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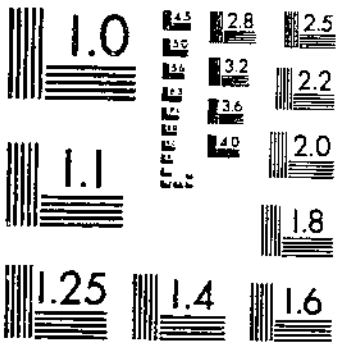
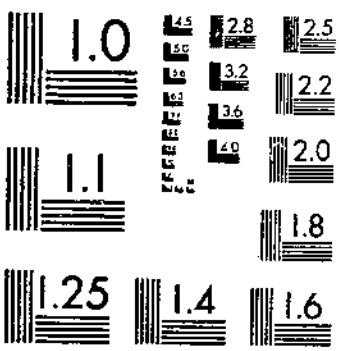


MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS-1963-A



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TB 1606/V80

Evaluation of Light Traps and Sex Pheromone for Control of Cabbage Looper and Other Lepidopterous Insect Pests of Lettuce

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ABSTRACT

Debolt, J. V., W. W. Wolf, T. J. Henneberry, and P. V. Vail. 1979.
Evaluation of light traps and sex pheromone for control of cabbage looper and other lepidopterous insect pests of lettuce. U.S. Department of Agriculture, Technical Bulletin No. 1606, 39 p.

Describes the design and installation of cabbage looper sex pheromone baited light traps and their evaluation as a means of reducing populations of cabbage looper and other lepidopterous pests on a large lettuce-producing ranch.

More than 28 million beet armyworm moths, 7 million cabbage looper moths, and 2 million corn earworm moths were estimated to have been removed from the ranch during the study. Lesser numbers of yellow-striped armyworm moths, alfalfa looper moths, granulate cutworm moths, and saltmarsh caterpillar moths were removed. Seasonal and year-to-year variations in trap catches were similar in both heavily and lightly trapped areas. Moth catches were generally lower in the heavily trapped area than in the lightly trapped area. Correlation was shown between reduced trap catch of cabbage looper and beet armyworm moths and distance in from the ranch perimeter. Pheromone-baited light traps reduced the cabbage looper male to female ratio by 73 percent and the mating percentage by 13 percent in the heavily trapped area. During peak egg laying, up to 14 times as many cabbage looper eggs were found in the lightly trapped area as were found in the heavily trapped area.

KEYWORDS: Light traps, pheromone, lettuce insects, cabbage looper, beet armyworm, corn earworm, alfalfa looper, yellowstriped armyworm, granulate cutworm, saltmarsh caterpillar, male annihilation.

FOREWORD

The research reported in this publication is the only study conducted to date to evaluate and determine the potential pheromone–light trap combination for the control of an economic insect pest, the cabbage looper. Similar experiments have not been conducted and, if initiated today, would require 6 to 10 years before results would be available.

The State of California reported that economic damage and control for the cabbage looper cost $20 million in 1975. The results of this research need to be published and will be an important contribution and source of information for further research to develop behavioral control methods for insect crop pests.

ACKNOWLEDGMENTS

We wish to thank Bud Antle, Inc., and Eddie Kobayashi, manager of their Red Rock and Picacho farms, for their excellent cooperation throughout this test. Special thanks are extended to J. W. Balock, R. W. Brubaker, J. H. Ford, O. A. Hills, D. L. Jay, R. G. Killinen, R. W. Ost, R. S. Seay, and M. S. Stands without whose help this experiment could not have been conducted.

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Issued January 1980

Evaluation of Light Traps and Sex Pheromone for Control of Cabbage Looper and Other Lepidopterous Insect Pests of Lettuce

By J. W. Debolt, W. W. Wolf, T. J. Henneberry, and P. V. Vail[1]

INTRODUCTION

In most areas, intensive use of insecticides is required to prevent crop loss and contamination from insects or insect fragments in marketing lettuce (*Lactuca sativa* L.). Several of the important insect pests are Lepidoptera, which are strongly attracted to light sources. The cabbage looper, *Trichoplusia ni* (Hübner), is one of the most injurious pests in all lettuce production areas; however, beet armyworms, *Spodoptera exigua* (Hübner); yellowstriped armyworms, *Spodoptera ornithogalli* (Guenee); several cutworm species; and *Heliothis* spp. also can reach economic infestation levels requiring control methods.

A comprehensive review and summary of research conducted with light traps as a tool in detection and as potential control agents has recently been published by Hienton (*8*).[2] The author concluded that light traps offer promise of suppressing insect populations when traps are used alone or in an integrated control program. Cantelo (*2*) reported on all the known published efforts to control native insect populations with light traps under crop production and isolated conditions. The results of reported studies have been extremely variable, ranging from no effect to a reported major impact resulting in greatly reduced population levels of target insect species.

Henneberry et al. (*7*) found that catches of male cabbage loopers could be increased greatly by baiting light traps with virgin looper females. Berger (*1*) reported success in identifying and synthesizing the sex pheromone of the cabbage looper female moth. The availability of the synthetic pheromone, usable in a simple dispenser (*12*), led to a combination light-pheromone trap and the possibility of population control through male annihilation of cabbage loopers, in addition to capture of other insects by the traps.

Thus, with increased interest in nonchemical methods of control, the potential value of pheromone baited light traps for reducing populations of cabbage loopers and other pests in lettuce production systems was investigated during 1967–69, and the results are presented in this bulletin. Preliminary reports of some of the data from these investigations were presented by Wolf et al. (*13*) and Ford et al. (*6*).

[1] Research entomologist, Biological Control of Insects Laboratory, 2000 East Allen Road, Tucson, Ariz. 85719; agricultural engineer and research entomologist, Western Cotton Research Laboratory, 4135 East Broadway Road, Phoenix, Ariz. 85040; and research entomologist, Stored-Product Insects Research Laboratory, 5578 Air Terminal Drive, Fresno, Calif. 93727; respectively.

[2] Italic numbers in parentheses refer to Literature Cited, p. 39.

LOCATION OF THE EXPERIMENTAL AND LIGHT TRAP INSTALLATIONS

The experiment was conducted on the Bud Antle, Inc., ranch near Red Rock, Ariz. The ranch was 1259 ha in size with 850 to 931 ha cropped during each year of the experiment. About 405 ha were planted to fall lettuce (September to December), 324 ha to spring lettuce (December to April), and 81 ha to cotton (May to October) annually. The ranch was selected in the hope that its location, 12.9 km from other cultivated hosts, would provide some degree of isolation from other pest reservoirs. The ranch is divided into fields, nominally 0.4 km by 0.8 km (32.4 ha), with service roads and irrigation canals around each field (fig. 1). Practices of aerial spraying and deep chiseling prevented installation of overhead power distribution or burial of cable in the fields. The only acceptable locations for the traps were along the roads around each field.

Barrel-mounted traps for control and survey

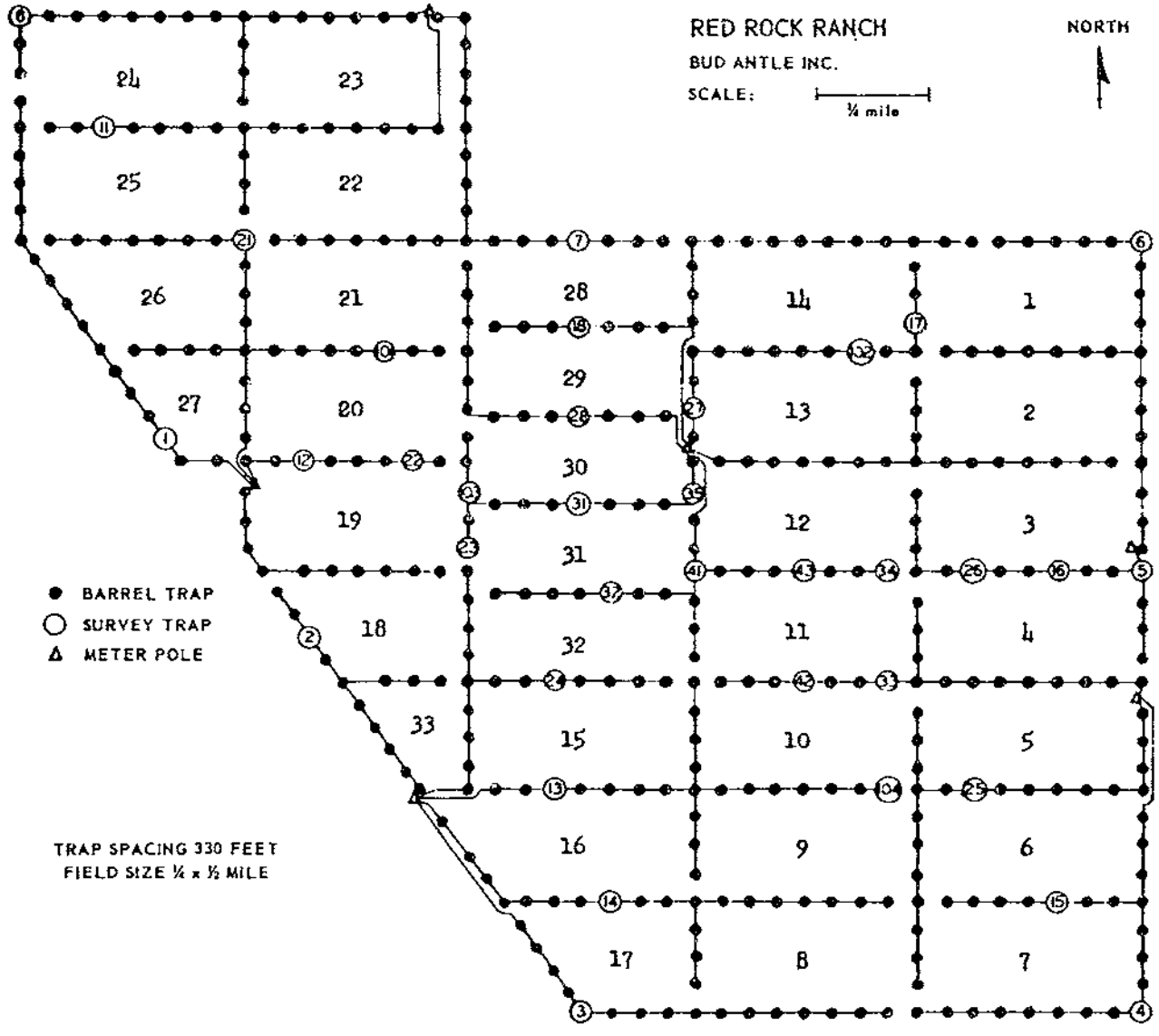

FIGURE 1.—Layout of Red Rock ranch, near Red Rock, Ariz., showing survey traps and barrel traps located along roads surrounding each field.

traps for monitoring adult moth populations were designed (fig. 2). Both traps had two 15-watt blacklight (BL) fluorescent lamps with baffles extending radially in four directions. The baffles were 48.9 cm high and 15.9 cm wide. A gap of 14 cm was left in the center for mounting the lamps, which were installed in line with two opposing baffles. High power factor ballasts were selected for the lamps to reduce line current, permitting use of smaller sized power-distribution cable.

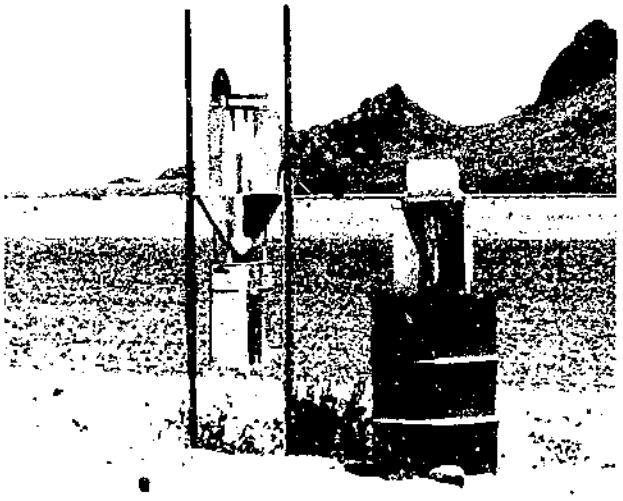

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FIGURE 2.—Survey trap location with barrel trap on left and survey trap on right. Pheromone dispenser hangs inside cylindrical rain shield above lamps.

The barrel traps had the lamps and baffle assembly fastened on standard 208 liter barrels using a locking ring. Diesel fuel and water were placed in these barrels, and the level was maintained within 15 cm of the top. An initial 7.6-cm layer of fuel was later increased to 30.5 cm. The specific gravity of diesel fuel was low enough to allow most insects to sink, leaving a clear catching surface for additional moths. A total of 415 barrel traps were installed at 100.6-cm intervals along the perimeter of each field.

The survey traps were identical to the barrel traps, except that a 45.7-cm diameter funnel attached to a killing container was substituted for the barrel (fig. 2). Thirty-six of these survey traps were installed on the ranch, eight were installed in the desert approximately 0.23 to 3.2 km outside the ranch. The survey traps were installed beside barrel traps on the Red Rock ranch. On nights when collections were to be taken, the barrel traps adjacent to the survey traps were turned off and the survey traps turned on.

Four traps were installed on a 324-ha ranch without barrel traps near Picacho, Ariz. The Picacho ranch was operated by the same organization and lies 14.5 km northwest of the Red Rock ranch. Both cotton and lettuce were grown at Picacho under cultural practices similar to those at Red Rock. The Picacho ranch, however, was bordered by large areas planted to cotton and other host crops.

Irrigation water for the ranch is obtained from wells equipped with electric pumps, so electric power was already available at widely separated points on the land. Using these pump sites as distribution centers, it was possible to work out a satisfactory subcircuit distribution system. Six distribution centers for 115- to 230-volt single-phase service were established with each panel including main fuses, a photocell, a magnetic relay, and fuses for six subcircuits.

The subcircuits were buried underground along the edges of the service roads for the reasons previously mentioned. Three-conductor, number 10 cable with chlorosulfonated cross-linked polyethylene insulation, selected to resist the alkaline soil conditions on the advice of Rural Electrification Administration engineers, was used for this installation. The conductors were triplexed with no outer jacket, and 41.8 km of cable were required. The cable was buried 45.7 cm deep along roads and 61 cm deep at all road crossings. There was a total of 23 separate runs from the distribution boxes. The longest run was 2 km (fig. 1). The two hot conductors of each run were fused in the distribution box. Traps operating on 120 volts were located every 100.6 m along the roads, and pairs of consecutive traps were connected to the same hot conductor to permit alternate traps to be turned off individually without unbalancing the system.

The cable was terminated at each location in a junction box inside a buried concrete water-meter box of the type used for domestic installations. A fused receptacle was mounted on the junction box, and the boxes were supported by pieces of conduit. Special cutouts in the meter

box lids allowed the drop cord from the trap to be plugged into the receptacle easily.

Initial cabbage looper pheromone dispensers consisted of 100-ml glass specimen bottles containing 40 g of sand (*12*). The pheromone was diluted with ether and poured on the sand. Enough pheromone-ether mixture was used to saturate the sand and provide 0.1 g of pheromone in each dispenser. In September 1967, these sand dispensers were replaced by wick dispensers (*4*).

The wick dispensers had 15 mm of No. 8 cotton thread extending from the small end of a modified disposable pipet. The pipet was cut so the small end had an inside diameter of 1.5 mm and an overall length of 6 cm. Silicone rubber sealed the large end (5.6 mm I. D.) and anchored the thread. Approximately 0.25 cm^3 of pheromone was placed in the pipet. The dispenser was protected from dust by inserting it in the lid of a 118-ml baby food jar. A rubber grommet in the jar lid held the pipet so the wick was centered inside the jar. Four 3.2-mm holes were drilled in the lids to permit escape of the pheromone. The jar was hung inverted inside a rain shield mounted on top of each trap.

The cost of the physical installation in 1967 averaged less than $64.25 per ha for the 1259 ha; however, if the installation cost were based on the 405 ha of fall lettuce most likely to benefit from the traps, the cost would have been $195.21 per ha. The installation was completed, and the lamps were turned on the first week of March 1967.

EVALUATION METHODS

The experiment permitted a comparison of effects of light traps alone on certain insect species in addition to the combined effects of light traps and sex pheromone on the cabbage looper populations. Evaluations of the effects of the traps were based on adult collections from survey traps, spermatophore counts from collected and dissected cabbage looper females, and egg and larvae counts on lettuce and cotton. Relative population changes were studied by comparing the 12-month moving mean trap catch to a base year. In addition, the total number of moths removed from the ranch was estimated.

The survey traps were so distributed that regression analyses were made on trap catches along various directions through the ranch, traps on the perimeter were compared with traps 305 m, 610 m, 914 m, or 1219 m from the perimeter. In addition, trap catches at all locations were compared, using analysis of variance techniques and standard error of the means to construct isotrap catch lines. Records were kept on corn earworms, *Heliothis zea* (Boddie), saltmarsh caterpillars, *Estigmene acrea* (Drury), beet armyworms, yellowstriped armyworms, alfalfa loopers, *Autographa californica* (Speyer), and granulate cutworms, *Feltia subterranea* (Fabricius), as well as cabbage loopers.

SEASONAL VARIATIONS IN LIGHT TRAP CATCHES

Seasonal light trap catches of cabbage looper, corn earworm, beet armyworm, yellowstriped armyworm, and granulate cutworms for the years 1963–66, in an area approximately 97 km northwest of the Red Rock area, were described by Hills (*9*). Hills located traps in the desert and agricultural areas, similar in vegetation and climate to those of Red Rock.

In our studies, the seasonal variations in light trap collections of the above species, plus the alfalfa looper and saltmarsh caterpillar were compared in heavily and lightly trapped areas.

