

STATUS OF INSECTICIDE RESISTANCE IN TOBACCO BUDWORM AND BOLLWORM IN LOUISIANA DURING 1998

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Abstract

In 1998, resistance was again documented in tobacco budworm populations to pyrethroid insecticides. Over 769 tobacco budworm moths were bioassayed for pyrethroid resistance from May through August 1997 using a discriminating dose of 10 μg in the adult vial test. Pyrethroid resistance levels in 1998 were slightly lower than in 1997. Percent survival in May, June, July and August was 41, 48, 51, and 60%, respectively. The high survival level in May and June indicates that a large percentage of the tobacco budworm population was resistant to pyrethroids before growers began to use pyrethroids for tobacco budworm control. The data suggests that pyrethroids may no longer provide effective control of tobacco budworm populations. Over 1950 male bollworm moths were assayed against a 5 μg /vial dose of cypermethrin. Bollworm moth survival levels increased dramatically in 1998. July survival levels were 27% , the highest observed since inception of monitoring in 1988. This data indicates that bollworm susceptibility to pyrethroid insecticides is changing.

Introduction

During 1986, pyrethroid resistance in tobacco budworm, *Heliothis virescens* (F.), was documented in Arkansas (Plapp et al. 1987), Mississippi (Roush and Luttrell 1987), Louisiana (Leonard et al. 1987) and Texas (Allen et al. 1987, Plapp et al. 1987) using several bioassay techniques. In response to this development, pyrethroid resistance management plans were initiated for the Mid-South states of Arkansas, Louisiana, Mississippi (Anonymous 1986) and Texas. Wide-spread monitoring of male tobacco budworm moths for pyrethroid resistance has been conducted in these states since 1987 using a glass vial technique (Plapp et al. 1987) commonly referred to as the adult vial test (AVT).

Tobacco budworm resistance to pyrethroid insecticides continued to increase from 1986 to 1992 (Graves et al. 1988, Graves et al. 1989, Graves et al. 1990, Graves et al. 1991, Graves et al. 1992, Graves et al. 1993, Graves et al. 1994, Bagwell et al. 1995 and Bagwell et al. 1996). Pyrethroid resistance levels peaked in 1993 when the seasonal mean survival reached 48 percent. Pyrethroid resistance levels declined slightly in 1994 to 39%, but still

remained high enough to result in field control failures. Tobacco budworm resistance to profenofos, methomyl and endosulfan also was detected in 1993. Thus, by 1993 tobacco budworm populations had developed resistance to the three major insecticide classes (carbamates, organophosphates and pyrethroids) used for tobacco budworm control. Over 24,500 male tobacco budworm moths were bioassayed for pyrethroid resistance from 1987 to 1993 against the 10 mg dose of cypermethrin utilizing the AVT.

Over 16,900 male bollworm moths were bioassayed for pyrethroid resistance from 1987 to 1994. Bollworm males were exposed to 1, 2 or 5 μg dose of cypermethrin utilizing the AVT. No significant changes in bollworm susceptibility to pyrethroids were detected during this period. Over 2100 male bollworm, *Helicoverpa zea* (Boddie), moths were bioassayed against 1,2 or 5 μg /vial doses of cypermethrin during 1995. Data from these bioassays were similar to those obtained from 1988-1994, but indicated that bollworm susceptibility to pyrethroids may be changing.

Resistance was again documented to representative chemicals from the three major classes of insecticides (carbamates, organophosphates and pyrethroids) used to control tobacco budworms, *Heliothis virescens* (F.), on cotton in the United States during 1995 (Bagwell et al. 1996). Over 2100 male tobacco budworm moths were bioassayed for pyrethroid resistance from May through September 1995 against a 10 μg dose of cypermethrin utilizing the AVT. Pyrethroid resistance levels during 1995 were similar to 1994 levels. Also, 200 male tobacco budworm moths were bioassayed for resistance to profenofos using the AVT. Resistance to profenofos was lower than in 1994. Low densities of tobacco budworm populations generally persisted in Louisiana during 1995. However, field control failures did occur in fields with moderate to heavy tobacco budworm populations. Topical application bioassays of larval progeny from several 1995 field collections of tobacco budworms indicated significant resistance to carbamate, pyrethroid and organophosphate insecticides. Resistance to all three classes also was detected from the progeny of an Alabama field collection of tobacco budworm.

