

Some Notes on the Biology and Control of Tomato Hornworms*

GEORGE E. GOULD, Purdue University

The common species of hornworm found on tomatoes in Indiana is normally *Protoparce sexta* Johan., although the other species, *P. quinquemaculata* Haw., occasionally becomes more abundant. Both species feed upon the foliage of the tomato plant and, when abundant, may eat into the green fruits. The two hornworms may be found together on the plants, although the relative abundance and life cycles of the two differ as does their reaction to certain insecticides. Serious losses from the feeding of these worms occur infrequently, although defoliation of plants in September is common.

In order to study the seasonal abundance and the damage of the hornworms, counts of the populations of five widely scattered fields around Lafayette were made at regular intervals in 1943, 1944 and 1945. In addition, counts were made in Botany and Entomology plots in these years and in 1946. The results of these counts given in Table 1 show that in two seasons the worms appeared early in July, while in the other two they appeared the last of July. The percentage of the true tomato hornworm (*sexta*) in the total population varied greatly but in three years out of the five increased as the season advanced. On the other hand, the total worm population in these fields reached its peak around August 1 in 1945 and 1946 and in late September in 1943 and 1944. In the latter two years when the worm population was high in September the worms also appeared early in the season.

Damage to the Indiana tomato crop by hornworms has seldom been serious over the entire state, but each year some sections have reported severe damage. The southern half of the state, especially the Vincennes area, has had some losses every year which at times have resulted in complete defoliation by late August. In the Lafayette area most fields were defoliated in late September in 1943 and many fields in 1944, while isolated outbreaks occurred about August 1 in 1945 and 1946. Extensive defoliation and the eating of green fruits of these early outbreaks caused more damage, according to growers, than the more populous late outbreaks in September. The destruction of the foliage late in the season exposed the fruit and hastened its maturity.

In making counts of worm injury in fields it was found difficult and time-consuming to locate all larvae. Consequently in the inspection either the worms or recent feeding was counted. The infestation in the fields varied considerably and was influenced by the date of planting, the

* In November, 1946, the common names of the two species of hornworms on tomatoes were reversed, so that the officially accepted common name for *P. quinquemaculata* is now the tomato hornworm.

TABLE I.—The percentage of tomato hornworm, *Protoparce sexta* Johan., and the percentage of parasitism in the total hornworm population found in tomato fields around Lafayette, 1943-1946.

Date	Percentage of all hornworms		Percentage of <i>sexta</i>
	during the season	parasitized	
July 6	1943	x	x
	1944	0	10
	1945	—	—
	1946	—	—
July 17	1943	5	—
	1944	7	12
	1945	No worms	—
	1946	No worms	—
July 27	1943	6	—
	1944	1	x
	1945	35	42
	1946	35	10
Aug. 7	1943	5	43
	1944	No worms	—
	1945	38	11
	1946	52	25
Aug. 17	1943	2	64
	1944	3	40
	1945	No worms	—
	1946	6	84
Aug. 27	1943	3	96
	1944	13	28
	1945	24	47
	1946	3	80
Sept. 10	1943	27	98
	1944	30	8
	1945	2	100
	1946	4	100
Sept. 20	1943	52	94
	1944	42	12
	1945	1	100
	1946	1	100

size of plants and the abundance of weeds. Weeds covering tomato plants and the early planting and harvesting of the crop greatly reduced the total number of worms, while in years such as 1943 and 1944 healthy, vigorous plants in September were stripped of foliage. In one field with light injury the count was 167 per 100 plants on September 23, 1943, while the following year no injury resulted on the same farm from counts of 123 on September 11 and 171 on September 22. On another farm where the yield was reduced 50 per cent by worms stripping the foliage and eating into the fruit, the counts on September 11 and 22 were 98 and 181 respectively. From observations in the various fields during the four-year period it was determined that a count of 60 per 100 plants around August 1 indicated possible damage from hornworms, while a count of 100 in late September indicated a dangerous population.

Both species of hornworm were found to overwinter in the soil as pupa at a depth of four to eight inches, with a few at a greater depth. The first emergence of moths in the spring varied with seasonal conditions, but usually occurred from June 15 to July 10. In 1946 an investigation of the unusual infestation revealed that 40 or 50 plants in a five acre field near Ash Grove were stripped on June 25. Since the larvae had already matured, it was assumed that eggs were on the Georgia-raised plants when set on May 30. The first moths caught at lights at Lafayette in 1946 were in early July.

