REPORT

of

Committee on Thesis

The undersigned, acting as a Committee of the Graduate School, have read the accompanying thesis submitted by Simon Mascovitch for the degree of Master of Science. They approve it as a thesis meeting the requirements of the Graduate School of the University of Minnesota, and recommend that it be accepted in partial fulfillment of the requirements for the degree of Master of Science.

A. S. Ruggles
Chairman

O. W. Gistlund

M. J. Dorsey

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THE STRAWBERRY WEEVIL
in MINNESOTA.

A Thesis submitted to the Faculty
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CONTENTS

THE STRAWBERRY WEEVIL IN MINNESOTA

(Anthonomus signatus Say).

Summary

1. A shortage in the number of blossoms is the first indication of the presence of the weevil.

2. The injury of this insect is due to the severing of the buds after oviposition, for the protection of the larva within. From 40 to 85% of the crop may be thus destroyed.

3. The strawberry weevil may be distinguished from other weevils in the beds, by the presence of two dark spots, one on each wing cover, and by its diminutive size, being about 1/10 inch long.

4. Adults appear between April 28 and May 5. Egg stage averages five or six days, larval, twenty to twenty-five days; entire life cycle about thirty-four days.

5. The eggs are laid within the bud; where the larvae feed on the contents within - principally the pollen; pupate within the fallen bud.

6. During oviposition, the adults feed principally on pollen which is likewise the principle food of the larva so that only the staminate varieties are usually injured. The new brood upon emerging in the summer were found to eat the leaves, making numerous small holes on the under surface. Upon coming out of hibernation in the spring the beetles feed in a similar manner.

7. The older beds are more seriously injured than the

newer ones.

8. The beetles were found in large numbers hibernating on August 25, 1915 in the strawberry beds among the dead leaves, and on the ground about the plants beneath the leaves. They were also found hibernating underneath the straw on April 18, 1916.

9. The natural enemies reared were the chalcids

Eupelmus coleopterophagus

Catoloccus perdubius

Habrocytus obscuryses

Polyneura consobremis

Eurytoma sp. and Lestodiplosis sp. of the family Cecidomyidae.

Control

10. With the one-crop system, injury can probably be done away with entirely.

11. All badly infested fields should be plowed under immediately after picking.

12. One or two rows of the old field should be left uncovered and used as a trap crop, and plowed up when the beetles congregate on them.

13. Leave the mulch or cover on as long as possible in the spring, so as to force the weevil to the trap rows.

14. Covering of the beds with muslin did not prove satisfactory.

15. Spraying with poisonous arsenicals in the spring is of little value, because the leaves lie so low that spraying on the under surface is impossible, and because the adults feed

principally on pollen at that time.

Spraying in the summer, when the new brood emerges, will probably be found much more effective.

Introduction.- If during the blossoming season of the strawberry, there appears to be a shortage in the number of blossoms, the strawberry weevil may be suspected. Where this insect is at work the buds will be found severed from the stem, some having dropped to the ground, while others are still attached by a few shreds in a drooping manner, ready to fall. Further examination around the buds may reveal a small snout beetle which is the cause of the injury, and which is marked with two dark spots, one on each wing cover. The females oviposit in the buds, after which operation they cut them off, in order to protect the larva within. (Fig. 1, Pl. 1.) As few farmers are acquainted with this insect due to its diminutive size, the shortage of blossoms or berries is usually attributed to frost, hail, or to some other agency.

Classification and Synonomy.- This insect belongs to the suborder Rhychophora or snout beetles, constituting a large and important group of beetles comprising some of our most important insect pests. In the genus Anthonomus, to which the strawberry weevil belongs, we find such notable pests as the cotton boll weevil, A. grandis, the cranberry curculio, A. suturalis, the apple curculio, A. quadribbus, the strawberry and apple blossom weevil in England, A. rubi and A. pomorum, respectively.

