The Development of a Second Generation of the European Corn Borer, *Pyrausta nubilalis* Hbn., in Indiana

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When the European corn borer first entered Indiana in 1926, this insect was distinctly a one brooded form. Since that date, occasional traces of a second generation have been noted from time to time, but it was not until 1935 that sufficient second-generation borers were found to indicate a distinct trend toward a definite second brood of economic importance. During the past three years, the number of second generation borers produced has been so great as to become an important factor in corn borer increase. This transition of the borer to a two-generation form will alter several phases of the corn borer problem which up to the past three or four years have been thought of as being practically stabilized.

Pupation

Information on the pupation of the first generation larvae is fragmentary during the period up to 1935. In 1935 the first pupae were found in the field in DeKalb County, in sweet corn, on August 7; in 1936, on July 21; in 1937, on July 20; and in 1938, on July 14. Contrary to the development of pupation among the over-wintering larvae, the pupation of those larvae which provide the second brood occurs rather abruptly and apparently affects only the early larvae of the first generation.

In 1938 in Allen County, second brood pupation began on July 14 and was complete by August 8, a period of 20 days. In 1937, pupation began on July 30 and was complete on August 8, a period of 19 days. These periods, denoting the time when pupae are present in the field, are much shorter than the time required for the over-wintering larvae to pupate.

Table I.—Figures Showing the Percentage of First Generation Larvae Which Pupated in Dent and Sweet Corn in DeKalb County in 1938.

Sweet Corn		Dent Corn	
Planting Date	Per Cent of Borers Pupated	Planting Date	Per Cent of Borers Pupated
April 29	16.1	May 6	7.5
May 6	14.1	May 7	7.0
May 7	8.5	May 11	6.3
May 10	2.0	May 21	3.0
May 27	2.0	May 27	1.0
June 6	3.0	June 8	0.0

The fact that only the earliest larvae of the first generation pupate has been rather clearly indicated by the increased proportion of borers which have pupated in early dent or sweet corn fields as compared to the number pupating in later fields which receive only those eggs which were laid late in the first generation moth flight (Table I).

The percentage of larvae pupating to provide a second brood is variable not only in different fields but also in different localities. The highest rate of pupation has been found in early sweet corn fields, these being the locations in which the earliest eggs of the first generation moths are most frequently laid. Exceptionally early and vigorous dent corn fields also frequently show correspondingly high rates of pupation because of the influence of the height of the corn in attracting the first moths for the purpose of oviposition, but few dent corn fields have been examined in which the borers show as high a rate of second generation production as do early sweet corn fields.

The general trend toward an increased rate of second generation production in the more southernly locations of the borers distribution has been shown by examinations of fields from Steuben County southward to Wayne County (Table II).

TABLE II.—Percentage of Borers Pupating in Seven Counties in Indiana From Steuben County in the North, Southward to Wayne County. Fields Selected Were the Earliest Available.

County	Per cent Pupating in Early Sweet Corn	Per cent Pupating in Early Dent Corn	Mean
Steuben	2.10	2.00	2.05
DeKalb	16.10	7.00	11.52
Allen	8.00	14.5	11.25
Adams	8.00	19.5	13.75
Jay	11.11	19.6	15.30
Randolph	18.00	.....	18.00
Wayne	19.64	.....	19.64

The rate of pupation in Steuben County was 2%, and in Wayne County it was 19.64%. Other counties located between these localities showed intermediate degrees of second-brood production. These figures, while varying somewhat in individual fields, tend to indicate a transitional area in central Indiana in which the European corn borer is changing its seasonal development to provide for a whole or partial second generation.

Moth Flight and Emergence

The use of light traps during the past four years, to determine the period of actual moth flight, has shown a variable period of flight of first- and second-generation moths, both from the point of view of the time of flight and the duration of flight. The beginning of first-generation flight has varied from June 7 in 1938 to June 28 in 1935, and the

end of the first flight has varied from July 16 to July 23 during the same years. The duration of flight was longest in 1936, when moths were captured at lights over a period of 37 days.

The second-brood flight has varied in its first appearance from July 26 in 1938 to August 4 in 1937, and the duration of active flight in those years when sufficient moths were captured to indicate a well defined second brood has varied from 20 days in 1937 to 47 days in 1938. Weather conditions which favor or inhibit the length of life of the moths has made the flight periods either very short or, as in 1938, very long. Since emergence was complete on August 8 in Allen County, where the light