Cabbage Looper

Seasonal and area variation in the trap catches of both sexes of cabbage loopers can be seen in figure 3. Actual mean weekly catches of cabbage loopers are shown in table 1. These data show that cabbage looper moths were abundant in all trapped areas, and no period was totally free of adult catches. Peak moth catches occurred during August or September each year. The earliest and also the greatest peak catch occurred

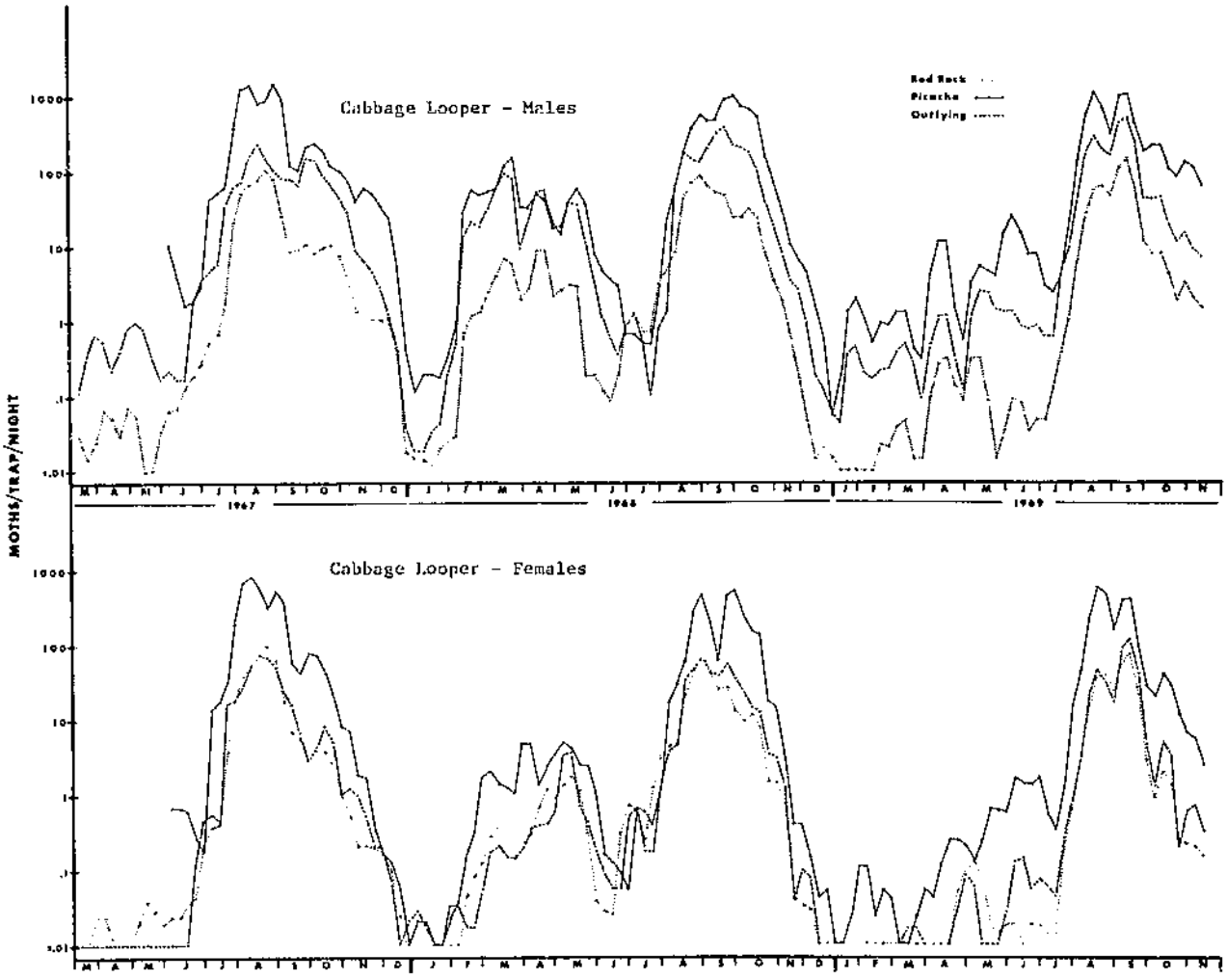

FIGURE 3.—Seasonal variations in cabbage looper BL trap catches, biweekly moving means.

on August 2, 1967, when mean catches of 1,005 females and 1,969 males per trap per night were recorded at Picacho. The latest peak occurred September 26 when 1,055 males per trap per night were recorded at Picacho. Peaks of both sexes and at different trap areas often did not occur simultaneously (table 1).

In 1967, male and female peaks occurred together at the three areas, but these peaks for the outlying area, August 9, followed the August 2 Picacho peak, whereas those peaks at Red Rock did not occur until August 22. In 1968, males and females at Red Rock and females in the outlying traps occurred on August 29, whereas males in the outlying traps did not peak until September 12. Following this, females peaked at Picacho September 19, whereas males peaked there on September 26. In 1969, all peaks occurred on September 9 except the peak of females at Picacho, which had occurred 3 weeks earlier on August 14. A steady climb toward these peaks began in June or July each year. After the peak, catches declined until they reached their lowest levels in December and January. In 1968, mid-January through February was very wet and warm. Cabbage looper catches increased rapidly to a series of peaks in March, April, and May, and then declined. These high spring catches in 1968 produced a curve similar to curves presented by Hills (*9*) for 1965 and 1966. Yearly curves for 1967 and 1969 had lower spring catches and more closely resembled Hills' 1964 curve.

TABLE 1.—*Mean numbers of cabbage looper moths captured in Red Rock, outlying, and Picacho area light traps*

Collection date	Mean No. moths per trap per night					
	Cabbage looper males			Cabbage looper females		
	Red Rock	Outlying	Picacho[1]	Red Rock	Outlying	Picacho[1]
1967						
March 9	0.04	0.11	—	0.01	0	—
16	.02	.11	—	0	0	—
23	.01	.56	—	.01	0	—
30	.04	.78	—	.04	0	—
April 6	.10	.33	—	0	0	—
13	0	.11	—	0	0	—
21	.05	.67	—	.02	0	—
28	.10	1.00	—	0	0	—
May 5	.01	1.00	—	.03	0	—
12	0	.56	—	.05	0	—
19	0	.11	—	.01	0	—
26	.06	.22	16.17	.03	0	0.75
June 2	.07	.22	5.33	.02	0	.58
9	.06	.11	2.67	.03	0	.75
16	.20	.22	.58	.04	0	.50
23	.18	3.44	3.56	.05	.22	0
30	.39	3.56	1.33	.39	.67	.67
July 7	.67	6.00	51.83	.35	.44	17.50
14	.70	0	0	.60	0	0
21	2.28	32.83	63.13	5.04	16.67	31.75
26	40.21	99.00	696.00	31.83	19.60	360.25
Aug. 2	62.27	63.00	1,969.75	43.10	36.50	1,005.00
9	77.21	278.50	964.75	67.62	76.67	668.50
16	91.88	149.00	492.00	95.45	68.67	306.00
22	129.79	149.33	1,429.33	101.76	71.67	328.00
29	39.06	62.00	1,700.00	30.00	31.00	708.00
Sept. 6	12.12	100.00	146.75	6.29	20.00	45.75
12	5.25	63.00	95.50	7.75	11.67	74.00
19	13.31	69.00	122.50	3.86	1.33	9.50
27	10.01	201.33	273.00	4.65	3.67	115.50
Oct. 5	6.60	88.33	212.25	3.10	5.00	35.25
11	12.76	101.00	177.00	4.68	11.50	53.75
19	9.53	44.44	84.83	1.12	.67	2.33
26	6.31	47.11	126.67	.90	1.44	14.00
Nov. 2	1.29	9.00	24.25	.18	1.00	.75
9	1.49	8.89	55.64	.23	1.00	3.09
16	1.08	4.67	65.67	.19	.17	.50
24	1.07	4.92	36.33	.20	.25	.25
30	.96	1.21	31.50	.14	.14	.08
Dec. 7	1.24	1.33	18.67	.06	0	.17
19	.02	.06	.81	.01	0	0
26	0	0	.04	0	.04	0
1968						
Jan. 3	.02	.03	.19	.01	.03	.03
9	.01	0	.21	0	0	0
16	.02	.06	.18	0	0	0
23	.02	.03	.18	.01	0	0
30	.03	.34	.50	0	.06	.04

See footnote at end of table.

TABLE 1.—*Mean numbers of cabbage looper moths captured in Red Rock, outlying, and Picacho area light traps—Continued*

Collection date		Mean No. moths per trap per night					
		Cabbage looper males			Cabbage looper females		
		Red Rock	Outlying	Picacho[1]	Red Rock	Outlying	Picacho[1]
1968—Continued							
Feb.	6	0.03	0.63	1.18	0.01	0	0.04
	13	1.37	24.38	55.29	.08	.02	.25
	20	1.03	18.02	62.36	.08	0	.32
	27	1.60	17.57	35.14	.17	.10	3.14
March	5	3.24	48.34	74.14	.38	.26	1.07
	11	4.87	68.22	41.75	.40	.17	1.88
	14	11.14	152.44	281.00	.22	.11	.08
	21	.74	7.61	40.50	.08	.17	2.00
	28	3.09	10.78	25.50	.36	.22	7.58
April	4	2.46	32.56	38.17	.23	.50	1.75
	11	15.06	76.22	72.00	1.13	.28	.78
	18	2.63	35.89	19.83	1.28	.56	3.50
	25	1.81	7.17	14.17	.50	.67	3.17
May	2	3.36	22.00	22.67	2.14	6.73	6.75
	9	2.86	50.94	53.67	1.46	1.00	1.83
	16	—	21.06	65.83	.61	.56	3.08
	23	.19	5.39	9.25	.06	.28	1.75
	30	.19	1.73	7.33	.02	.07	.25
June	6	.05	.67	2.25	.04	.11	.08
	13	.13	.61	5.08	.01	0	.17
	20	.24	.06	.67	.56	.11	0
	27	1.45	1.80	.67	.89	1.00	.11
July	4	1.06	.87	.67	.35	.33	1.08
	11	.37	.13	.33	.15	0	.08
	18	1.04	.07	.67	2.22	.33	.78
	25	5.40	1.67	3.33	4.15	3.00	1.67
Aug.	1	4.19	0	33.50	4.66	6.67	31.50
	8	22.83	106.75	106.50	6.30	3.25	19.25
	15	61.27	229.00	279.00	32.16	58.00	140.00
	22	80.41	61.20	434.67	54.84	35.00	353.33
	29	97.74	218.50	712.67	84.89	110.50	590.67
Sept.	6	45.30	194.25	392.50	18.70	7.38	57.00
	12	60.53	566.00	822.00	35.50	98.00	68.00
	19	35.31	265.83	975.50	18.03	28.17	642.00
	26	17.94	201.50	1,055.50	10.57	37.50	469.00
Oct.	3	28.51	206.75	416.50	8.39	8.00	59.00
	10	35.31	146.70	924.00	15.09	22.20	258.00
	17	10.47	50.10	179.50	1.32	2.60	9.88
	24	5.61	30.25	133.00	1.57	4.08	28.00
	31	2.16	12.17	38.17	1.38	2.28	7.25
Nov.	7	1.63	3.33	20.42	.10	0	.17
	19	.26	3.43	6.21	.02	.05	.50
	26	.08	1.64	6.64	.05	.14	.29
Dec.	3	.01	.26	2.14	0	0	0
	10	.02	.12	1.00	0	0	.07
	17	.02	.12	.11	0	0	.04
	30	0	.03	.02	0	0	0

See footnote at end of table.

TABLE 1.—*Mean numbers of cabbage looper moths captured in Red Rock, outlying, and Picacho area light traps—Continued*

Collection date		Mean No. moths per trap per night					
		Cabbage looper males			Cabbage looper females		
		Red Rock	Outlying	Picacho[1]	Red Rock	Outlying	Picacho[1]
1969							
Jan.	7	0	0.07	0.54	0	0	0.04
	20	0	.62	2.21	0	0	0
	27	.01	.33	1.96	0	0	.21
Feb.	3	0	.07	.14	0	0	0
	10	.01	.26	.89	0	0	.04
	17	.04	.17	1.00	.01	0	.07
	24	0	.29	.71	0	0	0
March	3	.07	.48	1.96	.02	0	0
	10	.02	.52	.64	0	.02	0
	17	.01	.05	.21	0	0	.04
	24	.02	.14	.41	0	0	.07
April	1	.16	.76	7.36	0	0	0
	7	.39	1.56	17.00	0	0	.25
	10	.19	.39	2.00	0	0	.25
	17	.08	.22	.83	.09	.06	.25
	24	.08	0	.25	.09	.11	.17
May	1	.53	2.22	6.25	.16	0	.08
	9	.14	2.75	4.81	.02	0	.38
	15	.02	1.86	4.33	.02	0	1.00
	22	0	.86	3.75	.01	0	.25
	29	.06	1.71	25.50	.03	.04	.92
June	5	.12	1.00	26.83	0	.11	2.42
	12	.04	.67	4.25	0	.07	.42
	19	.03	.85	10.92	.03	.04	2.33
	26	.06	.85	5.08	.01	.11	1.17
July	3	.03	.33	.75	.02	0	0
	10	.22	.85	3.83	.01	.07	.67
	17	.50	7.52	4.50	.34	.41	2.00
	24	1.76	11.93	39.33	.99	1.22	29.75
Aug.	1	14.38	85.44	284.00	5.88	5.44	70.25
	7	43.33	341.00	1,128.00	30.69	54.50	496.00
	14	68.33	275.00	1,177.33	43.61	38.75	753.33
	23	60.33	131.00	367.00	37.69	23.78	277.75
	28	31.22	184.22	225.67	11.11	10.44	15.67
Sept.	6	200.97	715.25	1,651.25	118.40	184.00	697.50
	11	102.37	373.00	574.75	41.71	70.22	135.25
	18	15.78	75.88	261.25	5.25	10.75	57.50
	25	6.50	13.00	98.00	.75	0	1.25
Oct.	2	8.91	73.38	342.00	1.16	2.75	39.50
	9	7.44	31.33	144.33	2.47	6.44	45.00
	16	.99	8.50	80.25	.43	.33	18.50
	23	2.61	14.50	81.00	.07	.06	2.83
	30	3.74	15.00	166.50	.38	1.11	10.13
Nov.	6	.82	4.67	77.92	.10	.46	2.83
	13	2.06	8.41	44.92	.21	.26	2.42

[1] Dashes indicate no data.

Corn Earworm

Seasonal and area variations in trap catches of both sexes of corn earworm moths are shown in figure 4. Actual mean weekly catches of corn earworm moths are shown in table 2.

Corn earworm moths were captured during most months of the study. In December of 1967 and 1968, however, catches were reduced to zero and remained there or at very low levels until the spring buildup started in February 1968 and April 1969. Catches of corn earworm moths rarely exceeded catches of cabbage looper moths, the highest corn earworm catch per trap per night being 258 females and 206 males September 12, 1967. Peak catches occurred from early August to early October during the study. As with the cabbage loopers, the highest peaks occurred during the first year of the study. The earliest peak occurred August 2, 1967 when male and female corn earworm moth catches peaked in the outlying traps, whereas the latest peak occurred when Picacho area males peaked October 2, 1969. As with the cabbage looper moths, simultaneous peaks for male and female corn earworm moths and for different areas did not always occur. Simultaneous peaks for males and females occurred in outlying traps August 2, 1967, and September 19, 1968, and in Picacho traps September 12, 1967, and August 22, 1968. At Red Rock, peak male and female catches never occurred together

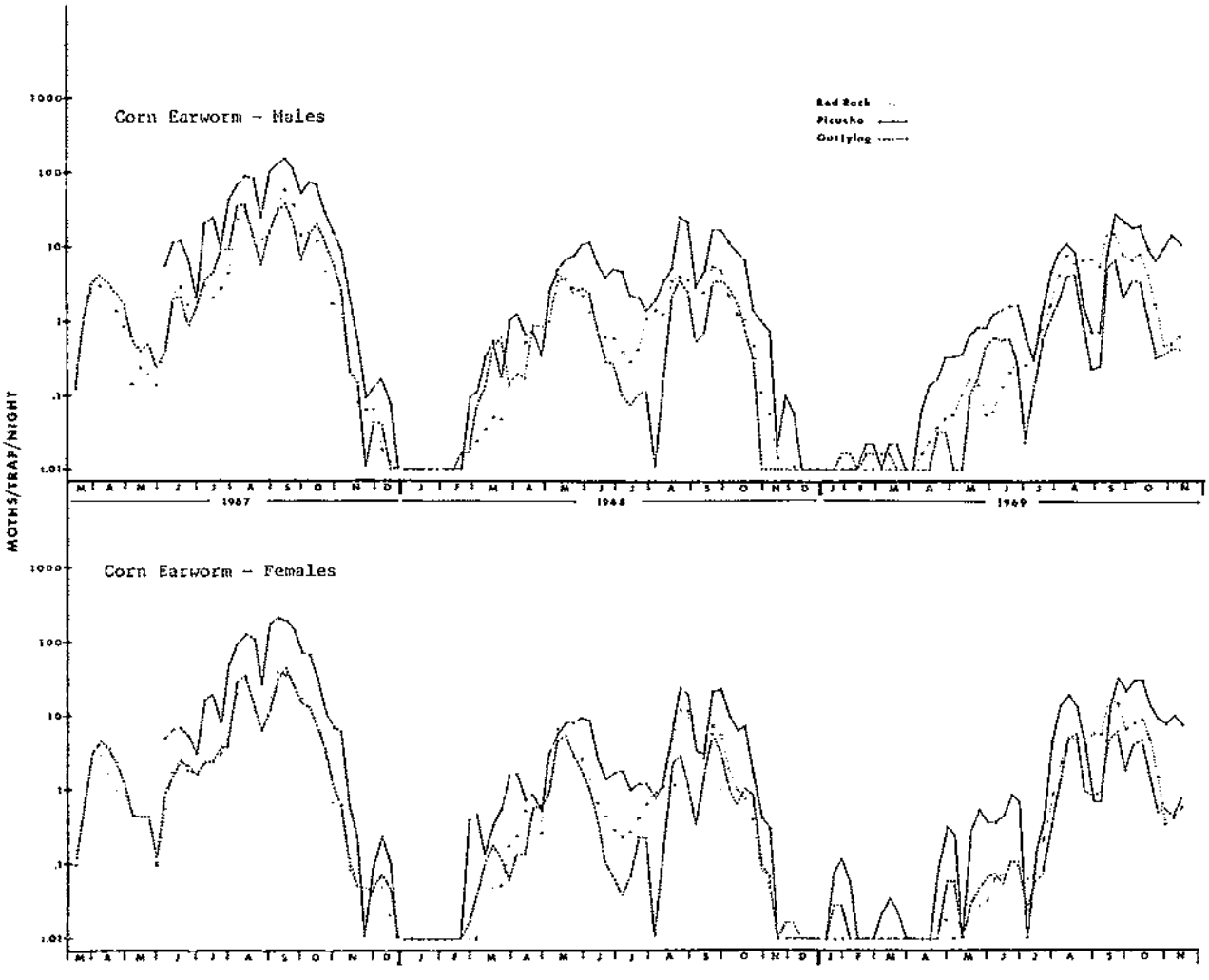

FIGURE 4.—Seasonal variations in corn earworm BL trap catches, biweekly moving means.