In 1885, Prof. Riley considered signatus identical with musculus, which name appeared in the literature of the strawberry weevil until Mr. Chittenden in 1897, upon the appearance of Dr. Deitz' paper on the Anthonomini identified the species as A. signatus. A. musculus is small and less robust, the

second joint of the female is scarcely longer than the third, and according to Dr. John Hamilton, is found only on huckleberry, and rarely after the first week in June, whereas signatus is found on various plants and shrubs, such as Rhus, Tilia, and Rosaceae.

History and Distribution.- The strawberry weevil is a native species, widely distributed, and was first reported as injurious in 1871 by Mr. Townsend Glover, at Silver Hill, Maryland. Since then, it has been reported from Missouri, 1873; Michigan, 1883; Staten Island, 1885; New York, 1886; Ontario, 1886; Quebec, 1887; Pennsylvania, 1888; Virginia, 1891; New Hampshire, 1891; Delaware, 1892; New Jersey, 1893; and North Carolina and Ohio in 1893.

In Minnesota this insect is first mentioned in Lugger's Fifth Report in 1899, as occurring in limited numbers. The insect is again mentioned by Washburn in 1903 and 1904. During the past two years, the weevil has appeared in such injurious numbers as to warrant further study of this insect.

Altho the weevil is very abundant at Hopkins, Minnesota, and in the vicinity of St. Paul, farmers have not reported it as being injurious in other parts of the state, due possibly to the fact that most growers are ignorant of this insect. The weevil was found as far north as Duluth by Mr. Valleau, cutting the buds of wild strawberries in great numbers, while the writer has found it at Stillwater. It is probably distributed over the entire state, wherever strawberries are grown.

Losses. When the strawberry weevil is pres-

ent, it undoubtedly inflicts serious losses, as it appears in large numbers in the early spring, cutting the most mature buds which would be the first to ripen and therefore the most valuable. In Virginia and some of the other southern states, the writer learns that many truck growers have abandoned the growing of strawberries, due to the work of the weevil. At Hopkins, one farmer reports a yield of twenty-two crates this year while from a similar patch, a few years ago, he obtained one hundred twenty-five crates. Altho some of this loss was due to winter-killing of the plants, the weevil is responsible for the greater share. At another farm 90 per cent of the buds were found cut.

Food Plants.- The weevil seems to be confined principally to buds of the family Roseaceae, having been reported as attacking the wild strawberry; black raspberry, blackberry, dewberry, red raspberry, rose, five-finger Potentela canadensis, and Cercis canadensis, and have been taken on Tilia, Rhus, and Monarda fistulosa. From my own observation, I found the weevil cutting the buds of the wild strawberry, dewberry, and red raspberry, especially hte latter (Fig. 1, Pl. 2). Blackberries near by were not injured.

Among the cultivated strawberries, the Dunlap is the most widely grown in Minnesota and the one that is generally attacked. In fact, at Hopkins, no other variety was found to be used, except sometimes the Warfield which is a pistillate form. As is well known, the weevil is restricted to the staminate varieties and these which furnish considerable pollen, since this con-

stitutes the chief food supply of both larvae and adults.

Adult.- Original Description.- A. signatus. "Body with numerous, prostrate, white hairs: rostrum longer than the head and thorax, slightly arquated, linear, lineated: scutel oval; elytra sanguineous, with punctured, impressed striae; region of the scutel to the middle of the suture, and band of three large, unequal spots behind the middle brown."

