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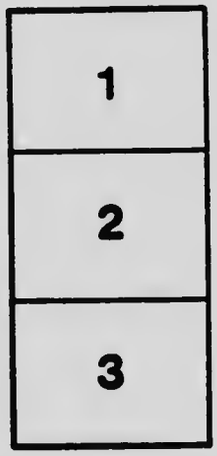

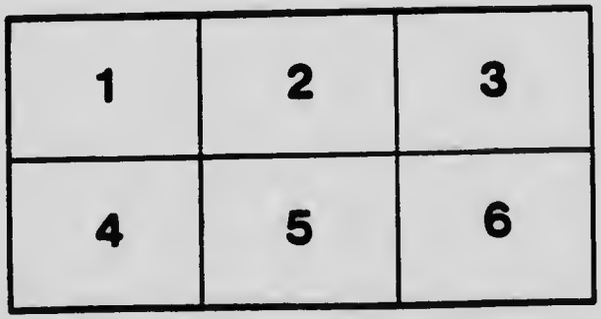

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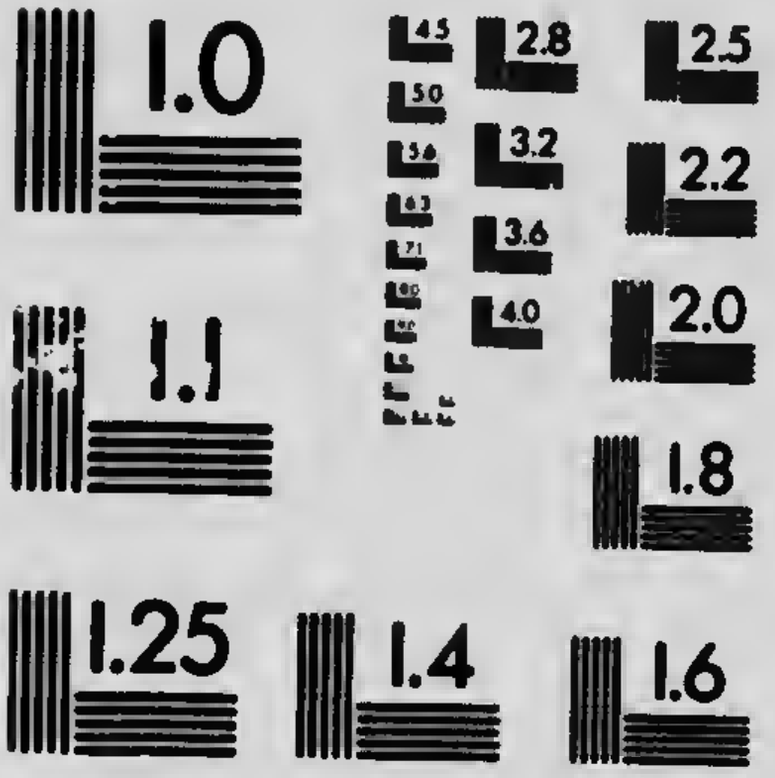

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DOMINION OF CANADA
DEPARTMENT OF AGRICULTURE
EXPERIMENTAL FARMS

DIVISION OF ENTOMOLOGY

Entomological Bulletin No. 8

THE STRAWBERRY ROOT WEEVIL

(*Otiorhynchus ovatus* Linn.)

IN BRITISH COLUMBIA

WITH

Notes on other Insects attacking Strawberry Plants in the Lower Fraser Valley

BY

R. C. TREHERNE, B.S.A.
Field Officer

BULLETIN No. 18—SECOND SERIES

Bulletins of the Second Series of the Bulletins of the Experimental Farms treat of such subjects as are of interest to a limited class of readers, and are mailed only to those to whom the information is likely to be useful

Published by direction of the Hon. MARTIN BURRELL, Minister of Agriculture, Ottawa

OTTAWA
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DOMINION EYPERIMENTAL FARMS,

Director, J. H. GRISDALE, B.Agr.

DIVISION OF ENTOMOLOGY

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NOTE.

All inquiries relating to insect pests, and packages (up to five pounds in weight) containing specimens, may be mailed "Free" as *third class matter*, not "parcel post," if addressed to the Dominion Entomologist, Department of Agriculture, Ottawa.

In all cases where it is possible, living specimens of the insects should be sent inclosed in a strong wooden or tin box to prevent damage in transit. Living insects should be supplied with a liberal quantity of their food plant, and in all cases they should be carefully packed.

The name and address of the sender should be written on the outside of the package, and a letter giving as full details as possible should in all cases accompany insects sent in for report.

OTTAWA, March 10, 1914.

SIR,—I have the honour to transmit herewith for your approval, Bulletin No. 18, of the Second Series, entitled The Strawberry Root Weevil in British Columbia, prepared by Mr. R. C. Treherne, B.S.A., Field Officer of the Division of Entomology.

As will be noted in the accompanying letter from the Dominion Entomologist, under whose supervision the work here reported on was conducted, the author of this bulletin carried on a very careful investigation and study of the Strawberry Root Weevil, and the results obtained should prove of value in the endeavour to combat its injuries.

I have the honour to be, sir,
Your obedient servant,

J. H. GRISDALE,
Director, Dominion Experimental Farms.

The Honourable
The Minister of Agriculture.

February 28, 1914.

J. H. GRISDALE, Esq., B. Agr.,
Director, Dominion Experimental Farms,
Ottawa.

SIR,—I have the honour to submit herewith for publication a bulletin entitled "The Strawberry Root Weevil (*Otiorhynchus ovatus* Linn.) in British Columbia, with notes on other Insects attacking Strawberries in the Lower Fraser Valley," which has been written at my request by Mr. R. C. Treherne, B.S.A., Field Officer of this Division, Agassiz, B.C.

The publication is based upon a careful study of the insect which Mr. Treherne carried out in 1912 and 1913, chiefly at Hatzie, B.C. The Strawberry Root Weevil constitutes the greatest obstacle to the successful growing of strawberries in certain sections of the Lower Fraser valley, a district eminently suited to the raising of this fruit. Our investigations demonstrated that the control of this insect was dependent upon cultural methods and the system of cropping, and for this reason these aspects of the problem have been fully discussed in addition to the economic questions involved in the control of the weevil.

I should like to take this opportunity of acknowledging our indebtedness to Mr. Arthur Brealey, of Hatzie, B.C., on whose farm the field experiments were carried out, thanks to his co-operation.

I have the honour to be, sir,
Your obedient servant,

C. GORDON HEWITT,
Dominion Entomologist.

CONTENTS.

THE STRAWBERRY ROOT WEEVIL.

SUMMARY OF LIFE-HISTORY.

Small dark brown beetles may often be found on the surface of strawberry plantations in the Fraser valley at the time the fruit of the spring crop is being picked. Often one will be seen on the packing table having been brought in by the pickers with the fruit it has been devouring. Later in the summer they attract attention again by their appearance in the houses. These are the adults of the Strawberry Root Weevil, *Otiorhynchus ovatus*. The larvæ or "grubs" of this species are found in the soil immediately around the roots of strawberry plants upon which they have been feeding. In these two stages they are liable to attract the notice of the farmer.

The eggs may be found, white to brown in colour, laid in a promiscuous manner in the soil near the roots of the plants. They will hatch, on the average, in 12-15 days but the period of egg deposition may be spread over two months (June, July and August). An individual female weevil will take from 5-15 days to deposit her eggs and she will lay approximately 50 eggs, on the average, of which about 40, that is, 80 per cent will hatch.

The larvæ emerging from these eggs work their way down to the roots, at times to the depth of 6 inches, and there commence to feed upon the roots, especially on those, at first, proportionate to its size. As the larva grows it works its way upwards towards the surface, still feeding. It will live as a larva from 10 to 11½ months. Taking cultivated and uncultivated land into consideration, larvæ will be found in the soil the entire year round, at varying depths and of varying sizes. They are white in colour and slightly curled, and attain a full length of 10 mm. They continue to feed on the roots of the plants until the fall when they become partially dormant, and so pass the winter. In the spring they continue feeding on the roots, gradually working their way towards the surface, where they pupate or pass into the dormant resting stage.

The pupa is formed in the soil from 1½ to 3 inches deep. It will be found to be pure white, incapable of feeding and only partially able to move. The individual stage lasts as long as 21 days, often less, but the pupal period extends over fully two months (May, June and July). As the pupa prepares to form the adult or full-grown stage, a gradual transformation takes place in the soil. The eyes form, the wing covers grow over the abdomen and fuse in the centre, and the whole insect assumes a yellowish colour, while it hardens its exterior. Eventually it will emerge from the soil to continue its life above ground. This transformation period lasts from 9 to 11 days.

The adult does not become active for several days, during which time it takes on a darker colouration until it is almost black. Its length is only about 6·25 mm. (¼ inch) It is only active at night, and then, except for two migratory periods during the summer, seems disinclined to travel very far. It will live for 42 to 53 days without any food at all, and about 62·5 days when food is allowed. Adults emerging from the soil late in the summer carry over a great part of the winter as adults under debris in the fields, under boards, or in the houses.

Eggs, as stated above, are laid during the months of June, July and August, and the full transformations through the larval and pupal stages to the adult insect is not completed until the following year.

SUMMARY OF REMEDIAL MEASURES.

The varieties of strawberries recommended to the average grower for the general market, and who prefers the "Two-year Cropping Plan," are the Dunlap, Wilson, Warfield, Williams and Willia. Belt. For special market requirements on the "One-year Cropping Plan," the Clarke Seedling, Magoon, Gandy, Jessie, Marshall and Brandywine are suggested.

Deep ploughing, deep cultivation, application of lime and stable manure, all previous to the year of planting, followed in June after the crop is removed, by the destruction of the old leaves and stalks, hoeing, handweeding and the application of a complete fertilizer, will be found the most expedient methods suitable to the culture of strawberries in a weevil-infested district. Fall planting can only be adopted in especially heavily infested localities.

The "One-Crop Plan" is recommended only for high quality berries, requiring careful management, in the field and on transit to special markets, whereby the increased price of the product offsets the reduced yield of fruit and the loss of the third season crop. The "Two-Crop Plan," *i.e.*, taking two main spring crops of berries from a plantation, coupled with suitable varieties is, in general, recommended for the average grower in the Lower Fraser valley, who is catering to the peculiarities of the general market. It is considered practically cheaper to handle a second season plantation on the matted row system than to prepare and reset a new plantation.

Ploughing the plantation at the termination of usefulness is best done *immediately* the spring crop is removed, especially on small farms of 5 to 10 acres. On large farms, owing to the rapid succession of other crops, ploughing is better delayed until September or October. Whatever the size of the farm, or prevailing conditions, it is advisable to plough at the end of June, or very early July, or let the ground remain untouched till fall.

The effect of crop rotation on large farms is marked, and represents one of the most efficient methods of controlling the depredations of the weevil. On small farms, the effect is not so marked. The use of chickens, in conjunction with rotation, is strongly urged, allowing them free range over the plantation following the summer ploughing.

Experiments have been carried on to test the efficiency of the following methods and substances as controls and repellents, viz.: Trap boards, trap lights, tanglefoot barriers, road oil barriers, gasoline torches, arsenical sprayings, soil injections and treatments by carbon bisulphide and powdered cyanide of potassium, but it was found that they cannot be recommended in practice. Repellents, such as powdered camphor, sulphur or fresh pyrethrum have no effect as a barrier against the migrations of the adult weevil.

INTRODUCTION.

The Lower Fraser valley is that portion of the province of British Columbia on the mainland, bordering the Pacific ocean, stretching inland from Vancouver some one hundred odd miles, along the two banks of the Fraser river. It comprises the important centres of Yale, Hope, Agassiz, Dewdney, Hatzic, Mission, Haney, Hammond, Burnaby, New Westminster and Vancouver, on the north shore of the Fraser river, and Chilliwack, Abbotsford, Mount Lehman, Ladner, Langley, Lulu Island, and the Delta on the south side.

Strawberry growing in the Lower Fraser forms an important branch of the small fruit industry of the valley. The fruit matures to perfection, and commands a good price on all the markets to which it is sent.

