STATUS OF INSECTICIDE RESISTANCE IN TOBACCO BUDWORM AND BOLLWORM IN LOUISIANA DURING 1996

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Abstract

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. 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 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. Over 3600 male bollworm, *Helicoverpa zea* (Boddie), moths were bioassayed against a 5 μg/vial dose of cypermethrin. Data from these bioassays were similar to those obtained from 1988-1995, but indicate that bollworm susceptibility to pyrethroids may be 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).

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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 µg dose of cypermethrin utilizing the AVT.

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. 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 adult vial test. Pyrethroid resistance levels during 1995 were similar to 1994 levels. Also, 200 male tobacco budworm moths were bioassayed for resistance to profenofos using the adult vial test. 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.

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.

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 1996. This information is essential to update and refine current insecticide resistance management guidelines.

Materials and Methods

Adult Vial Test

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 September. 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%.

During 1996, the AVT also was used to monitor for resistance to methomyl and profenofos. These chemicals were selected to represent the carbamate and organophosphate classes of insecticides. Preparation and storage of vials treated with these chemicals was accomplished as recommended by Kanga et al. (1993). Discriminating doses used for methomyl (2.5 µg/vial) and profenofos (10 μg/vial) were similar to those suggested by Kanga et al. (1993).

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.

Larval Topical Application Test

A laboratory susceptible strain of *H. virescens* (LSU-LAB) which has been maintained in the laboratory without exposure to insecticides for 19 years was used throughout the study. Field strains of *H. virescens* were collected in 1996 during May-September from an unsprayed site at the Macon Ridge (MRS) location of the Northeast Research Station (Winnsboro, LA). Larvae were collected as 1st instar from a cultivated stand of velvet leaf (*Abutilon theophrasti*) in May and June, and from cotton in September. In July and August, eggs and 1st instar larvae were collected from cotton from a neighboring site (Hebert, LA) which received repeated applications of pyrethroid, organophosphate and carbamate insecticides.

Laboratory strain (USDA-LAB) *H. zea* were obtained as pupae from the United States Department of Agriculture in Stoneville, MS. Field strains of *H. zea* were collected in 1996 during June, July and August from the Macon Ridge Research location of the Northeast Research Station (Winnsboro, LA). Insects were collected as larvae; from unsprayed field corn in June, and as survivors of pyrethroid applications on cotton in July and Bt-cotton (NuCOTN 33B) in August. Assays were performed on developmentally synchronous 5th instar larvae from the parental (P1) or first filial (F1) generations without laboratory selection with insecticides.

The toxicity of cypermethrin to 5th instar larvae was determined by topical bioassay similar to the standard ESA method (Anonymous 1970) for *Heliothis* spp. Larvae were treated on the dorsal surface of the mesothorax with a 1 µl drop of acetone (controls), or acetone containing technical grade cypermethrin, using a glass microsyringe fitted to a repeating ratchet dispenser. At least 40 larvae from each strain were treated as controls and at each dose of cypermethrin. For full dose-response bioassays, not less than 5 doses of cypermethrin were chosen from preliminary range finder bioassays giving mortality between 0-99%. Treated larvae were held at 27°C, 50% RH and a 14:10 (light : dark) photo period and mortality assessed after 72 h. The criterion for mortality was inability for larvae to make coordinated movement 15 seconds after prodding with a pencil point. Control mortality never exceeded 5% and was corrected for using Abbott's (1925) formula. Data were analyzed and probit regressions were estimated using a Polo Probit computer program.

Dose mortality lines for cypermethrin were established for 5th instars of the *H. virescens* (LSU-LAB) and *H. zea* (USDA-LAB) laboratory colonies (full data not shown). Derivation of the larval diagnostic doses for the two species differed. The diagnostic dose for *H. virescens* (1.75 µg/larvae was derived from 5 times the LD_{80} of the LSU-LAB strain. Previous years monitoring data for larval resistance in *H. virescens* in Louisiana have shown that a lower diagnostic dose (for example, the LD_{90} of the LSU strain) fail to reflect seasonal trends in pyrethroid resistance in this species (Ibrahim and Ottea 1995). Survivors of the 1.75 µg/larvae dose were all considered to be resistant to cypermethrin. The diagnostic dose for *H. zea* (0.79 µg/larvae) was derived from the LD_{90} of the USDA-LAB

strain and was chosen because it should differentiate between susceptible and resistant insects (Halliday and Burnham 1990).

