.0 (10)
Lonoke	July 10	11.1 (10)	0.0 (10)
Lonoke	July 14	0.0 (10)	20.0 (10)
Lonoke	July 15	0.0 (10)	0.0 (10)
Lonoke	July 16	20.0 (10)	0.0 (10)
Lonoke	July 17	0.0 (10)	0.0 (10)
Lonoke	July 20	0.0 (10)	0.0 (10)
Lonoke	July 21	13.0 (8)	0.0 (8)
Lonoke	July 22	0.0 (10)	0.0 (10)
Lonoke	July 23	10.0 (10)	0.0 (10)
GEORGIA			
Tift	July 13	0.0 (40)	0.0 (40)
Tift	July 20	0.0 (79)	1.4 (80)
Tift	July 27	14.6 (58)	0.0 (58)
Tift	August 3	1.4 (80)	0.0 (80)
Tift	August 10	1.7 (80)	0.0 (80)
Tift	August 17	0.0 (60)	0.0 (60)
LOUISIANA			
Richland (Hebert)	June 16	0.0 (10)	---
Red River(Coushatta)	June 17	5.0 (20)	---
Caldwell (Riverton)	June 17	45.0 (20)	---
Bossier(Red River Station)	June 23	10.0 (10)	---
Bossier (Red River Station)	June 30	50.0 (6)	---
Tensas (Waterproof)	July 7	0.0 (10)	---
Bossier (Red River Station)	July 7	25.6 (30)	---
Rapides (Alexandria)	July 14	27.8 (20)	---
Richland (Archibald)	July 13	0.0 (10)	---
Morehouse (Collinston)	July 13	11.1 (10)	0.0 (5)
East Carroll (Gassoway)	July 13	10.0 (10)	0.0 (10)
Morehouse (Mer Rouge)	July 13	20.0 (10)	20.0 (10)
Ouachita (Monroe)	July 13	0.0 (10)	0.0 (5)
Bossier (Red River Station)	July 14	16.7 (20)	---
Richland (Start)	July 13	60.0 (10)	0.0 (10)
Madison (Swampers)	July 13	20.0 (10)	0.0 (10)
Tensas (Sommerset)	July 13	12.5 (10)	---
Rapides (Cheneyville)	July21	11.1 (20)	---
Red River (Coushatta)	July 21	10.0 (10)	---
Bossier (Red River Station)	July 21	12.5 (10)	---
East Carroll (Gassoway)	July 28	0.0 (8)	---
Ouachita (Monroe)	July 28	11.0 (9)	---
Morehouse (Mer Rouge)	July 28	0.0 (8)	---
Rapides (Alexandria)	August 4	0.0 (10)	---
Bossier (Red River Station)	August 4	0.0 (15)	0.0 (10)
Richland (Start)	August 5	10.0 (10)	---
Madison (Swampers)	August 5	0.0 (10)	---
Rapides (Alexandria)	August 11	0.0 (20)	0.0 (20)
Caddo (Gilliam)	August 11	28.3 (10)	0.0 (10)