Of the insects which attack this fruit, by far the most important is the Strawberry Root Weevil (*Otiorhynchus ovatus*). A larger but similar species (*Otiorhynchus sulcatus*) is closely associated with *O. ovatus* in the strawberry

plantations, while it is probable that even a third species (*Otiorhynchus rugifrons*) may, on occasion, be found. These three species all have similar life-histories. The first named species in particular will be dealt with in the pages that follow.

Other root-feeding insects will also be found; none of them, however, have as yet proved themselves of economic importance.

There is a small chrysomelid root worm which, in its pupal form, closely resembles the pupal form of *O. ovatus* and may often, by the uninitated, be mistaken for the latter insect. The larval characteristics, however, are different. The presence of this insect up to the present, has not been sufficient to attract the attention of the grower, but there is little doubt that the larvæ feed, to a certain extent, on the roots of the strawberry.

Certain tipulid larvæ may also be found, but again, not in sufficient numbers to warrant attention.

Of the insects affecting the fruit and leaves, there are none that require the application of spray. The adults of *Otiorhynchus* undoubtedly feed on the foliage and fruit, but not sufficiently to denude the plant of leaves or to materially affect the yield of fruit.

Certain cercopids (spittle insects) which form objectionable masses of saliva-like material are annoying, but it is quite questionable whether it is feasible to treat these to reduce their numbers.

A species of *Aristotelia*, the caterpillars of which bore through and destroy the crown of the plants, has been reported from the Okanagan district, but not, as yet, from the Lower Fraser.

One species of Flea-beetle, *Haltica evicta* Lec., is reported affecting strawberries in British Columbia (Kootenay). Ground beetles (*Carabidæ*) are common to all strawberry plantations, and while the adults have been reported, in records, as devouring the ripe fruit, yet no actual proof of this is reported from British Columbia.

The larvæ of click beetles (wireworms) and of the Western June Beetle (*Polyphylla decemlineata* Say) have on occasion been reported as possibly injurious to the roots of strawberry plants in the province. Caterpillars of *Mesoleuca truncata* Hufn., a geometrid moth, are reported from Vancouver Island as injurious to plantations. Cutworms of the species *Scopelosoma tristigmata* and *Agrotis ypsilon* have proven destructive, at times, both on the Coast and in the Kootenay districts.

The Western Strawberry Crown Borer, *Tyloderma foveolatum*, is also recorded as a pest in the province.

It is fortunate, therefore, that the strawberry industry in the province is free, at present, from any outstanding insect menace that is not amenable to treatment. It is true that the larvæ of *Otiorhynchus ovatus* are detracting large profits from the industry, but, as will be pointed out in the pages that follow, by judicious care and management the ill-effects may be almost entirely eliminated. In the Lower Fraser Valley, with the exception of the above weevil, the industry is practically unencumbered at the present time. The industry of the Okanagan is, at present, not very large, and no notable insect trouble has presented itself. There is little doubt, however, that if the areas in strawberries increase in the future, the growers will be confronted with the attacks of the larvæ of the chief insect this bulletin describes, namely, *Otiorhynchus ovatus*. There is little doubt also that the *Aristotelia* larvæ will cause considerable trouble. More study on this latter-named insect is required, so as to be prepared for the future.

THE ECONOMICS OF THE SITUATION.

As has been pointed out in the introduction, the only insect which is proving of marked economic importance to the strawberry industry of the Lower Fraser valley is the Strawberry Root Weevil (*Otiorhynchus ovatus*).

It has been shown by experience that this weevil is capable of entirely destroying a strawberry plantation, the chief damage being caused by the larvæ at the roots.

In fact, in those areas where strawberries are being grown commercially, and in quantity, this weevil, if present, has shown itself quite capable of wiping out the whole industry or rendering it profitless. This setback to the industry has been proved in certain small fruit localities in the United States. In the Lower Fraser valley, particularly on the north side of the river, where the principal strawberry growing centres are located, this insect is very prevalent and, in a few cases, at any rate, complete devastation of the crop has resulted.

The strawberry industry is as yet quite small in British Columbia, and it is impossible to gauge with any degree of accuracy the proportionate area of strawberries grown now as compared with a few years ago. It is stated from various sources that the industry has declined in recent years, but the decline may not have been so much the result of the attacks of the weevil as of real estate advancement, poor marketing conditions, due, in the main, to lack of proper organization, and the cultivation of other more profitable crops. One thing is certain, however, that the presence of this weevil is very largely detracting from the profits of the industry as a whole. Its injurious nature is more particularly noted on farms of small area; in fact, there is little hesitation in saying that unless radical steps are taken to control the weevil in plantations of five acres or less, the continuous growing of strawberries will prove wholly unprofitable. Especially will this be noticed where the small farms are congregated and close together.

The force of this remark will be more clearly seen when the general habits of this insect are reviewed.

On farms of ten acres or more, it is possible to grow strawberries at a profit with the weevil present, provided judicious care is exercised in proportioning the area devoted to strawberries to that of other cultivated land. It may be tentatively stated or considered that no more than one bearing acre in ten should be planted to strawberries in a weevil-infested district.

The evidence points further that, as a general rule, the first main spring crop is not materially affected, but records from the season of 1912 indicate that the yield, at the time of the second main spring crop, in the third season of growth, is reduced at a minimum of 50 crates to the acre—a material loss.

If the plantation be allowed to continue for the fourth season, it has been observed that a very diminished and totally unprofitable crop is obtained.

It is also reported on occasions, that the first main spring crop may be so badly attacked as to necessitate ploughing before the crop is off. This is certainly unusual, but it demonstrates the possibility that is likely to occur if the weevil becomes permanently localized in a thickly populated strawberry growing community.

There are, of course, several other reasons accounting for possible loss in Lower Fraser plantations, among them being old plants, poor drainage, overproduction of bloom (owing possibly to the absence of timely spring frosts) inferior marketing facilities, and unsatisfactory labour in picking; but as these are chiefly economic and horticultural problems we are not much concerned with them.

Among insects, however, the only one that is producing an economic loss to the grower is the above-mentioned Strawberry Root Weevil. An insect, to cause an economic loss, must be one such that, as a result of its depredations on the plant attacked, the average annual cash value is impaired below the actual cost of production. When such is the case, the insect immediately warrants attention, but only to that extent whereby the cost of the remedy is within the margin of profit. The law of increasing and decreasing returns is variable in so far as individual conditions change and the costs of production vary, consequently

the financial limits for remedies applied vary in accordance with individual conditions.

The cost of producing an acre of strawberries on the matted row system in the Lower Fraser valley from the spring of planting to the removal of the first crop, varies from $400 to $460, including in this, interest on land, cost of plants, planting, hoeing, cultivating and picking.

The yield from an acre of berries on the matted row system, varies from 200 to 400 crates (24 lb.) and the gross returns, again, vary from $2·00 to $3·00, f.o.b., per crate.

The cause of these variations is, as stated, due to individual conditions, such as better soil, better drainage, better individual pickers, in short, better business ability and farm manipulation, as compared to conditions not so good. Consequently the matter rests with the individual grower to determine for himself his cost of production, his returns, and then, after allowing a reasonable rate of interest on his investment, to place the remaining cash value, if necessary, towards instituting remedial measures.

With regard to the control measures against the weevil, no annual artificial method of spraying, fumigation or trap setting has yet proved entirely satisfactory. Consequently, until such is found we are saved a great deal of trouble in estimating the outlay for annual expenditure in the matter of control. As will be pointed out in the pages that follow, any cost for control measures may be classed under the heading of capital expenditure, that is to say, some permanent erection, such as wiring or boarding, may be resorted to, which will remain in place for a greater or lesser number of years, and yet give equal service from year to year. Such an expenditure, coupled with suitable varieties, correct manipulation of the soil, and expedient rotation, will be found to offer the most satisfactory measures to offset the depredations of the weevil.

While it is not the object of this bulletin to enlarge on the horticultural problems at issue in the question, nevertheless, in so far as the remedial measures are mainly horticultural in nature, a few timely suggestions may be offered.

The choice of suitable varieties, for the Lower Fraser valley can be best decided from the following considerations, viz:—

(1) Strong, vigorous varieties, suitable to the district and very productive of fruit, adapted to general market requirements, and market prices, suitable for canning, not requiring too high a degree of cultivation, and capable of remaining remunerative in the third season of growth. Such varieties as Dunlap, Warfield, Wilson, Williams and William Belt are suggested.

(2) Medium growing varieties, suitable to the district, fairly productive of fruit, of fine quality, firm, large, adapted to special markets, requiring careful cultivation and handling, fetching higher prices to offset decreased yield, being grown especially for the "one crop" system. Such varieties are Magoon, Clarke's Seedling, Marshall, Sample, Gandy and Jessie.

The Lower Fraser valley is particularly well adapted to strawberry growing. The open winter, mild autumn, moist summer and early spring, coupled with fertile soil, lend themselves to promote the highest degree of remuneration from this crop. Satisfactory autumn crops are commonly obtained and, in this regard, growers are advised to consider this crop with more seriousness. To obtain the best results for the autumn crop three considerations are necessary:—

(1) The rejuvenation of the plants by removal of the old leaves and stalks, as soon as the last crate of berries has been picked.

(2) Hand-weeding in July.

(3) The application of a complete fertilizer, following weeding.

Deep ploughing, thorough cultivation of the soil and applications of lime at the rate of one ton to the acre in the fall previous to the following spring planting,

will be found to increase to a remarkable degree the productivity and yield of strawberry plantations in the Valley.

As will be seen later, these horticultural considerations are immensely more important and practical in the control of the Strawberry Root Weevil than any insecticide or artificial application, consequently, it behooves the grower to pay marked attention to these points: (1) choice of variety (2) cultivation of the soil; (3)crop management; (4) fertilization; (5) rotation.

Fig. 1. The Strawberry Root Weevil, *Otiorhynchus ovatus*, greatly enlarged (original).

COMMON NAMES OF *OTIORHYNCHUS OVATUS* LINN.

A variety of names have been assigned to this weevil. Dr. Lugger, in Minnesota Bulletin No. 66, refers to it as the "Pitchy Legged *Otiorhynchus*." R. A. Cooley, of Montana, and Edith M. Patch, of Maine, call it the "Strawberry Crown Girdler." Dr. Fletcher, of Ottawa, describes it as the "Sleepy Weevil." It has even been termed the "Graveyard Bug" from a local prevalence in a cemetery.

It appears, therefore, that there is some confusion in assigning it a name descriptive of its appearance and habits.

Considering the facts that the larvæ of this weevil work entirely on the main and fine roots of the plant and do not normally appear to attack or "girdle" the crown, and from the prevalence of this species in strawberry plantations over *O. sulcatus* or *O. rugifrons*, the name of the "Strawberry Root Weevil" is now suggested as a general name for *O. ovatus*.

GEOGRAPHICAL DISTRIBUTION.

This insect is believed by some authorities to be an introduced species from Europe. It is known to occur in Europe and in Siberia. It is recorded from the Atlantic coast* to the Pacific in both the United States and Canada.

On the Pacific coast, in Oregon, according to Mr. A. L. Lovett, of the Corvallis Agricultural College, it occurs principally along the northern boundary of the state in the Milton, Freewater, Hood River and Portland districts. It is not known to occur at the present time at a point south of McMinnville, in the Williamette valley.

In the state of Washington, according to Prof. A. L. Melander, of Pullman Agricultural College, it is to be found in the Puyallup, Tacoma, Seattle, Lake Washington and Spokane districts.

*A. L. Lovett. Biennial Crop Pest Report, 1911-1912, page 122, Corvallis, Oregon: Also Fletcher, J.; Report, Entomologist and Botanist, Annual Report Experimental Farms, Ottawa, 1904.

In the province of British Columbia, the first published report of its occurrence was in 1904, but there is little doubt that this insect was present several years previous.* It occurs throughout the entire Lower Fraser valley, including such localities as Vancouver, Hammond, Burnaby, Haney, Mission, Hatzic, Agassiz, being at present the principal strawberry growing centres.

