November 1963

ARS-33-91

EFFECT OF LIGHT TRAPS ON HORNWORM POPULATIONS IN LARGE AREAS

Agricultural Research Service
UNITED STATES DEPARTMENT OF AGRICULTURE
in cooperation with
North Carolina State College
and
North Carolina Department of Agriculture

CONTENTS

EFFECT OF LIGHT TRAPS ON HORNWORM POPULATIONS IN LARGE AREAS

By F. R. Lawson and Cecil R. Gentry, Entomology Research Division, and James M. Stanley, Agricultural Engineering Research Division, Agricultural Research Service

The tobacco hornworm (Protoparce sexta (Johannson)) is a major pest of tobacco and tomatoes wherever these crops are grown in the United States. The tomato hornworm (P. quinquemaculata (Haworth)) attacks the same crops, but is less numerous in most of the tobacco-growing areas.

The biology of the hornworms has been discussed by Gilmore (1938),1/ Madden and Chamberlin (1945), and Metcalf (1909). Morgan and Lyon (1928) found that amyl salicylate was attractive to hornworms and developed methods of using this bait to trap the moths. These authors reported that when six traps were placed in and around a 16-acre field of tobacco in Tennessee, the population of eggs and larvae was 2.63 per plant as compared with 6.67 in surrounding fields. The next year in a field with eight traps per 8 acres, there were 4.1 hornworms as compared with 6.3 in the checks.

Gilmore and Milam (1933), also working in Tennessee, tested the same attractant in devices containing sugar water and tartar emetic. Moths feeding from these containers were killed. Feeders were placed at varying densities near tobacco fields in areas ranging from 9 to 25 square miles. The percent reduction in hornworm populations averaged 51.7 in 1929, 68.9 in 1930, and 53.7 in 1931. Scott and Milam (1943), again working in Tennessee, tested traps and poisoned feeders with the same attractant in a randomized-block experiment consisting of nine treated plots each 1 square mile in area. The results showed a percent reduction in the numbers of eggs laid amounting to 62.6 in trapped plots and 66.3 in baited plots.

Stahl (1954) tested bait traps and electric-light traps in North Carolina. He stated: "Field studies indicated that the use of either bait or light traps had little effect on the abundance of and damage caused by hornworm larvae on tobacco at or near the traps."

For 3 years in succession Stanley and Dominick (1958) placed three black-light traps on each of three tobacco fields of about 5 acres in Virginia. The mean reduction in number of plants damaged by hornworms was about 16 percent.

In brief, experiments with bait traps and poisoned feeders in Tennessee indicated that these devices reduced the numbers of eggs laid by more than 50 percent when they were used on areas of 1 square mile or more. On smaller areas in North Carolina and Virginia, neither bait nor light traps caused an appreciable reduction in hornworm numbers or damage.

1/ The year after the authors' names is the key to the reference in Literature Cited at the end of this report.

The experiments described here were designed to use light traps as a means of investigating the numbers, habits, and movements of hornworm moths and to test the possibility that such traps might be used to reduce populations in large areas. The work was done near Oxford, N.C., in 1961-62.

DESCRIPTION OF TRAPS

Both bait and light traps were used in these experiments. The bait traps were of the type described by Scott and Milam (1943). They were screen cages 3 feet high, 3 feet long, and 2 feet wide. The ends consisted of a shallow funnel with an 8-inch hole opening inward. A screen baffle was hung from the top of the trap between the two openings to prevent moths flying straight through. Each trap was equipped with a vial containing iso-amyl salicylate dispensed by a cotton wick that projected about an inch from the container, which was placed near the ground in the center of the trap. Half the traps were also equipped with a piece of fiberboard 4 inches square impregnated with the bait and attached to the top of the baffle on June 14. Twenty-five of the traps were old ones that had been used in previous years and 37 were new. There was no evidence that differences in traps affected the catch.

One of the light traps used in 1962 is shown in figure 1. The attractant

Figure 1.--Light trap used in 1962.

was a 15-watt black-light fluorescent lamp, which radiated primarily between 3,200 and 4,000 angstroms with a peak emission near the center of this near-ultraviolet region. Moths flying toward the trap hit the baffles or dived into the funnel and fell into the cage below. The long downspout was used only on certain traps so that the cage would be within reach of a man standing on the ground.

The sides of the cage were made of 1/3-inch mesh screen, so that most of the small insects could escape. The bottom of the cage had a hole 5 inches in diameter covered with a sliding door for easy access. Some hornworm moths were killed or injured when caught, and all had badly battered wings if left too long in the trap, but most appeared to be in excellent condition early in the morning.

The light traps used in 1961 were very similar, except that the cage was larger and made of finer mesh screen, and the traps were mounted closer to the ground.