Records from both bait traps using amyl salicylate and light traps were used in determining the seasonal abundance of the two species. A bait trap at the edge of a 14-acre tomato field captured 278 female and 166 male moths in 1943, while in 1944 the two species were separated with a count of 7 females and 10 males of *P. sexta* and 99 females and 51 males of *quinquemaculata*. In 1945 the trap was located on a farm several miles from where tomatoes were growing or had been grown in the previous year and captured 4 females and 4 males of *sexta* and 30 females and 6 males of *quinquemaculata*. Records from the moths caught at bait and light traps as well as field counts of larvae indicated one and at least a partial second generation of both species. For instance in 1943 the moth catch from July 20 to August 8 was low and the larval counts from August 12 to 24 were low, while in 1944 the moth catch from July 11 to August 2 was low and larvae were almost completely absent from July 26 to August 15. In addition, no larvae were found in 1945 on the August 17 inspection, while in 1946 larvae were scarce around August 20.

Moths of both species flew at dusk and were attracted to such flowering plants as petunia, Jimson weed and tobacco. Eggs laid by the females on the tomato foliage or stems hatched in three or four days in July and August and four to six days in September. It was difficult to separate the small larvae of the two species by the characteristic white markings of the large worms, but even in the first instar the red horn on the abdomen of *sexta* and the blue or black horn of *quinquemaculata* were quite distinct. The larval development of *sexta* required a period of about eighteen days in August with two days in

the first instar, three days each in the second and third instars, four days in the fourth instar and six days in the fifth instar. In September these periods were somewhat longer. The life cycle of *quinquemaculata* was similar to *sexta* and required about twenty-one days in early September.

At maturity the larva left the plant and entered the soil for pupation. Frequently larvae crawled several hundred feet before entering the soil.

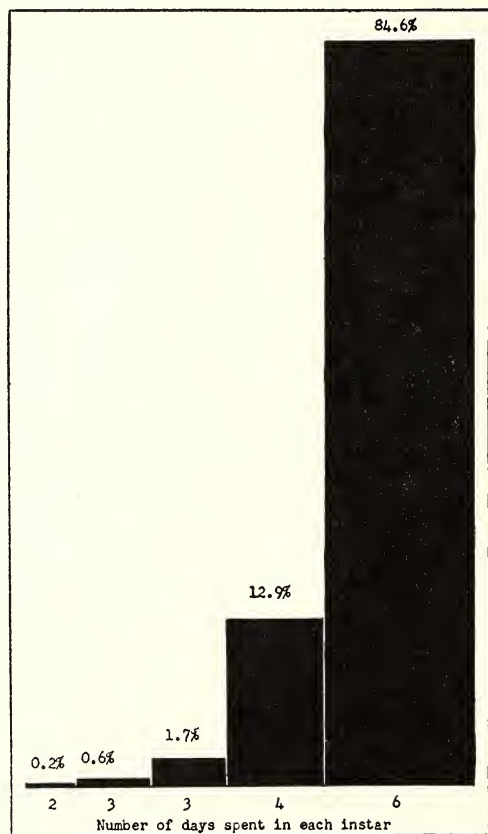


Fig. 1. The number of days in each larval instar and the relative proportion of the total larval food consumed in each larval instar of *Protoparce sexta*.

In cages the mature larvae did no feeding, but frequently crawled around the edge for hours and sometimes for days before pupation. Of eight mature larvae of *quinquemaculata* placed on a caged tomato plant from July 6 to 13 six moths emerged August 2 to 9, or approximately 26 days as pupae. The pupal period for larvae maturing around August 1 was about 30 days, although only a small per cent emerged. Larvae maturing in September did not emerge as moths the same season.

In the laboratory several larvae were reared, and their daily weight and the amount of tomato foliage consumed were determined. At hatching the larvae weighed about 2 mg. each and consumed about 2 sq. cm. of foliage in the first instar. In the fifth (last) instar larvae of *sexta* consumed 1420 sq. cm. of foliage in six days and reached a peak weight of 7650 mg. The larvae of *quinquemaculata* required a similar quantity of food although their weight was somewhat higher. The enormous quantity of foliage consumed in the fifth instar as compared with the other four instars is shown in figure 1 and indicates the importance of controlling the worms early in their development.