TABLE 2.—*Mean numbers of corn earworm moths captured in Red Rock, outlying, and Picacho area light traps*

Collection date	Mean No. moths per trap per night					
	Corn earworm males			Corn earworm females		
	Red Rock	Outlying	Picacho[1]	Red Rock	Outlying	Picacho[1]
1967						
March 9	0.03	0	—	0.04	0	—
16	.45	.22	—	.14	.22	—
23	1.34	1.89	—	1.03	1.33	—
30	3.59	4.22	—	3.56	4.78	—
April 6	2.58	4.00	—	2.44	4.33	—
13	1.26	2.33	—	.92	3.00	—
21	1.62	2.44	—	1.05	1.67	—
28	.08	.89	—	.69	.67	—
May 5	.19	.22	—	.28	.22	—
12	.28	.56	—	.33	.67	—
19	.10	.44	—	.09	.22	—
26	.16	0	2.33	.10	0	2.67
June 2	.66	.78	7.92	.83	1.78	7.17
9	3.82	3.22	14.75	2.64	1.44	6.25
16	1.98	1.00	9.83	2.72	3.44	7.75
23	1.24	.67	2.22	1.15	.89	2.56
30	3.74	2.44	1.33	2.22	2.33	4.00
July 7	2.20	4.44	24.67	2.46	2.44	19.75
14	1.60	0	0	1.73	0	0
20	3.18	9.17	9.00	3.59	3.83	7.75
26	5.39	8.40	73.00	7.08	3.40	87.75
Aug. 2	41.49	55.33	63.50	32.21	51.67	104.75
9	18.59	19.00	120.25	13.23	17.67	151.25
16	8.15	2.00	16.00	7.27	5.33	18.00
22	16.15	8.67	31.67	19.15	6.67	34.67
29	13.22	23.33	152.00	15.67	15.33	30.00
Sept. 6	50.62	35.33	107.50	61.82	43.33	135.75
12	67.03	40.00	206.00	10.89	42.67	258.00
19	9.67	3.00	22.00	16.81	6.67	22.00
27	15.56	7.67	63.00	17.93	18.67	94.00
Oct. 5	15.31	21.33	87.00	15.53	7.33	38.50
11	9.67	19.33	52.00	6.97	7.00	25.00
19	1.25	6.67	15.08	.19	1.33	2.33
26	2.11	5.33	15.67	1.19	1.11	11.33
Nov. 2	.30	.11	3.00	.10	.11	.75
9	.15	.33	1.09	.08	.11	.45
16	0	0	0	.02	0	0
24	.11	0	.17	.10	.08	0
30	.02	.07	.08	.05	0	.17
Dec. 7	.02	0	.25	.06	.13	.33
19	0	0	0	0	0	0
26	0	0	0	0	0	0
1968						
Jan. 3	0	0	0	0	0	0
9	0	0	0	0	0	0
16	0	0	0	0	0	0
23	0	0	0	0	0	0
30	0	0	0	0	0	0
1968—Continued						
Feb. 6	0	0	0	0	0	0
13	0	0	0	0	0	0
20	0	.02	0	0	0	0
27	.02	0	.18	0	.02	.82
March 5	.02	.14	.04	.02	.06	.14
11	.05	.11	.67	.06	.17	.13
14	.06	1.11	.33	.04	.22	.75
21	.03	.17	0	.06	0	.33
28	.25	.11	2.08	.29	.11	2.92
April 4	.14	.28	.50	.19	.17	.50
11	.85	.06	.89	.86	.11	1.00
18	.70	1.67	.67	.31	1.06	.83
25	.04	.06	0	.19	.17	.17
May 2	5.13	2.13	4.67	8.17	1.87	5.75
9	3.68	4.72	5.08	5.56	6.94	5.83
16	0	2.94	8.50	0	3.94	10.75
23	2.86	2.17	6.67	2.95	2.17	5.50
30	1.79	3.47	15.50	2.17	1.47	13.83
June 6	1.04	1.44	8.17	.69	.72	4.08
13	.67	.11	3.58	.60	.11	1.42
20	.59	.44	4.00	.30	.11	1.42
27	.62	.07	6.56	.29	0	2.11
July 4	.21	.13	3.17	.19	.07	1.67
11	.34	0	1.33	.37	.07	.33
18	.48	.20	3.22	.47	.40	2.44
25	1.64	0	0	.82	0	.33
Aug. 1	1.24	0	3.83	1.00	0	1.17
8	1.30	.25	2.00	1.60	.25	1.50
15	5.90	3.60	11.50	7.59	3.80	15.00
22	2.13	3.40	35.33	16.34	2.20	30.00
29	5.22	1.50	8.00	6.93	0	9.33
Sept. 6	1.87	0	1.00	1.75	.50	1.00
12	3.24	2.00	19.00	4.06	4.00	11.00
19	7.47	4.17	16.50	11.28	6.83	28.00
26	3.40	3.00	17.00	2.87	1.42	21.00
Oct. 3	1.24	2.75	6.13	1.26	.83	.13
10	1.30	.90	11.00	.89	.40	12.50
17	.85	.70	2.50	.71	1.80	2.50
24	.14	0	0	.10	.08	.17
31	.08	0	1.50	.09	.11	.58
Nov. 7	.03	0	0	0	0	0
19	.01	0	.07	0	0	0
26	.01	0	.11	.02	.02	0
Dec. 3	0	0	0	0	0	0
10	0	0	0	0	0	0
17	0	0	0	0	0	0
30	0	0	0	0	0	0

See footnote at end of table.

TABLE 2.—*Mean numbers of corn earworm moths captured in Red Rock, outlying, and Picacho area light traps—Continued*

Collection date	Mean No. moths per trap per night					
	Corn earworm males			Corn earworm females		
	Red Rock	Outlying	Picacho[1]	Red Rock	Outlying	Picacho[1]
1969						
Jan. 7	0	0	0	0	0	0
20	0	0	0	0	.05	.14
27	0	.02	0	0	0	.11
Feb. 3	0	0	0	0	0	0
10	0	0	0	0	0	0
17	0	.02	.04	0	0	0
24	0	0	0	0	0	0
Mar. 3	.01	.02	0	.01	0	.04
10	0	0	.04	0	0	.04
17	0	0	0	0	0	0
24	0	0	0	0	0	0
April 1	0	0	0	0	0	0
7	.02	0	.13	0	0	0
10	.03	0	.17	.01	0	0
17	.05	.06	.17	.03	0	.17
24	.06	0	.50	.01	.11	.50
May 1	.06	0	.17	.01	0	0
9	.14	0	.50	.04	0	0
15	.20	.19	.83	.03	.05	.67
22	.08	.14	.83	.03	.05	.50
29	.03	.71	.75	.04	.08	.25
1969—Continued						
June 5	0.09	0.48	1.83	0.09	0.07	0.50
12	.17	.67	1.08	.06	.04	.42
19	.24	.52	2.25	.12	.19	1.42
26	.33	.04	1.17	.08	.04	0
July 3	.18	0	.08	.05	0	0
10	.54	.26	.50	.23	.11	.25
17	1.04	.81	2.00	.19	.04	.50
24	2.19	1.26	6.58	1.26	.67	9.08
Aug. 1	7.55	2.89	11.50	4.02	2.78	22.88
7	9.11	6.50	11.50	7.75	10.00	16.00
14	2.69	2.00	4.00	2.17	2.13	10.00
23	20.50	0	0	16.20	0	0
28	3.08	.44	1.67	3.08	1.78	1.67
Sept. 6	13.30	0	0	16.80	0	0
11	15.26	9.44	15.00	17.91	9.33	25.75
18	15.36	3.88	41.25	12.81	3.63	43.25
25	.47	.44	2.50	.67	.22	.25
Oct. 2	13.47	7.00	33.25	16.41	8.88	63.50
9	5.63	1.67	11.00	6.97	3.22	12.00
16	3.21	.50	9.00	2.92	.72	15.25
23	.26	.13	2.83	.18	.31	1.67
30	.69	.56	15.50	.51	.83	12.88
Nov. 6	.36	.33	14.17	.37	.17	9.58
13	.92	.52	8.75	.85	1.37	6.33

[1] Dashes indicate no data.

with females peaking 1 and 4 weeks ahead of males in 1967 and 1968, respectively, and females peaking 3 weeks after males in 1969.

As with the cabbage looper catches, the corn earworm curves for 1967 and 1969 resemble Hills' (*9*) 1964 curve, whereas the 1968 curve, with its higher spring populations, more closely resembles Hills' 1965 and 1966 curves.

Beet Armyworm

Seasonal and area variations in trap catches of beet armyworm moths and weekly mean catches can be seen in figure 5 and table 3, respectively.

Beet armyworm moths, the most abundant species counted, occurred in virtually all collections during the study, January 16, 1968, being the only collection date when none were caught on any of the three areas. One was captured the following week at Red Rock. The highest peak catches of beet armyworm moths, with two exceptions, occurred during September each year. In 1967, catches from all three areas peaked on September 12 with the highest catches for all areas for the study, whereas in 1968 the peaks were spread from September 12 to September 26. In 1969, the catch at Red Rock peaked on September 6; the other two areas were not counted on this date, but a peak for outlying and Picacho traps did occur on August 7. As with the cabbage looper and corn earworm, the highest spring population catches occurred in 1968. The beet armyworm peak, however, occurred in early May. Beet armyworm catch curves for 1968 and 1969 resemble Hills' (*9*) 1966 curve for this species, whereas the

1967 curve more closely resembles Hills' 1965 curve.

Alfalfa Looper

Seasonal and area variations in alfalfa looper catches and mean weekly catches can be seen in figure 5 and table 4. Alfalfa looper moths were not abundant during this study. The highest number collection, 11 moths per trap per night was recorded for March 28, 1968. The greatest peak of alfalfa looper catches occurred from late February to early May 1968. Only the Red Rock area had a higher peak during any other period, the Red Rock peak of five moths per trap per night, occurring August 28, 1969. During the rest of the study, catches only occasionally reached one moth per trap per night. Although few moths were caught, catches, overall, tended to increase in the spring, decrease rapidly after the peak, rise in late August to early October, and show another rise in November.

Yellowstriped Armyworm

Seasonal variations in yellowstriped armyworm catches and mean weekly catches can be seen in figure 6 and table 5. Yellowstriped armyworm moths were not caught in great numbers during this study. The highest collections of

Text continues on page 18.

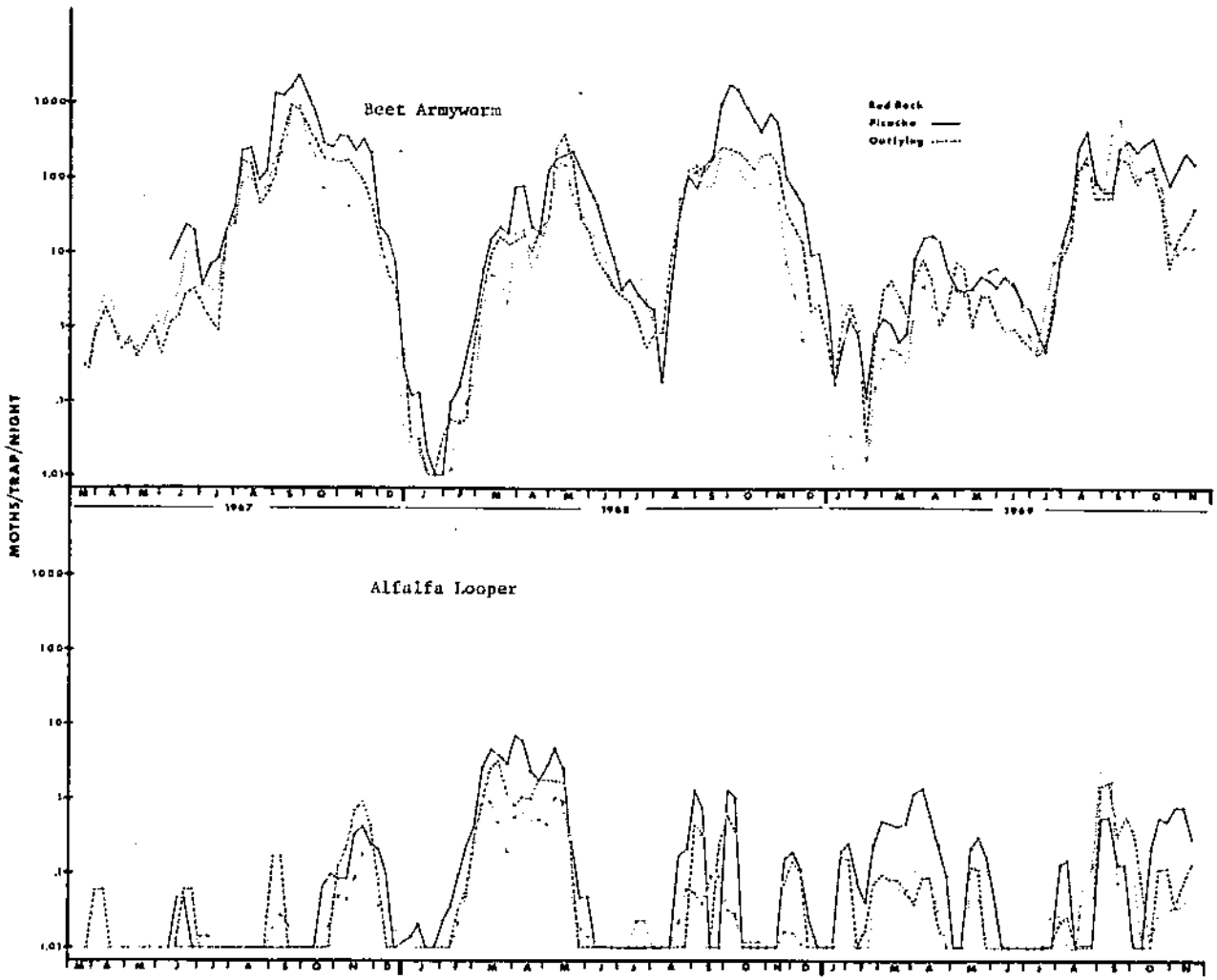

FIGURE 5.—Seasonal variation in beet armyworm and alfalfa looper trap catches, biweekly moving means.

TABLE 3.—*Mean number of male and female beet armyworm moths captured in Red Rock, outlying, and Picacho area light traps*

Collection date	Mean No. moths per trap per night			Collection date	Mean No. moths per trap per night		
	Red Rock	Outlying	Picacho[1]		Red Rock	Outlying	Picacho[1]
1967				1967—Continued			
March 9	0.25	0.33	—	Feb. 6	0.01	0.06	0.18
16	.37	.33	—	13	.12	.05	.14
23	.30	.22	—	20	.09	.07	.71
30	1.98	1.56	—	27	.33	1.86	1.79
April 6	3.80	2.11	—	March 5	3.79	4.74	9.82
13	.21	.22	—	11	6.01	14.53	20.71
21	.86	.78	—	14	2.27	19.56	23.50
28	.40	.67	—	21	1.74	6.11	11.33
May 5	.53	.11	—	28	38.64	21.50	139.58
12	2.33	1.22	—	April 4	4.99	11.50	16.08
19	1.16	.78	—	11	6.23	8.22	27.89
26	.77	.11	5.83	18	19.83	31.61	9.58
June 2	3.20	2.11	10.00	25	39.69	29.06	229.92
9	2.65	.78	17.42	May 2	263.57	508.80	130.92
16	19.96	4.56	29.83	9	55.60	290.22	264.17
23	3.88	2.11	4.56	16	0	31.61	186.83
30	5.17	1.56	.67	23	33.42	25.67	70.67
July 7	1.27	.89	8.33	30	10.60	9.33	64.33
14	7.40	0	0	June 6	11.94	6.50	19.42
20	26.38	20.50	19.88	13	3.48	4.11	15.67
26	22.38	41.00	62.25	20	2.93	2.67	2.25
Aug. 2	1,571.39	265.83	425.75	27	10.64	2.33	4.11
9	49.79	44.00	95.25	July 4	9.37	1.93	4.50
16	70.21	44.33	86.00	11	4.18	.27	0
22	81.85	77.00	173.33	18	.41	.67	3.89
29	269.64	136.67	2,290.00	25	1.76	1.00	0
Sept. 6	184.44	564.67	249.00	Aug. 1	2.53	0	.33
12	1,677.33	1,304.00	2,982.00	8	6.90	14.50	11.50
19	271.69	349.00	1,832.00	15	61.55	49.20	129.50
27	324.12	506.00	1,164.00	22	142.56	196.20	92.67
Oct. 5	66.84	100.00	285.63	29	93.07	81.00	47.67
11	81.76	264.50	308.25	Sept. 6	67.45	136.38	167.75
19	15.55	105.33	217.92	12	86.97	272.00	271.00
26	72.00	217.78	523.33	19	307.44	245.17	1,252.50
Nov. 2	15.02	124.89	178.42	26	180.38	245.25	2,079.00
9	34.03	122.22	294.55	Oct. 3	103.81	195.17	949.50
16	18.09	55.42	384.17	10	71.54	148.10	940.00
24	18.59	25.83	32.83	17	76.92	114.20	306.88
30	4.38	3.21	10.25	24	95.07	256.08	562.50
Dec. 7	1.41	7.53	22.33	31	80.25	189.28	822.33
19	.08	.94	.50				
26	.02	0	0	Nov. 7	15.05	79.60	201.58
				19	4.35	18.00	54.07
1968				26	1.35	24.81	81.89
Jan. 3	.04	.05	.22	Dec. 3	.07	.83	4.64
9	0	0	.04	10	.16	2.36	13.32
16	0	0	0	17	.16	1.45	5.64
23	0	0	0	30	.01	.27	.23
30	.02	.06	0				

See footnote at end of table.

TABLE 3.—*Mean number of male and female beet armyworm moths captured in Red Rock, outlying, and Picacho area light traps—Continued*

Collection date	Mean No. moths per trap per night			Collection date	Mean No. moths per trap per night		
	Red Rock	Outlying	Picacho[1]		Red Rock	Outlying	Picacho[1]
1969				1969—Continued			
Jan. 7	0	0.05	0.07	June 5	3.96	0.96	5.83
20	.02	2.40	1.21	12	3.09	1.00	1.92
27	.06	1.76	1.50	19	.76	.41	2.17
Feb. 3	.01	0	.04	26	.80	.67	1.25
10	.02	.05	.18	July 3	.17	.15	.50
17	.28	.86	1.50	10	4.43	1.04	.42
24	.46	5.55	1.21	17	10.37	4.48	2.83
Mar. 3	.62	3.05	1.07	24	13.20	13.00	26.25
10	.32	2.21	.18	Aug. 1	38.47	20.67	38.75
17	.31	.50	1.54	7	289.39	339.00	707.00
24	4.91	10.05	15.74	14	59.58	54.38	96.67
April 1	2.46	6.57	16.96	23	182.80	0	0
7	1.12	1.28	17.63	28	34.06	54.00	65.33
10	1.97	.61	9.00	Sept. 6	1,657.40	0	0
17	1.89	3.06	2.33	11	332.37	190.11	266.00
24	4.24	11.83	4.17	18	173.28	133.00	385.50
May 1	1.19	.39	2.00	25	27.50	35.22	53.75
9	.91	1.83	4.31	Oct. 2	216.00	228.75	553.50
15	4.06	3.33	5.67	9	119.29	99.67	211.33
22	7.50	2.00	2.92	16	25.78	8.17	131.38
29	5.22	.79	3.92	23	2.61	3.44	12.50
				30	16.83	25.67	237.63
				Nov. 6	9.42	20.96	218.92
				13	14.41	53.22	88.08

[1] Dashes indicate no data.

TABLE 4.—*Mean number of male and female alfalfa looper moths captured in Red Rock, outlying, and Picacho area light traps*

Collection date	Mean No. moths per trap per night			Collection date	Mean No. moths per trap per night		
	Red Rock	Outlying	Picacho[1]		Red Rock	Outlying	Picacho[1]
1967				1967—Continued			
March 9	0	0	—	June 2	0	0	0
16	0	0	—	9	0	.11	.08
23	0	0	—	16	0	0	0
30	0	.11	—	23	0	0	0
April 6	.01	0	—	30	.02	0	0
13	0	0	—	July 7	.01	0	0
21	.01	0	—	14	0	0	0
28	.01	0	—	20	0	0	0
May 5	0	0	—	26	0	0	0
12	0	0	—	Aug. 2	0	0	0
19	0	0	—	9	0	0	0
26	0	0	0	16	0	0	0
				22	0	0	0
				29	.03	.33	0

See footnote at end of table.

TABLE 4.—*Mean number of male and female alfalfa looper moths captured in Red Rock, outlying, and Picacho area light traps—Continued*

Collection date	Mean No. moths per trap per night		
	Red Rock	Outlying	Picacho[1]
1967—Continued			
Sept. 6	0.03	0	0
12	0	0	0
19	0	0	0
27	0	0	0
Oct. 5	0	0	0
11	0	0	.13
19	.03	0	.08
26	.07	.22	.08
Nov. 2	0	.22	.08
9	.16	1.11	.64
16	.22	.75	.25
24	.05	.17	.25
30	.03	0	.17
Dec. 7	.05	0	0
19	0	0	0
26	0	0	0
1968			
Jan 3	0	0	.03
9	0	0	0
16	0	0	0
23	0	0	0
30	0	0	.04
Feb. 6	0	0	.04
13	.04	.05	.14
20	.07	.07	.32
27	.59	.55	.64
March 5	1.28	1.14	4.57
11	.54	3.83	4.38
14	.23	1.78	2.67
21	.15	.50	3.00
28	.97	1.06	11.00
April 4	.33	1.00	1.08
11	.67	.94	3.89
18	.42	2.61	.08
25	.46	1.00	5.33
May 2	1.61	2.60	4.58
9	.22	.78	.42
16	—	0	0
23	.02	0	.08
30	0	0	0
June 6	0	0	0
13	0	0	0
20	0	0	0
27	.01	0	0
July 4	0	0	0
11	.04	0	0
18	0	0	0
25	0	0	0

Collection date	Mean No. moths per trap per night		
	Red Rock	Outlying	Picacho[1]
1968—Continued			
Aug. 1	0	0	0
8	0	0	0
15	.03	0	.50
22	.09	0	0
29	0	1.00	2.67
Sept. 6	.05	0	0
12	0	.33	0
26	.04	.75	2.00
Oct. 3	.01	0	0
10	0	0	0
17	.01	0	0
24	0	0	0
31	.01	0	0
Nov. 7	0	0	0
19	.02	.10	.21
26	.01	.19	.18
Dec. 3	0	0	.04
10	0	0	0
17	0	0	0
30	0	0	0
1969			
Jan. 7	0	.02	0
20	.02	.31	.39
27	.01	0	.14
Feb. 3	0	0	0
10	.01	.02	.07
17	.06	.12	.43
24	.05	.07	.64
March 3	.08	.10	.32
10	.06	.07	.54
17	0.05	0.05	0.43
24	.16	.03	2.11
April 1	.12	.14	.79
7	.04	.03	.29
10	0	0	.17
17	0	0	0
24	0	0	0
May 1	0	0	0
9	.09	.21	.38
15	0	0	.25
22	.02	0	.08
29	0	0	0
June 5	0	0	0
12	0	0	0
19	0	0	0
26	0	0	0
July 3	.01	0	0
10	0	0	0
17	.05	0	0
24	.01	.04	.25

See footnote at end of table.