Table 1. Continued

Location (County/Parish)	Date	% Survival (No.Tested) 5ug	% Survival (No. Tested) 10ug
Richland (Hebert)	August 12	0.0 (5)	---
Madison (Swampers)	August 12	0.0 (5)	---
Richland (Start)	August 12	0.0 (5)	---
Richland (Archibald)	August 12	0.0 (7)	---
Catahoula (Deer Creek)	August 12	0.0 (15)	0.0 (10)
Caldwell (Riverton)	August 18	0.0 (5)	0.0 (5)
Bossier (Red River Station)	August 18	10.0 (20)	0.0 (20)
Franklin (Macon Ridge)	August 19	0.0 (10)	0.0 (10)
Richland (Start)	August 19	0.0 (10)	---
East Carroll (Gassoway)	August 19	0.0 (10)	---
Concordia (Vidalia)	August 26	0.0 (10)	0.0 (5)
MISSISSIPPI			
Leflore	June 18	0.0 (50)	0.0 (50)
Leflore	June 23	0.0 (52)	0.0 (48)
Leflore	July 8	0.0 (50)	0.0 (50)
Leflore	July 15	0.0 (100)	0.0 (99)
Leflore	July 24	0.0 (100)	0.0 (100)
Leflore	July 31	0.0 (75)	0.0 (75)
Leflore	August 5	2.1 (50)	0.0 (50)
Leflore	August 15	1.3 (85)	0.0 (85)
Leflore	August 20	0.0 (115)	0.0 (115)
Leflore	August 28	0.0 (25)	0.0 (25)
MISSOURI			
Pemiscot (Portageville)	August 8	10.0 (10)	0.0 (10)
Pemiscot (Portageville)	August10	25.0 (20)	0.0 (20)
Pemiscot (Portageville)	August 11	8.0 (13)	0.0 (13)
Pemiscot (Portageville)	August 12	16.6 (7)	0.0 (7)
Pemiscot (Portageville)	August 13	13.3 (20)	0.0 (20)
Pemiscot (Portageville)	September 9	7.0 (15)	0.0 (15)
Pemiscot (Portageville)	Sept. 10	0.0 (15)	0.0 (15)
Pemiscot (Portageville)	Sept. 11	13.3 (18)	0.0 (18)
NORTH CAROLINA			
Washington(Albemarle Beach)	July 25	0.0 (20)	0.0 (20)
Washington(Albemarle Beach)	July 30	4.5 (25)	0.0 (25)
Washington(Albemarle Beach)	July 30	5.0 (25)	0.0 (25)
Washington(TRS-Hassell)	August 1	0.0 (25)	0.0 (25)
Washington(TRS-Hassell)	August 6	0.0 (25)	0.0 (25)
Chowan(Sandy Point Farm)	August 23	13.0 (8)	0.0 (8)
Washington(James Small Farm)	August 24	10.5 (20)	5.3 (20)
Chowan(Sandy Point Farm)	August 25	10.4 (13)	0.0 (13)
Chowan(Sandy Point Farm)	August 25	0.0 (13)	0.0 (13)
Washington(James Small Farm)	August 25	6.8 (42)	0.0 (42)
Chowan(Charlotte Small Farm)	August 26	22.0 (9)	0.0 (9)
Chowan(Sandy Point Farm)	August 26	15.6 (21)	0.0 (21)
Washington(James Small Farm)	August 26	11.1 (47)	0.0 (47)
Perguimans(River Bridge)	August 26	20.9 (28)	0.0 (28)
Washington(James Small Farm)	September 2	5.1 (33)	0.0 (33)
Chowan(Charlotte Small Farm)	September 2	0.0 (9)	0.0 (9)
Chowan(Sandy Point Farm)	September 2	0.0 (12)	0.0 (12)
Chowan(Sandy Point Farm)	September 3	0.0 (7)	0.0 (7)
Chowan(Sandy Point Farm)	September 3	0.0 (4)	0.0 (4)
Perguimans(River Bridge)	September 3	30.4 (50)	6.5 (50)
Washington(James Small Farm)	September 3	10.0 (20)	0.0 (20)
Washington(James Small Farm)	September 4	12.4 (28)	4.5 (28)
Chowan(Sandy Point Farm)	September 4	0.0 (22)	0.0 (22)
SOUTH CAROLINA			
Darlington(PDREC)	June 9	50.0 (2)	0.0 (2)
Dillon (McSwain)	June 9	0.0 (2)	0.0 (2)
Dillon (McSwain)	June 12	0.0 (2)	0.0 (2)
Darlington (PDREC)	June 12	0.0 (5)	0.0 (5)
Hampton (Luray)	June 13	0.0 (13)	0.0 (13)
Bamberg	June 13	0.0 (5)	0.0 (5)
Allendale (Ulmer)	June 13	0.0 (13)	0.0 (13)
Calhoun (Whetstone)	June 15	0.0 (3)	0.0 (3)
Hampton (Luray)	June 16	0.0 (7)	0.0 (7)
Allendale (Ulmer)	June 16	0.0 (5)	0.0 (5)
Clarendon (Manning)	June 16	20.0 (5)	0.0 (5)
Marlboro (P. Rogers)	June 16	11.1 (10)	0.0 (10)
Dillon (McSwain)	June 16	16.9 (17)	0.0 (17)

