

THE LARVAL PERIOD OF DIAPREPES ABBREVIATUS L.

GEORGE N. WOLCOTT, *Entomologist*,
Insular Experiment Station, Río Piedras, P. R.

In proportion to its economic status, the weevil root borer of the West Indies, *Diaprepes abbreviatus* L., (= *spengleri* L.) has received surprisingly little careful study. Most of our information regarding the insect has been confined to the period of its aerial existence; what happens to the subterranean forms is for the most part inferred rather than known. The exclusively aerial adults, large weevils striped with black and white or bright colors, feed on the tender leaves of many kinds of trees and plants. Clusters of from ten or a dozen to several hundred oval eggs are laid between two older and tougher leaves glued together, hatching of the grubs occurring in six to ten days. The grubs do not burrow thru the leaf, all such holes being made by the wasp parasites, but wiggle out from between the leaves, dropping at once to the ground, into which they burrow. From the beginning, they feed only on live vegetable tissue, so far as known attacking all kinds of plant roots with impartiality. After a larval period presumed to occupy most of a year, pupation occurs in a cell at some depth in the earth. The pupal period is short, about fifteen days according to all observers. Some time may be spent as adult in the pupal cell, but once the adults have emerged from the earth, they never again return to it.

Injury to economic plants is caused by both larva and adult, citrus trees and sugar-cane being most often attacked. In Barbados, the insect is practically restricted in all host relationships to sugar cane: the adults feeding on the leaves, the females laying eggs between the split tips of the leaves, the young grubs feeding on the roots, the older grubs burrowing into the root-stalk, and the pupa often being formed in a cavity in the cane stool. Elsewhere the adults feed on the leaves of many wild and a few economically valuable plants, and the grubs are apparently unrestricted in their choice of roots on which to feed.

The range of the insect is from Barbados to eastern Hispaniola, and over this range the adults differ so greatly in color markings and general appearance that numerous varieties and species have been described, all of which, we are assured by the systematists, belong to but a single species. The variation in the size, color and habits

of the adults may appear in the grubs as a variation in behavior and length of the larval periods, for regarding the latter, no observers agree. Over thirty years ago, that enthusiastic amateur entomologist, the Rev. N. B. Watson, in Barbados reared a few individuals from egg to adult and determined the larval period as being from 300 to 312 days. A dozen years later, Wm. Nowell in Barbados found 261 days, 326 days and 334 days as the length of time before pupation for rearing immatures grubs of small size. Judging by the few completed rearing records, the larval period in Puerto Rico may be considerably shorter. Three grubs only, out of the hundreds used in the experiments that have been conducted here in the past two years, have been successfully reared from the just hatched larva to pupa, the larval periods for these three grubs being 202 days, 238 days and 268 days respectively. (See Table, p. 259.)

All of the grubs have been carefully observed as to molting; the one attaining the pupal period in 202 days pupating from the 10th larval instar, the one pupating in 238 days having attained complete larval development in only six instars, while the one requiring 268 days to become a pupa changed from the ninth instar. From such a small number of individuals, no generalization of value can be made, and indeed one can not be sure that these individuals pupating in such a short period are not exceptional rather than normal individuals. Other grubs have molted to the 16th instar, in one case after only 220 days, while other individuals have lived over a year as larvae. Not one of these other grubs, however, has succeeded in evading the varied perils inherent in the more or less unnatural conditions attendant on artificial rearing and constant observation, and most of them have died before pupation. Unquestionably, all of these grubs were sound and healthy in their earlier instars, while they were growing rapidly and making constant gains in size and weight, but having attained maximum weight, they entered a period of inactivity and failure to eat, a cul-de-sac from which the only escape was not pupation, but death. A few of these grubs are still alive, but the stimulus which will cause them to continue their transformation is not yet determined. Admittedly the present paper is incomplete and essentially preliminary. While the completed rearing records may be considered as finished and final, all the general statements made are tentative, and subject to change as additional results accumulate.

The first year's rearing was conducted at Isabela, the second at Río Piedras, and despite the fact that the same type of container, the same cabinet for holding the rearing boxes, the same food and in

many cases the same soil were used in both localities, the grubs attained full size in a much shorter time at Río Piedras. The factors of difference, so far as known, are three. The grubs were examined every week at Isabela, but at Río Piedras they could be watched more carefully, examinations being made usually three times a week. The water used to moisten the soil at Isabela was taken from the irrigation ditch; that at Río Piedras was city water which often was heavily chlorinated. The mean minimum air temperatures at Río Piedras averaged two or three degrees lower than at Isabela during the winter only, otherwise they were practically the same. How this affected the soil temperatures is problematical. The speeding up to growth in Río Piedras applies also to the total larval period, for the minimum of 202 days was obtained here, the other two records being of Isabela grubs. It was not a characteristic of the grubs themselves, for some of the grubs reared at Río Piedras were from egg-clusters collected at Isabela, others were from Florida (between Arecibo and Barceloneta), only the minority being obtained locally.