In 1996, resistance was documented to representative chemicals from the three major classes of insecticides (carbamates, organophosphates and pyrethroids) used to control tobacco budworms, *Heliothis virescens* (F.), on cotton in the United States (Bagwell et al. 1997). Over 1900 male tobacco budworm moths were bioassayed for pyrethroid resistance from May through August 1996 against a 10 μg dose of cypermethrin utilizing the adult vial test. Pyrethroid resistance levels during 1996 were similar to 1995 levels. Two-hundred male tobacco budworm moths were bioassayed for resistance to profenofos using the adult vial test. Resistance to profenofos was similar to 1995 levels. Also, 199 male tobacco budworm moths were

bioassayed for resistance to methomyl using the adult vial test. Resistance to methomyl was similar to 1995 levels. Generally, resistance to carbamates, organophosphates and pyrethroids appears to have stabilized based on monitoring data from 1987 through 1996. Low densities of tobacco budworm populations generally persisted in Louisiana during 1996. However, field control failures did occur in fields with moderate to heavy tobacco budworm populations. Topical application bioassays of larval progeny from several 1996 field collections of tobacco budworms indicated significant resistance to carbamate, pyrethroid and organophosphate insecticides. Over 3600 male bollworm, *Helicoverpa zea* (Boddie), moths were bioassayed against a 5 μg /vial dose of cypermethrin. In 1997, resistance was again documented in tobacco budworm populations to pyrethroid insecticides.

Over 745 tobacco budworm moths were bioassayed for pyrethroid resistance from May through August 1997 using a discriminating dose of 10 μg in the adult vial test (Bagwell et al. 1998). Pyrethroid resistance levels were the highest documented since inception of monitoring in 1987. Percent survival in June was 51%. Previously, the highest level of survival observed in June between 1987 and 1996 had been 29%. This data indicates there was an increased use of pyrethroids in June 1997. Over 1821 male bollworm moths were assayed against a 5 μg /vial dose of cypermethrin. Bollworm moth survival levels continue to increase slowly. July survival levels were 14% , the highest observed since inception of monitoring in 1988. This data indicates that bollworm susceptibility to pyrethroid insecticides is changing.

The success of insecticide resistance management relies heavily upon the intelligent use of all available classes of insecticides and non-chemical management practices. It is important to monitor susceptibility to the various insecticides to detect any changes or problems which may occur. This study was conducted to evaluate the susceptibility of tobacco budworm and bollworm from Louisiana to selected insecticides in 1998. This information is essential to update and refine current insecticide resistance management guidelines.

Materials and Methods

Wire cone traps (Harstack et al. 1979) baited with artificial sex pheromone lures (Hendricks et al. 1987) were used to collect tobacco budworm and bollworm male moths from May through August. Although males were collected from most cotton production areas of Louisiana, more intensive sampling was conducted on or near the Northeast Research Station (St. Joseph Location, Tensas Parish), Northeast Research Station (Macon Ridge Location, Franklin Parish) and Red River Research Station (Bossier Parish).

The interior of glass scintillation vials (20 ml) were coated with cypermethrin (10 μg /vial for tobacco budworm and 5

μg /vial for bollworm). The 10 μg /vial dose of cypermethrin is lethal to homozygous pyrethroid susceptible tobacco budworm moths as well as moths heterozygous for pyrethroid resistance (Plapp et al. 1987). Only homozygous pyrethroid resistant tobacco budworm moths survive 10 μg /vial dose, and it can be used as a discriminating dose for this species. A discriminating dose has not been determined for the bollworm. Vials were stored in a dark area to prevent photodegradation of the pyrethroid insecticide. Acetone-treated vials were used to check for natural moth mortality, which was generally less than 10%.

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 May through August 1998, 769 male tobacco budworm moths from 18 parishes were bioassayed for pyrethroid resistance using the AVT at the discriminating dose of 10 μg of cypermethrin per vial (Tables 1, 2, and 3 and Figure 1). When these data are summarized by location (parish) and month (Table 2), several observations can be made. Pyrethroid resistance (i.e. percent survival) was lowest during May(17-45%), then increased slightly in June to (13-90%) and remained high through August. This data indicates that insecticide resistance to tobacco budworm was present long before growers began using pyrethroids for this control.

Comparing the mean yearly responses of tobacco budworm moths bioassayed at 10 μg cypermethrin per vial during 1998 to that determined for the period of 1987-1997 revealed that pyrethroid resistance levels were the (Table 3 and Figure 1). Overall survival in 1998 was 50%, 55% in 1997, 39% in 1996, 39% in 1995, 39% in 1994, 48% in 1993, 40% in 1992, 36% in 1991, 37% in 1990, 25% in 1989, 16% in 1988 and 15% in 1987.