On Vancouver Island it is recorded from Victoria, and doubtless occurs at points north of this. In the dry belts of the interior it occurs at Vernon. The weevil is particularly abundant in the moist, humid climate of the immediate coastal regions of British Columbia, where conditions are favourable to the growth of strawberries and to the life of the beetles.

LIFE-HISTORY.

The Egg.

The egg of this weevil is very minute, almost spherical, breadth ·25 mm. When freshly laid it is milky white in colour, changing after a day to a pale shade of brown; the ensheathing 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 incubation period is on the average of 15·11 to 20·15 days with a minimum of 12 days and a maximum of 25 days.

When the generation as a whole is considered, we find that the period in which eggs are laid in the field, extends over two months. More detailed reference to this will be made under the heading of "Period of Oviposition."

The young larva, preparing to emerge from the egg, can be seen through the shell of the egg resting in a curved position. It eats its way through the shell and emerges through an irregular-shaped rupture.

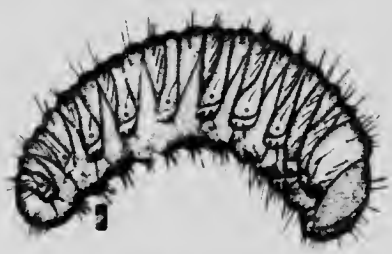

Fig. 2. Larva of Strawberry Root Weevil (original).

The Larva.

Description—When newly hatched, the larva is slightly longer than the egg from which it emerged and measures ·5 mm. It is a characteristic weevil larva in shape and colour. The body is lightly covered with minute hairs, is slightly curved, whitish, with a head of the same colour, but smooth. In a short time the head assumes a light shade of brown, the body remaining white, sometimes coloured pink or grey from the nature of the contents of the intestines. As the age of the larva increases the same characteristics are withheld, the mouth parts, however, assuming a darker shade of brown than the colour of the head.

*Since going to press, it has been noted that Harrington in Ent. Soc. Ont. Report, 1894, states that *O. ovatus* occurs commonly at Sydney, B.C.

"The full grown larva is three-eighths of an inch long by one-eighth of an inch wide; white, except the head, which is light brown, with the mouth parts darker and the edges of the jaws black. The head is smooth except for four transverse rows of light brown hairs. The body is arched; on each segment is a row of reddish brown hairs, curved at the tip on the back, but shorter and not curved on the under side. The dorsum, or upper part of each ring, is divided into three transverse lobes or folds, all except the first and the next to the last of which are smooth. On the under side of the first three segments are tubercles in place of feet; these possess stiff hairs. On the sides of each segment are two triangular tubercles, each bearing two hairs, one of which is but half as long as the other, a longitudinal fissure separates the upper row of tubercles from the lower."*

Moults.—At periodic intervals the larva moults. A small earthen cell is formed in the soil to suit the size of the larva and in this the larva lies in a curved position while it casts its old skin and takes on a new one. Freshly moulted, the head is white and smooth, but it gradually takes on the brown coloration of the mature larva. At least one moult occurs during the winter, when the larva is $\frac{1}{8}$ to $\frac{1}{4}$ of an inch (4 mm. to 6 mm.) in length.

Duration of larval stage.—The weevil is single brooded, and, as will be noted later, under "Period of Oviposition," egg deposition, under Lower Fraser conditions, commences about the middle of June. As already mentioned, the period of incubation lasts 15 to 20 days, consequently, the young larvæ commence hatching from the eggs during the latter part of June and early in July.

From experiments carried out it was noticed that the larvæ hatching from eggs laid in June, July and August, developed from one-quarter of an inch (6·25 mm.) to three-eighths of an inch (10 mm.) by October and November, and so pass the winter in the half-grown and in the full-grown states.

When the spring opens up, those larvæ that were mature in the fall probably transform immediately to pupæ in small earthen cells. The first pupæ are formed in the latter part of April and the beginning of May.

Those larvæ that were only 6·25 mm., or one-quarter of an inch in length in the fall, continue feeding on the roots until the beginning of July, when they in turn form pupæ and rest.

The great majority of the larvæ follow the example of the latter class and pass the winter as half-grown larvæ. This point is emphasized more strongly when it is observed that the greatest amount of injury to strawberry plantations takes place in the spring and early summer and not in the fall.

In the 1912 experiments in the laboratory, judging from the performances of 384 adults in confinement, egg deposition ceased on August 22. In 1913, owing to a cold and wet summer, this date was extended to the latter part of August. Allowing for the incubation period of 15 to 20 days, by the middle of September the greatest number of larvæ are in the soil. Such appears to be the case, for observations derived from field records demonstrate that on September 14, and on during the winter and spring, the greatest number of larvæ are present in the soil.

From these notes it will be seen that a larva hatching between June 15 and July 1, and reaching full growth by fall, pupates in spring between April 15 and May 1, thus representing a period of 10 months. It may, however, continue to feed in the spring until it pupates in the middle of July, representing a maximum period of 11½ months.

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*Weed, C. M., Mich. Hort. Soc. Rept. 1884, p. 85.
Oregon Biennial Crop Pest and Horticultural Report, 1911-1912.

The movements of the larvæ in the month of November are decidedly less than during the earlier months. The general movement of the larvæ is downwards during the later months of the summer, as borne out by the depths at which larvæ were found in September and October. It is interesting to note that experiments prove clearly the ability of larvæ to move in the soil.

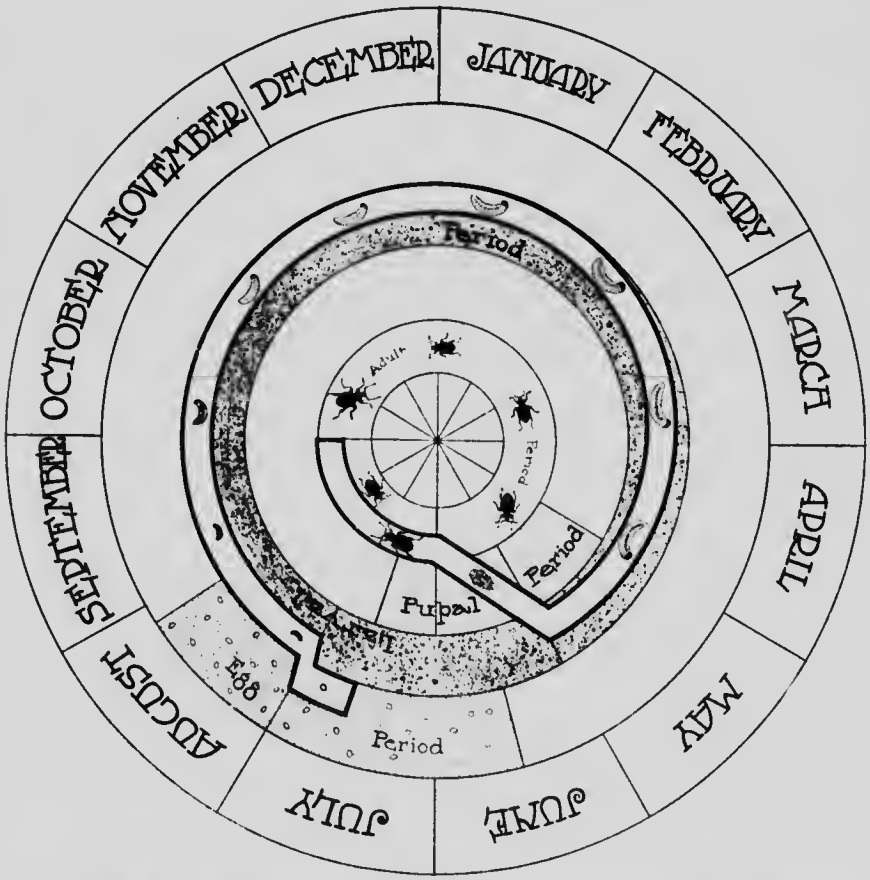

Chart illustrating diagramatically the life-history of the Strawberry Root Weevil (*Otiorhynchus ovatus*) throughout the whole year. The chart indicates that the eggs may be found from June to August; larvæ may be found in every month of the year; the pupal stages occur from the beginning of May until after the middle of July, and adults may be found all the year round. Within the heavy black line is shown the typical life-history of an individual insect (original).

Pupation.—As the period for pupation approaches, the mature larva, by continual feeding on the roots of the plant, has worked its way towards the surface of the soil. Here pupation takes place commonly at the depth of half an inch, sometimes two or three inches deep. Occasionally, however, it has been noted that some larvæ pass their entire life from the egg to the pupa in the surface zones of the soil. Pupation occurs in a rough earthen cell formed by the larva in the soil. As a small proportion of the larvæ becomes full grown by winter, it

is probable that some construct the pupal cell in the fall, though remaining unchanged till spring.

The Pupa.

Description.—The pupa is milky white in colour, very soft and delicate. It lies in its little earthen cell in the soil, free and not enclosed by any 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, antennæ, and elytra being carefully folded on the ventral surface of the body. The appendages are covered by a pupal membrane, which sloughs off as the adult stage is approached.

Duration of Pupal Stage.—The pupal period varies in duration in accordance with climatic conditions and influences. The evenings and nights of the Fraser Valley are usually chilly and cool, and this has the effect of delaying and lengthening the period of rest through which the insect passes previous to its transformation to the adult. It has been found that 21 days commonly elapse for this period in the Valley.

The change from the pupa to the adult takes place in the soil at the point of pupation. It has been observed that various parts of the pupal body gradually take on brown or yellow colourations; the eyes turn black and the mouth parts dark brown, while the wing covers gradually harden. When the exterior is sufficiently strengthened, the still immature insect works its way to the surface of the soil to commence its normal activities above ground. From 2 to 4 days elapse from the termination of the pupal period to the time when it escapes from the soil. Here on the surface of the soil beneath the debris of leaves in the plantation, the adult insect daily assumes a darker colouration until it is complete and normal in every particular. Individuals in captivity at times require 7 to 9 days to complete their full colouration after emergence from the soil.

The Adult Beetle

Description.—The adult, when fully developed, is dark brown, almost black in colour, egg-shaped in general outline, about one-quarter inch (6·25 mm.) long by one-eighth inch (3 mm.) broad; thorax deeply pitted, elytra striated, convex deeply punctured in the striæ, slightly shiny; antennæ, segments hairy, arising from the rostrum, elbowed, tapering to a slight enlargement at the tip. The elytra, or wing-covers, are fused together in a median line over the abdominal segments, consequently they are useless for flight and only serve for protection: they are hard and horny, overlying the abdominal segments laterally and at the extremity posteriorly; the legs specially adapted for walking are very strong. There is also a spur on the femur of each leg.

Duration of Life of Adult.—Adults, bred through from the pupa and confined without food or moisture, lived from 42 to 53 days.

The following notes are recorded in connection with adults held in confinement and fed during a series of experiments on egg deposition:—

—	Captured in field as adult.	Died.	Duration.
Weevil No. 7	July 18	Sept. 20	65 days.
Weevil No. 12	July 18	Sept. 23	68 days.
Weevil No. 17	July 18	Sept. 21	66 days.
Weevil No. 25	July 18	Sept. 19	64 days.
Weevil No. 36	July 22	Sept. 19	60 days.
Weevil No. 51	July 30	Sept. 19	52 days.

Average 62·5 days

Thus, 62.5 days represents a possible minimum duration of life when food is supplied.

As has already been noted under "Duration of Larval Stage," the first pupæ are formed in the latter part of April and the beginning of May. Allowing 21 days for the pupal stage and 9 days for transformation, we would expect to find adults emerging in the latter part of May and the beginning of June. Such appears to be the case.

Allowing two months for the normal duration of the adult stage, we would expect to find a mortality of the weevils at the latter part of July and the beginning of August. It was noticed that around July 6 the greatest number of adults are emerging from the soil. Allowing two months for the duration of life, we would expect the heaviest mortality around September 6. This, from our records, again appears to be the case.