TABLE 4.—*Mean number of male and female alfalfa looper moths captured in Red Rock, outlying, and Picacho area light traps—Continued*

Collection date	Mean No. moths per trap per night			Collection date	Mean No. moths per trap per night		
	Red Rock	Outlying	Picacho[1]		Red Rock	Outlying	Picacho[1]
1969—Continued				1969—Continued			
Aug. 1	0	0	0	Oct. 2	0	0	0
7	0	0	0	9	0	0	.33
14	0.14	0	0	16	.06	.22	.75
23	.10	0	0	23	.01	0	.17
28	5.28	3.11	1.33	30	.06	.06	1.25
Sept. 6	0	0	0	Nov. 6	.03	.08	.51
11	.09	.56	.25	13	.08	.19	.08
18	.19	.63	0				
25	.05	.11	0				

[1] Dashes indicate no data.

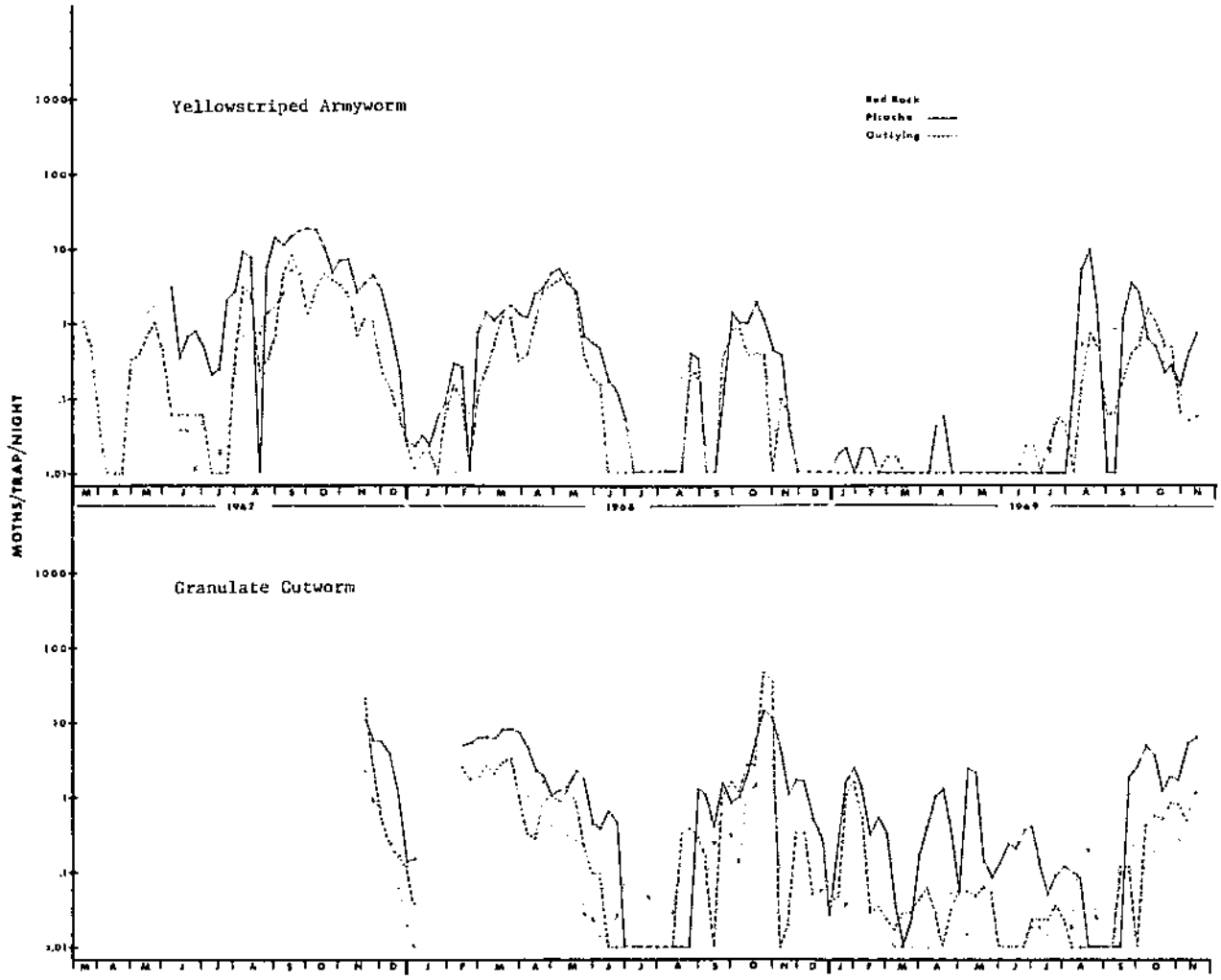

FIGURE 6.—Seasonal variations in yellowstriped armyworm and granulate cutworm BL trap catches, biweekly moving means.

TABLE 5.—*Mean number of male and female yellowstriped armyworm moths captured in Red Rock, outlying, and Picacho area light traps*

Collection date	Mean No. moths per trap per night		
	Red Rock	Outlying	Picacho[1]
1967			
March 9	0.10	1.22	—
16	.18	1.00	—
23	.06	.11	—
30	0	0	—
April 6	0	0	—
13	0	0	—
21	0	0	—
28	.40	.67	—
May 5	.53	.11	—
12	2.33	1.22	—
19	1.16	.78	—
26	.77	.11	5.83
June 2	0	0	.25
9	.06	.11	.42
16	.01	0	.92
23	0	.11	.67
30	.11	0	0
July 7	.02	0	.25
14	0	0	0
20	.11	0	2.13
26	.39	.80	3.38
Aug. 2	1.00	5.00	15.50
9	.72	.33	0
16	.61	0	0
22	2.26	.67	13.33
29	1.06	.67	16.00
Sept. 6	4.06	8.67	6.25
12	6.78	8.00	24.00
19	2.08	1.33	12.00
27	3.13	1.33	23.00
Oct. 5	2.51	4.67	13.25
11	1.90	4.67	9.13
19	.27	3.11	1.67
26	1.48	3.56	12.67
Nov. 2	.26	1.11	2.42
9	.10	.22	2.73
16	.21	1.83	4.17
24	.19	.33	4.75
30	.33	.14	.75
Dec. 7	.06	.13	1.08
19	.01	.03	.03
26	0	0	0
1968			
Jan 3	0	0	.03
9	0	.03	.04
16	0	0	0
23	0	0	.11
30	.01	.11	.07
Feb. 6	0	.20	.54
13	0	0	0
20	.13	0	0
27	.05	.21	1.57
1968—Continued			
March 5	0.05	0.26	1.32
11	.43	.81	.75
14	.16	2.11	2.83
21	.07	.28	.67
28	.09	.33	2.00
April 4	.05	.44	.33
11	.36	1.39	5.33
18	.99	4.44	1.25
25	.79	2.11	8.17
May 2	2.19	5.73	2.75
9	.78	4.00	4.17
16	0	.72	1.00
23	.05	.06	.33
30	.03	.33	.75
June 6	.03	0	.17
13	0	0	.17
20	0	0	.08
27	0	0	0
July 4	.01	0	0
11	0	0	0
18	.04	0	0
25	0	0	0
Aug. 1	0	0	0
8	0	0	0
15	.38	0	0
22	.22	.40	.67
29	.15	0	0
Sept. 6	.05	0	0
12	.12	0	0
19	.22	.50	.25
26	.06	1.00	2.00
Oct. 3	.10	.67	0
10	.23	0	2.00
17	.58	.80	2.00
24	.10	0	0
31	.01	0	.67
Nov. 7	0	.20	.08
19	0	0	0
26	0	0	0
Dec. 3	0	0	0
10	0	0	0
17	0	0	0
30	0	0	0
1969			
Jan. 7	0	0	.04
20	0	0	0
27	0	0	0
Feb. 3	0	0	.04
10	0	0	0
17	.01	0	0
24	0	.02	0

See footnote at end of table.

TABLE 5.—*Mean number of male and female yellowstriped armyworm moths captured in Red Rock, outlying, and Picacho area light traps—Continued*

Collection date	Mean No. moths per trap per night			Collection date	Mean No. moths per trap per night		
	Red Rock[1]	Outlying[1]	Picacho[1]		Red Rock[1]	Outlying[1]	Picacho[1]
1969—Continued				1969—Continued			
March 3	0	0	0	July 3	0.03	0.04	0
10	0	0	0	17	.14	.07	0
17	0	0	0	24	.04	0	0
24	.01	0	0	Aug. 1	.22	0	.38
April 1	0	0	0	7	1.08	.50	16.00
7	.03	0	.08	14	1.83	1.00	2.67
10	0	0	0	23	0	0	0
17	0	0	0	28	0	.11	0
24	0	0	0	Sept. 6	3.80	0	0
May 1	0	0	0	11	1.69	.33	2.25
9	0	0	0	18	1.47	.50	5.00
15	0	0	0	25	.25	.56	0
22	0	0	0	Oct. 2	1.38	2.75	1.25
29	0	0	0	9	.29	.17	0
June 5	0	0	0	16	.32	.83	.38
12	0	0	0	23	.19	.13	.17
19	0	.04	0	30	.03	0	.13
26	0	0	0	Nov. 6	.10	.08	.58
				13	.06	.04	.92

[1] Dashes indicate no data.

this species in all areas were made during the weeks of August 6, 1967, when the peak for outlying traps of 8.67 moths per trap per night was reached, and August 12, 1967, when Red Rock and Picacho collections peaked at 6.78 and 24.00 moths per trap per night, respectively. Although catches during 1968 and 1969 increased from summer lows during August through November, they did not reach the 1967 level. Spring peaks occurred in 1968, during the weeks of April 25 and May 2. Collections in 1967 were also high during May. In 1969, however, yellowstriped armyworms were only caught occasionally until July. Just as the yellowstriped armyworm curves shown here for the 3 years do not compare well with each other, they match poorly, with the possible exception of 1967, with those presented by Hills (*9*).

Granulate Cutworm

Seasonal variations and weekly mean catches for graunlate cutworm moths are shown in figure 6 and table 6. Granulate cutworm moths were not counted on a regular basis until November 1967 and were not counted during a 5-week period in early 1968. Catches of granulate cutworms were not high during this study. The highest catches were, however, recorded during the cooler months. Catches were at a relatively high level and declining when counts were first made in November 1967.

Catches in all three areas peaked on March 14, 1968, and then declined. Catches during the spring of 1969 were very erratic, and, while peaking occasionally, failed to reach the spring 1968 levels. In August 1968, catches began to climb to reach their highest levels of the study for all three areas on October 24, 1968. In 1969, the climb began in September and was still apparent when the study ended in November. The curves presented by Hills (*9*) for the granulate cutworm show a more consistent rise through the year to the late fall peaks than shown by our study. This is due primarily to the less drastic midsummer reduction in catch, especially in 1964 and 1965, shown in the Hills data.

TABLE 6.—*Mean number of male and female granulate cutworm moths captured in Red Rock, outlying, and Picacho area light traps*

Collection date	Mean No. moths per trap per night		
	Red Rock	Outlying	Picacho[1]
1967			
Nov. 9	3.93	46.56	18.73
16	1.07	4.75	4.25
24	.80	.83	7.17
30	.64	.29	4.08
Dec. 7	.18	.20	3.67
19	.03	.16	.16
26	0	.07	.11
1968			
Jan. 3	0	0	.19
9	—	—	—
16	—	—	—
23	—	—	—
30	—	—	—
Feb. 6	—	—	—
13	.98	2.50	5.14
20	.15	1.05	5.39
27	1.84	2.76	7.29
March 5	1.77	2.40	5.29
11	3.17	1.89	7.00
14	4.15	5.11	10.33
21	1.85	1.50	6.33
28	1.80	.61	8.67
April 4	.18	.06	1.08
11	2.87	.50	3.78
18	.39	1.28	.58
25	.45	.72	1.50
May 2	.36	1.07	1.00
9	.26	1.33	1.83
16	0	.44	2.83
23	.03	0	.58
30	.02	.20	.33
June 6	.01	0	.42
13	.01	0	.92
20	.04	0	0
27	.12	0	0
July 4	.06	0	0
11	.08	0	0
18	0	0	0
25	0	0	0
Aug. 1	0	0.37	0.67
8	.10	0	0
15	.38	.60	0
22	.13	.20	0
29	.04	.50	2.67
Sept. 6	.08	0	.50
12	.56	0	0
19	.83	1.67	2.50
26	.06	1.67	0
1968—Continued			
Oct. 3	0.19	0.67	2.00
10	2.16	5.40	2.00
17	.65	.10	9.50
24	8.94	89.92	21.83
31	.11	0	7.17
Nov. 7	.07	0	2.17
19	.03	.02	.61
26	.05	.69	2.93
Dec. 3	.01	0	.54
10	0	.10	.54
17	.02	.02	.04
30	.01	.05	.02
1969			
Jan. 7	0	0.07	0.39
20	.07	2.19	2.82
27	.08	1.12	2.43
Feb. 3	0	0	.11
10	0	.05	.54
17	.02	.02	.25
24	0	.02	.07
March 3	0	0	0
10	0	.05	0
17	0	0	.04
24	0	.08	.30
April 1	.01	.05	.50
7	.05	0	1.75
10	0	0	.75
17	.09	.06	0
24	.02	.06	.08
May 1	0	.06	4.92
9	.03	.04	.19
15	.01	.10	.08
22	0	0	.08
29	0	0	.17
June 5	0	0	.33
12	0	0	0.08
19	.01	0	.67
26	.03	.04	.17
July 3	0	0	.08
10	.02	.04	0
17	.03	.04	.17
24	.01	0	.08
Aug. 1	.03	0	.13
7	.39	0	0
14	.03	0	0
23	0	0	0
28	0	0	0

See footnote at end of table.

TABLE 6.—*Mean number of male and female granulate cutworm moths captured in Red Rock, outlying, and Picacho area light traps—Continued*

Collection date	Mean No. moths per trap per night		
	Red Rock[1]	Outlying[1]	Picacho[1]
Sept. 6	0	0	0
11	.51	.22	0
18	.25	0	4.00
25	0	0	1.50
Oct. 2	.22	.88	9.00
9	.19	.44	0
16	.11	.61	2.13
23	.19	1.13	1.83
30	.39	.56	1.75
Nov. 6	.04	.46	8.08
13	.34	1.85	5.00

[1] Dashes indicate no data.

Saltmarsh Caterpillar

Seasonal variations and weekly mean catches for saltmarsh caterpillar moths are shown in figure 7 and table 7. Saltmarsh caterpillar moths were caught during most weeks except the coldest periods during the study. Counts on this species were not begun until June 1967. The highest collections of this species during the study for all areas were made during the weeks of September 12 and 19, 1967. Mean catches of 96 and 1,387 per trap per night were recorded from outlying and Picacho traps, respectively, on the earlier date and 119 per trap per night from Red Rock traps on the latter date. Lesser, late summer peaks occurred from August 22 to 29, 1968, and from September 6 to 18, 1969. In all three cases, catches rapidly declined to very low levels by November. While spring to early summer catches in 1968 were higher than those in 1969, they exceeded one per trap per night only at Picacho, peaking there at five per trap per night on June 20, 1968. Catches did tend to drop in August before climbing to their late summer peaks.

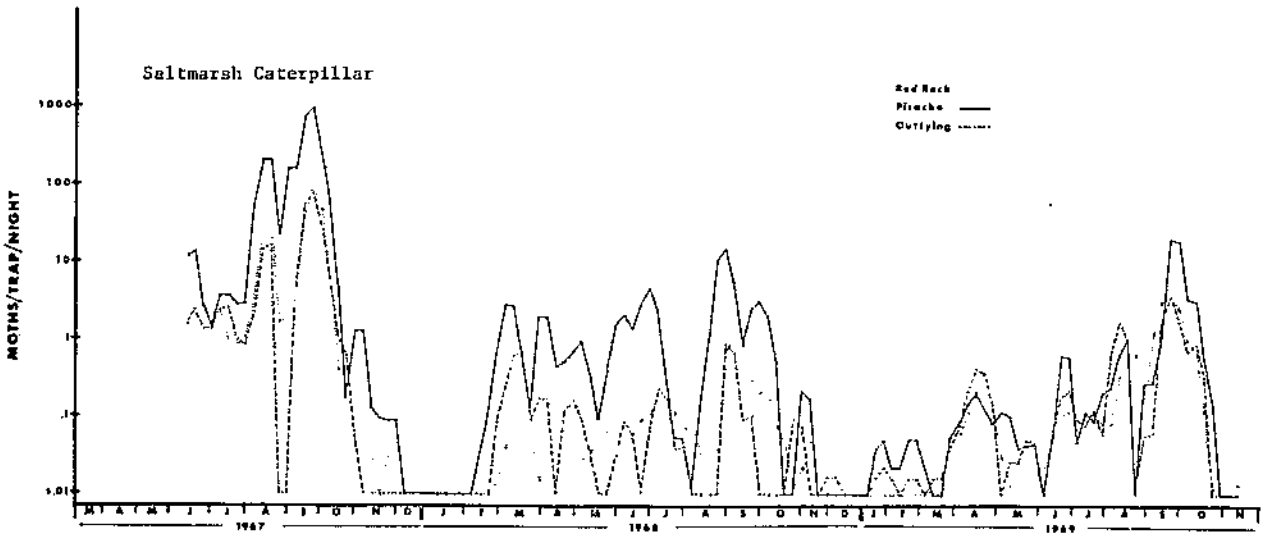

FIGURE 7.—Seasonal variations in saltmarsh caterpillar moth BL trap catches, biweekly means.