Various sizes of tin salve boxes have been used as containers, but finally the two ounce size was adopted for all work as being the most desirable. The soil used was that most readily available outside the laboratory door, the only selection being to eliminate large sticks, stones or other debris, the earth particles carried up out of their tunnels by ants often being selected. At first, soil brought from Isabela was used at Río Piedras, until a considerable expansion of the experiment required additional amounts, which were picked up locally. In many cases, previously discarded soil which had been thoroly dried or baked was used in preference to obtaining fresh soil from the garden. Moisture was added by means of a medicine dropper, attempting to keep the soil reasonably moist at all times, and only excessively moist when seeds were to be sprouted.

As food for the grubs, corn only was used at first; later, fresh lima beans were added. As the lima beans were subject to rot, sword beans were substituted, the usual combination placed in one box with a grub being two grains of corn and one bean. So far as could be determined, the grubs fed on the corn or beans with strict impartiality, and apparently thrive equally well on either. To determine the effect of food on rapidity of growth, half the grubs from one egg-cluster hatching on October 5th were placed in cans supplied only with corn, the others in cans supplied only with sword beans.

In the first instar, the mortality was greater among the grubs supplied only with corn, so that only five survived, as compared with twice as many which lived to eat beans. Yet these five grubs eating corn averaged from two to fourteen days less time in reaching each instar up to the ninth. By the tenth instar, however, when all the grubs had ceased feeding, those which had previously eaten only sword beans molted nine days ahead of those previously eating corn. In the molt to the 11th instar, the corn-eating grubs were one day ahead, in the molt to the 12th, nine days ahead, yet in the molt of the 13th, their respective positions were again reversed, those which had eaten corn being three days ahead (214 days vs. 217 days). Such slight differences may be considered as due to individual variation, and indicate that no significance is to be assigned to food.

Extreme seasonal variation in abundance of adults has repeatedly been noted, yet adults are present at all times, and egg-clusters have been collected during every month of the year at both Isabela and Río Piedras. No special effort has been made to rear grubs from the eggs of every month, and indeed only minor differences are to be noted in rapidity of growth of the grubs during the warmest and the coldest months. It is possible that the grubs grow most rapidly during cooler (tropical) weather, and the majority of the rearings would appear to indicate this, yet so many individual exceptions are to be noted that it is by no means certain. Some grubs hatching from egg-clusters laid in December have attained maximum size in two months, or a little longer, but other individuals from the same cluster required as long, or longer, than grubs hatching out early in August. Individual variation is much greater than seasonal variation, some of the grubs from one large egg-cluster hatching in December requiring more than twice as long to make the same gains in size and weight as others from the same cluster. Some grubs are exceptionally slow in the earlier instars, others in the later growth instars, all from the same egg-cluster, and reared under as nearly as possible the same conditions. Individual variation in rapidity of growth does not follow the normal curve, for the majority of grubs are close together, making rapid gains in size and weight with none greatly in advance, but the minority strings out almost interminably behind. Some of the delayed minority may later catch up, or almost catch up with those which have made the most rapid growth at first, and others are permanently greatly delayed, yet they seem as healthy and normal as any others. (See Plate XX.)

No explanation can be given of the failure of some grubs to eat and grow as fast as others from the same cluster, more especially

when all were in the same container during the earlier instars. An abundance of food was available at all times, and the grubs were so active that they could hardly have failed to come into contact with it. Molting, however, at least during the earlier instars, is to some extent dependent on soil moisture, being inhibited when the soil is dry, but ensuing within a few minutes after a sudden access of water. Wm. Nowell is of the opinion (2) that pupation also normally follows spring rains after the comparatively dry winter weather of Barbados, but no pertinent observations on this point have been made in Puerto Rico.