LOCATION AND DESIGN OF EXPERIMENTS

There were four successive experiments, the first three in 1961 and the fourth in 1962. In the first experiment, 62 bait traps were placed in four concentric circles. The inner circle had a radius of one-fourth mile; the second, one-half; the third, three-fourths; and the outer, 1 mile. The area was 3.14 square miles. Traps were located at approximately quarter-mile intervals on each circle regardless of vegetation or terrain, except that they could not be placed in fields of row crops or in pastures. At these locations the traps were placed on the nearest field border.

The center of the experiment was about three-fourths mile northwest of Providence, N.C. In addition to the bait traps, two light traps similar to those previously described were located outside but near the bait-trap area. One was 1.26 miles northeast of the center, the other 1.53 miles northwest. Another light trap of an older design was located at Oxford.

In the second experiment, 14 light traps were placed in an area of approximately 2 square miles. Most of the moths caught in these traps were marked and released near the center of this 2-square-mile area, and the remainder were released in the center of the bait-trap experiment, which was still in operation. The distance of the light traps from the first release point ranged from 0.18 to 1.04 miles, except for trap 15, which was 2.43 miles distant. The second release point ranged from 1.52 to 2.69 miles from light traps 1 to 14 and was 1.33 miles from trap 15.

In the third experiment, the same 14 light traps were located in a much larger area covering approximately 25 square miles. The center of this area, where the moths were released, was 6 miles west of Oxford. The traps were 0.89 to 4.36 miles from this point. These traps were operated from August 19 to September 25. Six additional light traps were located 4 to 10 miles from the center on September 9.

In 1962 the experimental area consisted of two tangent circles, each 12 miles in diameter. The western circle had 6 light traps placed at about 1-mile intervals in each of four directions from the center outward, with a total of 24 traps in 113 square miles. The eastern circle had 324 light traps in an area of the same size, or about 3 per square mile. In addition, six traps were placed at about 1-mile intervals extending out 6 miles from the outer edge of the eastern circle in a north, south, and east direction. The center of the eastern circle was 6 miles west of Oxford. The land in this area is gently rolling and about half of it is wooded.

In 1961, the light traps were placed near farmhouses to obtain power. In 1962, they were located close to secondary electric service, which in some instances was near farmhouses.

METHODS OF HANDLING AND MARKING MOTHS

In 1961, bait traps were examined at intervals of 2 to 3 days. Most of the time light traps were emptied daily. In 1962, certain traps were examined daily and all hornworms counted. The remainder were emptied at intervals of about 10 days, but no counts were made since most of the moths were dismembered by predaceous beetles.

In marking experiments, live moths were removed from the traps early in the morning and placed in carrying cages. When all were collected, those showing no injury were marked on the wings and released immediately or sometimes put back into carrying cages and released later. At first, various kinds of lacquer were painted on the wings, but these materials failed to stick even when the scales had been removed. Small round holes were then punched in the wings, but these tended to fray out and become unrecognizable. Legs and antennae were clipped, but this technique proved to be unreliable when many unmarked moths were found with missing appendages. The most reliable mark was a smear of artist's oil paint on the wing. It was necessary to rub in the paint with the head of a nail or some similar object. Different colors were used for releases in different places or on different days.

COMPARATIVE CATCHES OF BAIT TRAPS AND LIGHT TRAPS

The numbers of hornworm moths caught in the first experiment in 1961 are shown in table 1. Twenty-eight bait traps caught nothing, and the catch of the remainder was never more than a small fraction of the numbers taken by the light traps. Bait traps caught nothing before June 13, although the light-trap catch indicated a fairly heavy flight of moths. The mean catch of P. sexta in the light traps was 206 times that in the bait traps, and for P. quinquemaculata it was about 36 times. In the bait traps the percentage of males was 53 for P. sexta and 54 for P. quinquemaculata, whereas in the light traps it was 85 for P. sexta and 64 for P. quinquemaculata. In reared material of both species, males comprise about 50 percent. Thus, it appears that although the catch of bait traps was nearly normal in sex ratio, the number captured was very low in comparison with light traps at all seasons and zero during the early part of the season.

TABLE 1.--Comparative catches of hornworms in 3 light traps and 34 bait traps, Oxford, N.C., 1961

Date	Mean number of hornworms captured per trap per day			
	P. sexta		*P. quinquemaculata*	
	Light traps	Bait traps	Light traps	Bait traps
June 1-10	3.077	0	4.308	0
11-20	7.654	.003	5.038	.015
21-30	2.310	.009	.896	.041
July 1-10	1.600	.021	.233	.012
11-20	1.600	.009	.367	.012
21-30	1.567	.021	3.966	.179
July 21-Aug. 9	7.000	.053	13.700	.632
Aug. 10-18	2.037	.013	8.345	.121
Total catch	714.000	43.000	976.000	340.000
Season's mean	3.306	.016	4.519	.126

EFFECT OF VEGETATION AND TERRAIN ON TRAP CATCH

The low catch in bait traps was due in part to trap location, as shown by table 2. The catch was greatly reduced in or near woods. The moths must have either avoided the woods or they did not respond to the traps in these locations. The traps that caught the highest numbers were not only in open fields but also on or near the top of hills. There were indications that the catch increased when the downhill direction away from the trap led to open fields rather than to woods. Thus, two traps were only one-fourth mile apart and both were in the open near the top of hills, but there were open fields downhill from one and woods downhill from the other. The first caught nine moths and the second only four.