Results and Discussion

Adult Vial Tests

From May through August 1996, 1966 male tobacco budworm moths from 17 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 and June (0-47%), the period when pyrethroids are not recommended for use in the Insecticide Resistance Management Plan for Louisiana (Bagwell 1996). Resistance to pyrethroids increased dramatically in July (19-87%) as soon as the pyrethroid use period began and declined slightly in August (4-65%). These data indicate that the non-pyrethroid use period is still useful in managing pyrethroid resistance.

Comparing the mean yearly responses of tobacco budworm moths bioassayed at 10 μg cypermethrin per vial during 1996 to that determined for the period of 1987-1995 revealed that pyrethroid resistance levels were similar to 1994 and 1995 (Table 3 and Figure 1). Overall survival in 1996 was 39%, 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 1996, 3697 male bollworm moths from 19 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 0-29%, 0-15%, 2-13%, and 0-15% 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. Survival at 5 µg of cypermethrin per vial during 1996 appeared to be similar to survival at these doses during 1988-1995 (Table 6 and Figure 2). There is no clear indication that bollworms are developing resistance to pyrethroids.

Responses of male tobacco budworm moths during 1996 to 10 μg/vial of profenofos are given in Tables 7 and 8. Mean survival at 10 μg/vial was 7%. Resistance levels to profenofos were similar in 1996 to that of 1995.

Responses of male tobacco budworm moths during 1996 to 2.5 µg/vial of methomyl is given in Tables 9 and 10. Mean survival at 2.5 µg/vial was 7%. Resistance levels to methomyl were similar to 1993 and 1994 levels.

Larval Topical Application Tests

Tobacco budworm larval survival at 1.75 µg cypermethrin was recorded in each of the 1996 field strains and increased during the early season from a low of 38% in May, to 77% in June and a peak of 95% in July. Selection for pyrethroid resistance at the beginning of the season may have been due to unscheduled applications of pyrethroids targeting bollworm infestations of seedling cotton. In the mid/late season, survival at the diagnostic dose plateaued and declined slightly (85% survival in August and 80% survival in September).

Bollworm larval survival at 0.79 µg cypermethrin was recorded in each of the 1996 field strains and increased steadily through the season from 17% in June, 30% in July, and 51% in August. This increase in diagnostic dose survival may have reflected sustained pyrethroid selection pressure in this region during the production season and was corroborated by observations of bollworm survivors in commercial fields receiving pyrethroid applications adjacent to the Macon Ridge site.

Implications

Resistance in tobacco budworm to carbamate, organophosphate and pyrethroid insecticides was documented again during 1996. Resistance levels to pyrethroids, carbamates, and organophosphates in tobacco budworm were similar in 1996 to 1995. Overall populations of tobacco budworm were low in 1996. As a result, few tobacco budworm field control failures occurred although control in most fields was not satisfactory despite high control costs. Although there appears to be a trend for increased bollworm survival, there have been no reported cases of inadequate field control of bollworm populations. These data indicate that the Insecticide Resistance Management Plan has helped forestall the loss of pyrethroid insecticides for bollworm/tobacco budworm control in cotton.

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Table 1. Responses of tobacco budworm male moths to cypermethrin during 1996.

