

The prevailing color of the body behind these segments is purplish-brown. Commencing with the first hump is a series of triangular pinkish markings on four segments plainly seen. Posteriorly the last two extend more towards the legs and stretch each side of the white V-shaped mark already mentioned—being separated therefrom by a darker band, which also forms a V (with the apex towards the head). There are also two small cream colored markings (like the "gamma" mark on some of the moths of the *Plusia* family) on each side just above the fourth pair of legs—on the same segment as the broad part of the white V, and just below it. The larvae are found on apple, plum, apricot and other plants. They are not plentiful nor likely to become so numerous as to be a pest. They, however, appear to have a fine appetite and eat a good many leaves without showing much trace of their ravages. The larvae often rest with their anal legs raised, and when in this position may easily be mistaken for part of a curled leaf with brown edges. The larvae are found in September; spin up in cocoons and produce moths the following June. The expanse of the male moth is 36mm. Both the larvae and perfect insects possess the well known characteristics of the *Notodontidae*, of which family this species is a branch. In the moth state the male is often attracted to light. The female, which is slightly different from the male in markings and shape of antennae, and somewhat larger, is less frequently seen.

GEO. O. DAY.

Duncans, B. C.

LIFE HISTORY OF OTIORHYNCHUS OVATUS, THE STRAWBERRY ROOT WEEVIL, UNDER LOWER FRASER CONDITIONS.

By R. C. TREHERNE, Dominion Field Officer.

The insect with which I wish to deal this afternoon is one which is becoming a large economic factor in the culture of the strawberry in the Lower Fraser Valley. There is no question at all that the depredations of this insect are causing considerable loss to the growers of this fruit not only in the Lower Fraser Valley alone, but also in those sections on the Pacific Coast where strawberries are being grown commercially and in large quantity.

I had an exceptional opportunity this summer for studying this insect, and I believe I have definitely determined some good points in its

life history. There are a number of points which require more corroboration by further experiments, consequently I wish this paper to be considered more or less in the light of a preliminary report founded on a few months' observations taken during the past summer (1912).

The weevil has been assigned a variety of names. We will find it referred to as the "Pitchy legged Otiorhynchus," "the Strawberry Crown Girdler" and the "Sleepy Weevil." I prefer to give it the name which heads this paper—the Strawberry Root Weevil—because it seemed to me that none of the names assigned to it are really applicable to its nature or appearance. It does not appear to affect the crown in any instance that I have observed, and it only feeds, I believe, on the roots of the plant which permeate the ground in all directions and which arise in a mass from the crown. Larvae can be found feeding on the fine roots 6 to 8 inches deep in the ground, and at depths varying from this to the roots on the immediate surface of the ground. Its numbers so far exceed those of its near relative, *O sulcatus*, that I feel justified in claiming this insect, under B. C. conditions, as the prime injurious species of the two and therefore more worthy of bearing the general name of the Strawberry Root Weevil or "Root Girdler."

DISTRIBUTION.

This insect occurs in B. C. at Hammond, Haney, Mission, Hatzic, Agassiz, Burnaby, on the shore of North Vancouver, in the Victoria district and in the interior at Vernon. Its distribution probably is general in the province, but at present it is only on the immediate coastal districts of B. C. that it has become an economic pest of first magnitude.

THE INDIVIDUAL EGG.

Is very minute, almost spherical, breadth .25mm. When freshly laid it is milky white in color, changing after a day to a pale shade of brown; the bounding membrane is hard and firm, and there does not appear to be any mucilaginous material on the exterior to retain it securely in the position it may be deposited in the soil or on the crown of the plant. The period of incubation lasts in the neighborhood of 21 days.

THE INDIVIDUAL LARVAE

Is characteristic of weevil larvae in shape and color; body lightly covered with minute hairs, white, sometimes colored pink or grey from the nature of the contents of the intestines, and slightly curved. The head is white at hatching, and after each moult, smooth, gradually assuming a light shade of brown as age increases; mouth parts a darker shade of brown to the color of the head.