TABLE 2.--Effect of vegetation on catch of hornworm moths in bait traps

Vegetation	Number of traps		Season's total number of moths per trap	
	Total	Catching moths	*P. sexta*	*P. quinquemaculata*
Woods far from open fields	14	0	0	0
Edge of woods near open fields	15	4	.14	.40
Edge of open fields near woods	11	11	.27	5.27
Open fields far from woods	22	19	1.72	12.54

Many traps were near tobacco fields. Some of these caught moths and some did not. If tobacco had any effect on catch, it was obscured by other factors. However, in the second experiment with light traps the catch was definitely higher in traps near tobacco, as shown by table 3.

TABLE 3.--Mean number of hornworm moths caught in light traps in relation to tobacco fields, Aug. 19-Sept. 29, 1961

Trap location	Number of traps	Mean number per trap of--			
		P. sexta		*P. quinquemaculata*	
		Male 1/	Female 2/	Male	Female 1/
Near tobacco----------------	6	198.3	49.2	111.7	51.7
Far from tobacco----------	8	96.0	31.7	82.6	32.0

1/ Difference significant at 1-percent level.

2/ Difference significant at 5-percent level.

RANGE OF TRAPS

In 1961 moths were marked and released at varying distances from one trap. The results are shown in table 4. There was no apparent difference in the number recaptured in this trap up to 0.19 (3/16) mile, but nine other traps that were 0.31 to 1.43 miles distant caught more moths than were taken nearby. On August 11 and 28 a total of 218 moths were marked and released within 50 feet of a trap. Forty-two, or 19.3 percent, were recaptured in this trap. Nine were taken in more distant traps. Obviously not all the moths released at any given time will be caught.

DISTANCE TRAVELED BY HORNWORMS

In 1961 most of the moths caught each day were marked and released. The total numbers released and recaptured in different experiments are shown in table 5. In the first experiment the numbers recaptured with bait traps and the two light traps within range were too low to have much meaning. In the second experiment with 14 light traps distributed in a circular area having a radius of 1 mile and an additional light trap 2.43 miles away, there was no relationship between distance from the point of release and trap catch. Since the trap at 2.43 miles also caught moths moving far beyond the 1-mile radius, the traps were relocated in a much larger area for the next experiment and moths were again released at the center.

TABLE 4.--Number of hornworm moths released on Aug. 9-10, 1961, at varying distances from trap 9 and number recaptured

Distance released (miles)	*P. sexta*				*P. quinquemaculata*				Total	
	Male		Female		Male		Female			
	Released	Recaptured	Released	Recaptured	Released	Recaptured	Released	Recaptured	Released	Recaptured
1/16----------	19	2	4	0	38	2	17	0	78	4
1/8-----------	18	0	3	1	30	3	20	2	71	6
3/16----------	18	1	2	0	36	3	19	0	75	4
1/4-----------	21	0	2	0	34	0	19	1	76	1
Total	76	3	11	1	138	8	75	3	300	15
Percent recaptured in trap 9-	---	3.9	----	9.1	-----	5.8	----	4.0	-----	5.0
Percent recaptured in other traps-----	---	3.9	----	0	-----	5.1	----	10.7	-----	6.0

TABLE 5.--Number of hornworm moths released and recaptured

Experiment	*P. sexta*		*P. quinquemaculata*	
	Male	Female	Male	Female
June 15-July 26, 1961:				
Number released----------------------	322	40	278	208
Number recaptured:				
62 bait traps---------------------	0	0	3	2
2 light traps---------------------	6	0	2	0
Total recaptured---------------------	6	0	5	2
Percent recaptured-------------------	1.8	0	1.8	1.0
July 26-Aug. 16, 1961:				
Number released----------------------	729	148	1,369	841
Number recaptured, 15 light traps----	32	4	51	7
Percent recaptured-------------------	4.4	2.7	3.7	.8
Aug. 19-Sept. 25, 1961:				
Number released----------------------	2,011	511	1,462	598
Number recaptured, 15 light traps----	379	24	107	28
Percent recaptured-------------------	18.8	4.7	7.3	4.7

The number of females recaptured was low, and the correlation between trap distance and catch was again not significant. The data for males are shown in figure 2. The numbers of moths recaptured fell off sharply with increasing distance from the point of release and the rate of decline was constant. By substituting appropriate values in the equation, it can be calculated that the number of *P. sexta* males recaptured was reduced 50 percent with each 0.61 mile of increasing trap distance. *P. quinquemaculata* was reduced the same amount in 1.80 miles. Thus, *P. quinquemaculata* males traveled farther than *P. sexta* before they were lost. The greatest distance that hornworms were known to travel was 6.3 miles for two *P. sexta* males and one *P. quinquemaculata* female in 1961 and 8.1 and 8.2 miles for two *P. sexta* males in 1962.