Parish[1] (Location)	Date	%Survival[2] (No. Tested) (10 µg/vial)
Madison (Waverly)	May 28	43(7)
Caddo	May 29	33(12)
Natchitoches (Derry)	May 29	11(18)
Franklin (Fort Necessity)	May 30	11(9)
Tensas	May 30	37(8)
Ouachita	May 30	20(10)
Madison (Waverly)	June 3	9(12)
Bossier (Red River Station)	June 4-6	33(9)
Natchitoches (Powhatan)	June 5	28(18)
Natchitoches (Derry)	June 5	50(18)
Avoyelles (Bunkie)	June 5	22(9)
Franklin (Fort Necessity)	June 6	20(10)
Caldwell (Columbia)	June 6	14(7)
Pointe Coupee	June 6	12(8)
Ouachita (Richwood)	June 6	15(20)
Madison (Waverly)	June 10	11(9)
Ouachita (Sterlington)	June 10	7(30)
Franklin (Crowville)	June 10	0(12)
West Carroll (Epps)	June 10	12(16)
Tensas (Somerset)	June 10	0(3)
Morehouse (Bonita)	June 10	12(17)
Avoyelles (Bunkie)	June 11	25(20)
Rapides (Dean Lee Station)	June 11	37(8)
Grant (Colfax)	June 11	33(9)
Natchitoches (Derry)	June 11	27(30)
Caddo	June 11	53(30)
Franklin	June 11	20(20)
Ouachita (Bosco)	June 11	10(20)
Pointe Coupee (Lettsworth)	June 12	47(40)
Concordia (Shaw)	June 12	30(10)
Concordia (Monterey)	June 12	0(6)
Concordia (Spokane)	June 12	59(17)
Franklin (Crowville)	June 14	29(34)
Natchitoches (Derry)	June 18	10(20)
Caddo	June 18	12(17)
Bossier (Red River Station)	June 18-19	60(10)
Pointe Coupee (Lettsworth)	June 19	0(10)
Franklin (Fort Necessity)	June 19	10(20)
Natchitoches (Derry)	June 24	25(20)
Franklin (Fort Necessity)	June 25	10(20)
Ouachita (Sterlington)	June 28	21(28)
Natchitoches (Derry)	July 1	19(16)
Caddo	July 1	33(15)
Ouachita	July 2	20(20)
Franklin (Fort Necessity)	July 2	23(13)
Madison (Tallulah)	July 9	40(10)
Franklin(Fort Necessity)	July 10	50(10)
Pointe Coupee (New Roads)	July 11	60(10)
Morehouse (Oak Ridge)	July 15	79(14)
Madison (Tallulah)	July 15	60(20)
Madison (Waverly)	July 15	43(14)
Franklin (Crowville)	July 15	57(37)
Bossier (Red River Station)	July 16-18	57(14)
Caddo (Gilliam)	July 17	44(9)
Natchitoches (Derry)	July 17	25(4)
Franklin (Fort Necessity)	July 17	40(5)
Ouachita (Bosco)	July 17	12(17)
Caldwell (Columbia)	July 17	40(10)
Franklin (Crowville)	July 19	68(25)
Franklin (Baskin)	July 20	55(31)
Morehouse (Collinston)	July 23	68(38)
East Carroll (Milliken)	July 23	86(7)
East Carroll (Monticello)	July 23	87(8)
Caddo (Gilliam)	July 23	54(70)
Caddo (Belcher)	July 23	40(20)
Natchitoches (Derry)	July 23	17(6)
Ouachita (Richwood)	July 24	60(10)
Ouachita (Bosco)	July 24	76(17)
Caldwell (Columbia)	July 24	74(23)

Table 1. Continued

Parish[1] (Location)	Date	%Survival[2] (No. Tested) (10 µg/vial)
Franklin (Fort Necessity)	July 24	25(12)
Tensas (Somerset)	July 24	70(23)
Tensas (Waterproof)	July 24	50(6)
Concordia (Shaw)	July 24	25(8)
Madison (Waverly)	July 24	36(50)
Franklin (Fort Necessity)	July 30	25(16)
Caldwell (Columbia)	July 30	42(24)
Ouachita (Bosco)	July 30	50(10)
Ouachita (Richwood)	July 30	50(10)
Richland (Hebert)	July 31	25(12)
Richland (Alto)	July 31	50(6)
Franklin (Crowville)	July 31	35(20)
Morehouse (Collinston)	July 31	58(12)
Ouachita (Sterlington)	July 31	73(30)
Franklin (Crowville)	Aug 1	24(17)
Franklin (Baskin)	Aug 1	62(8)
Richland (Hebert)	Aug 2	52(90)
Richland (Alto)	Aug 2	69(16)
Avoyelles (Bunkie)	Aug 6	50(8)
Natchitoches (Derry)	Aug 6	40(10)
Bossier (Red River Station)	Aug 6	65(20)
Caddo (Belcher)	Aug 6	60(30)
Ouachita (Richwood)	Aug 6	17(18)
Richland (Hebert)	Aug 6	0(15)
Morehouse (Bonita)	Aug 6	10(22)
West Carroll (Epps)	Aug 6	40(5)
East Carroll (Monticello)	Aug 6	25(4)
Ouachita (Sterlington)	Aug 6	20(5)
Morehouse (Collinston)	Aug 6	20(20)
Richland (Hebert)	Aug 6	25(28)
Caldwell (Columbia)	Aug 7	62(16)
Franklin (Fort Necessity)	Aug 7	57(14)
Pointe Coupee (Lettsworth B)	Aug 7	42(24)
Franklin (Baskin)	Aug 21	40(90)
Madison (Tallulah)	Aug 21	4(24)
Tensas (Waterproof)	Aug 27	60(20)
Ouachita (Richwood)	Aug 27	62(50)
Grant (Colfax)	Aug 28	55(20)
Rapides (Dean Lee Station)	Aug 28	44(9)