TABLE 7.—*Mean number of male and female saltmarsh caterpillar moths captured in Red Rock, outlying, and Picacho area light traps*

Collection date	Mean No. moths per trap per night		
	Red Rock	Outlying	Picacho
1967			
June 2	0.18	0.33	1.17
9	3.36	2.78	22.58
16	1.04	2.11	4.67
23	.76	.56	.56
30	3.65	2.22	4.00
July 7	1.21	2.67	3.67
14	.20	0	0
20	1.15	1.00	2.75
26	.85	.60	3.00
Aug. 2	4.90	3.50	108.50
9	36.24	25.67	311.25
16	1.85	0	5.00
22	1.50	0	42.67
29	2.17	0	244.00
Sept. 6	6.79	11.33	81.00
12	64.61	96.00	1,387.00
19	118.86	60.67	574.00
27	10.69	9.33	111.00
Oct. 5	.56	.67	10.00
11	.28	1.33	.25
19	.04	.11	.08
26	.29	0	2.50
Nov. 2	.07	0	.08
9	.01	0	.18
16	.01	0	0
24	.06	0	.17
30	.04	0	0
Dec. 7	.01	0	0
19	0	0	0
26	0	0	0
1968			
Jan. 3	0	0	0
9	0	0	0
16	0	0	0
23	0	0	0
30	0	0	0
Feb. 6	0	0	0
13	.02	0	.07
20	0	0	.18
27	.07	.17	1.29
March 5	.07	.29	4.32
11	.09	.94	.79
14	.02	.17	.17
21	.01	0	.08
28	.11	.33	3.92
April 4	.02	0	0
11	.17	0	1.00
18	.05	.22	.17
25	.01	.11	1.17

Collection date	Mean No. moths per trap per night		
	Red Rock	Outlying	Picacho
1968—Continued			
May 2	0.06	0.07	0.75
9	.06	0	0
16	0	0	.17
23	.04	0	.58
30	.03	.07	2.42
June 6	.09	.11	1.83
13	.09	0	.83
20	.12	0	4.83
27	.28	.13	4.56
July 4	.17	.33	.58
11	.05	0	0
18	.10	.07	.11
25	.05	0	0
Aug. 1	.02	0	0
8	0	0	.50
15	.07	0	2.00
22	1.34	0	16.00
29	.85	2.00	14.67
Sept. 6	.45	0	1.00
12	.06	.25	0
19	.36	0	3.75
26	.09	0	3.00
Oct. 3	.07	0	1.00
10	0	0	0
17	.01	0	0
24	.03	.17	0
31	.06	0	.33
Nov. 7	.02	0	0
19	.01	0	0
26	0	.02	0
Dec. 3	0	0	0
10	0	0	0
17	0	0	0
30	0	0	0
1969			
Jan. 7	0	0	0
20	0	.02	.07
27	.01	.02	.04
Feb. 3	0	0	0
10	0	0	.04
17	.01	.02	.07
24	0	0	.04
March 3	.01	0	0
10	0	.02	0
17	0	0	0
24	.03	.08	.11
April 1	.09	.07	.07
7	.16	.42	.25
10	.26	.50	.17
17	.25	.28	.08
24	.05	0	.08

TABLE 7.—*Mean number of male and female saltmarsh caterpillar moths captured in Red Rock, outlying, and Picacho area light traps—Continued*

Collection date	Mean No. moths per trap per night			Collection date	Mean No. moths per trap per night		
	Red Rock	Outlying	Picacho		Red Rock	Outlying	Picacho
1969—Continued				1969—Continued			
May 1	0.02	0	0.17	Aug. 1	0.18	1.78	0
9	.01	.04	.06	7	.61	2.00	2.00
15	.04	0	0	14	.81	0	0
22	.03	.10	.08	23	.20	0	0
29	.01	0	0	28	.17	.11	.67
June 5	.03	0	0	Sept. 6	4.70	0	0
12	.08	.07	.08	11	2.89	3.67	2.25
19	.13	.30	1.25	18	4.61	4.00	40.50
26	0.12	0.19	0	25	.31	0	0
July 3	.03	0	.08	Oct. 2	1.75	1.50	7.00
10	.10	.15	.17	9	.24	.67	.83
17	.14	.11	0	16	.01	0	.25
24	.03	0	.42	23	0	0	0
				30	0	0	0
				Nov. 6	.01	0	0
				13	.02	0	0

SPATIAL VARIATION IN LIGHT TRAP CATCHES

Regressions

Survey traps were located along lines in eight directions from the ranch center. Regression analysis relating trap catches to distances along these lines consistently indicated lower trap catches toward the center of the ranch.

Therefore, regression analysis relating trap catch to distance from the edge of the ranch was performed. Distance was measured from each trap to the nearest edge of the ranch. The trap catches were arbitrarily grouped by months for each regression analysis. To correct for variations in population fluctuations during the month, the number caught in each trap was divided by the total caught in all traps for each collection date. These ratios (relative catch) ranged from 0 to 0.2; therefore, a square root transform was performed prior to calculating regressions (*10*).

Separate regressions were run on ranch traps only, ranch plus outlying traps, and ranch plus outlying plus Picacho traps. In addition, these regressions were run on male cabbage loopers, female cabbage loopers, and beet armyworms (tables 8, 9, and 10). Regression coefficients are listed for those months when the trap catches averaged more than one insect per trap per collection. Negative regression coefficients indicate fewer moths caught toward the center of the ranch. Coefficients were tested for the null hypothesis that the variation in trap distance from the edge of ranch did not contribute to trap catches.

Male cabbage looper catches were consistently lower toward the ranch center (table 8). Regression slopes for all traps (ranch plus outlying plus Picacho) were significantly negative for all months except July 1968. Similar trends were present for outlying plus ranch traps. When only ranch traps were considered, 13 months (out of 21) had significant decreasing catches toward the ranch center. Only October 1969 had a significant increase toward the ranch center, and the remaining 7 months had no significant regression.

Regression coefficients for catches of male cabbage looper moths were converted back to

TABLE 8.—*Regression coefficients relating male cabbage looper trap catch to distance from edge of Red Rock ranch, for months when trap catch averaged more than one moth per trap collection*

Month	All traps	Ranch only	Ranch plus outlying
1967			
July	−0.066 ***[1]	−0.174 ***	−0.252 ***
August	− .066 ***	− .182 ***	− .108 ***
September	− .057 ***	− .130 **	− .294 ***
October	− .058 ***	− .027 N S	− .242 ***
November	− .074 ***	− .046 N S	− .173 ***
1968			
February	− .069 ***	− .289 ***	− .251 ***
March	− .056 ***	− .256 ***	− .245 ***
April	− .041 ***	− .246 ***	− .203 ***
May	− .062 ***	− .200 *	− .298 ***
June	− .044 ***	+ .010 N S	− .126 ***
July	− .002 N S	+ .086 N S	+ .058 N S
August	− .041 ***	− .042 N S	− .084 ***
September	− .064 ***	− .250 ***	− .226 ***
October	− .061 ***	− .110 **	− .156 ***
November	− .062 ***	− .193 *	− .244 ***
1969			
April	− .061 ***	+ .139 N S	− .061 *
July	− .055 ***	− .323 *	− .176 ***
August	− .059 ***	− .332 ***	− .198 ***
September	− .045 ***	− .121 ***	− .127 ***
October	− .073 ***	+ .014 **	− .144 ***
November	− .074 ***	+ .136 N S	− .102 ***

[1] Significance level indicated by: * = 5-percent level, ** = 1-percent level, *** = 0.5-percent level, N S = Not Significant.

TABLE 9.—*Regression coefficients relating female cabbage looper trap catch to distance from edge of Red Rock ranch for months when trap catch averaged more than one moth per trap collection*

Month	All traps	Ranch only	Ranch plus outlying
1967			
July	−0.053 ***[1]	−0.050 ***	−0.062 *
August	− .054 ***	− .146 ***	− .039 N S
September	− .047 ***	− .063 N S	− .043 N S
October	− .046 ***	+ .047 N S	− .027 N S
1968			
March	− .038 ***	− .171 *	− .030 N S
April	− .028 ***	− .192 ***	− .003 N S
May	− .036 ***	− .274 ***	− .087 ***
June	− .008 N S	+ .154 N S	+ .049 N S
July	− .003 N S	− .038 N S	− .035 N S
August	− .037 ***	+ .058 N S	+ .004 N S
September	− .060 ***	− .235 ***	− .082 ***
October	− .049 ***	− .201 ***	− .066 ***
1969			
July	− .050 ***	− .177 N S	+ .010 N S
August	− .055 ***	− .248 ***	− .053 ***
September	− .033 ***	− .018 N S	− .008 N S
October	− .073 ***	+ .008 N S	− .036 N S

[1] Significance level indicated by: * = 5-percent level, ** = 1-percent level, *** = 0.5-percent level, N S = Not Significant.

original relative catch units and resulting equations were plotted (figs. 8, 9, 10, 11).

A 3-year regression was obtained by using data from all months when average catch was more than one insect per trap. No correction for annual population differences was necessary since the transform was made on relative trap catch for each trap collection. The detransformed regression was $y = 1.915 - 1.602\ x + 0.333\ x^2$ where y is relative catch and x is distance in kilometers. This regression was significant at the 0.5-percent level and indicates an 89-percent reduction in trap catches near the center of the ranch (1.2 km from edge) as compared with traps 1.2 km outside the ranch (fig. 12).

The regressions for female cabbage loopers showed significantly lower catches near the ranch center as compared with Picacho (table 9, all traps) except for June and July of 1968. For the ranch traps, 8 months out of 16 showed significant negative regression coefficients. For the ranch plus outlying traps, only 5 months out of 16 showed significant negative regression coefficients (fig. 13). No significant positive regressions occurred.

The 3-year combined regression (using all 16 months where ranch trap catches average more than one) was $y = 1.618 - 0.218\ x + 0.0022\ x^2$ (fig. 12). This regression was also significant at the 0.5-percent level and indicates 28 percent fewer females caught near the center as compared with 1.2 km outside the ranch.

Beet armyworm regressions for all traps (ranch plus outlying plus Picacho) showed significantly lower catches toward the ranch center for 16 out of 24 months (June and August 1968 and May through September 1969 were not significant) (table 10). Regressions for just

ranch traps showed only 6 of the 24 months had significant regressions (April and August 1967, September and November, 1968 and June and November 1969). One month (August 1968) showed an increase in catch toward the center of the ranch. Regressions for ranch plus outlying traps had significantly lower catches during 13 months out of 24 (figs. 14, 15, 16). July 1968 and May 1969 had significantly greater catches toward the ranch center.

The 3-year combined regression (using 24 months when ranch trap catches averaged more than one per trap) was $y = 2.052 - 0.258\ x + 0.00947\ x^2$ (fig. 12). This regression was also significant at the 0.5-percent level and represents a 26-percent reduction of beet armyworm moths caught near the center as compared with 1.2 km outside the ranch.

TABLE 10.—*Regression coefficients relating beet armyworm trap catch to distance from edge of Red Rock ranch for months when trap catch averaged more than one moth per trap collection*

Month	All traps	Ranch only	Ranch plus outlying
1967			
July	−0.014 ***[1]	−0.037 N S	−0.019 N S
August	− .018 ***	− .082 **	+1.630 N S
September	− .021 ***	− .039 N S	− .056 ***
October	− .036 ***	− .031 N S	− .135 ***
November	− .037 ***	− .062 N S	− .104 ***
1968			
March	− .029 ***	− .012 N S	− .078 ***
April	− .019 ***	− .066 N S	− .036 ***
May	− .029 ***	− .245 ***	− .132 ***
June	− .008 N S	− .060 N S	+ .010 N S
July	+ .015 **	+ .110 N S	+ .090 **
August	+ .044 N S	+ .165 *	+ .011 N S
September	− .030 ***	− .083 *	− .037 ***
October	− .041 ***	− .040 N S	− .061 ***
November	− .057 ***	− .093 *	− .175 ***
1969			
February	− .028 ***	− .046 N S	− .065 *
March	− .017 ***	− .040 N S	− .107 ***
April	− .030 ***	− .070 N S	− .048 ***
May	− .059 N S	+ .037 N S	+ .036 ***
June	− .098 N S	− .135 *	+ .030 N S
July	+ .033 N S	− .036 N S	+ .036 N S
August	− .055 N S	+ .111 N S	+ .007 N S
September	− .002 N S	+ .059 N S	+ .032 N S
October	− .028 ***	+ .031 N S	+ .014 N S
November	− .045 ***	− .106 ***	− .075 ***

[1] Significance level indicated by: * = 5-percent level, ** = 1-percent level, *** = 0.5-percent level, N S = Not Significant.

Trap-Catch Contours

Isotrap-catch contour lines were constructed by connecting points representing equal trap catches. Two periods were selected during rela-

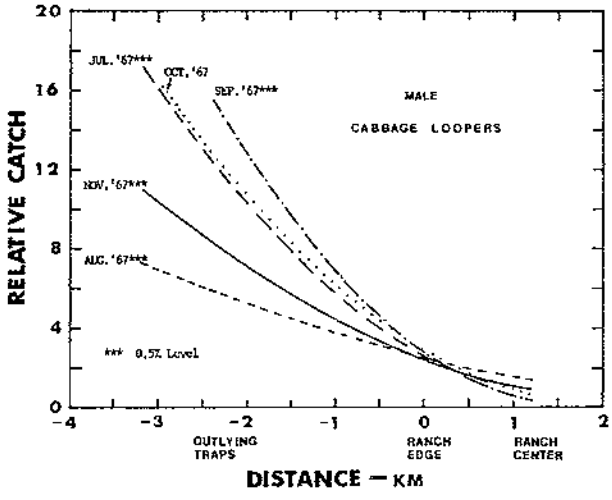

FIGURE 8.—Male cabbage looper detransformed regression equations relating relative trap catch to distance from ranch edge for outlying plus ranch traps in 1967.

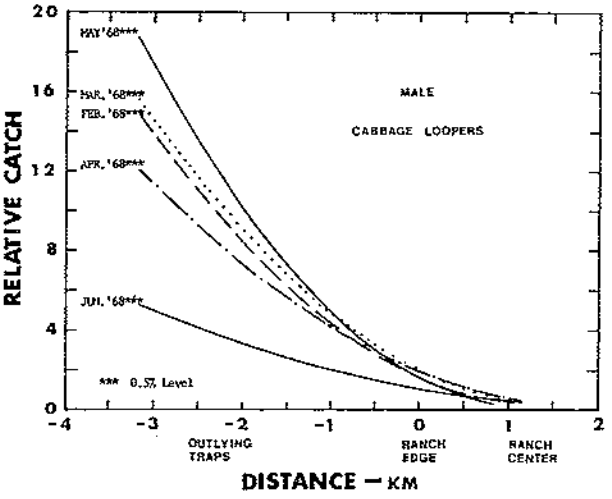

FIGURE 9.—Male cabbage looper detransformed regression equations relating relative trap catch to distance from ranch edge, for outlying plus ranch traps during February to June 1968.

tively high male cabbage looper catches. During the first period (February, March, and April 1968), the primary host crop on the ranch was lettuce; during the second (September and October 1968), the primary host was cotton. Trap catches were analyzed during each period, using trap location as treatments and collection dates as blocks. No significant differences occurred among traps within the ranch; however, most outlying traps had significantly higher catches than ranch traps.

The standard error of the mean from the analysis variance was used as the interval between isotrap-catch lines. These lines were linearly spaced between trap locations and interconnected by estimation (figs. 17 and 18).

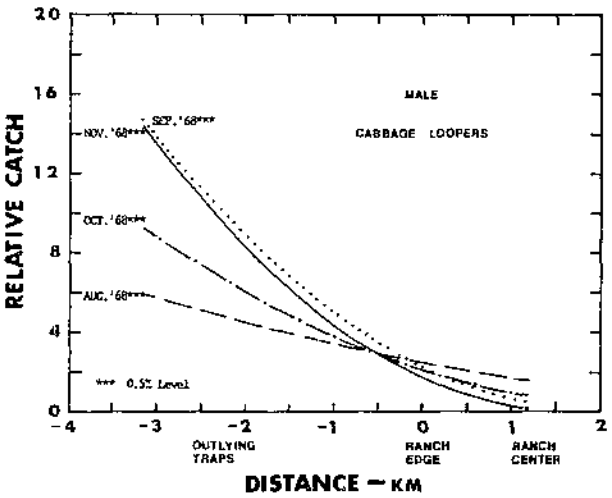

FIGURE 10.—Male cabbage looper detransformed regression equations relating relative trap catch to distance from ranch edge for outlying plus ranch traps during August to November 1968.

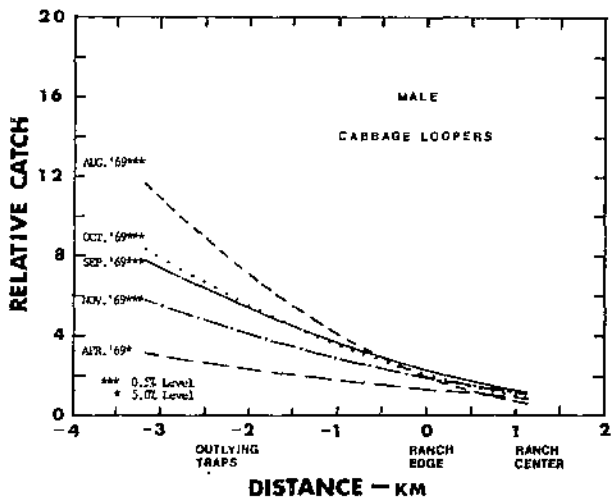

FIGURE 11.—Male cabbage looper detransformed regression equations relating relative trap catch to distance from ranch edge for outlying plus ranch traps in 1969.

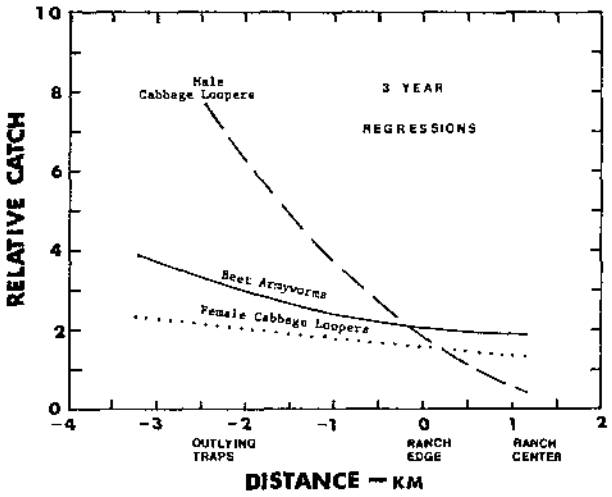

FIGURE 12.—Combined detransformed regressions for 3 years for male and female cabbage looper and beet armyworms. Relative catch vs. distance from ranch edge for outlying plus ranch traps in 1967, 1968, and 1969.

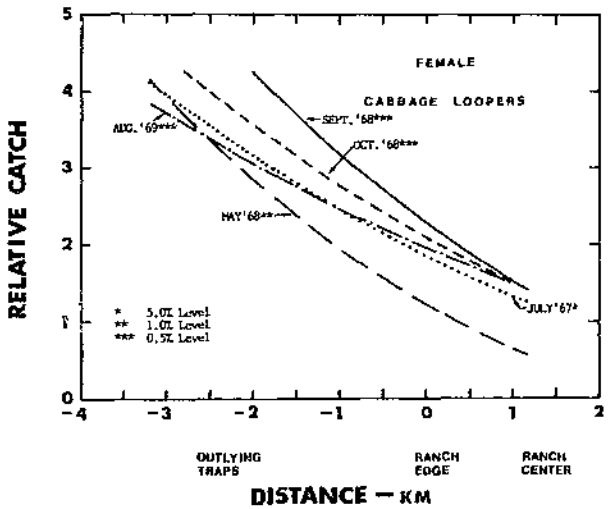

FIGURE 13.—Female cabbage looper detransformed regression equations relating relative trap catch to distance from ranch edge for outlying plus ranch traps in 1967, 1968, and 1969.

The shapes of contour lines were similar for both periods. The Red Rock ranch was the center of depressed trap catches. Contour lines tended to be closer together toward the south and east of the ranch in the spring and toward the north and west in the fall.