The duration of the larval stage is, at least, seven months, the winter period being experienced in the middle of the stage, during which time the larva forms a rough earthen cell in the soil at varying depths and apparently becomes entirely dormant.

THE INDIVIDUAL PUPA

Is milky white in color, very soft and delicate. It lies in its little earthen cell in the soil, free and not enclosed by an special silken or shell-like device. The size approximately corresponds to that of the adult. The various parts of its anatomy are distinctly apparent, its legs, antennae, and elytra carefully folded on the ventral surface. The appendages are covered by a pupal membrane, which sloughs off as the adult stage is approached.

The pupal stage lasts from 21 to 24 days.

TRANSFORMATION.

Several days elapse from the time the pupa first changes to the adult in the soil and the time that the adult leaves the soil finally to assume its normal adult life and color. During this period the immature adult, which resembles the mature adult in all respects but color, gradually hardens its exoskeleton sufficient to withstand pressure through the soil and gradually changes its color from that of a white to that of a yellow. I would judge that at times fully five days elapse from the termination of the pupal stage to the assumption by the adult of a pale yellow color.

Furthermore, some additional days elapse from the time the adult has appeared on the surface of the ground to the time it assumes its fully developed normal color. I should judge that in some cases, at any rate, seven days elapse—making 12 from the pupa—to complete the full transformation. I cannot tell as yet what physical influences increase or decrease these transformation stages, under strictly natural conditions, as the records above were made under laboratory conditions.

THE INDIVIDUAL ADULT

Is dark brown, almost black, when fully developed, egg-shaped in general outline, about $\frac{1}{4}$ -inch long by $\frac{1}{8}$ -inch broad; thorax deeply pitted; elytra striated, convex and deeply punctured in the striae, fused together in a median line over the abdominal segments, consequently useless for flight and only serving for protection, very hard and horny, overlying the abdominal segments laterally and at the extremity posteriorly.

The duration of life of the adult without food, moisture or exercise, bred through from the nearly mature pupa, was determined by experiments thus far carried on, to be on the average of 42 days. Adults, fed but confined as used in the "egg deposition" tests, lived 67 days in some cases. There seems no doubt, however, that some adults are empowered by a greater degree of longevity under natural conditions than the instances mentioned above, for we find adults carrying over the winter on the surface of the ground, under shelter of rocks, boards and in crevices. There can be no doubt about this, for the last pupa was found in the ground in the early part of *July, so that if we only allowed three months longevity per individual we would expect to find no adults on the surface of the ground during winter. But we do; consequently 67 days duration of life becomes more of a minimum standard than a maximum. The adult insect has a peculiar habit of "playing possum" when disturbed, and it remains in this peculiar attitude for some time after interference. It does its feeding at night and is only active then. It remains dormant during the daytime, hidden in crevices of the soil, under leaves and debris. I am inclined to think that egg-laying is an entirely nocturnal affair. Chickens have been shown on several occasions to be fond of the larvae, and, I have no doubt, of the adults as well.

FOOD HABITS OF LARVA.

This insect is a general feeder. During the past summer larvae were taken in a clover and timothy grass sod, and larvae were bred to the adult on the roots of timothy grass alone in the laboratory. Larvae were also taken in the roots of the wild strawberry at sea level and at the elevation of about 500 feet. There is evidence to show that the larvae will feed, furthermore, and thrive on roots of the cultivated peach tree in cleanly cultivated orchards. There is no direct evidence as yet that potato plants in fields infested by this insect are attacked by the larvae, although larvae have been taken in volunteer potato plants in fields two years free from strawberry plants. The same has occurred with rhubarb, and there is a current opinion prevailing in the Lower Fraser plantations that crops following infected strawberries suffer to some extent and may take several years to recover. Popular opinion, on the other hand, claim that red or crimson clover is not

*This refers to the cultivated strawberry plantation. As a matter of fact, pupae were found in the ground in bush land and in uncultivated places two weeks later than this.