From May through August 1997, 1950 male bollworm moths from 20 parishes were bioassayed for pyrethroid resistance using the AVT at a dose of 5 μg of cypermethrin per vial (Tables 4,5 and 6). Survival at 5 μg per vial by parish ranged from 0-40%, 0-42%, 0-71%, and 0-66% in May, June, July and August, respectively (Table 5). Survival was similar in all parishes regardless of pyrethroid usage. Survival was highest during July. July is the time that bollworms occur in cotton in the greatest numbers and pyrethroid insecticides are recommended for use (Bagwell 1996). Survival at 5 mg of cypermethrin per vial during 1998 was the highest observed since the inception of

monitoring. Although no documented cases of field control failures occurred in 1998, the data does indicate that bollworm susceptibility to pyrethroids is changing.

Implications

Resistance levels to pyrethroids in tobacco budworm in 1998 was slightly lower than in 1997. High levels of pyrethroid resistance were documented in tobacco budworm populations in May. This may indicate that either a reversion to susceptibility during overwinter did not occur or that at-planting pyrethroid applications selected for resistant individuals. Regardless, pyrethroids did not offer an effective control tool for tobacco budworm in 1998. Overall populations of tobacco budworm were low in 1998. However, in those fields where tobacco budworm populations were high, insecticide control was not satisfactory and control costs were high. Bollworm survival increased dramatically in 1998, however, there have been no documented cases of inadequate field control of bollworm populations. These data indicate that the pyrethroids may no longer offer effective control of tobacco budworm populations and that pyrethroid control failure on bollworm may occur in the near future.

Acknowledgements

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Table 1. Responses of tobacco budworm male moths to cypermethrin during 1998.

Parish ¹ (Location)	% Survival ² (Number Tested)	
	Date	(10 µg/vial)
Caddo (Gilliam)	May 12	56 (9)
Concordia (Vidalia)	May 13	44 (25)
Red River (Coushatta)	May 19	17 (6)
Caddo (Dixie)	May 19	33 (6)
Rapides (Alexandria)	June 2	33 (6)
Bossier (Red River Sta.)	June 2	78 (9)
Bossier (Red River Sta.)	June 9	52 (25)
Madison (Waverly)	June 9	85 (9)
Madison (Swampers)	June 9	95 (4)
Morehouse (Mer Rouge)	June 9	47 (7)
Richland (Start)	June 16	55 (11)
Bossier (Red River Sta.)	June 16	50 (20)
Grant (Colfax)	June 23	0 (10)
Desoto (Evelyn)	June 23	40 (5)
Bossier (Red River Sta.)	June 23	25 (4)
Caddo (Dixie)	June 23	38 (8)
Concordia (Vidalia)	June 24	13 (8)
Rapides (Alexandria)	June 30	25 (6)
Grant (Colfax)	June 30	75 (8)
Rapides (Alexandria)	July 14	64 (11)
Grant (Colfax)	July 14	77 (13)
Morehouse (Collingston)	July 13	88 (16)
Catahoula (Deer Creek)	July 15	60 (5)
Desoto (Evelyn)	July 14	50 (5)
Morehouse (Mer Rouge)	July 13	85 (20)
Bossier (Red River Sta.)	July 14	71 (10)
Caldwell (Riverton)	July 14	60 (5)
Rapides (Alexandria)	July 21	38 (11)
Grant (Colfax)	July 21	10 (17)
Red River (Coushatta)	July 21	24 (7)
Caddo (Dixie)	July 21	0 (3)
Caldwell (Riverton)	July 21	60 (5)
E. Carroll (Gassoway)	July 21	70 (10)
St. Landry (St. Landry)	July 28	0 (4)
Rapides (Alexandria)	July 28	75 (4)
Red River (Coushatta)	July 28	29 (7)
Bossier (Red River Sta.)	July 28	0 (10)
Caddo (Dixie)	July 28	10 (10)
Alexandria	August 4	89(9)
Red River	August 4	60(15)
Concordia (Vidalia)	August 5	40 (5)
Red River (Coushatta)	August 11	24 (17)
Bossier (Red River Res. Stn)	August 11	56 (18)
Red River (Coushatta)	August 11	24 (17)
Caldwell (Riverton)	August 11	14 (7)
E. Carroll (Gassoway)	August 12	50 (10)
Madison (Swampers)	August 12	30 (10)
E.B. Rouge (Ben Hur)	August 12	50 (10)
Franklin (Winnsboro)	August 13	80 (20)
Richland (Hebert)	August 19	92 (12)
Red River (Coushatta)	August 18	60 (11)
Bossier (Red Riv. Res. Stn)	August 18	77 (30)
Rapides (Alexandria)	August 18	98 (14)
St. Landry	August 18	21 (6)
Franklin (Macon Ridge**)	August 19	33 (15)
Catahoula (Deer Creek)	August 19	56 (20)
Franklin (Macon Ridge)	August 19	30 (20)
Morehouse (Jones)	August 19	90 (20)
Tensas (NERS)	August 19	100 (10)
Morehouse (Mer Rouge)	August 19	80 (10)
Ouchita (Monroe)	August 19	100 (9)
Rapides (Alexandria)	August 25	80 (10)
Bossier (RRRS)	August 25	15 (20)
Red River (Coushatta)	August 25	63 (10)
Caddo (Dixie)	August 25	88 (20)
Franklin (Macon Ridge)	August 25	80 (5)
Catahoula (Deer Creek)	August 26	75 (20)
Concordia (Vidalia)	August 26	50 (10)