Table 1. Continued

Location (County/Parish)	Date	% Survival (No.Tested) 5ug	% Survival (No. Tested) 10ug
Dillon (Bryant)	June 16	0.0 (27)	0.0 (27)
Bamberg	June 17	0.0 (12)	0.0 (12)
Darlington (PDREC)	June 17	18.0 (11)	0.0 (11)
Hampton (Furman)	June 19	0.0 (2)	0.0 (2)
Hampton (Luray)	June 19	0.0 (5)	0.0 (5)
Clarendon (Manning)	June 19	30.0 (10)	0.0 (10)
Dillon (McSwain)	June 19	0.0 (10)	0.0 (10)
Marlboro (Rogers)	June 19	0.0 (10)	0.0 (10)
Darlington (PDREC)	June 19	0.0 (10)	0.0 (10)
Bamberg	June 20	0.0 (20)	0.0 (20)
Marlboro (Rogers)	June 24	10.0 (10)	0.0 (10)
Darlington (PDREC)	June 24	0.0 (10)	0.0 (10)
Hampton (Luray)	June 26	0.0 (3)	0.0 (3)
Hampton (Furman)	June 28	0.0 (4)	0.0 (4)
Hampton (Luray)	June 28	0.0 (7)	0.0 (7)
Allendale (Ulmer)	June 28	0.0 (16)	0.0 (16)
Hampton (Luray)	June 30	0.0 (8)	16.0 (8)
Allendale (Ulmer)	June 30	0.0 (10)	0.0 (10)
Bamberg	July 1	0.0 (20)	0.0 (20)
Hampton (Furman)	July 7	0.0 (12)	0.0 (12)
Allendale (Ulmer)	July 7	0.0 (12)	0.0 (12)
Calhoun (Dantzler)	July 8	0.0 (4)	0.0 (4)
Bamberg	July 8	0.0 (14)	7.0 (14)
Hampton (Furman)	July 12	0.0 (25)	0.0 (25)
Hampton (Luray)	July 12	25.0 (20)	0.0 (20)
Allendale (Ulmer)	July 12	13.6 (16)	0.0 (16)
Calhoun (Dantzler)	July 15	0.0 (15)	0.0 (15)
Calhoun (Bull)	July 15	0.0 (12)	0.0 (12)
Hampton (Furman)	July 15	0.0 (20)	0.0 (20)
Hampton (Luray)	July 15	0.0 (20)	0.0 (20)
Bamberg	July 15	0.0 (20)	0.0 (20)
Allendale (Ulmer)	July 15	0.0 (20)	0.0 (20)
Lee (Mayesville)	July 15	0.0 (10)	0.0 (10)
Clarendon (Manning)	July 15	11.1 (10)	11.1 (10)