affected to any appreciable extent, and it is therefore recommended to be planted following a crop of infected strawberry plants.*

Rumex acetosella, a common weed in strawberry plantations, is also fed upon by the larvae of this weevil. It was curious to note that roots of this weed intermingling in the row with the roots of the strawberry plant, were chosen by the larvae for food in preference. This indicates the impartiality and general feeding characteristics of the larvae. Besides these few notes, literature on this weevil shows that the following plants have been recorded as attacked by the larvae: Roots of cultivated strawberry, blue grass, *Potentilla glandulosa*, *Balsamorhiza sagitata*, timothy grass, *Poa cerotina*, *Poa pratensis*, and white clover.

FOOD HABITS OF ADULT.

During this past summer, adults were seen feeding directly upon the fruit of the strawberry, on the fruit of the raspberry, on the vine, on a fallen peach on the ground, and also on a fallen apple. The foliage of the strawberry plant is devoured, but not, in my opinion, to any appreciable extent.

In literature further records are as follows: Foliage of raspberry and of the potato, both under natural conditions. Miss Patch, of Maine, has given a long list of plants fed to adults in confinement, which clearly shows that under laboratory conditions any kind of vegetation will offer itself as food to this insect.

SUSCEPTIBILITY OF VARIETY.

From the foregoing account of the feeding habits, larval and adult, I feel safe in claiming that *no susceptibility of any one variety of strawberry over any other exists, and vice versa, no immunity from attack can be claimed by any variety of strawberry.* This point is further borne out by observation in the field. Certain varieties of strawberries may resist an attack better than others, but this degree of resistance is not resultant upon any standard of immunity possessed by the variety so much as by the productivity and vegetative capabilities of that variety, viz., deep rooted and vigorous varieties, capable of producing a number of runners, which throw the heaviest yield the first spring from planting. The varieties recommended in this regard from Lower Fraser conditions are the Dunlap, Wilson, Warfield, Williams, and William Belt. The varieties not so suited are the Magoon, Clarke's Seedling, Jessie, and the Marshall.

*The inference is not intended that red or crimson clover is immune from attack, but rather that it is able to withstand an attack without apparent injury to itself.

NATURE OF INJURY.

Small irregular feeding areas on the edge of the leaves of the strawberry plant indicate the feeding habits of the adult weevil. The larvae attack the roots at all depths in the soil to which roots penetrate. Portions of the epidermis of the root forming longitudinal slits are devoured. This is evidently an initial stage leading either to a complete "girdling" of the root or to a longitudinal feeding area on the root, resulting sometimes in a spiral effect. Some larvae apparently pass from the egg to the pupa in the immediate surface zones of the soil, but the majority, at the approach of winter, burrow to the depth of four to six inches, some reaching the depth of eight inches. There is no doubt that the larvae are capable of moving freely in the soil (sandy loam), and there also appears to be a general tendency of the larvae in the first place to burrow downwards to the finer roots of the plants and then gradually work their way towards the surface as the period of pupation approaches. The roots therefore are attacked at all depths, the most serious damage being done in early spring, when the larvae are nearly full grown and thereby better able to attack the main roots of the plant. I have never seen any larvae feeding directly upon the crown of the plant, but I have evidence in plenty where roots have been "nipped off" two inches or so from the crown. Plants therefore thus attacked, with their root system considerably diminished, naturally suffer from the drying effects of the sun and wind, and this taking place conjointly with the period of blossoming and continuing as the fruit begins to set, greatly interferes with the yield and the profit.

We can, however, accept this maxim from the study of the life history of this weevil: that *if no injury to the plantation has become apparent by the end of June of one year, no further injury will become apparent that year, or, in other words, the plants attacked in the spring of one year, having reached their highest degree of injury by the end of June, for the remainder of the year tend to improve and re-establish themselves in the soil.* This point should be made use of in the matter of applying commercial fertilizers.

DEPOSITION OF EGG.