[1] If a 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.

Table 2. Percent survival of tobacco budworm male moths at 10 µg cypermethrin per vial by parish and month during 1996.[1]

Parish	May	June	July	August
Avoyelles	--	24	--	50
Bossier	--	47	57	65
Caddo	33	38	48	60
Caldwell	--	14	54	63
Concordia	--	39	25	--
East Carroll	--	--	87	25
Franklin	11	17	47	41
Grant	--	33	--	55
Madison	43	10	43	4
Morehouse	--	12	69	14
Natchitoches	11	27	19	40
Ouachita	20	13	50	48
Pointe Coupee	--	34	60	42
Rapides	--	38	--	44
Richland	--	--	33	44
Tensas	37	0	66	60
West Carroll	--	13	--	40

[1] Percent 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 10 µg/vial, 1987-1996.

	Percent Survival[1] (Number Tested)						
Year	May	June	July	Aug	Sept	Oct	Total
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)

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

Table 4. Responses of bollworm male moths to cypermethrin during 1996.

Parish		% Survival (No. Tested)
(Location)	Date	(5 µg/vial)
Madison	May 28	0(4)
Tensas (Somerset)	May 28	0(6)
Morehouse (Bonita)	May 28	29(7)
Richland (Archibald)	May 28	0(3)
West Carroll (Epps)	May 28	0(2)
Rapides (Dean Lee Station)	May 29	0(15)
Caddo (Belcher)	May 29	7(30)
Bossier (Red River Station)	May 30	5(20)
Ouachita (Richwood)	May 30	3(30)
Caldwell (Bosco)	May 30	10(20)
Caldwell (Columbia)	May 30	7(30)
Franklin (Fort Necessity)	May 30	0(20)
Catahoula (Peck)	May 30	5(20)
Tensas (Justina)	May 30	3(30)
Tensas (Waterproof)	May 30	0(30)
Pointe Coupee (Lettsworth)	May 30	0(15)
Madison (Swampers)	June 5	0(8)
Natchitoches (Powhatan)	June 5	0(20)
Caddo (Belcher)	June 5	3(30)
Caddo (Dixie)	June 5	0(20)
St. Landry (Le Moyer)	June 5	0(8)
Rapides (Dean Lee Station)	June 5	10(10)
Avoyelles (Bunkie)	June 5	0(9)
Pointe Coupee (Lettsworth)	June 6	0(10)
Concordia (Shaw)	June 6	5(20)
Tensas	June 6	0(30)
Catahoula (Peck)	June 6	5(20)
Franklin (Fort Necessity)	June 6	0(30)
Caldwell	June 6	7(30)
Ouachita (Richwood)	June 6	5(20)
St. Landry (Le Moyer)	June 11	0(20)
Rapides (Cheneyville)	June 11	3(30)
Natchitoches (Derry)	June 11	5(20)
Concordia (Shaw)	June 12	0(20)
Concordia (Spokane)	June 12	3(30)
Madison	June 16	11(9)
Grant (Colfax)	June 18	5(20)
Bossier (Red River Station)	June 18-19	15(20)
Ouachita (Sterlington)	June 28	0(21)
Natchitoches (Derry)	July 1	5(20)
Grant (Colfax)	July 1	10(10)
Caddo (Dixie)	July 1	5(20)
Caddo (Gilliam)	July 1	7(30)
Ouachita (Richwood)	July 2	10(20)
Ouachita (Bosco)	July 2	7(30)
Caldwell (Columbia)	July 2	0(30)
Franklin (Fort Necessity)	July 2	0(17)
Catahoula (Peck)	July 2	10(10)
Tensas	July 2	8(25)
Pointe Coupee (Lettsworth)	July 2	5(20)
Ouachita (Sterlington)	July 9	10(40)
Richland (Archibald)	July 9	0(7)
Richland (Alto)	July 9	0(10)
Richland (Rhymes)	July 9	40(20)
Morehouse (Collinston)	July 9	20(5)
Morehouse (Mer Rouge)	July 9	7(30)
Morehouse (Oak Ridge)	July 9	27(11)
Morehouse (Bonita)	July 9	40(5)
Franklin (Baskin)	July 9	10(10)
West Carroll (Epps)	July 9	11(9)
East Carroll (Lake Providence)	July 9	11(18)
Madison (Tallulah)	July 9	0(8)
Rapides (Cheneyville)	July 10	0(20)
St. Landry (Le Moyer)	July 10	3(30)
Avoyelles (Bunkie)	July 10	0(10)
Grant (Colfax)	July 10	3(30)
Natchitoches (Derry)	July 10	0(10)
Natchitoches (Powhatan)	July 10	20(30)