Table 1. Continued

Parish ¹ (Location)	Date	% Survival ² (Number Tested) (10 µg/vial)
Bossier (RRRS)	September 1	38 (10)
Rapides (Alexandria)	September 1	86 (10)
Red River (Coushatta)	September 1	50 (10)

¹ If the specific location is not given for a parish, the data represent collections from two or more locations in the parish.

² Percent survival at 10 µg/vial is an estimate of the percent homozygous pyrethroid-resistant males present.

** Vials supplied by Greg Payne.

Table 2. Percent survival of tobacco budworm male moths at 10lg per vial by parish and month during 1998¹

Parish	May	June	July	August
Bossier	--	51	36	49
Caddo	45	38	5	88
Caldwell	--	--	60	14
Catahoula	--	--	60	66
Concordia	44	13	--	45
DeSoto	--	40	50	--
East Baton Rouge	--	--	--	50
East Carroll	--	--	70	50
Franklin	--	--	--	63
Grant	--	38	44	--
Madison	--	90	--	30
Morehouse	--	47	87	85
Ouachita	--	--	--	100
Rapides	--	29	59	89
Red River	17	--	27	46
Richland	--	55	--	92
St. Landry	--	--	0	21
Tensas	--	--	--	100

¹Percent survival is an estimate of the percent homozygous pyrethroid-resistant males present.

Table 3. Monthly summary of cypermethrin resistance monitoring data for tobacco budworms obtained using a discriminating dose of 10lg per vial, 1987-1998.

Year	Percent Survival ¹ (Number Tested)						Total
	May	June	July	Aug	Sept	Oct	
1987	20	13	18	12	15	---	15(2607)
1988	12	5	14	26	30	---	16(2214)
1989	11	9	19	40	36	28	25(3057)
1990	12	14	36	43	48	44	37(3605)
1991	16	21	31	42	49	36	36(3539)
1992	14	22	39	58	56	37	40(4281)
1993	22	29	46	58	68	---	48(2823)
1994	20	26	44	50	59	---	39(1716)
1995	18	20	37	49	49	---	39(2131)
1996	23	24	50	43	---	---	39(1966)
1997	26	51	51	63	---	---	55(745)
1998	41	48	51	60	---	---	50(769)

¹Percent survival is an estimate of the percent homozygous pyrethroid-resistant males present.

Table 4. Responses of bollworm male moths to cypermethrin during 1998.