The last pupa was found in the soil about the middle of July. Allowing a few days for transformation and two months for longevity, we would expect all adults to be dead at the latter part of October, and we would not expect to find any adults during winter or until the latter part of May of the following year. But, adults were taken early in May, consequently it is certain that a number of the insects pass the winter in the adult stage. Adults may be found the year round, in varying numbers on the surface of strawberry plantations.

FOOD PLANTS.

This insect in its adult and larval stages feeds upon a large number of plants. The following is a list of those plants reported by other observers and noted in our investigation as being attacked by *O. ovatus*.—

Attacked by the Adult.

Strawberry—fruit and foliage
Raspberry—fruit (on the cane) and foliage
Loganberry
Blackberry
Roses and other shrubbery
Borage
Currant
Muskmelon
Sorrel (*Rumex acetosella*)
Wild rose
Potatoes
Pears—fruit
Cauliflower
Wild buckwheat
Hemlock
Pumpkin
Wheat
Corn
Cabbage leaves
Cherry
Red clover
Apple—fruit
Dahlias—bloom
Orchid—fruit
Peach—fruit

Attacked by the Larvæ—(Attacking the root system.)

Strawberry (at sea-level and at 500 feet elevation,
Raspberry
Blackberry
Loganberry
Wild strawberry
Sorrel (*Rumex acetosella*)
Poa serotina
Poa pratensis
Timothy
Potentilla glandulosa
White clover
Hemlock
Balsam
Peach
Potato?
Rhubarb?

Adults in confinement under laboratory conditions, according to Edith M. Patch in the Maine Bulletin 123, appear to be capable of feeding on nearly every class of vegetation.

From the above records, it can be seen that this insect is a general feeder. No direct evidence has yet been received to show that the larvæ will feed on the tubers of potatoes or on the roots of rhubarb, although larvæ have been taken in the soil under volunteer potato plants, and rhubarb hills, on land two years free from strawberry plants. There is an opinion prevailing in Lower Fraser plantations that crops following infected strawberries, suffer to some extent, and may take several years to fully recover. This opinion is very reasonable, as the feeding habits of the adults and larvæ, coupled with the adults' structural inability to fly, would indicate. Popular opinion, on the other hand, claims that red or crimson clover, while not necessarily immune, is not affected to any appreciable extent by the larvæ. This is borne out by observing succeeding crops of affected strawberries.

Roots of weeds and grasses, intermingling in the row with the roots of strawberry plants, have been observed to be chosen as food by the larvæ in preference to the roots of the strawberry. This point indicates very clearly the impartial feeding characteristics of the larvæ.

It has been claimed from certain quarters that the adult weevil will completely strip a plant of its leaves. This has never been observed or reported in British Columbia, not even when as many as fifty adults were found in a square foot of row. The illustration (4) indicates the characteristic feeding areas on strawberry leaves by the adults.

SCEPTIBILITY OF VARIETY.

In consideration of the general feeding habits of this weevil, it is extremely doubtful whether there is any such thing as the susceptibility of one variety of strawberry over another or, vice versa, any immunity from attack by any one variety.

In the vicinity of Hatzic, a few years ago, it was commonly thought that the "Magoon" was peculiarly susceptible, in so far as it suffered heavily from the attacks of this weevil. But the "Magoon" at the time was the commonest variety grown, consequently the attack was more pronounced. "Magoons" now are being sparsely planted and "Dunlaps" are being grown in their stead and, as might be expected, the "Dunlaps" are reported the most severely attacked. During the season of 1912 a patch of "Dunlaps" growing beside a smaller patch of "Magoons" was observed to be the more seriously affected. Yet again, a patch of "Magoons" planted between two patches of "Dunlaps" were more severely attacked. Consequently, reports are contradictory, and it would appear that an infestation is governed by chance rather than by any special degree of preference. This is especially emphasized by the fact that clearly-defined areas of infestation may be observed in a plantation of one variety of strawberry and, further, from the fact that the adults are gregarious in habit. It can be stated, therefore, that so far as can be discovered, no greater susceptibility of any variety of strawberry over any other exists, and vice versa, no immunity from attack can be claimed by any one variety. Certain varieties of strawberries may resist an attack better than others, but this degree of resistance is not resultant from 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 question as to what varieties are peculiarly suitable from these considerations will be discussed more fully under the subject of "Remedial Measures"

Fig. 3. Two strawberry plants taken direct from the field at the same time. The left plant has been attacked by the larvæ of *Otiorhynchus ovatus*, the plant on the right being normal and healthy. Note how the roots of the attacked specimen have been removed close to the crown and two inches from it (original).

Nature of the Injury.

Small irregular feeding areas on the edge of the leaves indicate the feeding habits of the adult weevil. R. A. Cooley, in the Montana Bulletin No. 55, mentions the fact that the adults have been noticed occasionally to feed on the roots. Observations at Hatzic, in 1912, in the laboratory showed that leaf stalks are readily devoured. Under strictly natural conditions, however, uninfluenced by any experimental methods, the small areas devoured from the edge of the leaf, are by far the most common indications of the feeding habits of the adult. In Montana, further, it is reported that "the beetles came in such numbers, eating the foliage and boring holes in the stems, as to destroy the bed before it got a fair start." No such record as this has been taken in British Columbia, and it would appear that it would be a very poor stand of plants that would suffer in this way under local conditions in British Columbia, and especially in the Lower Fraser valley, where the growth is luxuriant and very rapid.

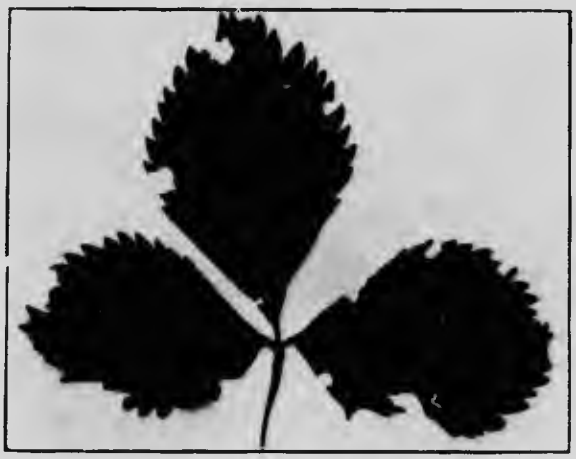

Fig. 4. Leaf of strawberry showing the characteristic injury caused by the feeding habits of the adult beetles. This leaf represents the worst injuries inflicted by a large number of adults kept in a confined area during the investigation. No instance has been recorded so far in British Columbia where adults of this weevil have completely stripped a plant of its leaves (original).

With the larvæ feeding on the roots, however, the case is different, and plants may be killed outright. The greatest amount of injury is caused in the spring when, affected also by the heat of the early summer sun, heavily infested plants wither up and die. A strawberry plantation may go into winter looking in splendid condition, even though the larvæ be present in numbers, owing to the fact that the larvæ are still small and their feeding not extensive, but in the spring the plants soon die, or the crop is considerably diminished. Furthermore, it is more or less characteristic of the larvæ to attack the fine roots in the latter part of the summer, at the extremities of the root systems, and work upon the larger and, consequently, the main roots in the spring, there being a correlation between the size of the larvæ and the root attacked. This again accounts for the fall and spring appearances of affected strawberry plantations.

In the spring time, an infested area can be deteeted some distance away The leaves of affeeted plants dry up and wither, giving a general grey colour to infested locations. The living shoots are short and stunted, and the berries are small and ill-shaped.

Three types of larval injury to the roots have been observed, viz., (1) the slit, (2) the spiral, and (3) the "nip."

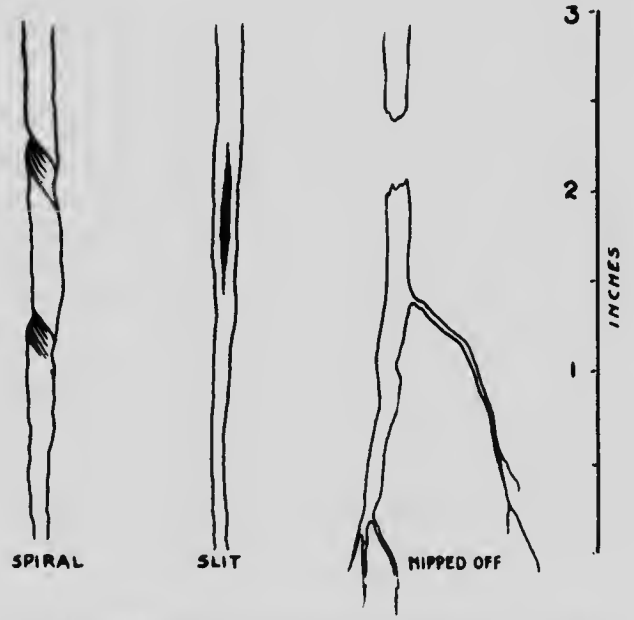

Fig. 5. Characteristic injuries to the roots of the strawberry plants caused by the larvæ of the Strawberry Root Weevil (original).

The larva will attaeh itself to a root suitable to its size and to its strength of jaw, and will eommenee to devour the epidermis. The growth of the natural tension of the root probably expands the ineision made by the larva to form a "slit." The larva may then feed on the eentral tissue of the root and may work its way up in a longitudinal or spiral manner, leaving a portion of the epidermis intact on one side. At times, and commonly, the larva will "nip" right through a root, severing the two parts.

The depths at whieh larvæ work has been dealt with in more detail in another plaee, (see page 9), but the eommon and exaggerated form of injury in the spring is where the larvæ have removed many of the main roots of the plants close to and within two inches from the crown. (See fig. 5). No direet evidenee has yet been received to show that the larvæ work direetly on or in the crown of the plant.

REPRODUCTION.

EGG FERTILITY.

To determine the percentage of egg fertility, a series of experiments were carried on with female weevils in confinement, and the following are the general results:—

From thirty-seven female weevils, 926 eggs were laid, of which 744 hatched, which indicates that approximately 80 per cent. of the eggs were fertile. These results were obtained under artificial conditions in the laboratory. It is probable that if they were obtained under natural conditions the percentage of egg fertility would be higher.

DEPOSITION OF EGG.

The age at which oviposition begins, following the emergence from the pupal state and the consequent copulation of the sexes, is a point which we can only gauge approximately. Weevils collected in the field and kept in confinement under observation determined the point in a general way. It was impossible to tell how many eggs the individual had laid previous to capture or when it emerged from the pupa, neither can we tell with accuracy what effect capture and confinement had upon the natural deposition of eggs in the laboratory.

With the above limitations, under laboratory conditions, on the average of forty-nine female weevils it was observed that a minimum of eight days elapse from emergence till the commencement of oviposition.

Eggs as laid naturally by the female weevil in the field, have been taken for the most part promiscuously on the surface of the soil, covered by surface debris, at a depth of one-quarter inch to one-half inch, and a few at one inch deep in the soil.

Some were observed in the crevices between the crown and the soil, others in the spaces and angles of an old crown, and yet others in the axils of leaf stalks partly covered by soil

PERIOD OF OVIPOSITION.

The time of year in which the weevil deposits eggs in the soil, extends, roughly, over a total period of two months. From notes received in 1912, the weevil commenced to lay eggs on June 22 and continued until August 22. The season of 1913 was a trifle later owing to more wet and cold weather, and the oviposition period was delayed somewhat. The period of oviposition then, under Lower Fraser conditions, begins at the latter part of June and continues until the latter part of August.

With the date June 22 representing the approximate date when adult weevils commence emerging from the soil to lay eggs and, after deducting a few days (eight) for the weevil to complete its growth, and mate, we find that the early part of June (June 15) fairly represents the period when the general emergence began. This was found to correspond favourably with the field records. Individual females are capable of laying in the neighborhood of fifty eggs, and the average of five days, with a maximum of fifteen days, has been noted as the duration of the oviposition period for the individual.

It is claimed by R. A. Cooley that in Montana the adult female weevils form small holes following the stems or leaves of the plants in the soil and that eggs may be found in these burrows. Such has not been shown to be the case in the Lower Fraser valley where the soil was of sandy loam, but as adult weevils are commonly to be found buried in the surface zones of the soil, presumably there for the

purpose of distributing eggs, it is possible that if the soil was clay, or less friable than in the Lower Fraser valley, these same tunnels might be found.