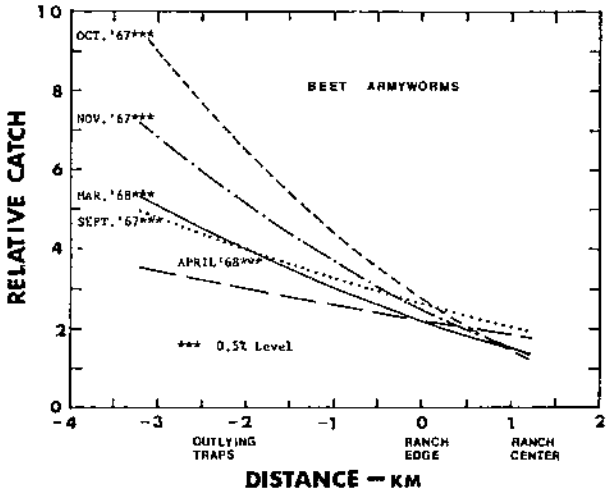

FIGURE 14.—Beet armyworm detransformed regression relating trap catch to distance from ranch edge for outlying plus ranch traps from September 1967 to April 1968.

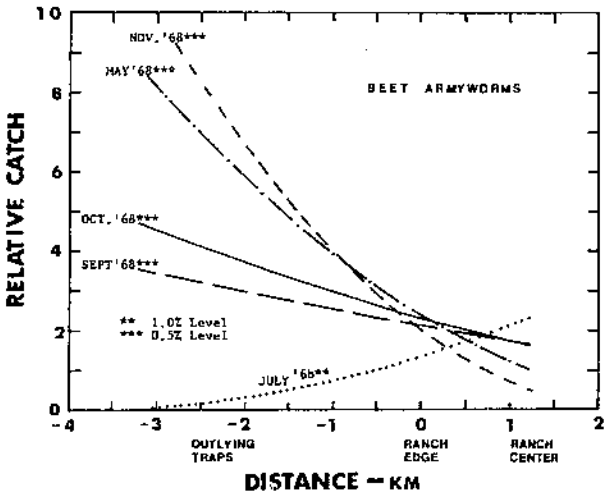

FIGURE 15.—Beet armyworm detransformed regression relating trap catch to distance from ranch edge for outlying plus ranch traps from May 1968 to November 1968.

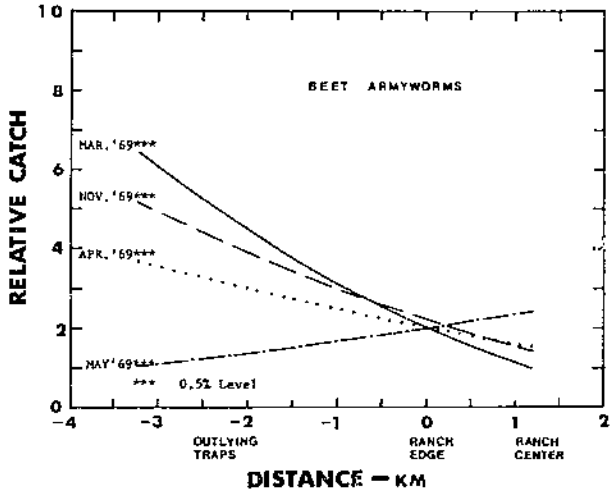

FIGURE 16.—Beet armyworm detransformed regressions relating trap catch to distance from ranch edge for outlying plus ranch traps in 1969.

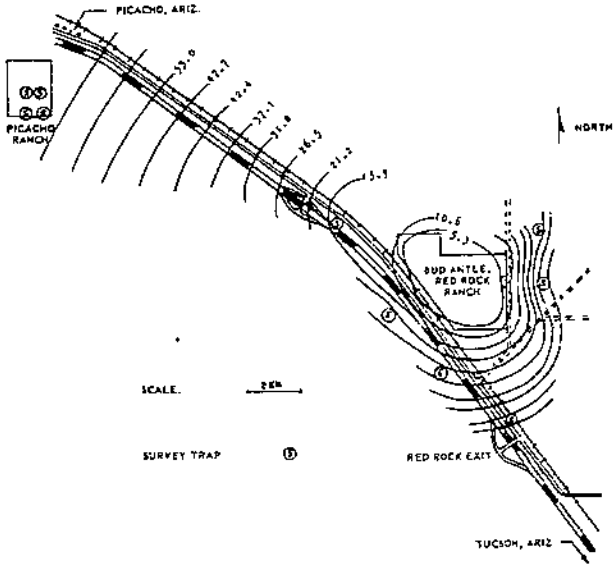

FIGURE 17.—Male cabbage looper isotrap catch contour lines spaced one standard error apart for 2-month period (September and October 1968).

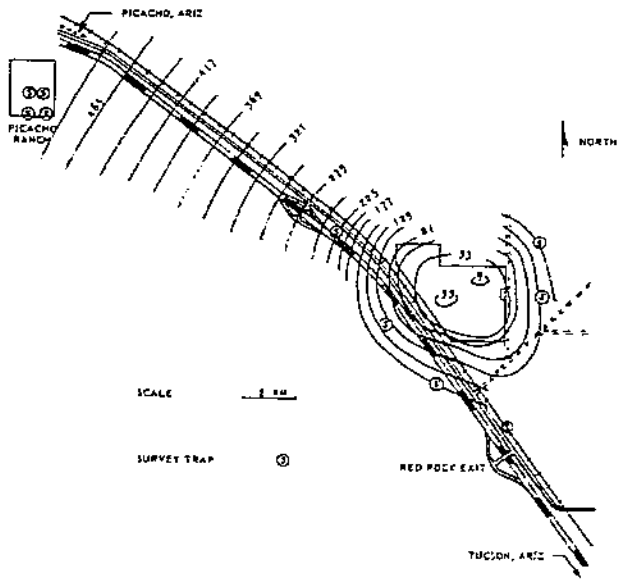

FIGURE 18.—Male cabbage looper isotrap catch contour lines spaced one standard error apart for 3-month period (February, March, and April 1968).

RELATIVE POPULATION TRENDS

Cantelo et al. (*3*) described changes in population levels of 17 insect species during a BL trapping program by using a 12-month moving mean collection compared to a base year. Although this method is limited due to inability to determine if the base year is "typical," it allows a relative comparison of populations over time. We applied the same procedure to the Red Rock collection data by using the first 12-month mean as a base year and then plotting on this the mean trap catch or each 12-month period of the test. Expressed as a percentage of the base year, that is, for cabbage looper males, the base year is May 1967 through April 1968, the points plotted on this are the mean catch for the 12 months ending May 1968, the mean catch for the 12 months ending June 1968, and so forth through the mean catch for the 12 months ending November 1969.

Cabbage Looper

The data shown in figure 19 indicates a relative lowering of cabbage looper male populations below the base year after June 1968 for the Red Rock and Picacho areas. This continued throughout the test at Picacho, but Red Rock

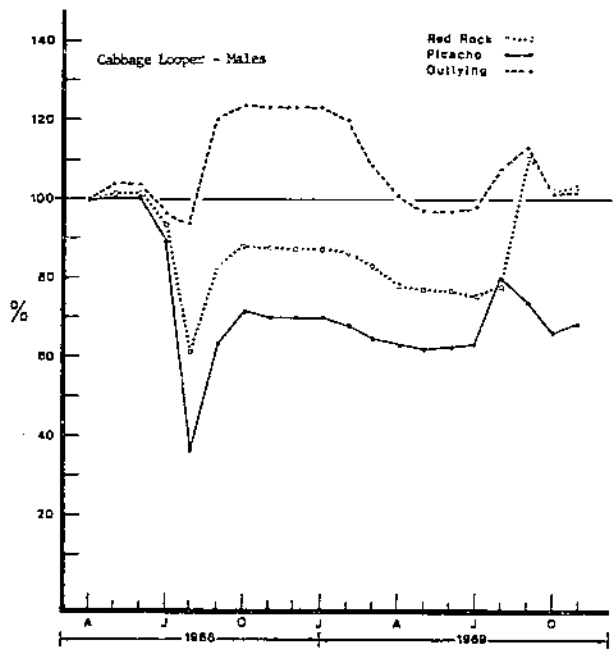

FIGURE 19.—Male cabbage looper 12-month moving mean trap catch as a percentage of the base year.

populations exceeded the base year during the last 3 months of the study. Except for two periods, relative populations in the outlying area stayed above those of the base year.

Curves for cabbage looper females (fig. 20) resemble those for cabbage looper males. The reduction below the base year was, however, greater for the Red Rock and Picacho areas, with the Red Rock females never exceeding the base. The outlying area females did not exceed the base year by as great a magnitude as the males.

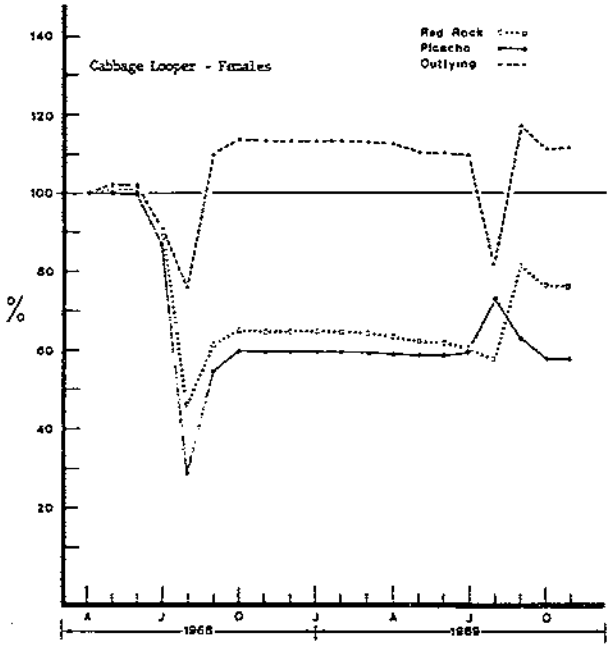

FIGURE 20.—Female cabbage looper 12-month moving mean trap catch as a percentage of the base year.

Corn Earworm

Data shown in figures 21 and 22 indicate a great reduction in relative corn earworm male and female populations in all three areas after the base year. That the reduction was slightly less at Red Rock is most notable with corn earworm females. All three areas showed a slight increase in populations in the second half of 1969.

Beet Armyworm

A reduction in relative beet armyworm populations after the base year is indicated in figure

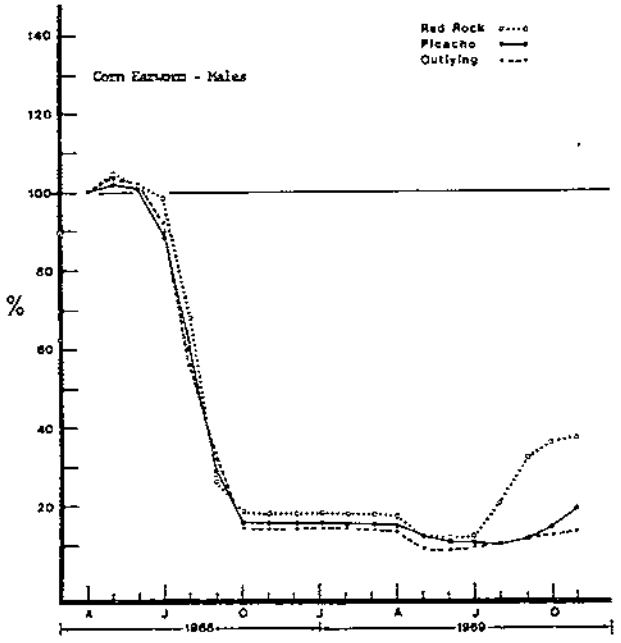

FIGURE 21.—Male corn earworm 12-month moving mean trap catch as a percentage of the base year.

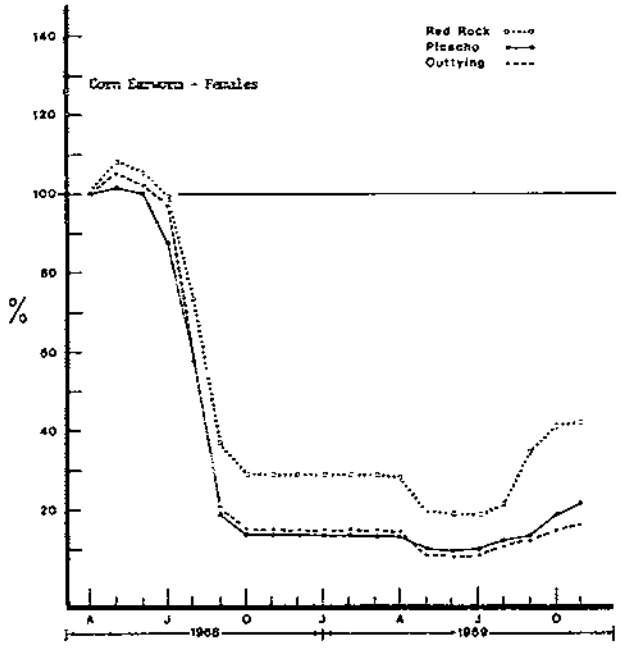

FIGURE 22.—Female corn earworm 12-month moving mean trap catch as a percentage of the base year.

23. The greatest reduction occurred in the Red Rock area and the least reduction at Picacho. There was some recovery at Red Rock during the second half of 1969 while the reduction was even greater at Picacho and outlying traps.

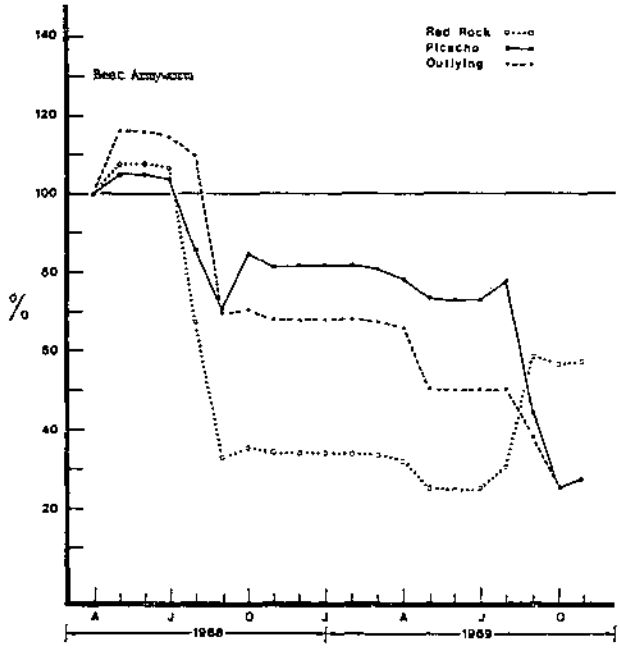

FIGURE 23.—Beet armyworm 12-month moving mean trap catch as a percentage of the base year.

Alfalfa Looper

Data shown in figure 24 indicate alfalfa looper populations were greater than during the base year in all areas during 1968 and much less than the base during 1969. The populations at Red Rock approached the base year during the second half of 1969 while Picacho and outlying areas remained low.

Yellowstriped Armyworm

Yellowstriped armyworm populations in 1968 showed a relative reduction over the base year which became even greater during the first half of 1969 (fig. 25). The reduction occurred later and was least in the outlying area until the second half of 1969 when populations rose at Red Rock and, to a lesser extent, at Picacho. For most periods, the reduction was somewhat less at Red Rock than at Picacho.

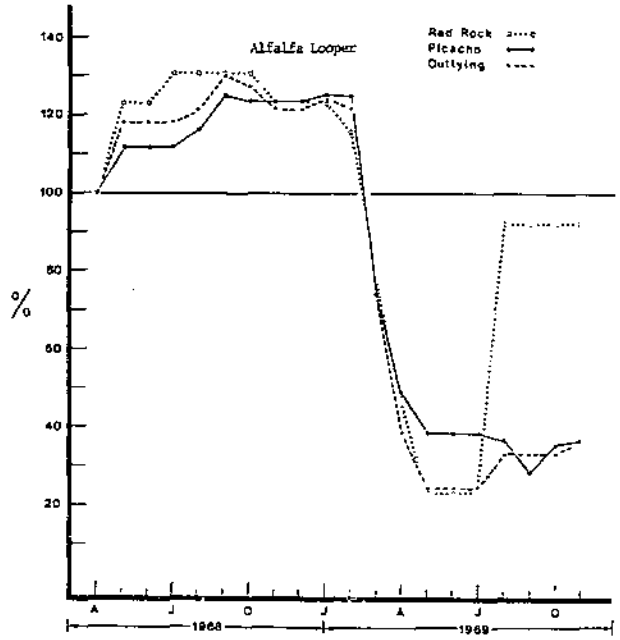

FIGURE 24.—Alfalfa looper 12-month moving mean trap catch as a percentage of the base year.

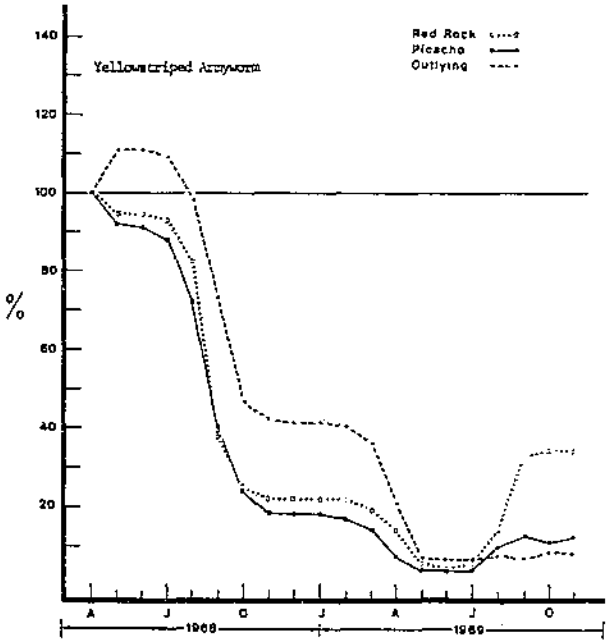

FIGURE 25.—Yellowstriped armyworm 12-month moving mean trap catch as a percentage of the base year.

Granulate Cutworm

Data for the granulate cutworm, for which the base year had to be adjusted as catches were not counted for this species until November 1967, are shown in figure 26. These data indicate a reduction in populations over the base year that became more pronounced throughout 1969.

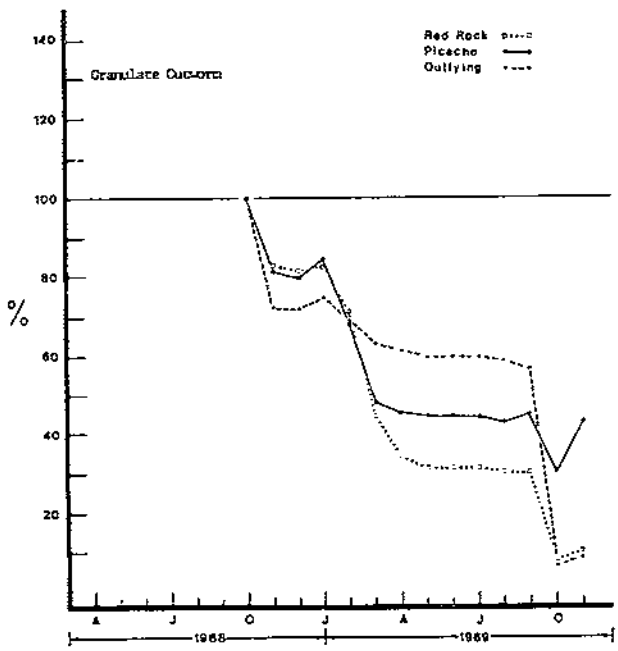

FIGURE 26.—Granulate cutworm 12-month moving mean trap catch as a percentage of the base year.

Saltmarsh Caterpillar

Saltmarsh caterpillar populations showed the greatest reduction over the base year (June 1967 to May 1968) of all species studied as indicated by figure 27. Relative populations stayed at a very low level in all areas throughout 1969 though a slight increase occurred in the latter half of the year.