The larval period of *Diaprepes* grubs falls into two parts: (1) a period of constant and rapid growth, extending from hatching to about the beginning of the eighth instar, during which time the head-size of each instar is noticeably different so that each instar may at once be recognized by examining the grub itself, and (2) a period of equal or even greater length when the size and weight of the grub remains constant, or tends to decrease, extending from the eighth instar, or earlier, to pupation, during which period the number of molts can be determined only by keeping track of the molted skins. In the first period, the grub is feeding most of the time, in the second it eats little or not at all. Some individual grubs in the second period molt almost as frequently as previously, but most of the grubs at much greater and very irregular intervals. Individual variation is even more marked than in the first period, and the problem of maintaining the grubs alive and healthy becomes increasingly difficult. So few of the grubs have successfully passed thru this period of inactivity under artificial rearing conditions that most of the data accumulated concerning it is admittedly false. It seems very improbable that under normal conditions it usually ends in the death of the grub. All the activities of the insect occupy less than half a year, but this long, indefinite and indeterminate waiting period of the larva before pupation stretches out the life-cycle so that it will fit into the seasonal pattern of a year. It suggests that the insect should be better adapted to a climate inducing a long period of hibernation or aestivation, altho the period does not, or may not, actually coincide with any extended period of temperature difference.

Regarding the first period of activity and rapid growth we can be much more certain that the data accumulated are reasonably correct. Grubs in both periods have been weighed during all instars, not the same individuals, but ten or a dozen individuals in each instar, and, with some minor adjustment of these averages, we can be reasonably certain that the majority of the grubs in this first period make

steady and constant gains in weight. To be sure, this steady gain is interrupted at every molt, for every molt results in a small temporary loss, but if one considers the gain from about the middle of one instar to the middle of the four succeeding instars, the resulting curve will be a straight line. Starting with the newly hatched larva weighing .000125 gr. each, in each of the succeeding five intervals of ten days, at Río Piedras, (from hatching to the middle of the first instar, from the middle of the first instar to the middle of the second, from the middle of the second to the middle of the third, etc., each one of which is approximately a ten day interval at Río Piedras) the increase in live weight is *four* times: to .0005 gr., to .002 gr., to .008 gr., to .032 gr., to .128 gr. by the middle of the fifth instar. This is the period of most rapid growth.

Following it is a transition period of less rapid growth. From the middle of the fifth to the middle of the sixth instar, the interval is no longer, but the increase in weight is only *three* times, to .384 gr. From the middle of the sixth to the middle of the seventh instar, the interval is one-half longer, to fifteen days, and the increase in weight is only one and one-quarter times, to .48 gr. Individual grubs may weigh considerably more than this in the 7th and later instars, the maximum observed for any grub being .74 gr. for one individual in the 9th instar. The average weight, however, of those in any of the later instars is .5 gr. or a little less. Most grubs attain their maximum weight in the eighth instar. For most grubs, and for the average of all grubs, molting to the eighth instar marks the end of the period of growth and the beginning of the period of inactivity preceding pupation. At Isabela, the period interval between the middle of succeeding earlier molts, instead of being ten days as at Río Piedras, was fifteen days, and in addition to being one-half longer, began to lengthen earlier, to thirty days between the middle of the fourth instar to the middle of the fifth, and to forty days for the succeeding instars.

Up to the middle of the fifth instar, the grubs are of insignificant size so far as the damage they are capable of causing to the roots of plants is concerned, but the slowing down of their rate of growth coincides with the period when they are of sufficient size so that the result of their feeding activities is a very noticeable loss to the farmer. That they should grow so rapidly in the first two months results in no noticeable and obvious injury to well established plants, but their feeding in the next month results in the maximum injury they are capable of causing. This point is of the greatest practical im-

portance to farmers, especially those who are growing vegetables between young citrus trees for instance. The appearance of large numbers of adult beetles feeding on the tender leaves of their citrus trees is not only a direct loss of foliage but indicates that in from two to three months later the roots of these citrus trees and the roots of vegetables growing between them will suffer the maximum injury from the grubs hatching from the eggs laid by the female beetles. After this period of greatest injury to the roots, fully grown grubs may be present in the soil and around the roots for several months, but the injury they cause is all past. They are no longer actively feeding. Their growth curve has dropped to zero.

Two kinds of curves may be drawn to represent what has happened. The one representing relative growth is at a high level for the first two months, drops slowly at first but later with increasing rapidity in the third month, and by the fourth month is below zero, continuing here until pupation. The curve showing absolute weights is scarcely apparent in the first month, rises rapidly in the second month, makes enormous gains in the third month, a slight gain in the fourth month (but still at a high level), and drops only a little below this high in the succeeding months to pupation. Except in the latter months, it parallels the curve of injury to the farmer's crops, insignificant in the first two months, attaining a maximum in the third and fourth months, but again dropping to insignificant proportions later, when the grub has ceased to feed and is merely waiting for pupation.