Table 4. Continued

Parish (Location)	Date	% Survival (No. Tested) (5 µg/vial)
Caddo (Dixie)	July 10	7(30)
Franklin (Fort Necessity)	July 10	10(20)
Caldwell (Columbia)	July 10	5(20)
Pointe Coupee (New Roads)	July 11	7(30)
Pointe Coupee (Lettsworth-A)	July 11	7(30)
Pointe Coupee (Lettsworth-B)	July 11	12(40)
Concordia (Shaw)	July 11	0(30)
Concordia (Spokane)	July 11	3(30)
Tensas (Justina)	July 11	0(40)
Richland (Archibald)	July 11	23(30)
Ouachita (Sterlington)	July 15	12(26)
Morehouse (Collinston)	July 15	5(40)
Morehouse (Oak Ridge)	July 15	4(25)
West Carroll (Epps)	July 15	0(5)
East Carroll (Lake Providence-A)	July 15	2(50)
East Carroll (Lake Providence-B)	July 15	6(18)
East Carroll (Milliken)	July 15	12(25)
Richland (Archibald)	July 15	17(30)
Richland (Rhymes)	July 15	0(36)
Franklin (Baskin)	July 15	5(40)
Madison (Tallulah)	July 15	13(30)
Madison (Waverly)	July 15	0(10)
Tensas (Somerset)	July 15	0(20)
Bossier (Red River Station)	July 16	10(20)
St. Landry (Le Moyer)	July 17	10(20)
Avoyelles (Bunkie)	July 17	10(30)
Rapides (Dean Lee Station)	July 17	15(20)
Grant (Colfax)	July 17	14(29)
Natchitoches (Derry)	July 17	0(20)
Natchitoches (Powhatan)	July 17	0(20)
Caddo (Dixie)	July 17	10(30)
Pointe Coupee (New Roads)	July 18	15(20)
Pointe Coupee (Lettsworth-B)	July 18	7(30)
Concordia (Shaw)	July 18	12(40)
Concordia (Monterey)	July 18	0(30)
Tensas (Justina)	July 18	3(30)
Richland (Archibald)	July 23	10(20)
Richland (Rhymes)	July 23	20(20)
East Carroll (Lake Providence-A)	July 23	5(20)
East Carroll (Milliken)	July 23	5(20)
Franklin (Baskin)	July 23	35(20)
Morehouse (Collinston)	July 23	5(19)
Morehouse (Mer Rouge)	July 23	15(20)
West Carroll (Epps)	July 23	10(20)
East Carroll (Lake Providence-B)	July 23	10(20)
Ouachita (Richwood)	July 24	13(30)
Ouachita (Bosco)	July 24	20(40)
Catahoula (Peck)	July 24	10(10)
Ouachita (Sterlington)	July 24	5(20)
Franklin (Gilbert)	July 24	25(20)
East Carroll (Lake Providence)	July 24	10(20)
East Carroll (Sondheimer)	July 24	15(20)
Madison (Waverly)	July 24	15(20)
Madison (Tallulah)	July 24	15(20)
Morehouse (Bonita)	July 24	5(20)
Franklin (Baskin)	July 25	8(62)
Franklin (Baskin)	July 31	15(20)
Franklin (Gilbert)	July 31	0(15)
Ouachita (Sterlington)	July 31	0(30)
Richland (Alto)	July 31	26(31)
Richland (Alto)	July 31	0(30)
Richland (Rhymes)	July 31	2(40)
Madison (Waverly)	July 31	0(19)
Madison (Swampers)	July 31	20(40)
East Carroll (Monticello)	July 31	25(20)
East Carroll (Sondheimer)	July 31	0(20)
East Carroll (Milliken)	July 31	10(20)
East Carroll (Lake Providence)	July 31	0(20)
Morehouse (Collinston)	July 31	6(31)
Morehouse (Bonita)	July 31	10(40)