The customary places where eggs were found to be laid during the past summer were as follows: In the crevice made in the soil by the crown of the plant, on particles of soil filling the crown below surface, below debris directly on the surface of the soil and laid promiscuously in the soil to the depth of one-half inch.

Invariably the eggs noted in situ, as above, were laid singly and individually, apparently devoid of any adhesive covering, consequently easily detached from the place where laid.

Adult female weevils are capable of laying 50 eggs each, as shown by records of individual weevils in confinement and also hypothetically shown by the multiplication of the average number of eggs laid in one night by 59 female weevils, viz., 10.6, and the average individual period of egg deposition, viz., 4.72 days. The maximum individual period of oviposition is shown by notes in hand thus far to be 15 days.

PERIOD OF OVIPOSITION.

Egg deposition for the generation as a whole began about the date of June 22nd of this year (1912), and it continued until August 22nd, a period of two months. During this period of oviposition a summer migration evidently occurs. This year it took place for two weeks around July 8th, midway in the oviposition period. The object of the migration, whether it be for the purpose of distributing eggs on new lands or for the purpose of rest, still remains dark. I have undoubted proof that certain of the migratory individuals lay eggs; furthermore, there seems no doubt that the weevil has a strong tendency to remain localized in one area, provided that area offers sufficient food and protection.

MIGRATION.

In addition to the above-mentioned, there occurs a second migratory period in the fall. This apparently is purely for the purpose of winter protection and hibernation, but what proportion of the brood, in this case again, travels at this time of year, still remains a question for hibernating adults can be found the year round on the surface of the ground in a strawberry plantation.

INJURIOUSNESS.

Crops of strawberries grown on the matted row system are not as a rule seriously affected the first year from planting unless the ground was previously infected. The injury is noticeable the third summer, often reducing the crop fully 50 crates to the acre from what with reason might be expected. When a plantation is kept down for more than three years, the crop may be totally destroyed.

When these points are understood, the object of rotation on a small scale is interfered with and in many cases means no rotation at all, for although the piece of ground down to strawberries changes one

year with another, the weevil is fairly localized within the area and free to infest the crop which is being grown. Rotation, however, on a large scale is much more effective, because the weevil not only has to travel a greater distance to find the new plantation, but its egg-laying period is per individual comparatively short and the larvae are capable of feeding on the roots of most vegetation on the way.

Two things are certain that the presence of this weevil is very largely detracting from the profits of the strawberry industry as a whole, and that the injurious nature of this weevil is more particularly noticed on farms of small area, in fact, there need be little hesitation in saying that unless radical steps are taken to prevent the introduction of this weevil into strawberry plantations, or fight it when it is in, on farms of five acres or less, the continuous growing of strawberries will prove wholly unprofitable.

SUGGESTED REMEDIAL MEASURES.

(1.) Varieties of strawberries should be grown which, by reason of their vigorous nature, are more apt to throw the best returns in yield the first spring from planting. Such varieties are recommended previously in the text of this paper for Lower Fraser conditions. (See "Susceptibility of Variety.")

(2.) Chickens devour the larvae in the soil with readiness. Use should be made of them in a rotation with strawberries. (See "Individual Adult.")

(3.) Adult weevils take shelter during the daytime under boards, etc., and thereby can be easily trapped. This method, however, is only practicable by growers on a small scale. (See "Individual Adult.")

(4.) A plan may yet be evolved which takes advantage of the weevil's inability to fly. It can only crawl, consequently any evil-smelling mixture placed around a field or some sticky mixture placed around a field, may in time be originated. Thus far no method can be advised for immediate adoption. (See "Individual Adult.")

(5.) Arsenate of lead applied in the form of a spray immediately after the first crop is taken off, may be tried in certain cases when the adult weevils are so numerous as to warrant attention. Under ordinary conditions this method can only be recommended as a minor remedy. (See "Food Habits of Adult.")

(6.) Cyanide of potassium and carbon bisulphide gas are effective fumigants. The cost of the operation militates against their use. It may be stated here *that it is extremely doubtful that any remedy,*

which will eradicate or kill the weevil, egg, larvae or adult, can be devised, which will not at the same time destroy the plant.