MIGRATIONS.

Two definite periods of migration occur during the course of the year, one in the early summer and one in the fall.

In the experiment performed to test the efficiency of "boards" as traps for the adult weevils, a series of twenty shingles was arranged around and about a young first-season strawberry plantation. Records were kept each day of the number and location of captured adults under the boards, and it was found that more or less definite routes of migration were adopted by the adults, which appeared to travel together with little regard for natural obstacles, as certain of the boards captured many beetles while others were left alone, no weevils being captured beneath them. From the middle of June and through July the migration continued; the heaviest migratory period, however, was in the first week of July (July 8), for at this time of year the greatest number of adults were taken from beneath the shingles.

In regard to the fall migratory period, no experimental data have been obtained. It is reported, however, from many quarters, that weevils would be found in numbers in the houses during the month of September.

No satisfactory solution can be offered as to the influences governing these two migratory periods. As the summer migration occurs midway in the oviposition period, and the fall migration occurs after all the eggs have been laid, the most reasonable solution appears to be that the former is for the purpose of distributing eggs on new territory and the latter for winter protection. There are objections, however, to both suggestions. In the first place, it seems to be a characteristic of the weevil to remain localized in one place, provided sufficient food and shelter is at hand, for we find infestation areas gradually extending their limits from some central area, one year after another.

It should be noted, in passing, that weevils captured under the boards in the above experiment, undoubtedly laid normal eggs in vials in the laboratory, which proves in part that the summer migration is for the purpose of distributing eggs on new land.

In the second place, adult weevils may be found the year round in strawberry plantations, and while it is conceivable that these in turn were migratory weevils, it is not probable, as the shelter offered by a well-grown plantation would appear to be all that is required for winter protection. The fact that adult weevils are taken in houses in summer and fall is no indication that the shelter of houses is specially desirable, as it has been shown by other experimenters that lights play no part in the attraction and that such infestation of houses is purely accidental. Consequently, no definite statement can be made on the reasons for migration, and the subject still awaits solution.

PROGRESS OF INFESTATION.

How a Field Becomes Infested.

In the "trap board" experiment there were ninety individual weevils captured between June 8 and August 14, 1912. The plantation (1½ acres),

as stated, was set in the spring of 1912, on new land; consequently, these ninety weevils were the forerunners of generations of weevils which would in two years' time cause the loss to the strawberry plantation.

Let us assume that in place of 90 weevils, 100 were captured. From our experiments we have arrived at the following data:—

(1) That fully* 34 per cent. of the weevils are females capable of laying eggs.

(2) That each female weevil can lay 50 eggs.

(3) That the percentage of eggs that hatch is 80 per cent.

Thus:

Summer 1912. (Planted May, 1912.)—
100 weevils migrate into field.
34 prove to be females.
1700 eggs are laid.
1360 eggs hatch to larvæ by fall.

Summer 1913. (First crop).
1330 larvæ feed, pupate, form adults.
462 prove to be females.
23,000 eggs are laid.
18,400 eggs hatch to larvæ by fall.

Summer 1914. (Second crop).
18,400 larvæ feed, pupate, form adults.
6256 prove to be females.

The plantation is usually ploughed during the course of the third summer (in July or August) and the act of ploughing forces 6256 female weevils, carrying 312,800 eggs into new land.

The above, of course, is merely hypothetical and not subject to natural conditions, for the mortality of larvæ and adults by predaceous insects is not taken into consideration, but it serves its purpose in demonstrating the rapid increase of the weevil in a plantation, and offers a possible explanation for the destruction of the plants following the second summer.

REMEDIAL MEASURES.

Natural Control.

Parasites, predaceous insects, predatory mammals, climate, structural characteristics of the various varieties of strawberries, and such methods of control, classed under the heading of Natural Control, are of great importance in the control of this insect.

Variety of Strawberry.—One of the most important of the remedial measures to be instituted against the weevil is the growth and cultivation of suitable varieties of strawberries.

*Sexes;—It is difficult to determine the sex while the individual is alive, but of the 160 weevils under observation in the egg deposition experiments only 55 laid eggs; thus 34·3 per cent. were certainly females.

It has already been stated under the heading of "Susceptibility" that it is very doubtful whether any condition of immunity or susceptibility exists among the various varieties of strawberries now in commercial use. But it was stated that it was most reasonable to suppose that those varieties that are deep rooted and vigorous would offer a better chance of withstanding an attack than shallow-rooted varieties, or those naturally unproductive of runners. The question as to what depth the roots of strawberry plants penetrate, does not appear to be so dependent on the matter of variety as on the character of the soil or the degree of cultivation previous to or concurrent with the planting of the crop. But we may assume that if certain varieties of strawberries differ in productivity under the poorest systems of cultivation, the same differences continue under the best.

The question as to which varieties throw many or few runners is based upon the characteristics of the various varieties themselves and, in connection with the presence of the weevil in a plantation, is of importance, for it includes the question of those varieties which throw their best returns the first or second year from planting.

The importance of this point is appreciated when it is considered that it is not usual to find plantations devastated or seriously attacked by the weevil the first year of planting. A study of the hypothetical increase of the weevil as mentioned under "Progress of infestation" will indicate that serious loss might be expected during the third summer, or coincident with the second main cropping.

Occasions have arisen, however, in which a plantation may be so badly affected previous to and during the spring of the first main crop that yields have been seriously impaired. Such occasions are more probably resultant from continuous planting on weevil-infested land or in close proximity to the same. As a rule, however, it is considered that a strawberry plantation is not materially affected by the weevil at the time of the first main crop, in the second summer of growth. The greatest degree of injury has been noticed (under the matted row system in the Lower Fraser valley) to take place in the spring and summer of the third season of growth.

From these considerations, therefore, hereunder will follow the commoner varieties of strawberries grown in the Fraser Valley, with notes on their vegetative capabilities:—

Magoon.—Hardy, good yielder, moderately productive of runners, fair shipper.

Jessie.—Berry large, fairly productive, requires careful cultivation.*

Brandywine.—Berry medium to large, moderately productive of fruit, runners very numerous, good market berry, suited to clay soil.*

Excelsior.—Berry large, very vigorous, fairly productive.*

Gandy.—Berry large, fine flavour, fairly vigorous and prolific under the best cultivation.*

Marshall.—Large firm berry, strong grower, moderately productive, needs high cultivation in clay soil.*

Mitchels Early.—Small berry, vigorous, prolific, used as a pollinizer.*

*Descriptions from the *American Fruit Culturist*, Thomas, 21st edition, 1903.

Sharpless.—Large often irregular berries, very productive, fails in some localities.*

William Belt.—Vigorous, setting an abundance of runners, berries large to very large, sometimes coxcombed. One of the best for home use.

Williams.—Medium size berry, good shipper, productive of runners.

Wilson.—Small to medium berry, hardy, exceedingly productive, succeeds well as a market variety. A good pollinizer.*

Buback No. 5.—Large sweet handsome berry, quality fair, moderately firm, hollow, light in producing runners, requires good cultivation, good near-by market berry.*

Glen Mary.—Very large sharpless seedling, fine quality, perfect flowered after the first few blooms, one of the best for forcing, light in runners.*

Greenville.—Large berry, vigorous grower and productive.*

Sample.—Medium to large berry, firm, of high quality, light in runners.*

Warfield.—Medium berry, firm, claimed to be very productive in certain soils. Good shipper and one of the best for canning.*

Clarke Seedling.—Medium to large berry, very firm, good shipper, moderately productive of runners.

Senator Dunlap.—Medium to large berry, good shipper, very productive and vigorous.

From the foregoing account of varieties, the grower can decide on the strawberry best suited to his requirements, bearing in mind that if he is situated in a weevil-infested district, the variety that will best withstand an attack is the one that is vigorous and productive of runners.

Mr. W. T. Macoun, Dominion Horticulturist, Ottawa, in a letter on the subject, states that he thought it was correct that Magoons were not as productive of runners as Dunlaps, in the first year of bearing, and "of the varieties of strawberries mentioned, the Wilson, Warfield, Williams and William Belt, should give the best crops the first year." "It is a question whether Brandywine and Gandy would give the best crops the first or second year, but it is likely that they would give the best crops the first year under good cultivation. Jessie, Marshall and Clarke Seedling would be more likely to give the best crops the second year."

Parasites.—No parasites have been bred from this species.

Predatory Enemies.—Among insects, the common carabid beetle, *Amara (Celia) fareta*† of the strawberry plantations of the Lower Fraser valley, plays an important part in controlling the numbers of the adult weevil, its pupæ and larvæ.

Both the adults and the larvæ of this carabid are useful in this regard. Frequently, fragments of elytra and appendages of the weevil may be found among

*Descriptions from the *American Fruit Culturist*, Thomas, 31st edition, 1903.
†Identified by Dr. E. C. VanDyke of San Francisco, Cal.

the débris in the strawberry row and, while the act of slaughter was not actually observed in the field, similar occasions in the laboratory leave little doubt as to the cause of death.

The adult carabids have also, in the laboratory, readily attacked the larvæ and pupæ of the weevil, which indicates with every reasonable degree of certainty that the same would occur in the field.

The larvæ of carabids are, in turn, well known to be predaceous in habit and as their numbers are quite appreciable in the soil of a weevil-infested plantation, it is probable that they also effect a radical control of the larvæ of the weevil.

There is at least one species of spider which has been observed in the field to attack the adults of the weevil. The spider will attack the weevil at the head end, and after holding it securely will make away at a great rate across the soil, towards its nest. Confinement of these spiders in the laboratory with live adult weevils showed that, on some occasions the weevils would be devoured, the various parts of the weevil being scattered about the tube, while on other occasions, no attention would be paid and the two would live together and stay alive for several days. It is sufficient to know, however, that to some extent at any rate the species of spider effects a method of natural control.

Probably the most important predatory enemy of the weevil is the common field mole. According to Railliet, the mole is essentially an animal feeder, capable of devouring approximately twice its own weight in a day, and that it is only under starvation conditions that it becomes a vegetable feeder.

The accompanying diagram (fig. 6) illustrates the characteristics of this mammal in the field. Its curious habit of circling completely round plants and doubling back on its burrow, leaves little doubt that its presence in the field is accounted for by the presence of the weevil larvæ at the roots. At other times it will form "searching burrows" in and between rows of strawberries, evidently prospecting for an area of infestation. Once such an area is found, the mole commences feeding, confining its attentions to one or more rows of strawberries.

While there is little doubt that the mole exerts a very beneficent influence against the numbers of the weevil, its action on the root system of the plantations is not only very annoying but harmful, and some growers attribute the greater injury to the mole. But as the mole is only secondary, in so far as its presence may be accounted for by the presence of the larvæ, and as it readily devours the larvæ whereas the larvæ devour the roots of the plant, it is probable that in a great measure, the injury caused by the tunnels of the mole is fancied. It is true the tunnels at times subject the roots of the plants to the drying action of sun and wind, but unless the moles are very abundant, the main root system of the plants is not disturbed to any marked extent, consequently no real damage results. It frequently happens that strawberry growers compress the soil around strawberry plants in the spring to offset any harmful raising action frost may have had on the plantation. If this is done for frost the same might be done for the mole.

Chickens, in their way, readily devour the larvæ of the weevil in the soil.

An effective and feasible plan for small farms (five to ten acres) combining chicken raising with the cultivation of small fruits is hereby suggested.