Parish ¹ (Location)	Date	% Survival (Number Tested) (5 µg/vial)
Red River (Coushatta)	May 12	16 (15)
Richland (Hatcher's Bridge)	May 12	0 (5)
Catahoula (Deer Creek)	May 13	0 (15)
Rapides (Alexandria)	May 19	0 (3)
Grant (Colfax)	May 19	40 (5)
Red River (Coushatta)	May 19	0 (10)
Bossier (Red River Sta.)	May 19	31 (12)
Caddo (Gilliam)	May 19	0 (5)
Catahoula (Deer Creek)	May 20	0 (5)
Concordia (Vidalia)	May 20	20 (5)
E. Baton Rouge (BenHur)	May 20	20 (5)
Bossier (Red River Sta.)	May 26	-----
Caddo (Gilliam)	May 26	-----
Richland (Hatcher's Bridge)	May 26	-----
E. Baton Rouge (BenHur)	May 27	-----
Bossier (Red River Sta.)	June 2	7 (14)
Caddo (Gilliam)	June 2	-----
Rapides (Cheneyville)	June 9	0 (3)
Rapides (Dean Lee Sta.)	June 9	0 (6)
Red River (Coushatta)	June 9	0 (8)
Bossier (Red River Sta.)	June 9	9 (14)
Monroe (Ouchita)	June 9	0 (5)
Madison (Waverly)	June 9	0 (3)
W. Carroll (Epps)	June 9	19 (12)
Catahoula (Deer Creek)	June 10	-----
Rapides (Dean Lee Sta.)	June 17	0 (10)
Rapides (Alexandria)	June 17	25 (4)
Desoto (Evelyn)	June 17	20 (10)
Red River (Coushatta)	June 17	37 (12)
Red River (Coushatta)**	June 17	20 total; 18 dead, 1 kd
Bossier (Red River Sta.)	June 17	10 (20)
Caddo (Dixie)	June 17	13 (10)
Caddo (Gilliam)	June 17	28 (9)
Caldwell (Riverton)	June 17	45 (11)
Caldwell (Riverton)**	June 17	20 total; 10 dead, 1 kd
Richland (Hebert)	June 17	10 (10)
Richland (Hebert)**	June 17	10 total; 10 dead, 0 kd
Tensas (NE. Res. Sta.)	June 17	13 (15)
Madison (Swampers)	June 17	0 (6)
Morehouse (Jones)	June 17	9 (11)
Franklin (Macon Ridge Sta.)	June 18	0 (5)
Catahoula (Deer Creek)	June 18	13 (15)
Concordia (Vidalia)	June 18	21 (8)
St. Landry (St. Landry)	June 23	25 (6)
Natchitoches (Derry)	June 23	0 (12)
Bossier (Red River Sta.)	June 23	20 (10)
Bossier (Red River Sta.)**	June 23	10 total; 9 dead, 0 kd
Caddo (Dixie)	June 23	10 (20)
Caddo (Gilliam)	June 23	10 (20)
Caldwell (Riverton)	June 23	30 (10)
Morehouse (Jones)	June 24	10 (10)
E. Carroll (Gassoway)	June 24	29 (7)
St. Landry (St. Landry)	June 30	0 (7)
Bossier (Red River Sta.)	June 30	30 (10)
Bossier (Red River Sta.)**	June 30	6 total; 3 dead, 0 kd
Caddo (Dixie)	June 30	0 (10)
Caddo (Gilliam)	June 30	0 (8)
Richland (Archibald)	June 30	30 (10)
Ouchita (Monroe)	June 30	0 (11)
Richland (Start)	June 30	57 (7)
Rapides (Cheneyville)	July 7	0 (10)
Rapides (Alexandria)	July 7	0 (4)
Bossier (Red River Sta.)	July 7	26 (26)
Bossier (Red River Sta.)**	July 7	30 total; 19 dead, 4 kd
Caddo (Dixie)	July 7	16 (8)
Caddo (Gilliam)	July 7	20 (10)
Caldwell (Riverton)	July 7	58 (12)
Catahoula (Deer Creek)	July 8	20 (10)
Concordia (Vidalia)	July 8	0 (5)