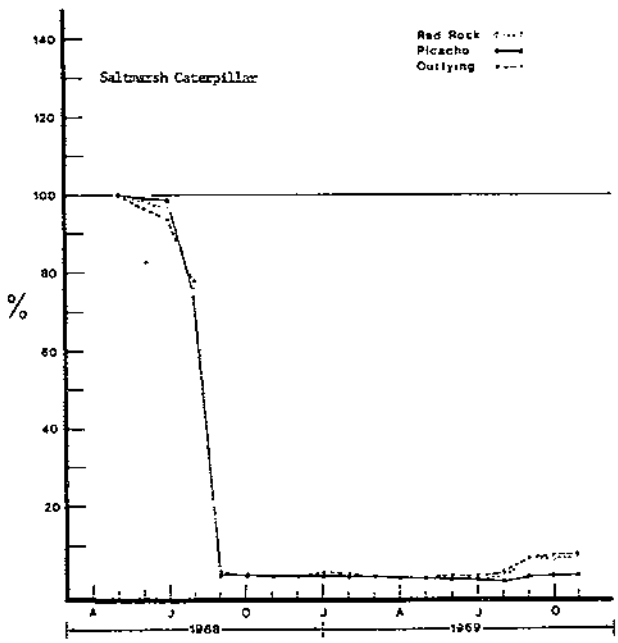

FIGURE 27.—Saltmarsh caterpillar 12-month moving mean trap catch as a percentage of the base year.

ESTIMATED REMOVAL OF MOTHS FROM THE RED ROCK RANCH

In tests run concurrently with the Red Rock study, barrel traps were shown to be at least as effective as survey traps in catching female cabbage looper, female corn earworm, yellowstriped armyworm, and saltmarsh caterpillar moths (*5*). In these tests, significantly higher catches of male cabbage looper moths and male corn earworm moths were obtained in barrel traps than in survey traps. An estimate was therefore made of the numbers of moths removed monthly from the ranch by using the formula: $415\ C_1N_1 + \ldots 415\ C_nN_n$ where 415 equals number of barrel traps on the ranch, C_n equals weekly mean catch per trap per night, N_n equals number of nights from the start of the period until the start of the next. Based on the data from Debolt (*5*), removal figures may be conservative for male cabbage looper and male corn earworm moths. Data present in table 11 show beet armyworm moths were removed in by far the greatest numbers. More than 28 million beet armyworm moths were estimated to have been removed, more than half of this total during the first 10 months. In one month, September 1967, over 7 million beet armyworm moths are estimated to have been caught. When the removal figures for the periods March through October (the period covered in each of the 3 years and the period

during which the vast majority of moths were removed) are compared, beet armyworm removals decreased in 1968 and 1969, 59.9 and 38.7 percent, respectively, from 1967 removals.

Cabbage loopers were removed in the next greatest numbers, followed by corn earworms, saltmarsh caterpillar, yellowstriped armyworm, granulate cutworm, and alfalfa looper in that

TABLE 11.—*Estimated numbers of moths removed per month from the Red Rock ranch by 415 Looplure-baited light traps*

Year and Month	Cabbage looper		Corn earworm		Beet armyworm	Alfalfa looper	Yellow-striped armyworm	Granulate cutworm[1]	Saltmarsh caterpillar[1]
	Male	Female	Male	Female					
1967									
Mar.	304	166	15,715	13,861	8,411	0	996	—	—
Apr.	692	55	16,074	14,802	15,300	83	1,162	—	—
May	189	326	2,122	2,316	13,936	0	13,936	—	—
June	2,629	1,529	33,224	27,757	101,258	57	532	—	26,101
July	126,747	108,048	35,272	42,423	158,957	28	1,467	—	9,504
Aug.	1,188,931	995,057	298,850	269,728	6,149,911	104	17,320	—	151,606
Sept.	113,170	62,902	394,034	286,469	7,062,746	73	44,947	—	580,962
Oct.	102,273	28,484	82,311	69,390	686,029	298	17,911	—	3,375
Nov.	17,130	2,731	1,665	1,003	261,774	1,318	3,195	18,694	516
Dec.	3,685	211	54	161	4,388	146	234	603	27
Total	1,555,750	1,199,509	879,321	727,940	14,462,710	2,107	101,700	19,297	772,091
1968									
Jan.	278	104	12	12	161	12	46	1,153	0
Feb.	11,726	975	69	12	1,563	2,000	529	8,600	242
Mar.	65,025	4,019	1,182	1,315	149,871	8,987	2,168	35,679	836
Apr.	63,786	9,110	5,041	4,534	205,528	5,460	6,352	11,312	701
May	19,178	12,454	48,854	68,422	1,318,850	6,724	11,062	2,553	706
June	5,412	4,352	8,467	5,464	84,206	27	81	518	1,708
July	22,848	19,952	7,768	5,360	45,684	108	141	861	1,042
Aug.	777,463	535,062	49,673	101,745	942,894	382	2,247	2,473	7,103
Sept.	447,464	233,056	43,295	53,287	1,738,139	786	1,211	4,111	2,634
Oct.	236,082	79,942	10,417	8,813	1,202,679	108	2,910	31,322	500
Nov.	6,410	512	153	81	66,524	92	0	463	98
Dec.	150	12	0	0	1,228	12	0	118	0
Total	1,655,822	899,550	174,931	249,045	5,757,327	24,698	26,747	99,163	15,570
1969									
Jan.	23	0	0	0	208	69	0	459	23
Feb.	150	23	12	0	2,239	362	35	58	23
Mar.	346	46	23	23	17,926	1,003	23	12	115
Apr.	2,464	561	434	146	33,452	459	69	473	2,255
May	2,213	688	1,494	443	59,166	309	0	120	300
June	807	119	2,836	1,126	26,007	0	0	142	1,199
July	8,740	4,777	13,262	6,067	92,791	196	625	171	865
Aug.	693,057	406,961	113,636	88,305	1,706,199	20,496	14,671	2,052	6,688
Sept.	862,513	433,426	123,435	133,010	5,675,724	1,117	19,362	2,603	34,369
Oct.	67,252	12,927	67,283	78,191	1,098,407	340	6,404	3,056	5,810
Nov. 1–13	4,955	557	2,199	2,131	45,295	175	367	534	51
Total	1,642,520	860,085	324,614	309,442	8,757,414	24,526	41,556	9,680	51,698
Total (all years)	4,854,092	2,959,144	1,378,866	1,286,427	28,977,451	51,331	170,003	128,140	839,359

[1] Dashes indicate no data.

order. Over 7 million cabbage loopers (males and females) were estimated to have been removed during the study, with over 2 million removed during August 1967 alone. When the March through October removal figures are compared, cabbage looper male removals for both 1968 and 1969 increased 6.7 percent over those removed in 1967. Female cabbage looper removals, however, decreased over 1967 removals 25.0 and 28.2 percent for 1968 and 1969, respectively. Over 2 million corn earworm moths (males and females) were estimated to have been removed during the study. Comparison of the March through October figures shows a decrease in corn earworm males removed during 1968 and 1969 over those removed in 1967 of 80.1 and 63.3 percent, respectively. Female removals for 1968 and 1969 decreased 65.8 and 57.8 percent, respectively, over the 1967 figure. Only small numbers of alfalfa loopers were removed during 1967. During the March through October period for 1968 and 1969, however, removals increased 35 times and 37 times the number removed in 1967, respectively.

Of the 170,003 yellowstriped armyworm moths estimated to have been removed during the study, 101,700 were removed during the first 10 months. During March through October, removals for 1968 and 1969 were 62.8 and 41.4 percent below 1967 removals, respectively. Most of the 128,140 granulate cutworm moths removed were caught during 1968, the 1969 removal being decreased 90.3 percent. Of the 839,359 saltmarsh caterpillar moths estimated to have been removed during the study, 92 percent were caught during the first 7 months. Removal figures for this species could only be compared for the June through October periods; however, most moths were caught during this period. Removals for 1968 and 1969 were decreased over the 1967 figure by 98.3 and 93.6 percent, respectively.

CABBAGE LOOPER MALE TO FEMALE RATIOS AND MATING SUCCESS

The effects of removal of male cabbage looper moths by pheromone baited BL traps on mating success were determined by counting spermatophores in captured females. The bursa copulatrix was dissected from up to 10 females per trap per collection, and the spermatophores were removed and counted. The monthly ratios of males to females in trap catches, numbers of females examined, percent mated, and mean numbers of spermatophores per females are shown in table 12. Due to the seasonal influence on variation in these data, all pairs of data were analyzed by a nonparametric signed rank test (*11*). Only data for periods when all three areas were represented were included in the analyses.

Large seasonal variations occurred in the ratio of male to female cabbage looper moths. The greatest ratios occurring during cooler months when few females were being caught while males were still attracted to the traps by pheromone baits. The outlying area had the highest mean ratio of males to females for the entire period while Red Rock had the lowest. Means for all three areas were significantly different at the 1-percent level. The highest percent mated females, up to 98.2 percent, occurred in all three areas during February and March 1968, a period of high male-to-female ratios. Linear regressions of percent mated females on male-to-female ratios, however, were not significant. The mean percent mated females at Picacho was significantly greater than that at either Red Rock or outlying areas. The mean numbers of spermatophores per mated female never went below 1.2 nor above 3 for any monthly period. The mean at Picacho of 2.18 spermatophores per mated female was significantly higher than the 2.01 for Red Rock.

EGG AND LARVAL COUNTS ON LETTUCE

Egg and larval counts were made on the lettuce crop during all growing seasons. Counts were made beginning at one corner of the field and progressing across the field in a diagonal line to the opposite corner. The first sampling point was located several rows in from the end of the

field. The other points were found by moving diagonally across enough rows to space the points equally across the field. Every fifth plant on alternate sides of a bed was counted, for a total of five plants per sampling point. Normally, 100 plants per field were counted, though this was sometimes varied. Counts commenced with the emergence of the lettuce and continued

TABLE 12.—*Monthly ratios of male to female cabbage looper moths, and mating data for females captured in Red Rock (RR), outlying (Out), and Picacho (Pic) area light traps*

	Ratio male:female[1]			No. females dissected			Percent females mated[2]			$\bar{X}$ No. spermatophores[2] per mated females		
Collection date	RR	Out	Pic	RR	Out	Pic	RR	Out	Pic	RR	Out	Pic
1967												
May	0.7	—	21.6	12	—	—	66.7	—	—	2.5	—	—
June	1.8	8.4	5.8	38	—	22	28.9	—	77.3	1.3	—	2.8
July	1.2	3.7	2.0	579	47	120	64.8	70.2	70.8	2.2	2.0	2.2
August	1.2	2.6	2.0	1,708	147	186	41.0	49.0	67.7	2.1	2.5	2.3
September	1.9	15.7	2.5	717	82	143	58.1	53.6	60.8	1.9	1.9	2.1
October	4.0	16.6	6.2	650	59	140	72.1	69.5	71.4	2.2	1.9	2.2
November	6.2	11.6	47.2	121	23	46	43.0	73.9	69.6	1.5	1.6	1.6
December	22.0	29.0	116.3	—	—	—	—	—	—	—	—	—
1968												
January	2.0	4.5	25.0	—	—	—	—	—	—	—	—	—
February	12.7	526.0	41.0	85	—	56	96.5	—	98.2	2.5	—	3.0
March	13.8	304.1	37.9	230	23	118	93.9	78.3	92.3	2.3	3.0	2.4
April	7.0	75.9	14.0	329	33	89	69.0	36.4	48.4	2.0	2.4	2.6
May	1.9	12.9	11.6	371	69	104	26.9	27.5	48.1	1.9	1.9	2.1
June	1.3	2.6	25.2	126	7	4	37.3	—	—	1.5	—	—
July	1.2	.8	1.4	229	16	21	48.5	43.7	61.9	2.5	2.1	2.5
August	1.4	2.9	1.4	1,040	137	141	61.7	63.5	61.7	1.9	2.3	2.2
September	2.0	7.3	2.5	1,055	178	130	32.7	20.8	40.8	2.0	1.6	2.2
October	2.9	11.6	4.7	913	125	162	29.6	17.6	32.1	1.8	1.6	1.5
November	10.5	33.3	25.4	27	—	20	33.3	—	65.0	1.2	—	1.4
December	—	—	34.0	—	—	—	—	—	—	—	—	—
1969												
January	—	—	19.6	—	—	—	—	—	—	—	—	—
February	—	—	23.0	—	—	—	—	—	—	—	—	—
March	—	30.0	27.0	—	—	—	—	—	—	—	—	—
April	7.0	37.5	46.3	13	—	11	30.8	—	72.7	1.7	—	3.0
May	3.8	189.0	16.7	20	—	30	45.0	—	53.3	2.0	—	1.9
June	6.0	10.5	7.4	—	—	49	—	—	30.6	—	—	1.4
July	1.9	12.0	1.5	87	39	76	70.1	0.8	61.8	2.4	1.8	2.7
August	1.7	8.1	2.1	2,214	443	275	64.0	1.4	73.1	2.1	2.1	2.2
September	2.0	4.5	2.9	1,115	257	152	51.4	52.1	71.7	1.7	1.7	2.0
October	4.9	10.9	6.8	189	115	144	28.8	23.5	49.3	1.7	2.1	2.1
November	9.5	19.0	23.4	—	—	—	—	—	—	—	—	—
$\bar{X}$[3]	5.06c	52.34a	18.43b				53.46g	42.61g	61.34f	2.01s	2.03rs	2.18r

[1] Means in this category followed by the same letter are not significantly different at the 1-percent level by Wilcoxon's signed rank test; a, b, c designate ratio of male to female cabbage looper moths.

[2] Means in these categories followed by the same letter are not significantly different at the 5-percent level by Wilcoxon's signed rank test; f, g designate percent females mated; r, s designate mean number of spermatophores per mated females.

[3] Means represent data only from periods when all 3 areas were represented.

Note: Dashes indicate no data.

until harvest. The entire leaf surface was examined until heading, after which only wrapper leaves were examined unless insect damage was apparent on the head. Unhatched eggs and larvae of the cabbage looper, corn earworm, beet armyworm, alfalfa looper, saltmarsh caterpillar, and cutworm were recorded. Those that were not identifiable in the field were returned to the laboratory for determination.

Cabbage Looper

Eggs and larvae of the cabbage looper were found during all growing seasons (figs. 28 to 33). Very few, however, were found during the springs of 1967 and 1969. No eggs and only two larvae were found at Red Rock during the spring 1967 season, while only four eggs and no larvae were recorded at Picacho. The highest spring egg and larval counts were during 1968 (fig. 28), when counts of 105 eggs per 100 plants and 48 larvae per 100 plants (fig. 29) were recorded at Red Rock on March 8 and 15, respectively. At this time, counts at Picacho had been discontinued due to lettuce harvest. Egg counts remained at a relatively high level throughout the rest of the season with 38 eggs per 100 plants recorded on the final day of counting, April 26. Larval counts declined from the peak on March 15 to seven larvae per 100 plants on April 26.

During the 1969 spring season (fig. 30), eggs were found at Red Rock only during February 10 to 14 and February 17 to 21, when counts of 0.5 and five eggs per 100 plants, respectively, were recorded. Larvae were recorded at Red Rock only during April 7 to 11 and April 14 to 18 (fig. 31), when 0.5 and three larvae per 100 plants, respectively, were recorded. At Picacho, after 1.8 eggs per 100 plants were recorded on the first count, November 25 to 29, 1968, eggs were not found again until March 17 to 21, when seven per 100 plants were recorded. One

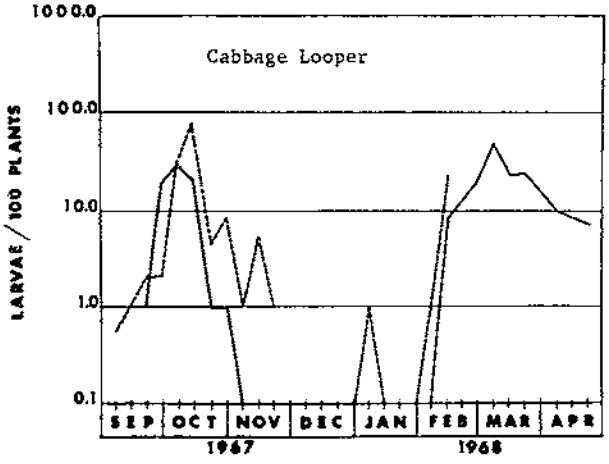

FIGURE 29.—Cabbage looper larvae on lettuce, September 1967 to April 1968. Solid line is Red Rock ranch, dash line is Picacho.

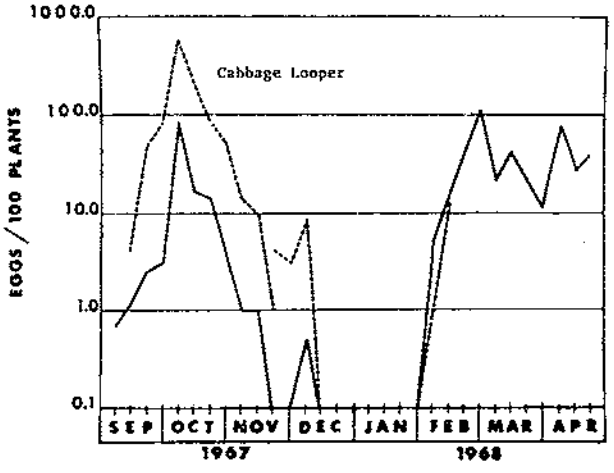

FIGURE 28.—Cabbage looper eggs on lettuce, September 1967 to April 1968. Solid line is Red Rock ranch, dash line is Picacho.

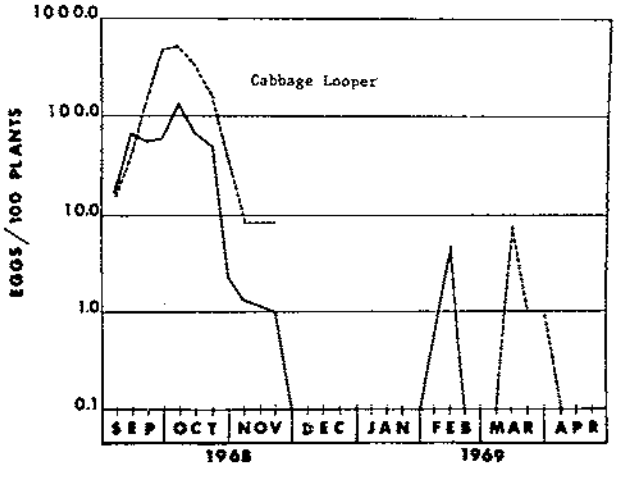

FIGURE 30.—Cabbage looper eggs on lettuce, September 1968 to April 1969. Solid line is Red Rock ranch, dash line is Picacho.

to two larvae per 100 plants were found at Picacho on several occasions, while the highest count was four larvae per 100 plants from April 7 to 11.

Fall crop egg and larval counts were higher than those of the immediately following spring

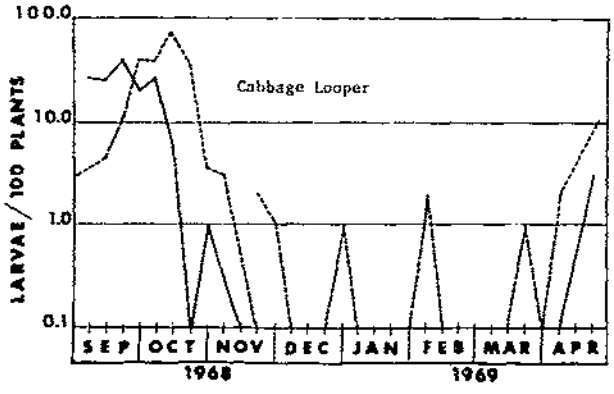

FIGURE 31.—Cabbage looper larvae on lettuce, September 1968 to April 1969. Solid line is Red Rock ranch, dash line is Picacho.