Description after Dietz. A. signatus.- Robust oval, piceous; elytra red, denuded fascia, and scutellar space darker, thinly clothed with whitish pubescence. Beak moderately slender, feebly curved, subopaque and rather densely striatopunctate; median carina smooth, distinct. Antennae testaceous, club darker, funicle rather stout, outer joints distinctly wider, second joint distinctly longer than the third, but not slender; joints 3-7 transversely rounded. Eyes moderately convex, free behind. Head convex, occiput somewhat shining, front with a few remote punctures, finely and indistinctly rugulose, frontal puncture distinct. Prothorax wider than long, moderately narrowed in front; sides not strongly rounded, feebly constructed at the apex and transversely impressed behind the anterior margin; surface rather coarsely and densely punctured, pubescence condensed along the median line. Elytra less than one-fourth wider at the base than the prothorax and about one-half longer than wide, a little widened to behing the middle; sides feebly rounded; striae impressed, punctures moderately large, close set and becoming smaller towards the lateral margin; interspaces slightly convex, shining with an irregular row of

fine punctures; the denuded fascia extends from the side to the third interspace, another denuded spot on the second interspace; scutellar space and along the suture darker; scutellum and intra-humeral spot densely pubescent. Thorax underneath more densely clothed with white, squamiform pubescence. Abdomen sparsely pubescent, segements transversely strigose, first and second segments rather long. Legs slender, femore feebly clavate, piceous, all armed with a sharp, well-marked tooth; tibiae paler, anterior feebly bisinuate, middle and posterior nearly straight, tarsi pale, first joint elongate. Long. 2-2.9;mm; .08 - .12 inch."

Pupa.- Length 2.3 mm. by 1.5 mm. wide. Color creamy white. The eyes are the first to turn to a dark-reddish color, while the mandibles and tarsal claws show thru the pupal skin. A little later the proboscis and elytra become darker than the rest of the body, and a day or two before emerging, the pupa becomes dark-colored. The beak rests on the venter of the body with the legs drawn up at the sides. The elytra curve towards the venter. A round spiracle is visible just below the eyes. The hairs appear to rise from small tubercles, there being a pair of very small ones just above the eyes, with a larger pair between the eyes. Another pair of hairs is found on the beak just above the insertion of the antennae, with a minute pair farther down the beak. There are three pairs on the prothorax just behind the head, a large pair on the mesoscutum and four pair on the metascutum.. The lateral spines on the abdomen are more prominent than the others. The last abdominal segment is produced into a pointed process bearing two prominent brownish

spines (Fig. 5, Pl. 5).

Larva.- Length 1.7 - 2.2 x 1 mm. wide. Width of head 2/5 to 3.5 mm. Color greenish white or whitish, sometimes mixed with patches of reddish-brown and forming a reddish stripe on the dorsum. Nearly cylindrical but slightly flattened on venter, with the abdomen curved ventrally. Anal segment somewhat lighter in color than the others. The dorsum strongly wrinkled, with the venter smooth. When nearly ready to pupate, the larva becomes cream-colored, swellings appear on venter of thorax and the body becomes straighter. The dorsum of each thoracic segment is composed of two folds while that of the abdomen of made up of three folds. Head about as long as broad; light-yellowish; front yellowish; epistoma and mandibles darker; epicranial suture extending nearly to epistoma. Antennae minute, one-jointed; situated at base of mandible. The latter dark-brown; bidentate. A small black eye spot lateral of the antennae. Body of larva covered with many fine hairs (Fig. 4, Pl.5).

The Egg.- The egg measures about .55 mm.in length by .40 mm. wide and is elliptical in form, altho the shape and size varies considerably. It appears smooth with no visible markings (Fig. 2, Pl. 5).

Life History and Habits.

Oviposition

Examination and Selection of Uninfested Buds.- Oviposition was observed several times and found to take place in the following manner:- The female crawls about a nearly

matured bud examining it carefully with her antennae. After a period of from one to two minutes, a spot is selected, usually at the base of an upright sepal. If the bud is already cut, with an egg inside of it, she refrains from ovipositing in it, and passes on to examine other buds that have not been cut, altho two and even three eggs have been found in a single bud at a time when the beetles are abundant and many buds are being cut. If two or more hatch in a bud, one is very apt to destroy the other, so that only one larva develops.