Table 4. Continued

Parish (Location)	Date	% Survival (No. Tested) (5 µg/vial)
St. Landry (Le Moyer)	Aug 6	7(15)
Avoyelles (Bunkie)	Aug 6	10(10)
Bossier (Red River Station)	Aug 6	15(20)
Rapides (Dean Lee Station)	Aug 6	10(20)
Grant (Colfax)	Aug 6	10(10)
Natchitoches (Powhatan)	Aug 6	5(20)
Caddo (Gilliam)	Aug 6	4(50)
Ouachita	Aug 6	11(28)
Franklin (Baskin)	Aug 6	0(30)
Richland (Hebert)	Aug 6	0(19)
West Carroll (Epps)	Aug 6	0(16)
East Carroll (Monticello)	Aug 6	0(10)
Ouachita (Sterlington)	Aug 6	0(20)
East Carroll (Lake Providence)	Aug 6	0(14)
Tensas (Somerset)	Aug 6	0(15)
Morehouse (Bonita)	Aug 6	0(4)
Caldwell (Columbia)	Aug 7	10(20)
Franklin (Fort Necessity)	Aug 7	4(50)
Tensas	Aug 7	3(30)
Pointe Coupee (Lettsworth-B)	Aug 7	7(30)
Franklin (Baskin)	Aug 13	0(14)
Ouachita (Sterlington)	Aug 13	0(14)
East Carroll (Lake Providence)	Aug 13	15(15)
Morehouse (Bonita)	Aug 13	10(20)
Ouachita (Sterlington)	Aug 20	0(10)
Franklin (Baskin)	Aug 20	11(28)
Richland (Rhymes)	Aug 20	11(18)
Morehouse (Bonita)	Aug 21	3(30)
East Carroll (Lake Providence)	Aug 21	8(37)
East Carroll (Lake Providence)	Aug 21	0(37)
Concordia (Shaw)	Aug 27	0(10)

Table 5. Percent survival of bollworm male moths at 5 µg cypermethrin per vial by parish and month during 1996.

Parish	May	June	July	August
Avoyelles	--	0	8	10
Bossier	5	15	10	15
Caddo	7	2	7	4
Caldwell 8		7	2	10
Catahoula	5	5	10	--
Concordia	--	3	5	0
East Carroll	--	--	8	4
Franklin 0		0	11	4
Grant	--	5	9	10
Madison 0		6	12	--
Morehouse	29	--	9	6
Natchitoches	--	3	7	5
Ouachita	3	2	10	4
Pointe Coupee	0	0	9	7
Rapides	0	5	8	10
Richland	0	--	13	5
St. Landry	--	0	6	7
Tensas	2	0	3	2
West Carroll	0	--	9	0

Table 6. Monthly summary of cypermethrin resistance monitoring data for bollworm moths, 1988-1996.

Dose	Year	May	June	July	Aug	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	5(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)

[1] Percent survival at indicated dose.
[2] Number in parenthesis indicates number of moths tested.

Table 7. Responses of tobacco budworm male moths to profenofos during 1996.