The hymenopterous parasite, *Apanteles congregatus* (Say), has been present each year, but the percentage of parasitism has varied greatly. Usually the parasitized worms were more abundant late in the summer, with the highest record of 80 per cent on August 27 in 1945. It was also noted that early in the season the parasite pupal cages were found on worms two-thirds grown or larger, while in September many of the worms dying from parasites were only a fourth grown.

In the past the standard insecticides for the control of hornworms have been calcium and lead arsenate. These two poisons were not effective at concentrations recommended for other insects, while at higher concentrations the possibility of poisonous residues on the ripening fruit had to be considered. Several of the new insecticides have been investigated to determine their efficiency in comparison with the standard materials in the control of hornworms.

Few tomato growers of the state have attempted hornworm control measures as suitable equipment has not been available, and, in addition, the expense of a sprayer or duster for tomatoes alone has seldom been justified by the infrequent worm outbreaks. Growers in the Vincennes area and tomato sections of southern Indiana have had some serious outbreaks and consequently have purchased some equipment. Row dusters and sprayers have been used on small tomato plants, but after the vines fill in the rows either spray booms must be carried over the plants or airplane dusting must be used. In the past six to eight years several thousand acres of tomatoes have been dusted one to three times each season for disease and insect control with a mixture containing an insoluble copper compound and about six per cent calcium arsenate. There has been no opportunity to check the efficiency of airplane dusting, but in tests on caged plants a 25 per cent calcium arsenate dust mixture was not satisfactory.

The hornworms used in cage tests were collected in the examination of fields and varied both in size and the proportion of the two species. In testing insecticides two methods were used: the plants were dusted or sprayed with the mixture and the larvae then placed on the plants, or the larvae were first placed on the plants and were hit by the insecticide application as it covered the plant. Screen wire cages were removed from the plants usually on the fourth day and counts were made of the live and dead insects.

In 1944 a 25 per cent calcium arsenate dust gave about a 66 per cent kill of *P. sexta* and *quinquemaculata*, while a 40 per cent cryolite

mixture was slightly better. A water spray containing .05 per cent DDT (dichloro diphenyl trichloroethane) killed small larvae of both species on the plant at the time of application and all small larvae of *quinquemaculata* placed on the plant one and three days following the application, while no small larvae of *sexta* placed on the plant the day after the application were killed. In five cage tests where the plants were dusted with a 3 per cent DDT 98 per cent of the *quinquemaculata* larvae of assorted sizes were killed and only 11 per cent of the *sexta* larvae.

In 1945 the .05 per cent DDT spray gave a 66 per cent kill of *quinquemaculata* and a 20 per cent kill of *sexta*. A three percent DDT dust gave 84 per cent kill of the former and a 25 per cent kill of the latter, while a 7½ per cent DDT dust gave an 88 and a 44 per cent kill respectively.

In 1946 two new synthetic insecticides in addition to DDT were given some preliminary tests. These materials were hexachlorocyclohexane or benzene hexachloride and a new chemical now called chlordane. The first of these materials has at present a persistent, musty odor which would probably be retained by ripening tomatoes. Improvements are being made in the material from the standpoint of eliminating the odor and increasing the gamma isomer, the toxic ingredient. A dust mixture of hexachlorocyclohexane containing .3 gamma isomer gave a 72 per cent kill of *P. quinquemaculata* and a 43 per cent kill of *sexta*. Chlordane prepared as a 5 per cent dust gave 73 and 30 per cent kills respectively, while a 2 per cent dust gave 91 and 43 per cent kills. Chlordane in an oil emulsion form gave an excellent but slow kill of the hornworms, with 84 per cent kill for *sexta* and 80 per cent for the other species. The 3 per cent DDT dust gave results similar to the two previous years with a kill of 20 per cent for *sexta* and 83 per cent for the other.

Summary. The two hornworms on tomatoes in Indiana have one and a partial second generation each year. The life cycle in July and August required about 50 days with 18 to 20 days of this time in the larval stage. In the fifth or last instar the hornworms consumed 87 per cent of the foliage eaten during the larval stage. The population of the two species varied from month to month in any season and from season to season. In three years out of five *sexta* became the predominant species in August and September. The identification of the species present in a field was important as it was found that *sexta* was more difficult to kill with some of the new synthetic insecticides. In cage tests DDT, hexachlorocyclohexane and chlordane gave fair results on the larvae of *quinquemaculata* but poor results with *sexta*. Although the hornworms were not destructively abundant in the state every year, isolated outbreaks did occur which often reduced the yields from 25 to 50 per cent.