Bamberg (Brubaker)	July 16	10.5 (20)	5.3 (20)
Calhoun (Perrow)	July 18	0.0 (10)	0.0 (10)
Hampton (Furman)	July 18	0.0 (10)	0.0 (10)
Hampton (Luray)	July 18	0.0 (10)	0.0 (10)
Allendale (Ulmer)	July 18	0.0 (10)	0.0 (10)
Bamberg	July 19	0.0 (20)	0.0 (20)
Bamberg (Brubaker)	July 19	0.0 (20)	0.0 (20)
Calhoun (Whetstone)	July 21	7.0 (15)	0.0 (15)
Calhoun (Dantzler)	July 21	0.0 (15)	0.0 (15)
Calhoun (Bull)	July 21	0.0 (10)	10.0 (10)
Bamberg	July 21	0.0 (10)	0.0 (10)
Bamberg (Brubaker)	July 21	0.0 (15)	0.0 (15)
Clarendon (Manning)	July 21	0.0 (10)	0.0 (10)
Darlington (Dargan)	July 21	0.0 (10)	0.0 (10)
Darlington (PDREC)	July 21	12.5 (10)	25.0 (10)
Dillon (Gaddy)	July 21	0.0 (6)	0.0 (6)
Hampton (Furman)	July 22	7.0 (15)	0.0 (15)
Hampton (Luray)	July 22	0.0 (15)	0.0 (15)
Allendale (Ulmer)	July 22	0.0 (15)	0.0 (15)
Darlington (PDREC)	July 22	0.0 (10)	0.0 (10)
Williamsburg (Carson)	July 22	16.3 (7)	0.0 (7)
Lee (Maysville)	July 22	28.6 (10)	14.3 (10)
Calhoun (Whetstone)	July 25	0.0 (10)	0.0 (10)
Calhoun (Perrow)	July 25	0.0 (10)	0.0 (10)
Calhoun (Bull)	July 25	0.0 (10)	10.0 (10)
Bamberg	July 25	0.0 (15)	0.0 (15)
Bamberg	July 27	0.0 (15)	0.0 (15)
Bamberg (Brubaker)	July 27	8.8 (15)	0.0 (15)
Bamberg (Brubaker)	July 28	0.0 (20)	0.0 (20)
Clarendon (Manning)	July 28	10.0 (10)	0.0 (10)
Williamsburg (Carson)	July 28	0.0 (10)	0.0 (10)
Darlington (PDREC)	July 28	26.3 (20)	10.5 (20)
Lee (Maysville)	July 28	0.0 (10)	0.0 (10)
Calhoun (Whetstone)	July 29	10.0 (10)	0.0 (10)
Calhoun (Perrow)	July 29	0.0 (10)	0.0 (10)