It is,therefore, of very great importance to the reproduction of the weevil to select uninfested buds, as this insures the most favorable conditions for the maturity of the largest number of offspring.

Place of Egg Deposition.- The spot selected for the egg puncture is usually in the crevice and at the base of an upright sepal, being a little above the middle of the bud. In a few instances, egg-laying punctures were observed to be made below the middle of the bud.

The Act of Oviposition.- The favorite position of the weevil in drilling a hole thru the calyx, is with its head towards the base of the bud. Having obtained a firm position, she proceeds to drill the hole with her tiny mandibles. With an up and down motion, the head is thrust into the bud where a place is cleared for the egg and some feeding on the anthers takes place. After this operation is finished she withdraws her beak, turns about, and places the tip of her abdomen directly over the puncture, into which the ovipositor is protruded. When

the egg has been inserted into the bud, the ovipositor is withdrawn and the beetle proceeds to cut the bud; the female will sometimes turn around after oviposition and poke the egg in with her snout. If the beetle is disturbed during the process of drilling the hole, it removes its snout, rests on one side of the bud, and completes the hole when the disturbance is over. Sometimes the female will fail to locate the hole with her ovipositor. She then runs back and forth over the bud nervously hunting the hole with her antennae and if successful thrusts her beak into the same puncture for a few minutes to make sure of the right place. The beak is then removed and oviposition is again attempted. This process may be repeated several times.

The severing of the Bud.- Crawling down to the base of the bud, she begins to sever it from the stem, about 1/16 in. from the base of the bud, altho stems have been found cut at various distances up to one inch from the bud. In doing this, she places her hind legs against the base of the bud, (Fig. 1,Pl.1) while the middle and front legs rest on the stem. As the beak sinks into the stem, the fore-legs are spread until they nearly clasp the stem. The stem is cut either straight across of more usually obliquely (Fig. 1, Pl. 2). Enough of the stem is cut, so that the circulation is cut off and the flow of sap arrested, the cut end turning black after a short time. Either soon after or within a few days, the bud droops, discolors, and finally falls to the ground.

Time required during Oviposition.- Observations on the time for making the egg-laying punctures varied from 7 to

12 minutes, with an average of about ten minutes. The time required to lay the egg varied from 30 seconds to two minutes, while the cutting of the stem varied from ten to forty-five minutes, according to the thickness of the stem. In the latter case, the weevil having started so obliquely ran into the bud proper, so that it could not cut it completely. At the time, a male was sitting on her back and perhaps distracted her.

Making puncture	Laying egg	Cutting bud
10 min.	1 min.	27 min.
11 min.	2 min.	13 min.
10 min.	3 min.	20 min.
7 min.	30 sec.	45 min.
Average 9.5 min.	1 min.	19.6 min.

The Egg-laying Period of the Female.- A fair average for complete oviposition, from the time the female begins to hunt for a suitable place to oviposit until the bud is cut, appears to be about 32 minutes.

Mr. Theobald reports that in case of the apple blossom weevil, oviposition takes about three-fourths of an hour, so that in fine weather when the blossom buds expand rapidly, a single female cannot lay very many eggs. In cold and unfavorable weather then, the weevil is more injurious in England, because the opening of the buds is retarded. The same fact appears to be true of the strawberry weevil, since it is very similar in habits.

Flight - Playing Possum.- When disturbed, the weevil raises its antennae and stands still. If further dis-

turbed, it drops to the ground and curls itself up. Upon being disturbed further, it slowly gives up the possum habit and crawls away, but will sometimes take flight.

Flight appears to be in a horizontal direction, the beetle having never been seen to fly upward. The distance covered varied from four inches to three feet. The males fly much more readily than do the females, in fact no females were observed to fly.

Copulation.- Copulation was observed to take place for about five minutes, altho the male will often ride around on the back of the female for a much longer period. Their bodies during this act are at right angles to each other, while the tips of their abdomens are together.