Arrangements should be made so that the chicken house is located at some convenient central point and then, as figure 7 represents, the wire netting may be arranged at right angles from the chicken enclosure to the boundaries of the farm. Thus the farm is divided into four more or less equal parts on which may be practised a four-year rotation plan. The manner and method of cropping is

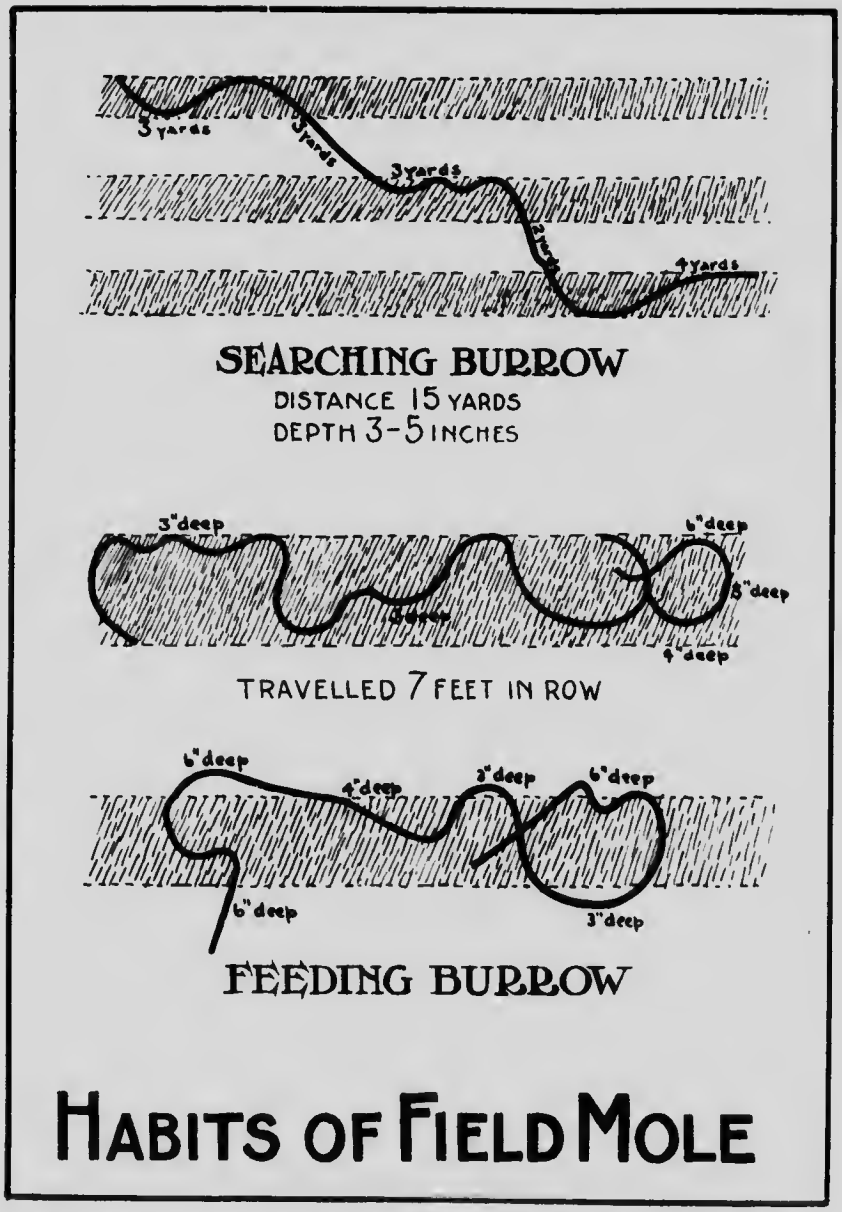

Fig. 6. Plans of burrows made by field moles in search of and feeding upon the larvæ of the Strawberry Root Weevil (orlginal.)

best left to the individual grower, but a combination of strawberries, rhubarb, potatoes, clover and ordinary truck crops is probably the most applicable to Lower Fraser conditions. Bush fruits, grown six or seven years in succession on the same plot of ground do not offer any interference to the plan. Orchard trees in turn may be planted over the whole or any part of the farm.

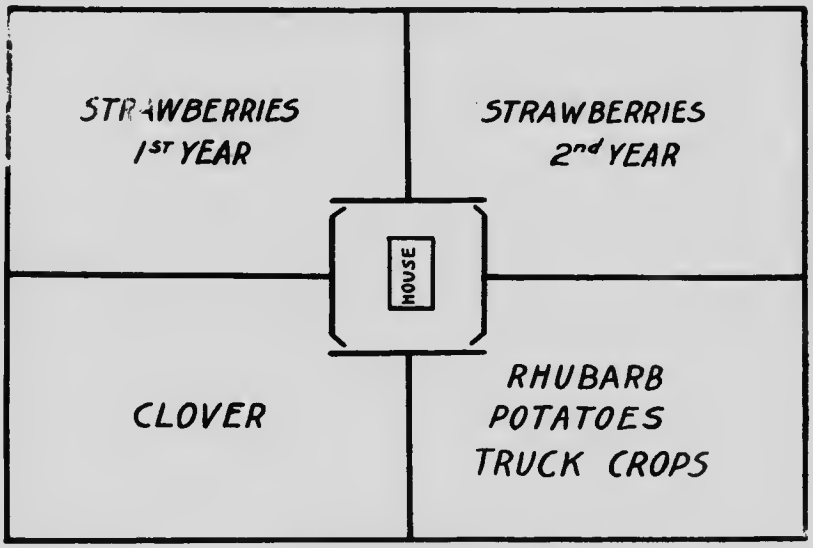

Fig. 7. Plan for division of land when poultry are used to clear areas under strawberries.

Immediately around the central chicken house an enclosure can be wired off to allow scratching ground for the chickens, and openings to each of the four areas should be arranged. In the latter part of June, after the second-year-old strawberry plantation has been picked and ploughed, the chickens may be allowed free range over that area. In this way the soil will not only be benefited by the chickens themselves, but a large number of the larvæ of the weevil and the adults as well, will be devoured. In the year following, the chickens may be allowed free range on another area, following the strawberry crop of that year.

There is one point that is very essential to remember in this plan. It is necessary to plough the old strawberry plantation *immediately* the last crate is shipped for the season, for the reason that the numbers of larvæ are decreasing in June and July, and the adults are increasing, and also owing to the fact that the weevil commences to migrate in numbers during the second week of July; consequently, unless ploughing is done, and chickens allowed access in time, the adult weevil will have matured and migrated to the near-by patch of strawberries.

Provided this plan is adhered to, the foregoing scheme should afford a reasonable solution to the strawberry grower, for experience has shown that where strawberries are being grown every year in a weevil-infested district, such as we have in most of the strawberry sections in the Lower Fraser valley, little success will attend the culture of the crop. As most of the farms are small in extent, and as most of the fruit growers produce strawberries in some measure

the small area practically necessitates the production of strawberries on the same piece of ground every other year. Rotation of crops, while being an elementary principle of successful agriculture, is also a necessity as a control measure against the weevil.

The weevil in nature is gregarious and is not inclined to move very far, provided an abundance of food is at hand.

As will be stated later, artificial methods have not proven themselves very applicable in the control of the strawberry weevil. We must resort to the cultural and natural methods to achieve any degree of success. In a combination of correct planting, suitable plants, rotation of crops, use of chickens and reliance on natural enemies will be found, under Lower Fraser conditions, the most satisfactory method of subduing the ill-effects of the Strawberry Root Weevil.

Cultural Methods Of Control.

introduction of the insect on plants.

It is frequently claimed by strawberry growers that the infestation of their lands has resulted from an importation of the eggs on the plants. This does not appear possible for two reasons; (1) The eggs are not glutinous and no special effort is made to deposit eggs at any particular place, in the soil or on the plant; and (2) while eggs have been observed in axils of leaf stems in the crowns of plants, the transplanting of strawberry plants takes place either in the spring or fall, either previous to or later than the period of egg deposition. There seems very little chance, therefore, of introducing the weevil or its eggs into new plantations through the medium of transplanting, consequently the fruit grower need have very little fear from this standpoint.

preparation of the soil.

In so far as deep ploughing and deep cultivation of the soil would be more likely to throw deeper rooted and more vigorous plants, the plough should be set six to eight inches, so as to give the plants every opportunity to outgrow or withstand an attack by this weevil.

The application of lime at the rate of one to two tons to the acre applied in the fall, every few years, will be found to increase the growth of strawberry plants to a large extent. Barnyard manure is preferably not applied during the years of the plantation, but during the growth of the crop preceding, thereby allowing weeds to grow and be killed in preparing the ground for strawberries. It is preferable to use commercial fertilizers in the month of July, or following the picking of the crop. Plants at this time of year are best assisted as the mature larvæ on the roots are almost absent, and the plants are recuperating and forming runners.

planting.

Commercial strawberry plantations in the Lower Fraser valley are more commonly grown on the semi-matted system, and planted in the spring. Growth in the valley is usually so luxuriant and rapid that wide rows and narrow interspaces are found impracticable for the successful culture of the berry and picking. According to Bulletin 21 of the British Columbia Department of Agriculture, "strawberry plants are grown in rows from 32 inches apart and 10 to 12 inches in the rows, to rows 3 feet 6 inches apart and 18 inches in the rows." An average distance is probably the most suitable in rows 3 feet apart and 15 inches in the rows.

Hill planting is apparently only practised in small areas on garden plantations.

The question of the best plan for a strawberry plantation in the Lower Fraser valley, in weevil-infested districts, can be discussed under several headings, viz., spring or fall planting, semi-matted row or the hill system, one-crop or the two-crop plan, for small or large farms.

SPRING VERSUS FALL PLANTING.

Assuming that a plantation is started in the spring of 1912, the following is a fair estimate of the yield (variety Dunlap):—

First Season of Planting.

In Spring.—A few crates to the acre may be obtained without injuring the plantation.

Fall.—A few crates may be picked three years in five.

Second Season of Planting.

In Spring.—An average crop of 250 crates to the acre may be expected. A wide variation of this amount occurs on different soils and under different conditions.

Fall.—Where a plantation is favourably situated and strawberries are being grown on a large scale, an average crop of 25 crates to the acre, three years in five may be expected. Growers claim to have picked as many as 50 crates to the acre between September and October in a favourable year.

Third Season of Planting.

In Spring.—An average crop of 200 crates to the acre is usually obtained. Here again a variation may occur.

Fall.—While it is not usual to continue cultivation and weeding during the course of the summer in anticipation of the fall crop, nevertheless, if this were done a fair crop might be obtained.

In regard to the fall cropping of strawberries the fertility of the soil and the favourable climatic conditions induce, probably three years in five, a profitable second setting of berries. Raspberries, on rare occasions, have been even known to bloom a second time in a year. It is only fair to say, however, that the majority of the strawberry growers, unless their acreage is extensive, seldom anticipate a profitable second crop, or deem it advisable to pick it owing to the cost of production. This may well apply to the cropping in the third fall, but provided the plantation is properly handled in the summer of the second year, a fair crop of berries might reasonably be expected in the second fall in the second season from planting.

It is advisable that a plantation be kept properly weeded and cultivated in the second summer to provide for the spring crop in the third season. This being done, the fall crop of the second year is rendered more accessible and no apparent harm will be exercised on the crop of the following spring.

Many growers practise a system of "plant renewal" in the second summer, to render weeding and cultivation easier and, at the same time, rejuvenating the plants. This can be done by burning, mowing or hoeing off the old leaves, forcing the growth of new and fresh leaves and shoots. Complete commercial fertilizers are best applied at this time of year, followed by hand weeding and horse cultivation. Under this system of management a satisfactory fall crop may be obtained.

From a spring plantation, therefore, carrying over from the spring of one year through the following year to the spring of the next year, an acre of strawberries may, on the average, produce a crop of 500 crates, probably worth, in gross receipts to the grower, approximately $1000.

IN FALL.

Experience has shown that strawberry plants may be set in the fall. This is not a common practice, however, the chief objections being reduced yield and the trouble of pressing the plants down in the spring after being raised by the frost.

The main point in favour of fall planting, despite a lessened yield, is the fact that the plantation may not suffer to any material extent from the weevil. It was noticed that the egg deposition lasts until the end of August, and by planting after this date one may be reasonably sure that no active migration will take place into that field until July of the following year, provided the field was clear at the outset.