Table 4. Continued

Parish ¹ (Location)	% Survival (Number Tested)	
	Date	(5 µg/vial)
E. Baton Rouge (BenHur)	July 8	0 (5)
Richland (Archibald)	July 8	71 (7)
Morehouse (Collingston)	July 8	33 (3)
Tensas (NE. Res Sta.)	July 8	0 (8)
W. Carroll (Epps)	July 8	10 (10)
Tensas (Waterproof)	July 8	50 (12)
Madison (Waverly)	July 8	29 (7)
Morehouse (Bonita)	July 8	0 (6)
Richland (Hebert)	July 8	20 (10)
Franklin (Baskin)	July 8	20 (10)
Tensas (Waterproof**)	July 8	10 total; 8 dead, 2 kd
Rapides (Alexandria)	July 14	40 (25)
Rapides (Alexandria**)	July 14	20 total; 9 dead, 6 kd
Richland (Archibald)	July 13	40 (10)
Richland (Archibald**)	July 13	10 total; 9 dead, 1
Franklin (Baskin)	July 13	35 (20)
E. Bat. Rouge (BenHur)	July 15	0 (10)
Morehouse (Bonita)	July 13	66 (15)
Rapides (Cheneyville)	July 14	40 (5)
Grant (Colfax)	July 14	75 (24)
Morehouse (Collingston)	July 13	44 (10)
Morehouse (Collingston**)	July 13	10 tot.; 5 d, 4 kd
Red River (Coushatta)	July 14	76 (25)
Rapides (Dean Lee Sta.)	July 14	42 (12)
Catahoula (Deer Creek)	July 15	0 (20)
Natchitoches (Derry)	July 14	0 (13)
Desoto (Evelyn)	July 14	71 (7)
E. Carroll (Gassoway)	July 13	40 (10)
E. Carroll (Gassoway**)	July 13	10 tot; 5 d, 4 kd
Caddo (Gilliam)	July 14	0 (14)
Franklin (Macon Ridge Sta.)	July 14	19 (20)
Morehouse (Mer Rouge)	July 13	60 (10)
Morehouse (Mer Rouge**)	July 13	10 tot; 4 d, 4 kd
Ouachita (Monroe)	July 13	44 (10)
Ouachita (Monroe**)	July 13	10 tot; 6 d, 4 kd
Tensas (NE Res. Sta.)	July 13	33 (20)
Bossier (Red River Sta.)	July 14	31 (25)
Bossier (Red River Sta. **)	July 14	20 tot; 15 d, 3 kd
Caldwell (Riverton)	July 14	5 (25)
Richland (Start)	July 13	30 (20)
Richland (Start*)	July 13	10 tot; 4 d, 3 kd
Madison (Swampers)	July 13	50(20)
Madison (Swampers**)	July 13	20 tot; 16 d, 2 kd
Tensas (Sommerset)	July 13	60 (10)
Tensas (Sommerset*)	July 13	10 tot; 5 d, 4 kd
Concordia (Vidalia)	July 15	19 (20)
St. Landry (St. Landry)	July 21	0 (10)
Rapides (Cheneyville)	July 21	10 (10)
Rapides (Alexandria)	July 21	20 (10)
Grant (Colfax)	July 21	0 (10)
Red River (Coushatta)	July 21	0 (10)
Bossier (Red River Sta.)	July 21	29 (17)
Caddo (Dixie)	July 21	0 (4)
Tensas (NE. Res. Sta.)	July 21	30 (10)
Ouchita (Monroe)	July 21	40 (10)
Richland (Start)	July 21	71 (14)
E. Carroll (Gassoway)	July 21	20 (10)
Morehouse (MerRouge)	July 21	20 (10)
Tensas (Sommerset)	July 21	20 (10)
Catahoula (Deer Creek)	July 22	40 (10)
Concordia (Vidalia)	July 22	15 (20)
Rapides (Cheneyville**)	July 21	20 tot.; 18 d, 0 kd
Grant (Colfax**)	July 21	10 tot.; 10 d, 0 kd
Red River (Coushatta**)	July 21	10 tot.; 9 d, 0 kd
Bossier (Red River Sta. **)	July 21	10 tot.; 8 d, 1 kd
Catahoula (Deer Creek**)	July 21	16 tot.; 13 d, 3 kd
Rapides (Cheneyville)	July 28	10 (10)
Grant (Colfax)	July 28	6 (20)
Caddo (Gilliam)	July 28	40 (20)