LENGTH OF LIFE OF RELEASED MOTHS

If it is assumed that the catch of marked moths on successive days after release is proportional to the number remaining within the area covered by traps, then the rate of disappearance of marked moths can be estimated from recapture data. The data for *P. sexta* males are shown in figure 3. Curves for the other species and sexes are similar.

The regression equations for all groups are given in table 6. By substituting appropriate values of y in these equations, the time required for the numbers recaptured to be reduced by half, or the half life of released moths, can be calculated. These are also given in table 6. Females of both species lived longer or remained in the area longer than males. *P. sexta* males disappeared faster than *P. quinquemaculata* males, but the reverse was true of females.

TABLE 6.--Regression of number of marked hornworm moths recaptured in light traps on number of days after release, Aug. 19-Sept. 25, 1961

Species and sex	Regression equation	Probability	Calculated half life
P. sexta:			
Male----------	$\log y = 2.51 - 0.27X$	< 0.001	1.12
Female--------	$\log (y + 1) = 0.97 - 0.11X$	< .01	2.74
P. quinquemaculata:			
Male----------	$\log (y + 1) = 1.76 - 0.19X$	< .001	1.59
Female--------	$\log (y + 1) = 1.04 - 0.14X$	< .01	2.14

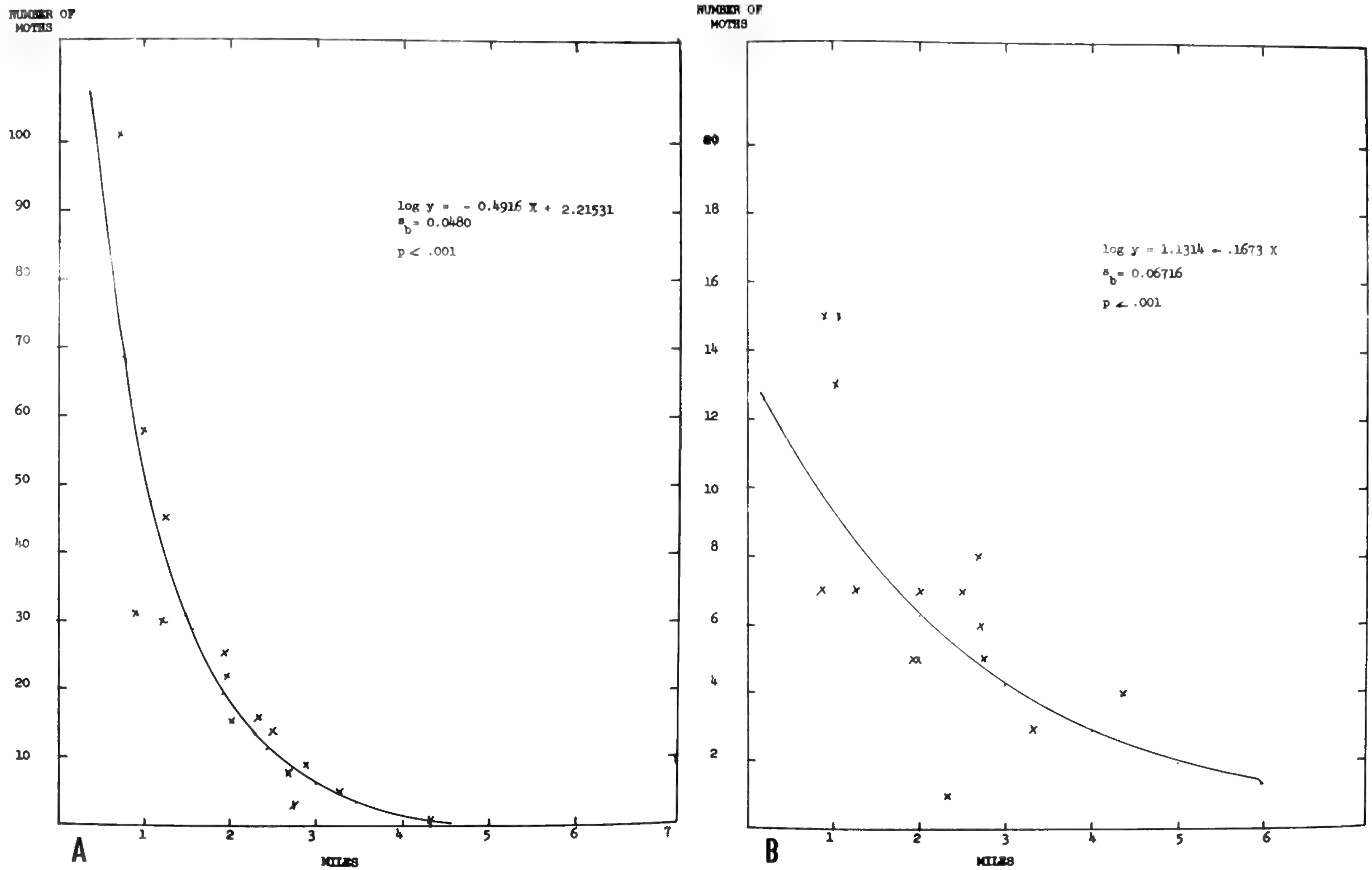


Figure 2.--Regression of number of marked hornworm males recaptured in light traps on distance from point of release, 1961: A, P. *sexta*; B, P. *quinquemaculata*.

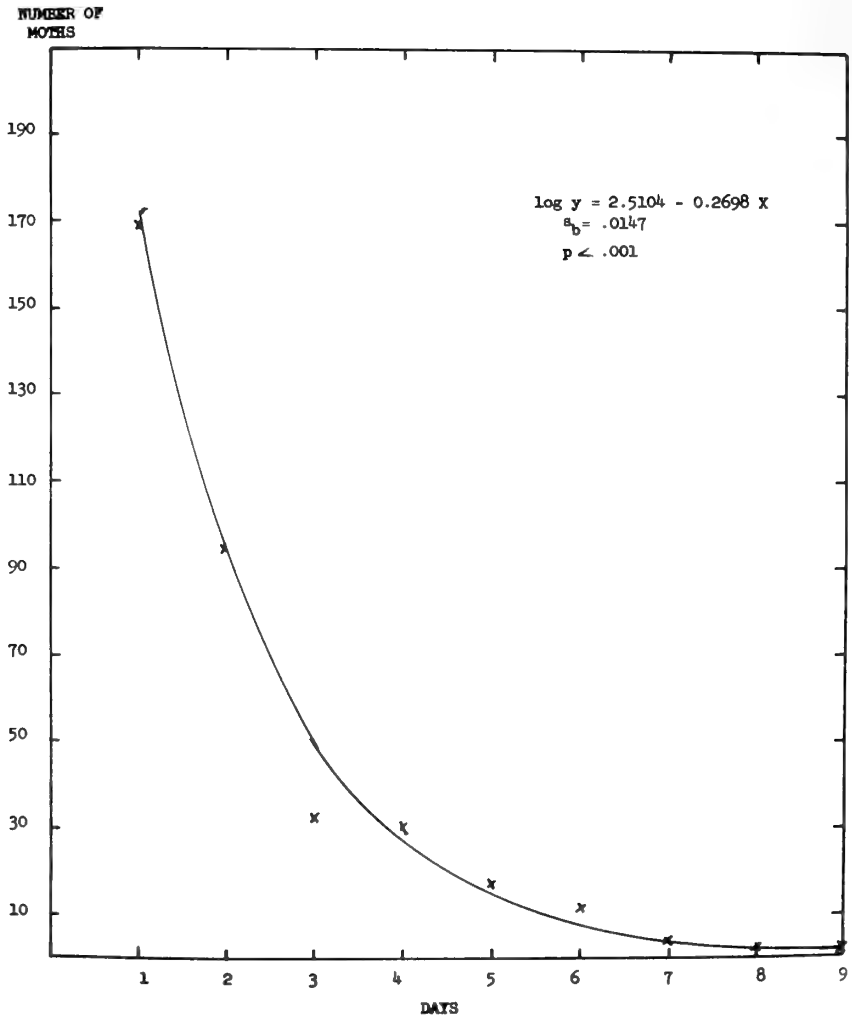


Figure 3.--Regression of number of marked P. sexta males recaptured in light traps on days after release, 1961.

EFFECT OF TRAPS ON HORNWORM NUMBERS

It was apparent from the 1961 data that hornworm moths were strong fliers and capable of moving 3 or 4 miles in a single night. Thus, if any control method is applied to a small area, this area will almost certainly be flooded by moths flying in from outside. The size of the area required for a control experiment can be estimated from the 1961 trap data, provided some allowance is made for the movement of moths over a larger and larger area as they dispersed from a central point. To correct for the distance factor, we assumed that moths dispersed at random and the effective range of all traps was the same and circular. If the diameter of this circle is "d" and the distance of a trap from the point of release is "r," then the catch of the trap should be approximately proportional to $\frac{d}{2\pi r}$. Since "d" and "2π" are constants, an approximate correction can be obtained by multiplying the catch by "r."