Table 1. Continued

Location (County/Parish)	Date	% Survival (No.Tested) 5ug	% Survival (No. Tested) 10ug
Calhoun (Bull)	July 29	0.0 (10)	0.0 (10)
Hampton (Furman)	July 29	10.0 (10)	0.0 (10)
Hampton (Luray)	July 29	0.0 (10)	0.0 (10)
Bamberg	July 29	0.0 (10)	0.0 (10)
Allendale (Ulmer)	July 29	0.0 (10)	0.0 (10)
Bamberg (Brubaker)	July 29	0.0 (15)	0.0 (15)
Hampton (Furman)	July 31	0.0 (13)	0.0 (13)
Allendale (Ulmer)	July 31	10.0 (10)	0.0 (10)
Hampton (Luray)	July 31	0.0 (10)	0.0 (10)
Hampton (Furman)	August 2	0.0 (7)	0.0 (7)
Hampton (Luray)	August 2	0.0 (15)	0.0 (15)
Bamberg	August 2	0.0 (10)	10.0 (10)
Allendale (Ulmer)	August 2	0.0 (15)	0.0 (15)
Calhoun (Bull)	August 6	0.0 (10)	0.0 (10)
Hampton (Furman)	August 6	0.0 (15)	0.0 (15)
Bamberg	August 6	0.0 (20)	5.3 (20)
Hampton (Furman)	August 8	0.0 (10)	0.0 (10)
Allendale (Ulmer)	August 9	0.0 (10)	0.0 (10)
Bamberg (Brubaker)	August 2	0.0 (10)	0.0 (10)
Darlington (PDREC)	August 4	25.0 (10)	0.0 (10)
Hampton (Luray)	August 6	0.0 (15)	0.0 (15)
Allendale (Ulmer)	August 6	0.0 (10)	0.0 (10)
Hampton (Luray)	August 8	0.0 (10)	0.0 (10)
Allendale (Ulmer)	August 8	0.0 (10)	0.0 (10)
Calhoun (Whetstone)	August 12	12.5 (10)	0.0 (10)
Calhoun (Bull)	August 12	0.0 (10)	0.0 (10)
Hampton (Furman)	August 12	0.0 (10)	12.5 (10)
Allendale (Ulmer)	August 12	0.0 (10)	0.0 (10)
Hampton (Luray)	August 13	0.0 (15)	0.0 (15)
Allendale (Ulmer)	August 13	0.0 (15)	0.0 (15)
Hampton (Furman)	August 14	0.0 (15)	0.0 (15)
Calhoun (Dantzler)	August 15	0.0 (10)	0.0 (10)
Bamberg	August 15	0.0 (15)	0.0 (15)
Calhoun (Whetstone)	August 16	0.0 (10)	0.0 (10)
Calhoun (Bull)	August 16	0.0 (10)	0.0 (10)
Bamberg (Brubaker)	August 16	0.0 (15)	0.0 (15)
Calhoun (Whetstone)	August 19	0.0 (10)	0.0 (10)
Calhoun (Dantzler)	August 19	0.0 (10)	0.0 (10)
Calhoun (Bull)	August 19	0.0 (10)	0.0 (10)
Hampton (Furman)	August 19	0.0 (5)	0.0 (5)
Hampton (Luray)	August 19	0.0 (10)	0.0 (10)
Allendale (Ulmer)	August 19	0.0 (5)	0.0 (5)
Hampton (Furman)	August 23	0.0 (10)	0.0 (10)
Hampton (Luray)	August 23	0.0 (15)	0.0 (15)
Allendale (Ulmer)	August 23	0.0 (15)	0.0 (15)
Bamberg (Brubaker)	August 24	0.0 (5)	0.0 (5)
Bamberg	August 25	0.0 (15)	0.0 (15)
Calhoun (Whetstone)	August 26	14.0 (7)	29.0 (7)
Calhoun (Dantzler)	August 26	0.0 (7)	0.0 (7)
Calhoun (Bull)	August 26	0.0 (7)	0.0 (7)
Hampton (Furman)	August 26	0.0 (15)	0.0 (15)
Hampton (Luray)	August 26	0.0 (10)	12.5 (10)
Bamberg	August 26	10.0 (10)	0.0 (10)
Allendale (Ulmer)	August 26	0.0 (15)	0.0 (15)
Hampton (Furman)	August 29	0.0 (15)	0.0 (15)
Bamberg	August 30	0.0 (15)	0.0 (15)
Bamberg (Brubaker)	August 30	7.4 (15)	0.0 (15)
Hampton (Furman)	September 2	0.0 (15)	0.0 (15)
Hampton (Luray)	September 2	7.4 (15)	0.0 (15)
Bamberg	September 2	0.0 (15)	0.0 (15)
Allendale (Ulmer)	September 2	8.8 (15)	0.0 (15)
Allendale (Ulmer)	September 2	7.4 (15)	0.0 (15)
Allendale (Ulmer)	September 2	80.0 (5)	0.0 (5)
Bamberg (Brubaker)	September 2	0.0 (15)	0.0 (15)
Hampton (Furman)	September 6	7.0 (15)	0.0 (15)
Hampton (Luray)	September 6	0.0 (6)	0.0 (6)
Hampton (Luray)	September 6	0.0 (15)	0.0 (15)
Bamberg	September 6	7.0 (15)	0.0 (15)
Allendale (Ulmer)	September 6	0.0 (15)	0.0 (15)