Table 4. Continued

Parish ¹ (Location)	% Survival (Number Tested)	
	Date	(5 µg/vial)
E. Carroll (Gassoway**)	July 28	8 tot.; 7 d, 1 kd
Madison (Waverly)	July 28	0 (10)
Ouchita (Monroe)	July 28	11 (9)
Ouchita (Monroe**)	July 28	9 tot.; 8 d, 0 kd
Morehouse (MerRouge)	July 28	0 (8)
Morehouse (MerRouge**)	July 28	8 tot.; 8 d, 0 kd
Morehouse (Bonita)	July 28	23 (13)
Richland (Start)	July 28	0 (11)
Richland (Archibald)	July 28	8 (13)
E. Carroll (Gassoway)	July 28	13 (8)
Catahoula (Deer Creek)	July 29	0 (10)
Rapides (Alexandria)	August 4	13 (10)
Rapides (Alexandria**)	August 4	10 tot.; 8 d, 2 kd
Bossier (Red River Sta.)	August 4	22 (15)
Bossier (Red River Sta.**)	August 4	15 tot.; 11 d, 4 kd
Caddo (Dixie)	August 4	47 (15)
Caddo (Gilliam)	August 4	27 (15)
Caldwell (Riverton)	August 4	14 (7)
Richland (Start)	August 5	0 (10)
Richland (Start**)	August 5	10 tot.; 9 d, 0 kd
Madison (Swampers)	August 5	20 (10)
Madison (Swampers**)	August 5	10 tot.; 0 d, 0 kd
Concordia (Vidalia)	August 5	20 (10)
Franklin (Macon Ridge Sta)	August 5	0 (7)
E. B. Rouge (Ben Hur)	August 5	25 (5)
Richland (Hebert)	August 12	22 (9)
Richland (Hebert**)	August 12	0 (5)
Madison (Swampers)	August 12	18 (11)
Madison (Swampers**)	August 12	0 (5)
Richland (Start)	August 12	0 (12)
Richland (Start **)	August 12	0 (5)
Morehouse (Collingston)	August 12	10 (10)
Richland (Archibald)	August 12	20 (10)
Richland (Archibald**)	August 12	16 (7)
West Carroll (Epps)	August 12	10 (10)
Tensas (Saranac)	August 12	8 (13)
Tensas (Waterproof)	August 12	0 (12)
Rapides (Dean Lee Res Stn)	August 11	0 (13)
Rapides (Alexandria)	August 11	7 (20)
Rapides (Alexandria**)	August 11	0 (20)
DeSoto (Evelyn)	August 11	14 (20)
DeSoto (Evelyn**)	August 11	33 (15)
Caddo (Gilliam)	August 11	28 (20)
Caddo (Gilliam**)	August 11	17 (10)
Caldwell (Riverton)	August 11	28 (20)
Catahoula (Deer Creek)	August 12	20 (20)
Catahoula (Deer Creek**)	August 12	0 (15)
E. B. Rouge (Ben Hur)	August 12	16 (20)
Concordia (Vidalia)	August 12	16 (8)
Franklin (Macon Ridge)	August 12	5 (20)
Caldwell (Riverton)	August 18	13 (15)
Caldwell (Riverton**)	August 18	0 (5)
Bossier (Red Riv. Res Stn)	August 18	20 (20)
Bossier (Red Riv. Res Stn**)	August 18	7 (20)
DeSoto (Evelyn)	August 18	89 (15)
Rapides (Cheneyville)	August 18	0 (10)
St. Landry	August 18	66 (15)
Natchitoches (Derry)	August 18	0 (10)
Caddo (Gilliam)	August 18	13 (10)
Caddo (Gilliam)	August 18	50 (5)
Franklin (Macon Ridge)	August 19	11 (10)
Franklin (Macon Ridge**)	August 19	0 (10)
Concordia (Vidalia)	August 19	11 (10)
E. B. Rouge (Ben Hur)	August 19	14 (10)
Catahoula (Deer Creek)	August 19	29 (10)
Richland (Start**)	August 19	0 (10)
Morehouse (Mer Rouge)	August 19	13 (10)
Tensas (Northeast Res. Stn)	August 19	25 (10)
Richland (Hebert)	August 19	38 (10)

Table 4. Continued

Parish ¹ (Location)	% Survival (Number Tested)	
	Date	(5 µg/vial)
East Carroll (Gassoway)	August 19	20 (10)
East Carroll (Gassoway**)	August 19	0 (10)
Tensas (Waterproof)	August 19	38 (10)
Richland (Start)	August 19	16 (14)
Bossier (Red River**)	August 25	25 (10)
Bossier (Red River)	August 25	20 (10)
Rapides (Alexandria)	August 25	0 (10)
Red River (Coushatta)	August 25	0 (5)
Caddo (Dixie)	August 25	40 (10)
Franklin (Macon Ridge)	August 25	0 (5)
Concordia (Vidalia)	August 26	25 (10)
Concordia (Vidalia**)	August 26	0 (10)
Catahoula (Deer Creek)	August 26	10 (10)
E. B. Rouge (Ben Hur)	August 26	14 (10)
E. B. Rouge (Ben Hur**)	August 26	0 (10)
Franklin (Macon Ridge)	September 1	13 (10)
Caddo (Gilliam)	September 1	0 (10)
Bossier (Red River)	September 1	0 (10)
Bossier (Red River**)	September 1	0 (10)
Rapides (Alexandria)	September 1	0 (10)
E.B. Rouge (Ben Hur)	September 2	0 (10)
Catahoula (Deer Creek)	September 2	0 (10)
Concordia (Vidalia)	September 2	0 (10)

¹ If the specific location is not given for a parish, the data represent collections from two or more locations in the parish.