If this correction is applied to the data for P. sexta males given in figure 2, the regression equation then becomes $\log \bar{y} = 2.003 - 0.266 X$, and the regression coefficient is highly significant. By substituting appropriate values in this equation, it can be calculated that 5 percent of a dispersing population will travel 4.89 miles.

Since a correction has been applied for the thinning effect of dispersal outward from a point, we can now say that in a circle with a radius of 4.89 miles, 5 percent of the moths at the center will have come from outside the circle. Since a certain minimum area is needed to measure a population, an experiment was designed in which the area trapped had a radius of 6 miles. It would be expected that somewhat less than 5 percent of the moths inside a center circle with a radius of 1 mile would come from outside the trapped area.

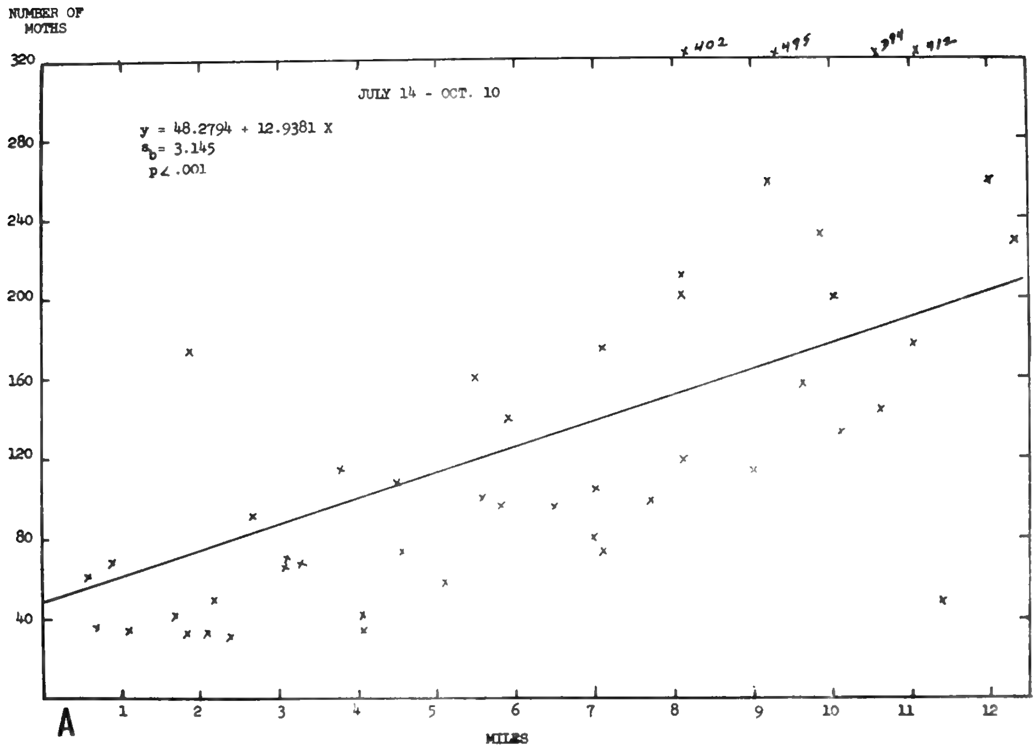
After estimating the increase in total catch to be expected from increasing the number of traps, it was concluded that three traps per square mile were necessary to control the population of P. sexta. Since there are a little over 113 square miles in a circle with a radius of 6 miles, the number of traps required would be 339, but in practice large areas of forest reduced the number to 324. This experiment was put in operation in May 1962. Not all the traps could be checked each day, and after some preliminary experiments 28 traps outside the trapped area and 24 inside were selected. These were examined each day from July 14 to October 10.

Figure 4 shows the relationship between the distance of each trap from the center of the trapped area and the total catch per trap of P. sexta. Curves for P. quinquemaculata were very similar. The catch per trap of both species and both sexes gradually increased as distance from the center increased, and in no case was there a sharp rise in catch at the edge of the trapped area. Thus, hornworm movement tended to obliterate differences between populations inside and outside the trapped area.

As a result, a simple comparison of mean catch inside and outside will underestimate the effect of the traps in reducing the population. A better estimate can be obtained by calculating the catch at the center and 12 miles out, that is, at equal distances from the border of the trapped area. These estimates are given in table 7.