The Egg.- Upon opening a bud, the egg is found to lie loosely among the anthers or against the petals, or upon the receptacle, a little to one side of the egg puncture. (Fig. 1, Pl. 5). About a day before the egg hatches, the mandibles can be clearly seen thru the chorion, moving back and forth.

Hatching.- The period required for an egg to hatch was found to vary from three to nine days, depending entirely upon weather conditions, averaging about five or six days.

The Larva

Habits of Larva.- To free itself from the egg shell, the larva wriggles and contracts, pushing out its mandibles until it is free from the egg-shell.

One egg was observed to hatch on May 5. The

young larva was then placed in water where it lived for four days. Upon hatching, the larva is whitish, with a yellowish head and dark-colored mandibles measuring about 3/5 x 1/5 mm. The first food is the pollen, and being a very nutritious food, it grows rapidly. Later it begins to attack the petals, pistils, and receptacles. In about a week's time, the larva will measure 1.5 - 2 mm. x 3/5 mm. At this time, the head is of a light-yellowish or greenish color with dark-brown jaws. The body has a flaky appearance with creamy white spots, mixed with orange-reddish patches, forming a distinct brownish line on the dorsum. There is less red on the thorax and anal segments.

On May 20th, some buds that were collected April 29th, were found to be entirely eaten out, nothing remaining but the sepals (Fig. 3, Pl. 5). The last thing to be eaten is the receptacle in which the larva makes a considerable depression. On all sides of the larva and filling the bud, the shreds of excrement are to be found, some of which forms a hard and tight cell about the larva, so that on opening a bud, it sometimes appears as if the larva was not present until the cell is broken open.

The Adult.

Feeding Habits.- On May 5, 1916 the weevils were found present in large numbers in an old patch and the young tender leaves conspicuously dotted with small punctures on the under surface. The leaves are close to the ground at this time, and spraying the under surface of the leaves would be impracticable. In a new patch 120 feet away, neither beetles nor feeding punctures

could be found. When the buds become more mature, the greatest share and the most important food of the adult weevil is upon the pollen within the buds. In one instance a beetle was found with his snout in the bud, clear up to the eyes, with the funicle of the antennae in the groove of the snout so that only the club is seen to project backward.

They also feed on the petals, after the buds open, making small round holes and to some extent, at the bases of the sepals and the tissue from which the anther filaments arise. In some cases, the filaments were girdled by their punctures so that later they turn brown.

On June 16th, four weevils that had emerged the day previous were confined in a wire cage over a strawberry plant. The buds had all opened so they had nothing but leaves to eat. In a few days, the lower epidermis of the leaves was found full of small conspicuous round holes (Fig. 1, Pl. 6), and one of the leaves that was badly eaten was found drooping. In a ripe berry, two weevils were found in a large cavity where they had been feeding (Fig. 3, Pl. 6). In the field, however, they do not attack the berries to any great extent, altho a few were found with holes characteristic of the weevil.

Some old weevils also confined in a cage made the same holes in the lower epidermis, but to a lesser extent. Recently emerged weevils when confined on June 28th, were found to have cut a few buds, but no eggs could be found in them.

On July 14, leaves with characteristic holes of

the weevil were found in the field; while on August 11, in a field where the weevils were very abundant, the leaves were conspicuously dotted with the tiny holes of the weevil, similar to one shown in the photograph.

On cloudy and rainy days the weevil rests quietly among the stems near the crown or beneath the buds. Sometimes they are found within the crown or on the ground near the crown.

Extent of Infestation.- After careful observation in many of the fields, it was found that the older the beds, the more heavily infested they were found to be. Plants set out the same spring do not seem to be attacked. Last year, the weevils were so numerous that the growers say they were equally destructive both on the new and the old fields. On a patch of berries uncovered early and in full bloom by May 5, no weevils were found present, due to the fact that it was a new patch set out the previous year.

