

# THE SEASONAL BEHAVIOR OF THE JAPANESE BEETLE IN OHIO

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The study of the seasonal behavior of the Japanese beetle, *Popillia japonica* Newm., in Ohio began in 1942 in Cleveland, Youngstown, and North Salem. It was later extended to include the newer epidemic areas as they were found. Hawley (1944) reported that as the beetle moved north or south from the center of infestation in Philadelphia its habits and reactions have been found to change. Greater differences in behavior will probably be found as the infested area becomes larger. This paper is intended to show the behavior of the insect in Ohio in an average year and the differences in its behavior between different areas in the State.

During the 10-year period, from 1942 through 1951, population studies were conducted in 2 to 12 locations in the State each year. For example, in 1943, 2 areas were studied, 1 in Cuyahoga County and 1 in Guernsey County. In 1951, 12 locations were studied, 4 in Cuyahoga County, 1 in Lake County, 1 in Trumbull County, 1 in Columbiana County, 2 in Jefferson County, 1 in Guernsey County, and 2 in Washington County. The number of locations surveyed changed from year to year due to the fluctuation in the soil population in the area selected for study thus making it necessary to discontinue the study in some areas before new ones were found. Also, in some years the study had to be changed in order to have it fit in with the overall Japanese beetle research program.

The soil population was determined by examining soil samples and noting the number of individuals of each stage present. Each sample in the various locations consisted of (a) 100 specimens or (b) the number of specimens found in ten one-third square foot cores of soil. The samples were taken at weekly intervals.

The data for the years from 1942 through 1951 have been compiled and averaged in table 1 by 7-day intervals from April 2 to October 14 in order to determine the approximate distribution of the various stages of the insect in an average year. A wide variation was obtained in the behavior of the insect during the 10-year period, but as years with ideal conditions for the development of the insect offset those with unfavorable ones, the data presented in table 1 show what can be expected in an average year.

The data in table 1 show that a few third instar larvae of the previous year's overwintering brood were found in the soil as late as October 14. This condition was especially common in the Cleveland area in 1943 and 1944 when there was scant rainfall throughout the two summers. The soil was very dry early in the spring and summer of both years. This was responsible, undoubtedly, for the delay in the transformation of the larvae. In this and other areas a delay has been caused also by the larvae becoming infected with the spores of the milky disease supposedly late in May or early June. When this happens the transformation is or seems to be delayed as much as a month or more without the usual death and decay of larvae especially during seasons with a low rainfall.

These data show also that on October 8 to 14 eighty-seven percent of the larvae were in the third instar, eleven percent in the second instar, and less than one percent in the first instar. On April 2 to 8 of the following year ninety-two percent were in the third instar and approximately eight percent in the second instar. In the spring of 1951 a few first instar larvae were found in the Cleveland area during the period April 30 to May 6 and again during May 14 to 20. The survival of first instar larvae may have been due to the mild weather that prevailed during the

winter of 1950-51. Throughout the whole winter period there was a heavy snow cover with very little frost in the ground. These data would indicate that some first instar larvae can survive the winter under such conditions.

During the course of this study some deviation occurred from year to year in the seasonal cycle from that shown in table 1. For example, in 1941 and 1942, ninety-seven percent of the larvae overwintered in the third instar, while in 1943 and 1944 and again in 1950, the percent of third instar larvae going through the winter period varied from 60 to 79 percent in the different locations.

TABLE 1

*The average percent of the various stages of the Japanese beetle in the soil in the different locations for the period from 1942 through 1951.*

Date of Examinations	Number of Specimens Observed	Overwintering Instars			Pupae	Adults	Eggs	Instars		
		1	2	3				1	2	3
Apr. 2-8	257		7.7	92.3						
	583		8.1	91.9						
	705		10.6	89.4						
	1387		8.7	91.3						
Apr. 30-May 6	2132	0.3	12.8	86.9						
May 7-13	2115		15.6	84.4						
	3083	0.3	14.3	85.4						
	3332		11.7	88.3						
May 28-June 3	3322		5.1	94.5	0.4					
June 4-10	4876		7.0	88.0	4.7	0.3				
	3472		1.2	79.1	19.3	0.4				
	3438		1.1	51.6	42.2	5.1				
	2474		0.1	31.8	42.0	20.5	5.6			
July 2-8	2039		24.3	25.5	31.5	18.5	0.2			
	2172			9.8	8.6	11.7	59.7	9.2	1.0	
	2372		4.3	4.3	3.2	66.4	19.5	2.2	0.1	
	2202		2.5	3.6	4.0	55.9	31.4	2.5		
July 30-Aug. 5	2027		3.8	2.5	3.8	34.0	50.5	5.2	0.2	
	2319		1.7	0.8	2.2	22.6	56.0	15.8	0.9	
Aug. 6-12	1691		2.0	0.2	0.8	13.4	45.7	36.8	1.1	
	2101		1.4		0.9	8.7	35.4	45.2	8.4	
	1636		0.6		0.1	7.9	19.1	49.1	23.2	
	1328		1.2			3.0	9.6	31.7	54.5	
Sept. 3-9	1296		1.2			0.5	10.7	27.9	59.7	
	1593		0.8			1.7	3.5	19.5	74.6	
	495		1.4		0.2	2.6	6.5	23.2	66.1	
	714		0.3				1.3	11.8	86.7	
Oct. 1-7	535		0.7			0.4	0.6	11.2	87.1	