Table 1. Continued

Location (County/Parish)	Date	% Survival (No.Tested) 5ug	% Survival (No. Tested) 10ug
Allendale (Ulmer)	September 6	0.0 (4)	33.3 (4)
Bamberg (Brubaker)	September 9	0.0 (7)	0.0 (7)
Bamberg	Sept. 13	10.0 (20)	5.0 (20)
Allendale (Ulmer)	Sept. 13	0.0 (10)	0.0 (10)
Bamberg (Brubaker)	Sept. 13	0.0 (15)	0.0 (15)
Bamberg	Sept. 17	7.0 (15)	0.0 (15)
Bamberg (Brubaker)	Sept. 17	0.0 (10)	0.0 (10)
Bamberg	Sept. 24	0.0 (15)	0.0 (15)
Hampton (Luray)	Sept. 29	0.0 (15)	0.0 (15)
Bamberg	October 1	33.3 (15)	11.7 (15)
TEXAS			
Burleson (Snook)	June 15	0.0 (20)	0.0 (20)
Burleson (Snook)	June 22	0.0 (30)	0.0 (30)
Burleson (Snook)	June 30	0.0 (30)	0.0 (30)
Burleson (Snook)	July 2	3.1 (30)	0.0 (30)
Burleson (Snook)	July 6	3.1 (30)	0.0 (30)
Burleson (Snook)	July 13	0.0 (30)	0.0 (30)
Nueces (Corpus Christi)	July 14	0.0 (7)	0.0 (7)
Nueces (Corpus Christi)	July 15	0.0 (3)	0.0 (3)
Nueces (Corpus Christi)	July 16	0.0 (4)	0.0 (4)
Nueces (Corpus Christi)	July 17	0.0 (4)	0.0 (4)
Nueces (Corpus Christi)	July 18	0.0 (2)	0.0 (2)
Nueces (Corpus Christi)	July 19	0.0 (2)	0.0 (2)
Burleson (Snook)	July 19	3.0 (30)	0.0 (30)
Nueces (Corpus Christi)	July 20	0.0 (4)	0.0 (4)
Nueces (Corpus Christi)	July 21	0.0 (3)	0.0 (3)
Burleson (Snook)	July 28	0.0 (20)	0.0 (20)
Nueces (Corpus Christi)	August 3	0.0 (6)	0.0 (6)
Nueces (Corpus Christi)	August 4	0.0 (4)	0.0 (4)
Burleson (Snook)	August 4	7.8 (30)	0.0 (30)
Nueces (Corpus Christi)	August 6	0.0 (13)	0.0 (13)
Nueces (Corpus Christi)	August 7	0.0 (4)	0.0 (4)
Nueces (Corpus Christi)	August 8	0.0 (3)	0.0 (3)
Nueces (Corpus Christi)	August 10	0.0 (3)	0.0 (3)
Burleson (Snook)	August 10	3.0 (30)	0.0 (30)
Nueces (Corpus Christi)	August 11	0.0 (10)	0.0 (10)
Nueces (Corpus Christi)	August 13	0.0 (8)	0.0 (8)
Nueces (Corpus Christi)	August 14	0.0 (4)	0.0 (4)
Nueces (Corpus Christi)	August 19	0.0 (5)	0.0 (5)
Nueces (Corpus Christi)	August 20	0.0 (33)	0.0 (33)
Nueces (Corpus Christi)	August 21	5.3 (19)	0.0 (19)
Nueces (Corpus Christi)	August 23	0.0 (5)	0.0 (5)
Nueces (Corpus Christi)	August 24	0.0 (3)	0.0 (3)
Nueces (Corpus Christi)	August 25	0.0 (3)	0.0 (3)
Nueces (Corpus Christi)	August 26	0.0 (16)	6.0 (16)
Nueces (Corpus Christi)	August 27	0.0 (23)	0.0 (23)
Nueces (Corpus Christi)	August 28	0.0 (8)	0.0 (8)

Table 2. Percent survival of bollworm male moths at 5µg cypermethrin per vial by state and month during 1998.

	% Survival (Number Tested)			
State	June	July	August	September
Alabama	---	10.8(95)	3.9(303)	---
Arkansas	8.2(206)	5.6(128)	---	---
Georgia	---	4.6(177)	1.1(220)	---
Louisiana	21.2(66)	12.9(225)	2.7(177)	---
Mississippi	0(102)	0(325)	0.7(275)	---
Missouri	---	---	15.1(70)	7.4(48)
North Carolina	---	3.5(70)	9.5(251)	13.7(185)
South Carolina	4.4(274)	3.3(786)	1.2(548)	4.4(272)
Texas	0(80)	1.9(169)	1.8(230)	---

Table 3. Percent survival of bollworm male moths at 10µg cypermethrin per vial by state and month during 1998.

	% Survival (Number Tested)			
State	June	July	August	September
Alabama	---	4.9(93)	0(278)	---
Arkansas	1.8(206)	1.6(128)	---	---
Georgia	---	1.0(178)	0(220)	---
Louisiana	---	3.8(50)	0(90)	---
Mississippi	0(98)	0(324)	0(275)	---
Missouri	---	---	0(70)	0(48)
North Carolina	---	0(70)	0.5(251)	3.0(185)
South Carolina	0.4(274)	1.4(786)	1.2(548)	0.8(272)
Texas	0(80)	0(169)	0.4(230)	---