A new patch of berries surrounded by grass land was found to be in almost perfect condition, only one or two buds being found cut. In another field, on June 7, about 60 per cent of the buds were cut on a two year old patch, while on a new patch separated only by a small blackberry patch, little injury was shown. The writer visited many fields and in all cases found those beds from which the first picking was to be made, much less injured. This is in accord with the hibernation habits of the adults, which winter over in strawberry beds.

Length of Stages

On May 2, an egg was placed in a pill box and hatched on May 10. The larva pupated on May 30, the adult having emerged June 5. In buds collected on April 29, many pupae, together with one adult, were found on June 2. The entire life cycle appears to be about 34 days in Minnesota.

In the field, however, it was not until July 1, that pupae together with a few adults were found commonly.

In the insectary pots, both the weevils and parasites were emerging in large numbers on July 8, while a few were even coming out on July 25.

Seasonal History.

Time of Appearance of Beetles in Spring.- The first buds found to be cut were in a single old uncovered row on April 20, 1915. Many buds were already in blossom in that row, being at least one week or ten days earlier than those that had been covered. On April 30, 1915 many of the buds were cut in that row, and the weevils were found feeding and ovipositing in a nearly-mature bud.

This seems somewhat early for their appearance in Minnesota, for a period of about two weeks of warm weather appears to have brought them out of their hibernating quarters. In 1916, the beetles were observed on the plants on May 5th, but no buds cut; However, from May 1st, 1915 and thru the whole month of May, excepting a few days, a period of cold, wet and rainy weather set in. Two rather heavy frosts occurred, May 9th and May 17th. On the latter date, altho a heavy snowstorm

occured the larvae were not killed in the buds.

By May 9th, the weevils were found fairly numerous on a two-year-old patch, altho on the new patches they were not yet to be found. On the same day the buds of a wild strawberry plant were found cut.

On May 12th, buds were found cut in some of the new patches, while in the old single row, a great many were already cut. It appears that, from this date, and on, the weevils do most of their work. By May 17th, the weevils were present in great numbers and rapidly increasing and appearing in the new patches.

On June 2d, the weevils were particularly abundant on a two-year-old patch, while on June 7th, 85 per cent of the buds appeared to be cut. The weevils were found to have cut many buds of the red raspberry on June 7th, but did not harm the blackberries that were near by.

On June 14th, and June 20th, the weevils were still cutting buds while on August 11, some weevils were yet present in the fields, both on strawberry and raspberry.

No weevils could be found on the plants on August 25th.

Hibernation

Concerning hibernation, Mr. Sherman at North Carolina writes in 1904 as follows:- "As yet it is impossible to say definitely just how and where the insect passes the winter. It seems certain that they winter in the adult stage, and it also seems certain that they hibernate around the edges of the field

or in woods, but exactly where, whether in stumps, rotten logs, under brush, rubbish, and leaves, or under the surface of the ground, remains a question. Two whole days of careful search on March 9th and 10th, looking under bark, sifting dirt, trash, pine straw, etc., failed to throw any light on this question."

In New Jersey, Professor John B. Smith, reports in 1911 as follows, on hibernation. "The results were not encouraging. Specimens in small numbers were found in almost all the places tested, but less in the strawberry fields themselves, than in the rubbish around the edges. They leave the strawberry fields after they mature, because they are more disturbed there than elsewhere and because it is too exposed and sunny in mid- and late summer. For shelter any rubbish-covered, moist, protected locality will answer and nothing seems more attractive than the edge of wood or scrub land, if such is near by."

On September 20, 1914, a whole day was spent in the fields to find the insect in the hibernating stage, but with no success. On September 30, 1914, another unsuccessful search was made. On August 25, 1915, however, the beetles were found hibernating on the ground around the crowns or beneath the dead leaves. When disturbed, they crawled slowly away.