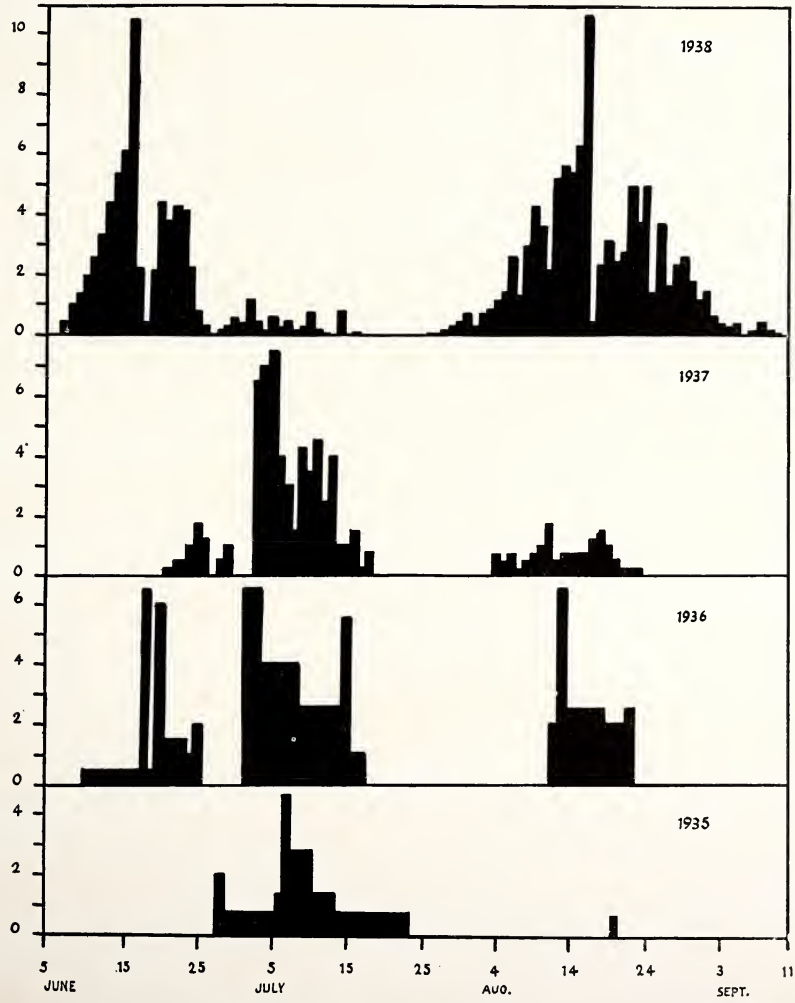

Fig. 1. Trend of moth flight as determined by light trap captures; 1935, 1936, 1937, moths per trap; 1938, moths per trap divided by two.

traps were situated in 1938 and where emergence was being observed, individual moths must have been in flight for a period of at least 34 days.

The proportion of first- and second-generation adults caught in light traps has varied from one second-generation moth to 23 first-generation moths in 1935, from one to 2.31 in 1936, and from one to 4.35 in 1937; and in 1938 the proportion of second brood adults to first generation was reversed and was 2.64 to one (Fig. 1). These figures do not necessarily indicate more moths in flight during the second than during the first generation, as the moths were in flight for a longer period of time during the second brood and the distance from which these moths drifted in to the lights could not be determined. With the longer period of flight after the completion of emergence, larger numbers undoubtedly drifted in from greater distances than in the first brood. In the first generation, moth flight ended 12 days after the completion of moth emergence, while in the second brood, moths continued to fly for 34 days after the last record of moth emergence in the field. Years of early first-generation moth emergence tend to show a higher degree of second-brood production by the European corn borer than do those years in which the emergence of the first brood has been delayed by seasonal climatic conditions.

Winter Mortality

The winter mortality of second-generation borers will be variable from year to year, depending on the stage of development in which the larvae go into the winter. This depends on the time at which the eggs are laid and the seasonal conditions in the fall which will permit the larvae to become mature. In 1935, second-generation larvae did not become mature before cold weather, and the winter mortality of second-generation borers averaged 98% in DeKalb County. During 1936 and 1937, moth flight and oviposition were complete by August 20, and the borers became full grown by cold weather. During these years the winter mortality was no greater than among first-generation larvae and was about normal. During the 1938-1939 season, a heavy winter mortality of second-generation borers may be anticipated as egg laying continued to September 11, and borers resulting from such late eggs will have little chance of becoming mature enough to pass the winter successfully.

Host Preference

So far as is known at the present time there has been little tendency for the second-generation moths to select host plants other than corn for oviposition. A single host other than corn was found during 1938 to be infested by the second-generation borers; this was gladiolus. Late corn is preferred to early corn by the second-generation, and many late fields carry higher borer populations, as a result, than do early fields. Populations of four plantings of dent corn, in experiments at Auburn during 1938, had populations ranging from 14 borers per 100 plants in corn planted on May 12 to 46 borers per 100 plants in corn planted on June 8. This condition was first noted in sweet corn plantings made in 1936, when sweet corn planted in five plantings between May 7 and June

14 had the following borer populations per 100 plants: May 7, 27.19; May 14, 17.02; May 28, .88; June 7, 0; and June 14, 21.48. Extremely early and extremely late plantings tend to carry the heaviest borer populations. This is particularly true of those fields in the southern area of infestation.

Discussion

The development of a second brood of corn borers in Indiana is important from the point of view of several factors. Heavy flights of second brood moths tend greatly to build up over-wintering populations and provide an increased abundance of borers for the succeeding season. Late-planted corn, which heretofore has been practically immune from corn borer, will be, and is being attacked. While the greater part of the second generation of borers became full grown too late in the season to reduce greatly the yields of dent corn, late sweet corn may be damaged to a severe extent. The additional flight of moths, which occurs when weather conditions are normally more conducive to longer life than earlier in the season, will undoubtedly hasten the spread of the borer to new territory and tend to build up populations more rapidly on the margins of the known infested areas. The possibility of an increase in the number of host plants is also an important consideration from the point of view of the damage the corn borer will do to such hosts and also from the greater difficulties encountered in effecting a satisfactory control where infestations might occur in host plants other than corn.