In order to determine whether the seasonal behavior of Japanese beetle stages in the soil varies in the different areas in Ohio, the State was divided into three sections later referred to as the southern, central and northern areas. The southern area falls between 39° and 40° north latitude, the central area between 40° and 41°, and the northern area between 41° and 42°. The data collected in the various areas on the seasonal cycle of the insect were compiled and averaged for the purpose of comparing the behavior of the species in the different sections.

From the data in table 2 it can be seen that the pupae appear about 10 days earlier in the southern area than in the central section and 14 days earlier than in the northern section. The difference is only 6 and 9 days in the adult stage, 0 to 6 days in the egg stage, 2 to 3 days in the first instar larvae, and no

difference to a slight reversal in development in the second and third instar larvae in the northern area. Based upon "Hopkins bioclimatic law" the appearance of the various stages in the southern section should have been approximately 8 days earlier than in the central and northern areas. No difference should be found between the central and northern sections because the greater elevation in central Ohio would tend to compensate for the difference in latitude. The data presented here agree with the law fairly closely during the fore part of the year but there seems to be some deviation from the expected result in the latter part of the year.

During the period from 1942 through 1951, traps were operated near each of the soil population study sites in order to obtain more information regarding the behavior of the adults during the summer. Ten traps were used in each location and the number of locations varied from three to eleven in the State each year.

TABLE 2

*Comparison of the average time of appearance of the various stages of the Japanese beetle in the soil in the southern, central, and northern areas in Ohio.*

Area	Average Time of Appearance of					
	Pupa	Adult	Egg	Instar		
				1	2	3
Southern	5-30	6-20	7-3	7-19	8- 2	8-23
Central	6- 9	6-26	7-2	7-21	8-15	8-27
Northern	6-13	6-29	7-9	7-22	8- 1	8-18

TABLE 3

*The average time of appearance of the first beetle taken in traps and the average peak of beetle flight in the southern, central, and northern areas in Ohio.*

Area	Time of Appearance of First Beetle	Greatest Number of Beetles Taken During Week Ending	50 Percent of Total Catch Reached Week Ending
Southern	6-23	7-17	7-21
Central	6-25	7-24	7-25
Northern	6-25	7-26	7-26

All traps were set out during the first week in June and removed during the second week in September. The traps were checked once a week during the summer except for the period from June 15 to 30 when they were checked daily for the purpose of determining the time the first beetle was taken in the traps.

Results of these studies were summarized and averaged in table 3 to show the average time of the first appearance of the adult in the traps and the average time the peak of beetle flight occurred in the three different areas in the State. The peak of beetle flight was determined in two different ways. By the first method, the peak was based upon the time the greatest number of beetles were taken in traps for any one week and by the second method it was based upon the time at which 50 percent of the total catch was taken. The data in table 3 were compiled for the 10-year period by averaging the times of appearance of the first beetle taken in the traps and also the time of the peak of beetle flight.

These data show that in an average year the beetles appear first in southern Ohio. However, the difference between the southern section and the central and

northern sections amounts to only 2 days. Slightly greater differences occur between the sections in regards to the peak of beetle flight. When the peak is based upon the greatest number of beetles taken in any one week, the difference amounts to 7 days between southern and central sections, 9 days between the southern and northern sections, and only 2 days between the central and northern areas. When the peak is based upon 50 percent of the total catch, the difference between the southern area and the central area is only 4 days, between the southern and northern sections 5 days, and only 1 day between the central and northern sections.

The first appearance of beetles in traps varied from June 17 to 28 in the southern section, from June 17 to July 5 in the central area, and from June 19 to July 3 in the northern section. The peak of beetle flight based upon the greatest number obtained in any one week varied from July 16 to August 6 in the southern section, from July 4 to August 11 in the central section, and from July 5 to August 14 in the northern section. When the peak of beetle flight was based upon 50 percent of total number taken, the peak varied from July 15 to August 3 in the southern section, from July 4 to August 6 in the central section, and from July 9 to August 12 in the northern section.

In summarizing the results of this study, the data indicate (1) that there are usually a few third instar larvae that are delayed in development and found present in the succeeding generation, (2) the seasonal development of the insect begins earlier in southern than in northern Ohio as shown by the earlier pupation and emergence, (3) development of the first, second, and third instar larvae proceeds at a more rapid rate in northern Ohio than in southern Ohio as shown by the average time of the first appearance of the various instars, and (4) the beetles appear and attain the peak of flight a few days earlier in the southern area than they do in the northern.

#### LITERATURE CITED

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