It has been observed, further, that it is not usual to find plantations seriously affected at the time of the first main spring crop. The reason for this has been pointed out in "Progress of Infestation." A fall-planted crop, therefore, will not be expected to suffer much in its second spring crop.

The extent to which an attack by the weevil will reduce a spring-planted crop can only be gauged in a general manner. It is believed, however, that the usual degree of infestation will reduce the crop, at the time of the second spring crop, fully 50 crates to the acre, a loss of approximately $100. In severe centres of infestation the yield may be reduced very much more than this, but unless such an infestation is present the fall planting plan is not recommended, for the reason that the yield in crates is heavier in a spring-planted crop, and carries the balance in its favour. But as a consideration in a heavily-infested locality, the fall planting plan is worthy of trial.

SEMI-MATTED ROW VERSUS HILL PLANTING.

No experience of hill planting, coupled with a weevil infestation has been obtained in British Columbia, consequently no comparative data are available. As a matted strawberry row possesses more crowns than a strawberry hill, and as the fruit is borne from stocks arising from the crowns, it seems more probable that a matted row would be able to withstand an attack better than a hill.

THE "ONE-CROP" VERSUS THE "TWO-CROP" PLAN.

By the "one-crop" plan is meant that only one main crop of berries is taken off a plantation. When the plantation is allowed to run on through the summer and a second crop is taken off the following spring, such is referred to as the "two-crop" plan. Virtues of the two systems are about evenly divided and there are as many growers adopting one as the other.

Growers of the "one-crop" plan claim that it is easier and cheaper to reset a new plantation than to keep an old one clean. Others disclaim this, and state the main objection raised to the "one-crop" plan is that the returns to be made from a plantation occur following the picking of the second main spring crop, and the yield at this time allows for the loss of a crop and the use of the land in the first summer of growth.

As intimated previously, it is probable that some varieties of strawberries do better under one system and some under the other.

Again, there may be a difference in the degree of an attack from year to year and in this regard it would be well to remember that if a plantation is not seriously affected at the end of the fruiting season of one year, no further damage may be expected that same year.

Furthermore, the degree of injury at the time of picking is indicative of the prospective injury the following spring. All things considered, it is probable that on a large farm in a weevil-infested district, where rotation can be practised, the "two crop" plan is preferable, while on small acreages the "one-crop" plan, with the growth of a suitable variety is best. A large farm of forty to fifty acres can, by rotation and correct manipulation of soil and variety, successfully combat the effects of the weevil, while a small farm, confined within a definite area, is seriously handicapped. Attacks within a small area can be best alleviated by suitable varieties, the "one-crop" plan, and the use of chickens.

FALL PLOUGHING.

It has been pointed out previously (page 30) that it is advisable to plough the plantation as soon as the crop has been removed owing to the fact that the larvæ at the latter part of June are rapidly transforming to the adult state, thus leaving the soil more or less free.

It has been noticed also that the period of oviposition begins about the latter part of June and continues until the latter part of August; consequently, unless the plantation is ploughed at the latter part of June it seems advisable not to plough until fall, so that the field may remain as an attraction sphere for the weevil to deposit eggs therein. In this way the young larvæ will be distributed and turned up to the action of the frost. The larvæ, on their part, however, are capable of movement in the soil, consequently it is well to keep the field constantly cultivated in the fall. There is difficulty in doing this owing to the fact that strawberry plantations are frequently set between the rows of young orchard trees, and for orchard trees it is not advisable to cultivate too late in the fall. However, by judicious management after growth has ceased, this can be done.

The ploughing in June must also be frequently followed by cultivation or run over by chickens, otherwise its virtue would be lost, as the omnivorous habits of the larvæ and adults permit them to feed on weed growth as well as on strawberries. The question, therefore, as to when to plough the strawberry plantation is best governed by the size of the farm.

For small farms (five to ten acres) it is best to plough in the middle of June, followed by frequent cultivation or overrunning by chickens. For large farms (thirty to fifty acres), owing to the fact that other fruits quickly succeed one another and little time is available at the early part of the summer, it is best to plough in September and cultivate as often as may be deemed advisable.

ROTATION OF CROPS.

From the arguments that the weevil is: (1) gregarious in habit, (2) incapable of flight, (3) omnivorous in habit, and (4) possessing but few days per individual for oviposition, the question of rotation of crops is most important. Large farms with carefully considered systems of rotation, coupled with the other issues already mentioned, need fear little from the attacks of the weevil, provided that due judgment is used in proportioning the acreage in strawberries to the other crops. It is considered that not more than one bearing acre in ten should be under strawberries in a weevil-infested district.

The following two plans are offered as suggestions towards maintaining a ten acre farm in the Lower Fraser valley, when the strawberry weevil is known to be present These are not arbitrary or conclusive in detail, but are offered to the prospective fruitgrower as suggestions.

Rotation Plan 1.— *"One Year Cropping Plan."*—

1912—Strawberries set (May)
1913—Strawberries cropped, ploughed, fallowed.
1914—Clover sown.
1915—Clover hay, ploughed in fall.
1916—Potatoes.

1912—Clover sown.
1913—Clover hay, ploughed in fall.
1914—Potatoes.
1915—Strawberries set.
1916—Strawberries cropped, ploughed.

1912—Blackberries set for six years.

1912—Rhubarb set.
1913—
1914—
1915—Rhubarb cropped, ploughed, clover sown.
1916—Clover hay, ploughed, fallowed.
1917—Strawberries set.

1912—Potatoes set.
1913—Strawberries set.
1914—Strawberries cropped, ploughed.
1915—Clover sown.
1916—Clover hay, ploughed.

1912—Clover sown.
1913—Clover hay, ploughed.
1914—Potatoes.
1915—Rhubarb set.
1916, 1917, 1918—Rhubarb.

1912—Turnips and truck crops.
1913—Potatoes set.
1914—Strawberries set.
1915—Strawberries cropped, ploughed.
1916—Clover sown.

1912—Raspberries set for six years.

1912—Rhubarb.
1913—1914—Rhubarb.
1915—Rhubarb ploughed.
1916—Strawberries set.
1917—Strawberries cropped, ploughed.

Acre for house and buildings.

Rotation Plan 2.– *"Two Year Cropping Plan."—*

1912—Strawberries set.
1913—Strawberries, first crop.
1914—Strawberries, second crop, ploughed, fallowed.
1915—Clover sown.
1916—Clover hay, ploughed.
1917—Turnips and truck crops.

1912—Rhubarb.
1913-14— "
1915—Rhubarb, ploughed.
1916—Clover sown.
1917—Clover hay, ploughed.
1918—Potatoes.

1912—Raspberries set for six years.

1912—Potatoes set.
1913—Strawberries set.
1914—Strawberries, first crop.
1915—Strawberries, second crop, ploughed.
1916—Turnips and truck crops.
1917—Clover sown.

1912—Blackberries set for six years.

1912—Rhubarb set.
1913-1914— "
1915—Rhubarb, ploughed.
1916—Strawberries set.
1917—Strawberries, first crop.
1918—Strawberries, second crop.

1912—Clover sown.
1913—Clover hay, ploughed.
1914—Potatoes.
1915—Strawberries set.
1916—Strawberries, first crop.
1917—Strawberries, second crop.

1912—Clover hay, ploughed.
1913—Potatoes set.
1914—Strawberries set.
1915—Strawberries, first crop.
1916—Strawberries, second crop.
1917—Rhubarb.

1912—Clover sown.
1915—Clover hay, ploughed.
1916—Potatoes.
1917—Strawberries set.
1918—Strawberries, first crop.

Acre for house and buildings.

ARTIFICIAL CONTROL.

At the outset it may be said that no satisfactory method of artificial control has yet been devised in the control of this weevil. Experiments have at times been performed with varying success, but no method has yet shown repayment for the trouble involved.

TRAP BOARDS.

It is characteristic of this weevil to be nocturnal in its habits. It feeds and migrates, for the most part, at night. During the day time the adults remain dormant, or nearly so. Advantage is taken of this characteristic in the matter of control. If boards are placed in and about a strawberry field, the adults will, to a certain extent use them as shelters during the day. Examination of these boards in the mornings will reveal the presence of weevils. These can be captured and destroyed. During the season of 1912, twenty shingles, each one foot by eight inches, were scattered around one acre and a half of strawberry field. Examination was made fifty-two times between June 8 and August 14 and a total of ninety weevils were captured under the boards. Approximately one-quarter of an hour was spent in making the daily observations, a total of thirteen hours being spent on the whole proceedings. The extent to which a field was benefited by this proceeding can be roughly gauged from the figures on page 25 under "Progress of Infestation." It is doubtful whether the proceeding would appeal to many of the fruit growers, as being too trivial in operation. But the benefit derived is, within certain limitations, undoubted, and may therefore be recommended as a minor control measure.

TRAP LIGHTS.

No experiments have been performed on this point in the Fraser Valley. The consensus of opinion, however, judging from the results of observations by other experimenters, is that lights play little or no part in the attraction of weevils to houses.

TANGLEFOOT.

On account of the fact that the weevil cannot fly and can only crawl, an experiment was performed in the season of 1912 making use of this peculiarity. A quarter of an acre of severely infested land was carefully boarded in by means of eight-inch boards. The arrangement was devised to suit the requirements of a small acre farm which could be boarded in permanently and properly. The boards were placed flush to the ground, and held in place by stakes. Soil was banked up to the boards in the hollows of the ground surface and "tanglefoot" (O. & W. Thum Co.) was smeared two inches wide and about one-eighth of an inch thick on the inside upper edge of the boards. The enclosed area was then ploughed in the normal manner (July 4). It took one man 1½ days to plough, place the boards, apply the "tanglefoot" and mound the soil to fill the hollows. About 15 pounds of the "tanglefoot" were used to the quarter of an acre. It was hoped that the adult weevils would be retained within the area and escape would be prevented.

Two difficulties immediately arose in the course of next few days. The boards were found to warp and loosen at the joints, and the soil would dry and shrink away from the boards. Both produced cracks and crevices sufficient to allow the escape of the weevils. Later, again, a third trouble arose in the form of rain which splashed particles of soil into the band of "tanglefoot." To rectify these faults considerable time and trouble was expended. The results obtained from the experiments indicated positive and negative results. For the most part, weevils would be seen travelling along the boards on the inside, making no

attempt to cross. These weevils finally stopped in a crevice of the soil. From this standpoint the experiment was a success in that the majority of the weevils might be led away from a plantation by the use of such boards. On other occasions, weevils were observed to cross the band of "tanglefoot" and progress across the soil on the other side without any apparent entanglement with particles of soil. On no occasion were adult weevils taken in the band of "tanglefoot."

Judging the experiment as a whole, there are many favourable points. Certain provisions for success, however, are necessary. In the first place, the scheme is only applicable on a small farm, where a permanent board fence can be arranged. Then the board must be intact at the joints and preferably laid on a level ground surface, or else the continual trouble of remounding to the board will make the plan unfeasible. Furthermore, in the moist climate of the Lower Fraser an overlap of tin is necessary to protect the "tanglefoot" band from rain and wind. For a large farm the plan is not considered practical.

ROAD OIL BARRIER.

In the latter part of June, 1913, an experiment of a similar nature, with the same objects in view, as the "tanglefoot" experiment above, was commenced with the use of road oil, testing 14° Beaume, as a barrier. A trench was dug around a strawberry plantation one foot deep by eight inches wide, the bottom was levelled and tramped solid. The oil was applied by use of a large watering can and poured into the trench. Circumstances did not allow this experiment a fair trial but, judging from observations on the cost of digging, the unevenness of the soil and the effect of rain on the sides of the trench, it is doubtful whether this scheme has any merits over the use of "tanglefoot" and boards.

INSECTICIDES.

No experiments have been carried on during the past two seasons on the use of the regular insecticides. The experiences of other experimenters in the use of arsenic as a spray against the adult weevil have shown, for the most part, negative results. Adults are known to feed on the foliage of plants, consequently it was thought that a spray containing arsenate of lead would prove effective. R. A. Cooley, of Montana, assumed that such applications would kill the weevils or drive them away. Neither proved to be the case in his experiments, for it was found that the ingenious beetles commenced to feed on the roots and thrived despite the poison. It seems almost useless to expect any marked results from spraying the plants with any form of arsenic as there is sure to be enough unsprayed leaf surface or fresh leaves present to provide sufficient nourishment for the beetles, for our experience has shown that the adult feeding habit is not sufficient to warrant attention of this nature.