** Vials supplied by Greg Payne.

Table 5. Percent survival of bollworm male moths at 5lg cypermethrin per vial by parish and month during 1997.¹

Parish	May	June	July	August
Bossier	31	15	29	21
Caddo	0	9	15	34
Caldwell	---	42	32	18
Catahoula	0	13	15	20
Concordia	20	21	11	12
DeSoto	---	20	71	52
East Baton Rouge	21	---	0	17
East Carroll	---	29	24	20
Franklin	--	0	25	5
Grant	40	---	27	---
Madison	---	0	26	10
Morehouse	---	10	31	12
Natchitoches	---	0	0	0
Ouachita	---	0	32	---
Rapides	0	6	20	4
Red River	8	19	38	0
Richland	0	32	34	16
St. Landry	---	13	0	66
Tensas	---	13	32	18
West Carroll	---	19	10	10

Table 6. Monthly summary of cypermethrin resistance monitoring data for bollworm moths, 1988-1997.

Dose	Year	May	June	July	August	Sept.	Total
1	1988	10 ¹	0	64	34	30	43(515) ²
2		0	-	7	15	20	13(253)
5		0	0	3	2	3	2(439)
1	1989	-	-	57	60	38	53(220)
2		-	-	49	48	30	43(220)
5		-	-	5	6	3	4(170)
1	1990	19	33	44	34	24	33(1064)
2		5	25	28	16	15	21(1040)
5		0	0	6	1	2	2(561)
1	1991	25	54	50	43	37	44(1909)
2		11	23	31	23	26	24(1830)
5		2	5	7	4	8	59(1666)
1	1992	31	32	55	45	46	42(1241)
2		24	19	41	34	19	31(1295)
5		3	2	11	7	12	8(932)
1	1993	-	22	53	50	55	49(530)
2		-	21	36	30	48	33(733)
5		-	0	7	7	9	7(483)
1	1994	37	50	60	56	-	55(643)
2		27	33	45	42	-	40(683)
5		3	9	10	8	-	8(500)
1	1995	53	40	67	58	-	59(773)
2		20	23	45	38	-	36(767)
5		3	0	8	7	-	6(580)
5	1996	4	3	9	5	-	7(3697)
5	1997	4	4	14	7	-	9(1821)
5	1998	12	14	27	19	-	18(1950)

¹ Percent survival at indicated dose.

² Number in parenthesis indicates number of moths tested.

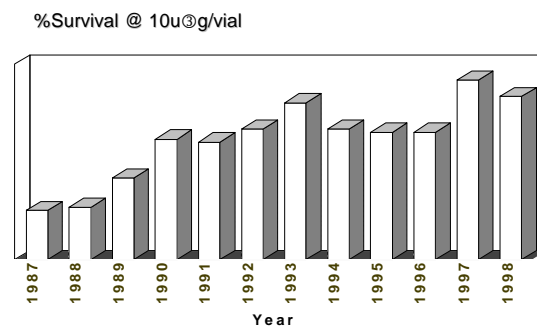


Figure 1. Percent survival of tobacco budworm male moths exposed to a discriminating dose (10 µg/vial) of a pyrethroid (cypermethrin) by month and year, 1987-1997.

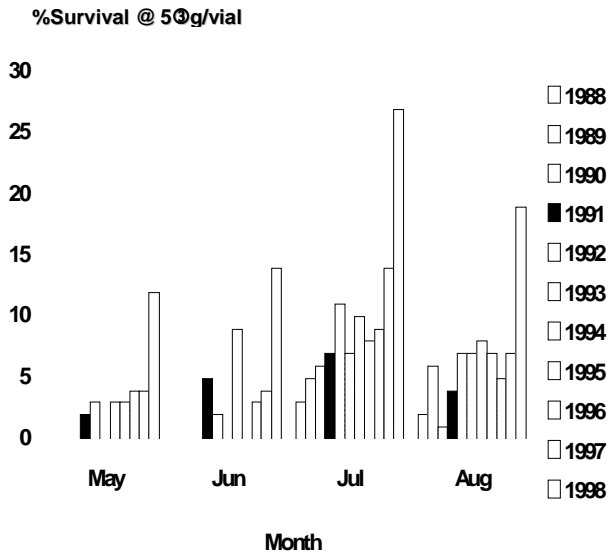


Figure 2. Percent survival of bollworm male moths exposed to 5 $\mu\text{g}/\text{vial}$ dose of a pyrethroid (cypermethrin) by year, 1988-1997.