TABLE 7.--Estimated reduction in populations of hornworm moths due to 3 light traps per square mile, July 14-Oct. 10, 1962

Species and sex	Calculated catch at--		Percent reduction
	12 miles	0 mile	
P. sexta:			
Male	203.5	48.3	76.3
Female	46.5	20.7	55.4
P. quinquemaculata:			
Male	130.4	14.7	88.7
Female	60.1	24.9	58.5



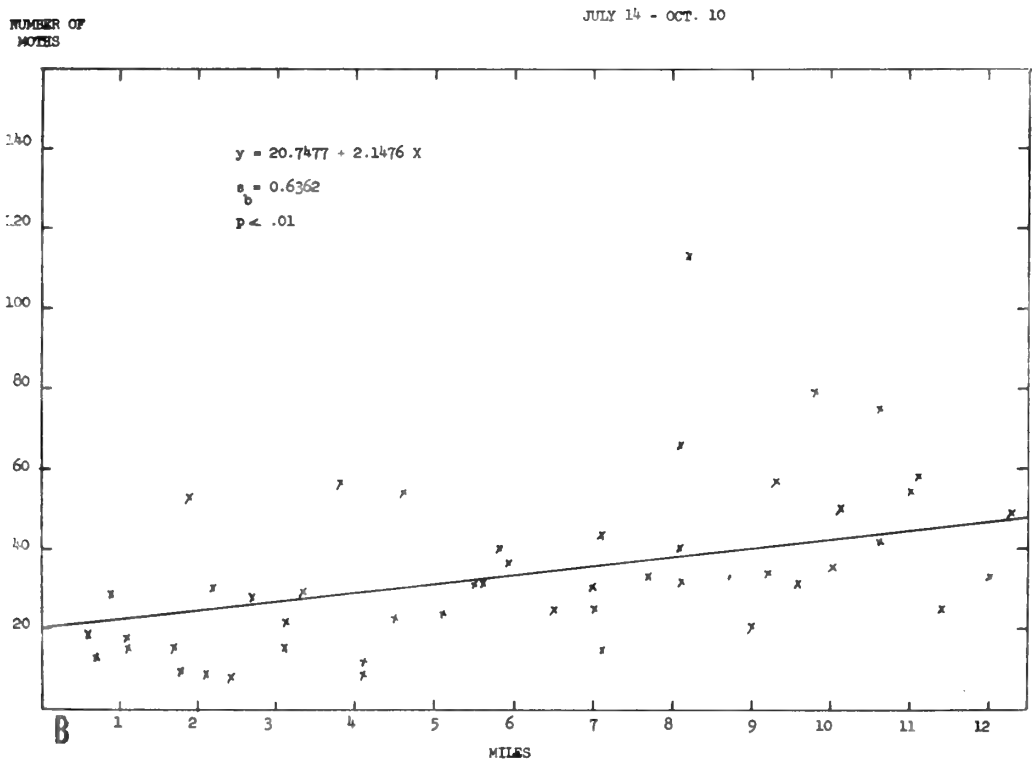


Figure 4.--Regression of mean number of P. sexta per trap on distance from center of trapped area with radius of 6 miles, 1962: A, Males; B, females.

Counts of hornworms were also made on tobacco fields inside and outside the trapped area during this period. When these were plotted, they also indicated a gradual increase in populations from the center outward, but the number of hornworms found was highly variable, primarily because the condition of the plants and the suitability for hornworm oviposition were also variable. The regression of number of hornworms on distance was not significant.

The mean numbers of hornworm eggs and first-instar larvae per 50 tobacco plants in seven counts in 12 fields at varying distances from the center of the trapped area between July 27 and August 16, 1962, were as follows:

Miles from center	Number of hornworm eggs and larvae
0-3	28
3-6	29
6-9	49
9-12	66

The percent reduction for 9-12 and 0-3 miles was 57.6. Differences between these means were not significant, but the percent reduction was about the same as the reduction in female populations indicated by the trap catch in table 7.

Table 7 indicates that the reduction in population in the trapped area was much greater for males of both species than for females. It might be expected that the fertility of females would be reduced by the destruction of so many males. Two methods were used to capture moths for dissection. Some were caught in the ordinary trap cages where most moths remained alive until removed, and they frequently mated after being caught. Some traps were equipped with a can containing dilute alcohol in which the moths were killed when captured. The spermatophore in these species is easy to find. It is about the size of a grain of barley with a tube nearly an inch long.

Table 8 indicates that the percentage of mated *P. sexta* was higher in the cages than in alcohol, but there was no difference in *P. quinquemaculata*. This result is somewhat odd, since both species were often found in copulation in the cages. There was little, if any, difference in the fertility of females caught in the trapped area and outside. Table 9 indicates that multiple mating is not common in either species, but it does occur.

DISCUSSION AND TENTATIVE CONCLUSIONS

The role that light traps might play in the practical control of hornworms on tobacco cannot be determined on the basis of results obtained during 1 year in one location. The preliminary data obtained in the sizeable area of approximately 113 square miles utilizing about 3 light traps per square mile, indicate, however, that male hornworm populations in the center of the trapped area might be expected to be reduced by 76 and 89 percent, respectively, for *P. sexta* and *P. quinquemaculata*. The corresponding reductions in the population of females were 55 and 58 percent, respectively, for the two species. The population levels of eggs and small larvae on tobacco in the trapped area in comparison with tobacco in the surrounding untrapped area were about the same as the reduction in female hornworm population in the trapped area.