SOIL FUMIGANTS.

Carbon Bisulphide.—The use of carbon bisulphide as a fumigant and larvacide was tested during the season of 1912. It was found that any heavier soil injection than half an ounce to the foot of row killed the plants. An experiment on this point was performed on May 8, 1912, at six locations in a row. Carbon bisulphide of varying strengths was applied by means of a spoon and placed in a

hole formed by the forefinger, and quickly sealed up with soil. The effects were as follows:—

Location.	Amount Carbon Bisulphide applied May 8.	Effects on May 13.
1	One tablespoon (½ oz.)	Normal.
2	Two tablespoons (1 oz.)	Sickly.
3	Three tablespoons (1½ oz.)	Sickly.
4	Four tablespoons (2 oz.)	Very sickly.
5	Eight tablespoons (4 oz.)	Dead.
6	— check	Normal.

To test the effect on the larvæ, three groups of plants in a well-set second-year-old patch containing six plants to a group were treated with: (1) 4 ounces Carbon bisulphide, (2) 2 ounces Carbon bisulphide; (3) 1 ounce Carbon bisulphide.

On examination among the roots on May 13: (1) 11 larvæ were taken dead, 3 more showing signs of life; (2) 22 larvæ found killed, 4 more showing signs of life; (3) 9 larvæ found dead, 4 more showing signs of life.

The plants suffered in each case; consequently, while probably an efficient larvacide it is hardly practical as a remedy owing to its cost and its effect on plant life.

Cyanide of Potassium.—To test the efficiency of powdered cyanide of potassium against the adult weevil, five ounces were weighed off and powdered with a hammer to the consistency of sugar.

In five yards of row, on June 17, 1912, at three locations each one foot square, examination was carefully made for adult weevils. All observed were removed. The three collecting areas presumably now free from the presence of adult weevils were staked. Twenty-five weevils were then liberated in the centre of each of the three locations and the powdered cyanide, at the rate of one ounce to the yard of row, was scattered in the row, including, in so doing, the three defined areas. The following morning the leaves of the row were burnt brown by the action of the gas and acid and the injury increased as the day advanced. The aroma was still very noticeable and small crystals still remained on the surface. The following morning examination of the three areas revealed the following:—

At Location A.—20 weevils dead, 2 alive, 3 missing.
At Location B.—12 weevils dead, 0 alive, 13 missing.
At Location C.—11 weevils dead, 7 alive, 7 missing.

Figuring respectively, 80 per cent, 48 per cent and 44 per cent were killed or, in other words, out of 75 weevils 43 were killed, an efficiency of 57.3 per cent. Considering the small area the result was promising as the percentage over a larger area would be sure to be increased. The plants were not killed outright for, after a while, fresh green leaves began to appear. It is unfortunate, however, that a number of carabid beetles were also killed by the action of the gas. In general, however, as a commercial proposition the use of cyanide of potassium is not to be recommended.

BURNING THE CROP.

In view of the large number of weevils on the surface of the soil after the crop is harvested, the question of the advisability of applying a straw mulch to the plantation and then setting fire to it immediately presents itself as a remedy. There is virtue in the proceeding provided a light wind is blowing at the time and the straw is not matted, so as to concentrate heat at any one point; otherwise the burning of a strawberry plantation does no harm and good often results. A number of adult weevils are bound to suffer from the effects of the heat generated. Here again the same points recur as pointed out on page 30. It is necessary in order to obtain the highest degree of efficiency, to burn *immediately* the crop is off, because during July and August the weevil is busy depositing eggs in the soil, and it is not probable that these eggs would be affected by the surface fire.

Owing to the fact that most of the strawberry plantations are being grown between rows of young orchard trees, a difficulty immediately presents itself in burning a plantation, for the young trees may suffer. Provided the fire is kept within due bounds by the use of cedar boughs or wet sacks, the plan may be effective.

Gasolene Torch.—Owing to the difficulty just mentioned of turning a fire loose in a strawberry plantation where young fruit trees are growing, the efficiency of a gasolene torch, similar to that used by plumbers, wire fitters and electricians, was tested. The torch only held a quart and it was capable of throwing a blast flame of about six inches. It was thought possible to travel along a row directing the flame at the plants, scorching the leaves and the surface of the ground and thus killing the adults. However, the experiment proved a failure and examination showed that apparently not a single weevil suffered. It yet would seem possible to devise a larger torch which would be capable of throwing a longer and stronger flame.

REPELLENTS.

The weevil seems particularly well adapted to withstand the effects of noxious repellents. Miss E. M. Patch, State Entomologist of Maine, recounts some experiments on house infestation and methods employed to keep the weevils out. Powdered camphor was first tried; "between thirty and forty beetles were placed in a space six inches in diameter surrounded by a circle of powdered camphor gum, piled an inch high. The beetles seemed neither stunned nor excited, but walked about in the space and climbed over the camphor apparently indifferently for quarter of an hour, when the beetles were taken and buried under a mound of camphor gum and left for nearly two hours. Shortly after the camphor was removed the beetles deliberately stalked out, to all appearances as well as ever. The experiment was repeated with flowers of sulphur with precisely the same results. Liberal applications of fresh pyrethrum powder were also tried but it also had no effect on the weevil.'

It can readily be seen that the weevil is possessed of peculiar resisting powers.

OTIORHYNCHUS SULCATUS.

In literature relating to insects affecting strawberries in British Columbia, this species has been described as being the most important as regards its injury to the plantations. It is possible that there is confusion between the various species of *Otiorhynchus* in the Fraser valley. The work of the past two seasons has demonstrated the fact, without further doubt, that, at present *O.ovatus* is by far the most numerous and injurious. No evidence has been received that

O. sulcatus is causing any marked or untoward injury to strawberries, and this is borne out by reference to the habits of the two species in question in the states of Oregon and Washington. *O. sulcatus* occurs probably wherever strawberries are grown, but not, it would appear, in sufficient numbers to cause material harm. Its chief injury is noticed to the roots of greenhouse, pot and garden plants.

Theobald* gives an account of it thus: "It damages the plant mainly in the grub stage, the larvæ feeding upon the roots. The beetles also feed upon the leaves and buds. Vines, raspberries, peaches and many pot plants are attacked by it. The weevil, like other otiorhynchids is wingless, and about one-third of an inch long. In colour it is nearly black, the thorax is granulated and the elytra rough, with several raised lines and with scanty pale hair tufts, the rostrum has a distinct groove or sulcus in the middle. They are mainly nocturnal feeders and, when disturbed, feign death."

Observations on this insect in the Fraser valley during the past two seasons indicate that the life-history compares in a manner very similar to that of *O.ovatus*.

The adults emerge from the soil in May, June and July and deposit eggs in the soil during June, July and August. The egg stage has not been determined, but it is probably about fifteen days. The larvæ hatching from the eggs feed on the roots of the plants from July to November. A partial dormancy under outside conditions probably occurs during winter, and feeding is continued in the very early spring during March, April and May. Pupæ are formed in the soil during April and May, later producing adults to continue the life cycle.

ROOT WORMS.

Certain chrysomelid larvæ are to be found in strawberry plantations. Confusion between forms of these insects and the forms of *O. ovatus*, especially in the pupal forms is likely to result from superficial observations.

TIPULID LARVÆ.

The larvæ of tipulid flies, the adults being commonly called "Daddy Long Legs," are found feeding on the roots of strawberries and grasses in the Lower Fraser valley. In certain parts of the European continent the larvæ of these flies are economic pests and materially affect meadows and pasture land. Here in British Columbia no evidence is at hand claiming injury from these insects.

ARISTOTELIA sp.

Numerous larvæ of moths, probably referable to a species of *Aristotelia*, have been taken in the crowns of strawberry plants received from the Vernon district. This insect is not reported from the Lower Fraser valley. A visit to Vernon in July, 1913, showed that several plantations immediately around Vernon were suffering from the attacks of the moth.

The species appears to be very heavily parasitised for, thus far, all attempts to breed the moth to maturity have failed. This failure, however, has been partly due to paucity of material.

The larvæ are pinkish, about half an inch long, and appear to pass the winter in the partially-grown larval state, imbedded in the tissue of the crown of the plant. Several larvæ may be found in a single crown.

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*Insects Pests of Fruits, Wye, England, 1909.

THE BRONZE FLEA-BEETLE (*Haltica evicta* Lec.)

Fig. 8. The Bronze Flea-beetle (*Haltica evicta*) enlarged four times.

"This species of *Haltica* which occurred at Nelson, B.C., in 1910, was abundant on the leaves of strawberry in the last week of April; 180 specimens were collected from a single plant."†

CARABIDÆ.

The adults of *Harpalus* sp., which are commonly regarded as beneficial may on occasion be injurious, by the adults devouring the ripe fruit in the plantations. The carabidæ or ground beetles, as a class, however, are useful insects and should not be destroyed.

CLICK BEETLES.

The common "wireworms," the larvæ of click beetles, are commonly found in strawberry plantations and they undoubtedly affect the plants to a certain extent.

WESTERN LINED JUNE BEETLE (*Polyphylla decemlineata* Say.)

In Bulletin No. 24 of the British Columbia Department of Agriculture, the larvæ (white grubs) of this species of June beetle are reported as injurious to plantations. No records, however, of injury have been received during the past two seasons. They are known to be destructive to the roots of grasses and young fruit trees in British Columbia.

MESOLEUCA TRUNCATA Hufn.

This geometrid is reported by Dr. James Fletcher in his annual report as Dominion Entomologist and Botanist for 1902 as destructive in the caterpillar stage to strawberry plants at French Creek (near Nanaimo), B.C. "The larva is slender, cylindrical, in colour yellowish-green, slightly glaucous, and has pale, indistinct longitudinal stripes along the body, viz., a double dorsal band of more intense yellow than the body, a subdorsal band of the same colour, but clear white on the anterior segments, and a distinct yellowish ventral stripe. The tubercles on the body are white, and each bears a single, short, slender bristle. The head and feet are concolorous with the body. Beneath the anal flap, on segment 13, is a pair of prominent slender tails, tinged with pink, each bearing a slender bristle at the tip. When mature, the caterpillar changes to a chrysalis within the folds of a leaf or between two leaves, which have been drawn together by threads of silk." The larva, when full grown, is about one inch in length.

† "Flea-beetles and Their Control", by Arthur Gibson, Entomological Circular No. 2, 1913, Division of Entomology, Dominion Department of Agriculture.

CUTWORMS.

The cutworm-like caterpillars of *Scopelosoma tristigmata* Grt. are reported by Dr. James Fletcher (1902) in the same report as the above, from French Creek. This same species is recorded by Mr. J. W. Cockle at Kaslo, B. C., feeding on wild raspberry. "When mature, the caterpillar is nearly an inch and a half in length, and in general appearance is a smooth, cylindrical noctuid larva, in colour a velvety seal brown, shading to a crimson brown beneath, the centre of the venter being greenish. The head is dark reddish brown, with the exception of a broad upper margin of pale brown across the top, and reaching down the sides of the face to the ocelli. There are inconspicuous dorsal and lateral stripes, paler in colour than the dorsum, also a pale substigmatal band. Under the lens the whole skin above this band is seen to be covered with streaks and blotches of a darker brown than the skin. The thoracic shield is darker than the body and rather conspicuous. The anal shield is yellowish brown. The thoracic feet are shiny dark brown, and the prolegs are concolorous with the venter."

The larvæ of the Greasy Cutworm, *Agrotis ypsilon*, one of the common species of cutworms throughout British Columbia, is also reported injurious to roots of strawberries.

THE WESTERN STRAWBERRY CROWN BORER
(*Tyloderma foveolatum* Say.)

This is reported in the annual report of the Dominion Entomologist and Botanist for 1897.