On October 1st, the weevil was again found hibernating in large numbers among the dead leaves beneath the strawberry plants. About 20 weevils were found within one-quarter of an hour, showing clearly that most of them are to be found in and among the dead leaves. By picking up a handful of the dead

leaves, and examining them carefully, four or five weevils were often found. They are also found on the ground beneath the leaves and around the crown of the plant. They do not appear to be present under sticks or stones between the rows, but always well protected under the old leaves. Search was made around the edges of the field and within the woods nearby, but no weevils were found. On April 18, 1916, the weevils were again found hibernating while the cover was still on the plants. By removing the straw, and examining the dead leaves carefully six weevils were found in about thirty minutes. Some of the beetles were lying on the ground still dormant, while others were crawling about very slowly.

Another fact which would tend to confirm that the weevils do not hibernate within the woods in Minnesota is that on May 1916, the weevils could be readily found in the old patches and feeding on the leaves, while in the new fields even tho they adjoined a woodlot, careful search failed to reveal their presence. The plants were equally mature in both fields, so that it is difficult to tell why they should not be present in equal numbers if they migrate from the woods in the spring. The weevils, at least in Minnesota, hibernate within the strawberry fields and not in the woods, as was thought; altho it is possible that a few might happen to migrate to the woods.

Intermittance of the Weevil.

Mr. Chittenden remarks:- "It is fortunate also that this weevil like so many other troublesome species is more or

less intermittent in the character of its attack, appearing in great abundance for one or more seasons in certain districts and showing a vast amount of damage, and then without any apparent reason relapsing into comparative obscurity only to reappear after a number of years and in perhaps some new locality."

From a study of the hibernation habits, the intermittance of this insect may perhaps be explained by the fact that sometimes a farmer may have all old beds, which would be plowed up at the end of the season to start with new beds the following year. As the beetles migrate slowly, the new beds would be comparatively free, because most of the weevils were probably killed by being plowed under the previous season.

Another factor is the character of the season, as was explained in a previous paragraph. In fine weather, when the blossom buds expand rapidly, the weevil is probably not able to cut so many buds because it works comparatively slowly. The following spring may be cold and rainy, and having more time, the injuries of the weevil may be much more noticeable.

Natural Enemies

To rear the parasites successfully, the buds must not be allowed to dry up, since the buds normally remain on the ground and keep moist. Two fern pots, one a little smaller, answered the purpose very well. The smaller one is placed within the larger one so that the bottoms are opposite. The crevice is filled with sand and a Comstock vial used in the opening to collect the parasites as they come to the light. The whole is sunk in moist soil to keep the buds from drying out.

Mr. Chittenden reports four parasites for this insect - Colyptus tibiator, Bracon anthonomi, Catoloccus anthonomi, and C. incertus. None of these were reared from this locality.

A number of buds were placed in the breeding jar on July 5th. A total of 419 weevils were reared and 184 parasites of which two are new species as reported by Mr. Girault as follows:

Chalcidoidea

Eupelmus coleopterophagus N.sp. 5♀'s

Catoloccus perdubius N. sp. 62♂'s and 45♀'s

Habrocytus obscuripes Ash 11♀'s and 28♂'s

Polynema consobremis Girault 1♀ and 3♀'s

Eurytoma sp. 1 mutilated

1 small encyrtid

Cecidomyidae a few Proctotrypidae

Lestodiplosis sp. 14

Midge larvae were occasionally found within the buds. The adults are a species of Lestodiplosis, as determined by Mr. E. P. Felt. Members of this genus are predaceous and possibly scavengers.

Lestodiplosis sp. - larva - 1.8 mm. long, orange-red; somewhat flattened and tapering to head end where the mouth parts are prominent. Ventral surface of each abdominal segment covered with small tubercles and with two hairs projecting from each.

This gives a total of 31.8 per cent parasitism, as determined by rearing.

Out of a total of 162 buds examined on July 1,

56 contained nothing
61 contained weevil larvae
46 contained parasites.