TABLE 8.--Fertility of female hornworm moths caught in light traps, July 25-29 and Aug. 14-Sept. 3

Miles from center of trapped area	Moths caught in cages				Moths caught in alcohol			
	P. sexta		*P. quinquemaculata*		*P. sexta*		*P. quinquemaculata*	
	Number	Percent fertile	Number	Percent fertile	Number	Percent fertile	Number	Percent fertile
0-3	30	76.6	46	78.3	69	66.7	55	60.0
3-6	67	85.0	93	67.7	84	66.7	61	70.5
6-9	79	87.3	63	66.7	52	63.5	59	66.1
9-12	155	86.5	154	70.8	116	62.1	125	77.6
Total or mean	331	85.5	356	70.2	321	64.5	300	70.7

TABLE 9.--Incidence of multiple mating in hornworm moths caught in light traps, July 25-29, 1962

Species	Number of females mated			Percent mated more than once
	Once	Twice	Thrice	
P. quinquemaculata	332	6	4	2.9
P. sexta	348	13	2	4.1

The influence of migrant moths moving into the trapped area in obscuring the total effect of the trapping operations cannot be fully assessed on the basis of data now available. The data suggest, however, that some additional reduction in hornworm moth populations above that achieved in this experiment could be expected, if traps of a like density were operating in an area of sufficient size to eliminate the influence of migrant moths. To appraise the significance of moth migration, it will be necessary to conduct experiments in larger areas or on the total population in an isolated situation such as an island.

Further experiments in different seasons to study higher or lower population densities and the effect of variable factors affecting hornworm abundance and survival in different areas must be undertaken to make a reasonable appraisal of the degree of control that will result from the use of light traps.

A change in cultural practices or a general reduction in the use of insecticides could lead to the survival of a higher percentage of the eggs and larvae that are produced by fewer moths, which could negate the influence of the trapping operation.

Irrespective of the influence of such variable factors, however, the results of the first full year of study in a relatively large area are regarded as encouraging. They certainly justify further investigations with every indication that the operation of light traps, integrated with other necessary control procedures, could materially contribute to more efficient tobacco hornworm control.

SUMMARY

A series of experiments were conducted in North Carolina in 1961-62 to test the effect of traps on populations of the hornworms *Protoparce sexta* (Johannson) and *P. quinquemaculata* (Haworth).

Traps using iso-amyl salicylate as a bait and spaced at quarter-mile intervals in an area of 3.14 square miles caught the most hornworms of both species in open fields and on the top of hills and caught nothing in wooded areas except at the edge. The mean catch for the season was very low in comparison with that for light traps and zero for the first 2 weeks.

When 14 light traps were scattered over 25 square miles and moths were marked and released, they dispersed rapidly in all directions. Many flew 3 to 4 miles in one night, and recaptures were made as far away as 8.2 miles. Five percent of the males of *P. sexta* moved 4.89 miles. When about three light traps per square mile were placed in a circular area 12 miles in diameter with a few check traps outside the circle, the mean catch increased gradually from the center of the circle outward to at least 6 miles beyond the edge. The percent reductions in population at the center were 76 and 89 for males of *P. sexta* and *P. quinquemaculata* and 55 and 58 for females. There was no difference in the fertility of the females. The reduction in populations of eggs and small larvae on tobacco between 9-12 and 0-3 miles from the center of the trapped area was 58 percent. This reduction was not statistically significant.

LITERATURE CITED

Gilmore, J. U.
1938. Observations on the hornworms attacking tobacco in Gennessee and Kentucky. Jour. Econ. Ent. 31: 706-712

_______ and Milam, J.
1933. Tartar emetic as a poison for the tobacco hornworm moths, a preliminary report. Jour. Econ. Ent. 26: 227-233.

Madden, A. H., and Chamberlin, F. S.
1945. Biology of the tobacco hornworm in the southern cigar tobacco district. U.S. Dept. Agr. Tech. Bul. 896, 51 pp.

Metcalf, Z. P.
1909. Insect enemies of tobacco. N.C. Dept. Agr. Spec. Bul., 70 pp.

Morgan, A. C., and Lyon, S. C.
1928. Notes on amyl salicylate as an attrahent to the tobacco hornworm moth. Jour. Econ. Ent. 21: 189-191.

Scott, L. B., and Milam, J.
1943. Iso-amyl salicylate as an attractant for hornworm moths. Jour. Econ. Ent. 36: 712-715.

Stahl, C. F.
1954. Trapping hornworm moths. Jour. Econ. Ent. 47: 879-882.

Stanley, J. M., and Dominick, C. B.
1958. Response of tobacco and tomato hornworm moths to black light. Jour. Econ. Ent. 51: 78-80.

UNITED STATES DEPARTMENT OF AGRICULTURE
BELTSVILLE, MARYLAND 20705

OFFICIAL BUSINESS

Postage and Fees Paid
U.S. Department of Agriculture