		% Survival (Number Tested)
Parish	Date	(10 µg/vial)
Caddo	Aug 28	5(80)
Caldwell	Aug 27	0(23)
Franklin	Aug 27	8(38)
Grant	Aug 28	10(20)
Ouachita	Aug 27	13(39)

Table 8. Monthly summary of profenofos resistance monitoring data for tobacco budworm, 1993-1996.

Dose	Year	June	July	Aug	Sept	Total
10	1993	-	-	23	43	34(135)
20		7	5	-	14	10(155)
10	1994	-	-	13	12	12(249)
20		-	-	7	0	5(280)
10	1995	-	-	6	-	6(200)
20		-	-	3	-	3(200)
10	1996	-	-	7	-	7(200)

Table 9. Responses of tobacco budworm male moths to methomyl during 1996.

		% Survival (Number Tested)
Parish	Date	(2.5 µg/vial)
Ouachita	Aug 27	6(100)
Bossier	Sept 13, 17-18	7(99)

Table 10. Monthly summary of methomyl resistance monitoring data for tobacco budworm, 1993-1996.

			% Survival (Number Tested)			
Dose	Year	June	July	Aug	Sept	Total
2.5	1993	5	7	7	17	11(360)
10.0		0	0	0	0	0(235)
2.5	1994	-	-	8	10	8(155)
10.0		-	-	0	2	1(155)
2.5	1995	-	-	-	-	-
10.0		-	-	-	-	-
2.5	1996	-	-	6	7	7(199)

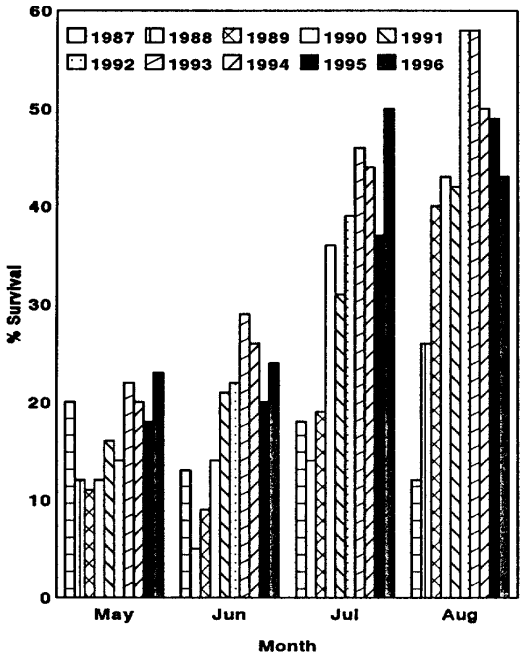

Figure 1. Percent survival of tobacco budworm male moths exposed to a discriminating dose (10 μg/vial) of a pyrethroid (cypermethrin) by month and year, 1987-1995.

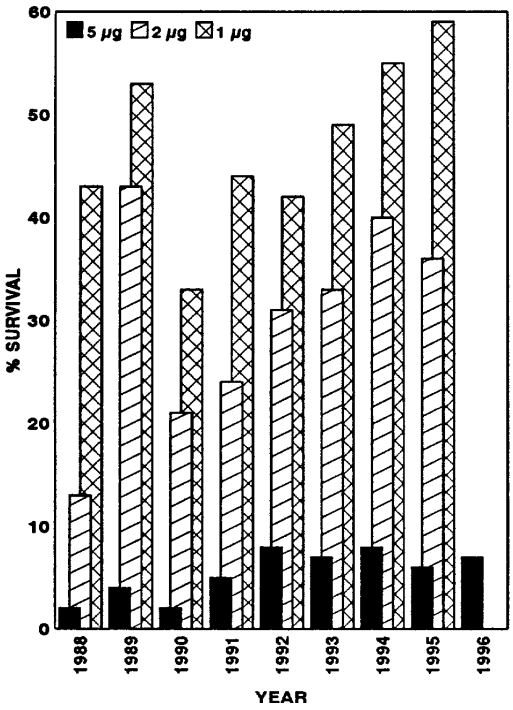

Figure 2. Percent survival of bollworm male moths exposed to 1, 2 and 5 μg/vial dose of a pyrethroid (cypermethrin) by year, 1987-1995.