(7.) Burning the crop is recommended, by application of a straw mulch on a day when a light wind is blowing.* *The whole efficiency of this measure depends upon the time it is done.* It should be done conjointly with the termination of the first crop. Every day's delay from this time reduces its efficiency, as the egg-laying period begins about June 22nd and continues till about August 22nd. The last crate of berries came off about June 29th this year (1912), and the adult weevils began emerging from the soil in the second week of June, reaching their maximum emergence about July 6th. The point, therefore, can be readily seen. (See "Period of Oviposition.")

(8.) Observing the dates given above (7), and noting the large proportion of weevils on the surface of the ground as compared to the number of larvae in the soil, which latter are reducing as the adults are increasing, it is recommended that the field be not ploughed up until at least the end of July or the beginning of August, thereby allowing the plantation to act as a trap crop for the emerging adults to deposit eggs in and preventing in a large measure the new plantation from attack. This course should be followed up by fall ploughing and as frequent cultivation as possible previous to or during winter. (See "Period of Oviposition.")

(9.) Fall planting is recommended for the Lower Fraser and can be followed with satisfaction. Possibly the same yield from the same area is not obtained as compared with the usual spring planting plan, but from the standpoint of the weevil, we must make some concession, and by planting after August 22nd, the benefit is apparent if the land is previously uninfected. (See "Period of Oviposition.")

(10.) A system of plant renewal is advocated during the middle of the *second* summer. This is accomplished either by burning or by the removal of the old leaves from the plants in July. An application of some commercial fertilizer—ammonium sulphate, nitrate of soda, or a complete fertilizer—would be found of most benefit to the plantation at this time of year. (See "Nature of Injury.")

(11.) The "one crop plan" of strawberry culture is recommended from the standpoint of the weevil and its nature, but from the standpoint of the local economics of strawberry culture in the Lower Fraser Valley it is not recommended. Those who cannot raise strawberries

*Care should be taken to see that the straw is not matted, but loosely laid so that there be no fear of concentrating heat at any one point.

on the "two year plan," owing to the depredations of the weevil, and who now prefer the "one crop plan," would in all probability obtain better financial results by substituting the "fall planting plan" for the "one crop plan." The "two year system" of strawberry culture is to be preferred when possible as being the most desirable plan of the three. The question of hill planting and the "four or five year plan" has many points in its favor, but it is not fully considered here.

(12.) Rotation of crops, while being strictly in accordance with the best agricultural practice, is strongly advocated against this weevil. From popular opinion, red clover is suited to follow strawberries, followed successively by potatoes and rhubarb. Growers with large acreage, under judicious management, can combat the effects of this weevil satisfactorily with proper rotation alone, assisted by general cultural methods, but the smaller growers of ten acres or less, more or less congregated into communities, as they usually are, will not find rotation the same comparative benefit as the large grower, although of course a benefit will be noticed. It may be tentatively stated that not more than one acre in ten should be down to strawberries in an infested locality so as to provide for a system of proper rotation.

THE HONORABLE MR. ELLISON, Minister of Agriculture, offered a few encouraging remarks to the meeting on their re-formation and evident progress. He said that he personally had been much interested in the discussions which he had been listening to, and he only wondered that more people were not active Entomologists to study these questions on insect pests which yearly cost the province so much. He assured the Society of his regard and promised to do all in his power to obtain for them the necessary financial assistance.

MR. WILSON, Chairman, briefly thanked the Honorable Minister for his kindness at being present and for his assurance of some financial assistance to the Society.

ADDRESS.

THOMAS CUNNINGHAM, Inspector of Fruit Pests.

Ever since the creation of man, and in all ages of man on earth, we have evidence from remotest antiquity that the agriculturist and horticulturist have suffered enormous loss by the depredation of destructive insects and plant diseases. No country in the world, as far as is known, is free from this scourge. Animals, including man, and plants suffer from infection.