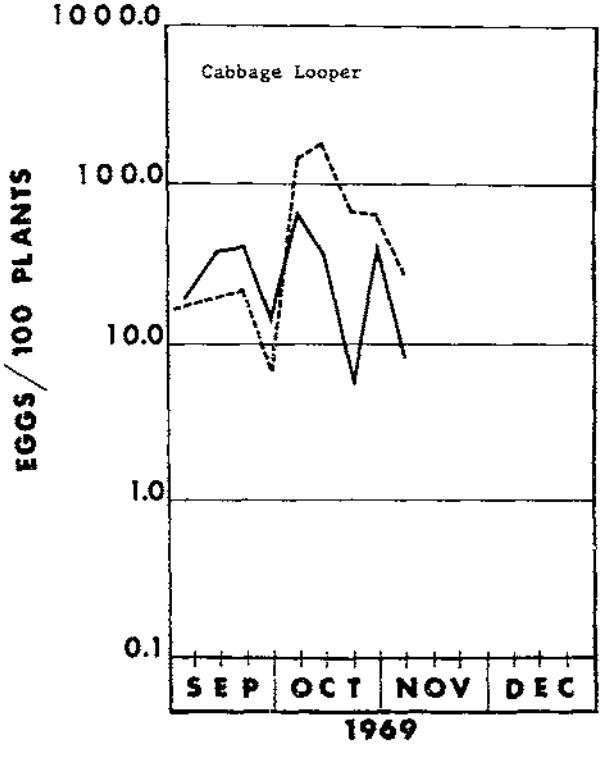

FIGURE 32.—Cabbage looper eggs on lettuce, September to December 1969. Solid line is Red Rock ranch, dash line is Picacho.

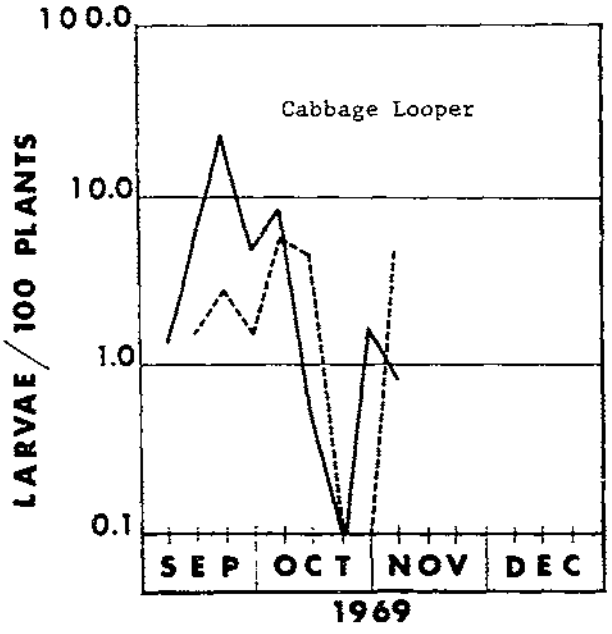

FIGURE 33.—Cabbage looper larvae on lettuce, September to December 1969. Solid line is Red Rock ranch, dash line is Picacho.

crops except for the spring 1968 crop (fig. 28), which had greater numbers of both eggs and larvae at Red Rock than the preceding fall 1967 crop. The peak fall counts at both Red Rock and Picacho occurred during the second week of October on every year o the study except 1969 (fig. 32), when the peak at Picacho was delayed for 1 week. The larval count peaks were not as consistent, occurring from mid-September to mid-October. The peak at Picacho followed that at Red Rock each year by from 1 to 3 weeks.

Beet Armyworm

With one exception, beet armyworm egg masses were found only on the fall lettuce crops. At Red Rock, one egg mass was found on the fall lettuce crops. At Red Rock, one egg mass was found on April 26, the last field check of the spring 1967–68 crop. Beet armyworm eggs were present on all three fall crops from the first counts in September until late October or early November (fig. 34). The peaks normally occurred during the last week in September or the first week in October, though the peak at

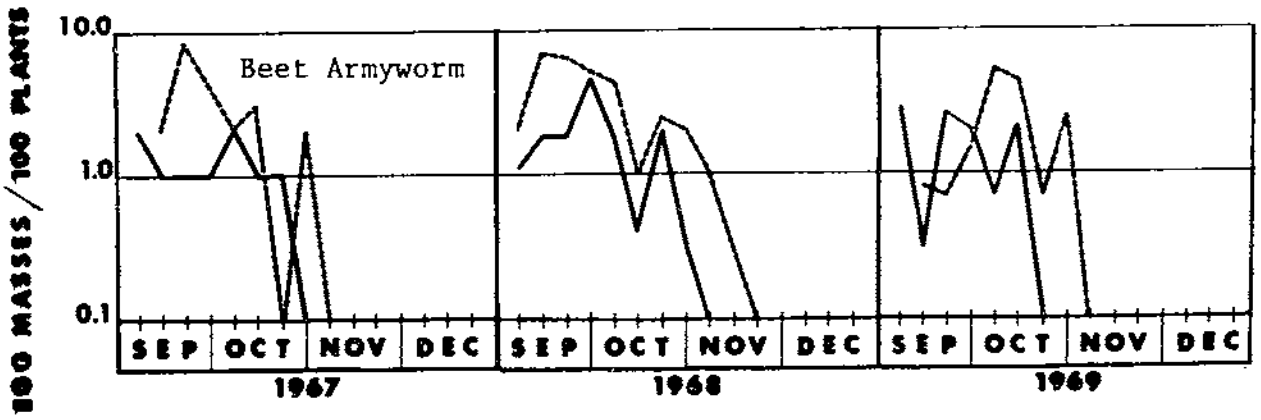

FIGURE 34.—Beet armyworm eggs on fall lettuce, 1967–69. Solid line is Red Rock ranch, dash line is Picacho.

Picacho on the fall 1968 crop occurred during the week of September 16 to 20. Each year the peak at Picacho was higher than that at Red Rock.

Beet armyworm larvae were found during all growing seasons, (figs. 35 to 37), though only three larvae were found during the spring 1967 crop. On the second day of counting, February 23, two larvae at Red Rock and one at Picacho were found.

Corn Earworm, Alfalfa Looper, and Cutworms

Eggs and larvae of these three groups were uncommon during the 3 years of the study. Corn earworm eggs and larvae were found in significant numbers only on the fall 1967 crop.

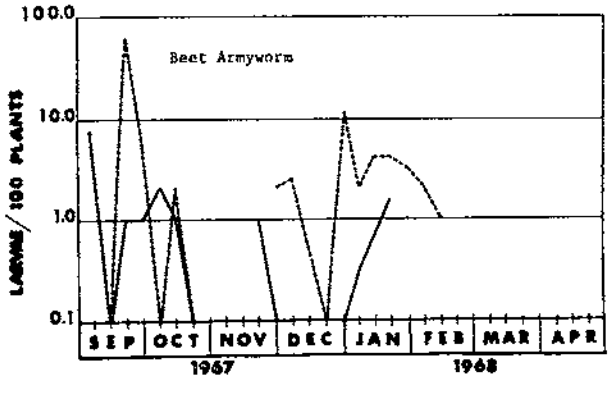

FIGURE 35.—Beet armyworm larvae on lettuce, September 1967 to April 1968. Solid line is Red Rock ranch, dash line is Picacho.

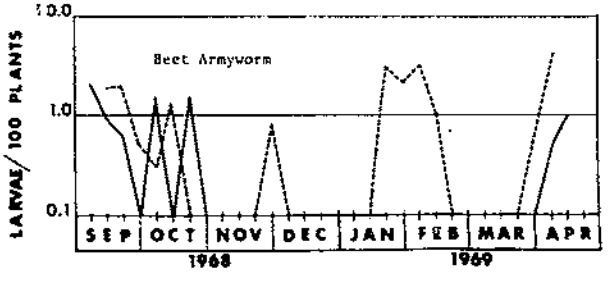

FIGURE 36.—Beet armyworm larvae on lettuce, September 1968 to April 1969. Solid line is Red Rock ranch, dash line is Picacho.

A mean of one corn earworm egg per 100 plants was recorded on the first day of counting, September 13, 1967, at Red Rock. Except for the second count, September 20, eggs of this species were found at Red Rock each week through October 19, after which no more were found. Two eggs per 100 plants, the highest numbers found at Red Rock each week for 4 weeks from September 27 through October 19 at Red Rock. The first corn earworm eggs found at Picacho were three per 100 plants on October 3. The next week the number had jumped to 14 eggs per 100 plants, after which the counts

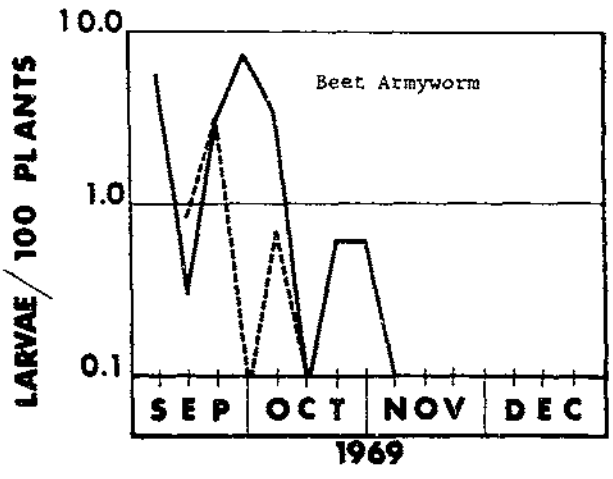

FIGURE 37.—Beet armyworm larvae on lettuce, September to December 1969. Solid line is Red Rock ranch, dash line is Picacho.

rapidly declined, the last eggs being found on October 26. Corn earworm larvae were found only during 2 weeks of this season. Mean numbers of two larvae per 100 plants at Red Rock and four larvae per 100 plants at Picacho were recorded on October 12, and one larva per 100 plants was recorded at Red Rock one week later, October 19.

Only on five other occasions during the 3 years were any corn earworm eggs found at Red Rock; one egg was found on the spring 1967–68 crop, and two were found on one day on the fall 1969 crop. Except for those found during fall 1967, only one corn earworm larva was found. This was recorded on January 26, 1967.

Alfalfa looper eggs were recorded only during February and March 1969. At Red Rock, 11 eggs were found during this period while two were discovered at Picacho. No alfalfa looper larvae were found. Only during the fall 1968 crop were cutworm egg masses found more than once during the season. At Picacho, counts of 2.8 egg masses per 100 plants were recorded during the week of September 16–20, 1968, after which they climbed to a peak of 6.3 per 100 plants during October 7 to 11, then declined to 0 by October 21 to 25. One larva was recorded at Picacho during September 16 to 20. No cutworm eggs or larvae were found at Red Rock during this season.

DISCUSSION

Management of pest populations focuses on control methods that affect total insect populations rather than small local infestations. Since many lepidopterous species are known to move great distances, large experimental areas or other barriers are necessary to prevent immigration of target species into the test area, obscuring the impact of the attempted suppression program. In research and applied control situations, isolation has been particularly difficult because of multiple cultivated and wild hosts, interpopulation movement, and migration of the target species. Climate and geographical barriers, such as large bodies of water, mountain ranges, and islands, may isolate certain species. In any event, under such experimental conditions, classical statistical evaluations, in terms of valid replications to compare treatment effects, are a physical impossibility, and biological and population homogeneity are questionable under such large area considerations. Thus, evaluation must be accomplished on the bases of historical data or repetitiveness in time and multiple measurements of the population studied.

Seasonal variations in trap catches were similar in both heavily and lightly trapped areas. The seasonal population curves generally agreed with curves previously published for the central Arizona area (*9*). Catches were usually much lower at Red Rock high trap density than at Picacho low trap density.

Lack of isolation and seasonal weather patterns prevented an accurate estimate of the effects of the installation on the magnitude of year to year moth populations during the study period. Other factors, such as variations in host crops, insecticide usage, nonhomogeneous insect populations, weather, insect movement, and trap density effects, were also influencing trap catches. Also, information was insufficient on normal populations in the areas before trapping commenced.

The mean curves for most species were raised above the base year for the first part of 1968.

This was probably due to a great abundance of wild host plants brought on by the warm, wet late winter period. Only in the cases of beet armyworms and granulate cutworms were the relative population reductions in the heavily trapped Red Rock area greater than those in the lightly trapped Picacho area. Climatic factors appeared to have had greater influence on year to year populations than the traps. The base year, however, was the first year during which all traps were operated, and for most species catches at Red Rock were much lower than those at Picacho. It is possible, therefore, that the major influence of the traps was during this initial year.

Corrections for population fluctuations (relative trap catch), however, showed correlation between reduced trap catch and distance in from the ranch perimeter. The shapes of the isotrap catch lines, plus the significant regression coefficients, indicate that the traps did reduce the populations of cabbage looper and beet armyworm adults during each year of operation on the Red Rock ranch.

Henneberry et al. (7) suggested that an experimental area to demonstrate the effects of virgin female baited blacklight traps should be at least 3.2 km in diameter and have a trap density of one trap per 2.4 ha. The Red Rock ranch was close to 3.2 km in diameter and had 415 traps on 1260 ha. The traps were culturally restricted to access roads and could not be equally spaced over the whole ranch. As expected, fewer adults were caught near the ranch center, but the installation was not large enough to prevent mated females from laying significant numbers of eggs on cultivated crops in the trapped area.

The cotton grown on the Red Rock ranch was the primary source of adult moths within the ranch. Cultural practices eliminated most wild host plants on the ranch, and insecticide usage eliminated most of the insects on lettuce. Other insect sources were wild hosts in the desert and other crops. The positive regression coefficients probably were caused by the absence of wild hosts outside the ranch at times when cotton on the ranch was producing large numbers of insects.

The general pattern of isotrap catch lines can be inferred from the slopes given in tables 8, 9, and 10. If regression coefficients were not significant for ranch traps, then no isotrap lines would occur on the ranch. If the regression coefficients were negative, then isotrap catch lines would decrease toward the ranch center. Regression coefficients using only ranch traps probably underestimate the effects of the traps, whereas regressions including Picacho traps (all traps) probably overestimate the trap effects. The regressions using ranch traps plus outlying traps are our best estimates of the effect of these traps on adult moth populations, assuming relatively homogeneous populations throughout this area. This assumption is substantiated by the data of Hills (9). He reported that the seasonal distribution and magnitude of catches were similar in cultivated areas and in areas 4 to 19 km distant. Our outlying traps were less than 3 km from the ranch border.

Though the large numbers of moths removed by traps on the Red Rock ranch were not sufficient to control the species considered, several effects of this removal could be seen. The removal of cabbage looper males by the pheromone baited BL traps resulted in a reduced ratio of males to females in trap catches and a resulting reduction in mating on the Red Rock ranch as compared with the Picacho area. The high male to female ratio in the outlying traps may have been due to males from greater distances attracted toward the high concentration of pheromone on the ranch and passing within range of these outer traps. While egg and larval counts at the Red Rock ranch were generally less than at Picacho, they were not reduced sufficiently to result in any significant reduction in insecticide usage. Due to the high value of the lettuce crop and grading standards requiring nearly insect free produce, egg and larval counts would have to be reduced to an extremely low level to reduce insecticide usage. The heavy spray schedule also prevented any accurate study of larval populations. The large numbers of female moths removed and reduced mating of the cabbage looper undoubtedly contributed to reduced oviposition at the Red Rock ranch; however, the factors already mentioned as influencing trap catches also prevented a direct measurement of the effect of the trapping on oviposition.

SUMMARY

This installation demonstrated that light traps could be installed and operated for extended periods over large areas. The trap installation performed as predicted in reducing the local moth population. The Red Rock ranch, however, was in an area of extremely high moth populations, and the surrounding desert failed to provide adequate isolation to the test area. Any trapping installation must remove significant numbers of fertile females before they can oviposit on the protected crop. Although large numbers of pest moths were removed from the population and mating of the cabbage looper was reduced, this did not prevent infestation of crops on the ranch.

Direct evaluation of the impact of these reductions on crop infestations was impossible since heavy insecticide use during the study period masked effects due to the trap system. Lack of pre- and posttest information on normal population levels is vital for evaluation of population suppression programs. The trapping concept may be useful in areas of lower pest population and for other crop-insect systems where immigration would not be as serious or could be controlled.

LITERATURE CITED

(1) BERGER, R. S.
1966. ISOLATION, IDENTIFICATION, AND SYNTHESIS OF THE SEX ATTRACTANT OF THE CABBAGE LOOPER, TRICHOPLUSIA NI. Annals of the Entomological Society of America 59: 767–771.

(2) CANTELO, W. W.
1974. BLACKLIGHT TRAPS AS CONTROL AGENTS: AN APPRAISAL. Entomological Society of America Bulletin 20:279–282.

(3) —— J. S. SMITH, JR., A. H. BAUMHOVER, and others.
1973. CHANGES IN THE POPULATION LEVELS OF 17 INSECT SPECIES DURING A 3½ YEAR BLACKLIGHT TRAPPING PROGRAM. Environmental Entomology 2:1033–1038.

(4) DEBOLT, J. W.
1970. DISPENSERS FOR BAITING TRAPS EQUIPPED WITH BLACKLIGHT LAMPS WITH SYNTHETIC SEX PHEROMONE OF THE FEMALE CABBAGE LOOPER. Journal of Economic Entomology 63:141–144.

(5) —— D. L. JAY, and R. W. OST.
1975. LIGHT TRAPS: EFFECT OF MODIFICATION ON CATCHES OF SEVERAL SPECIES OF NOCTUIDAE AND ARCTIIDAE. Journal of Economic Entomology 68:186–188.

(6) FORD, J. H., W. WOLF, and P. V. VAIL.
1972. USE OF LIGHT TRAPS FOR CABBAGE LOOPER CONTROL IN A LIMITED AREA. American Society of Agricultural Engineers Transactions 15:352–354.

(7) HENNEBERRY, T. J., A. F. HOWLAND, and W. W. WOLF.
1967. COMBINATIONS OF BLACKLIGHT AND VIRGIN FEMALES AS ATTRACTANTS TO CABBAGE LOOPER MOTHS. Journal of Economic Entomology 60:152–156.

(8) HIENTON, T. E.
1974. SUMMARY OF INVESTIGATIONS OF ELECTRIC INSECT TRAPS. U.S. Department Agriculture Technical Bulletin No. 1498, 136 p., illus.

(9) HILLS, O. A.
1968. SEASONAL POPULATIONS AND FLIGHT PATTERNS OF SEVERAL NOCTUID MOTHS IN SOUTH-CENTRAL ARIZONA. U.S. Department of Agriculture Production Research Report No. 100, 14 p., illus.

(10) STEEL, R. G. O., and J. H. TORRIE.
1960. PRINCIPLES AND PROCEDURES OF STATISTICS. McGraw-Hill, 481 p., illus. New York and London.

(11) WILCOXON, F.
1945. INDIVIDUAL COMPARISONS BY RANK METHODS. Biometrics 1:80–83.

(12) WOLF, W. W., A. N. KISHABA, A. F. HOWLAND, and T. J. HENNEBERRY.
1967. SAND AS A CARRIER FOR SYNTHETIC SEX PHEROMONE OF CABBAGE LOOPERS USED TO BAIT BLACKLIGHT AND CARTON TRAPS. Journal of Economic Entomology 60:1182–1184.

(13) WOLF, W. W., J. G. HARTSOCK, J. H. FORD, and others.
1969. COMBINED USE OF SEX PHEROMONE AND ELECTRIC TRAPS FOR CABBAGE LOOPER CONTROL. American Society of Agricultural Engineers Transactions 12:325–331, 335.

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