BIBLIOGRAPHY

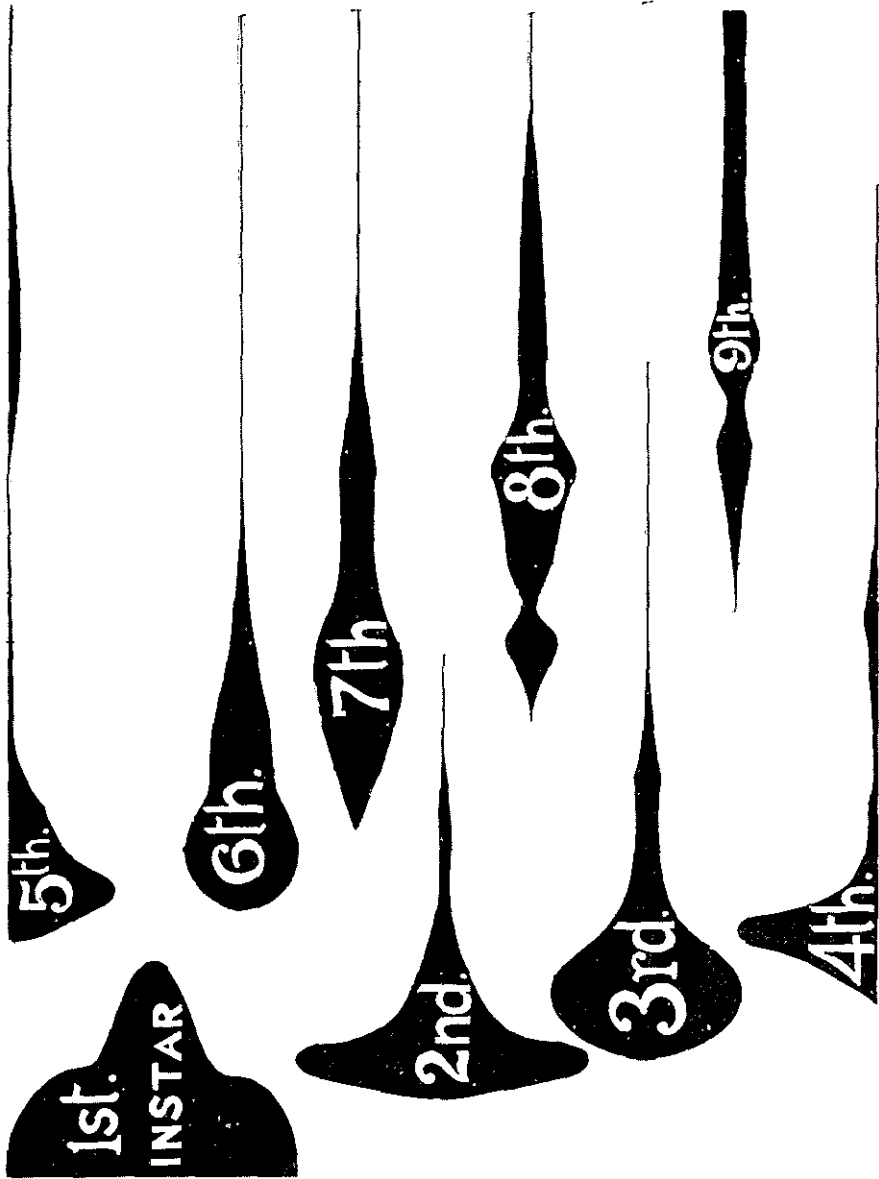
1. **Watson, N. B.**, "The Root-Borer of Sugar-Cane (*Diaprepes abbreviatus*)." West Indian Bulletin, 4: (1) pp. 37-47, fig. 3. Bridgetown, Barbados, 1903.

2. **Nowell, Wm.**, "Report of the Assistant Superintendent of Agriculture on the Entomological and Mycological Work carried out during the Season under review." Rpt. Dept. Agr. Barbados 1912-13, pp. 34-45. Bridgetown, 1913.

PLATE XIX.



Injury of caterpillars of *Fundella cistipennis* Dyar to pods of sword beans. Note only one uninjured pod of all those shown, the smaller pods being withered and about to drop, the larger ones being malformed by infestation at a later stage of growth. (Original).



Length of Larval Instars of *Diaprepes abbreviatus* L. at Río Piedras: total horizontal distance represents two hundred days, vertical distance indicates number of grubs. (Original. Drawn by Fernando Chardón.)