This gives 43 per cent parasitism of the buds which contained some kind of larva. Parasitic larvae were not found numerous until June 20 among which a very small larval parasite was often found. In a few instances hyperparasitism was observed, that is, small larvae were found on some of the parasitic larvae.

Ordinarily, when a bud is opened, the larva strikes violently back and forth. If, however, it is parasitized, it will remain motionless, altho it may look healthy, and apparently free from parasitic larvae. Upon examination, a small parasitic larva may be found on the body, sucking the juices. Altho only eggs of the parasites were often found on or near the weevil larva in a few cases, it already appeared dead.

Many of the buds (about 10 or 15 per cent) do not fall, but remain hanging. These are quite conspicuous because they turn brownish when they dry. Upon examination, about 50 per cent of them contained larva, while in the others nothing was found probably due to their having dried out. Many of the buds, upon falling to the ground are so covered with leaves that they remain very moist, and altho in some instances, fungus threads were all thru the bud, the larva was apparently very healthy, showing that they can withstand very moist conditions.

Control.

As the weevils only attack the staminate varieties the use of pistilate varieties would be an ideal method of con-

trol. However, it is very difficult to get pistilate forms that will be as satisfactory as the staminate ones, they being either shy bearers or else do not stand shipment.

The one-crop system is by all means one of the best methods of getting rid of the weevil because they hibernate within the old fields and do not disperse readily. Professor Crosby in his book on Fruit Insects has the following to say in regard to strawberry growing:- "Strawberry growing is more akin to the raising of field crops than to the cultivation of other fruits. Likewise in the control of strawberry insects less reliance is placed on spraying and more attention is given to crop rotation, fall plowing,clean cultivation,and similar practices. The one crop system of strawberry culture as now practiced by the majority of commercial growers greatly simplifies the problem of insect control." All the old as well as the one-year-old fields, if badly infested, should be plowed under immediately after picking and the next season started with new plants. There being no weevils in the new fields, they will be comparatively scarce. This one-crop method should be continued for one or two years until nothing is seen of the insect.

Trap Crops.- Mr. Chittenden advises the use of early blooming varieties to attract the weevils in the early spring. A better method is to leave one or two rows of the old field, when plowing it up, and leaving it uncovered. Such plants were found to bloom three or four weeks ahead of the others. This is more advantageous than an early-blooming variety because many of the farmers do not know what the early blooming varieties

are, and if they do, would not take the trouble to plant them. It is also advisable to keep the straw on as long as possible on the fields so that when the beetles emerge, the buds will be covered, and they will be forced to seek buds that are accessible. That this might very readily take place is substantiated by the fact that the writer found one field where the straw had blown off, to be worse infested than a neighboring field where it was on longer.

Covering of the beds.- The covering of the beds with light muslin is also advised by some during the period of injury by the weevil. This was tried and put up on May 15th but found unsatisfactory. The berries did not ripen sooner, and in fact the plants were found in poorer condition. This might possibly be due to having been on for over five weeks, which length of time was necessary on account of the wet, cold spring that prolonged the blossoming period and kept the buds from opening.

Spraying.- Spraying experiments were tried out on a small scale in the spring as the weevils began to appear. Powdered lead arsenate and sweetened liquid lead arsenate were both tried but with no apparent success.

From experiments carried on against the cotton boll weevil, it was found that a diet of pollen is absolutely necessary for the formation of eggs. The females feed almost exclusively on pollen during oviposition, while it is probable that the males are the ones that puncture the under side of the leaves, petals and stamens. Spraying them is useless at the

time they are cutting the buds. It was found, however, that the new brood, upon emerging, eat the leaves readily, as described, because they do not oviposit at that time. Spraying will be much more effective at this time if about half of the plants in each row are plowed up as is commonly done soon after picking, and the remainder sprayed.

Fencing.- As the weevils do not fly very far or high, it seemed possible to keep them out by means of a fence. A wire screen fence about 2 feet high was put up accordingly on April 30th, on a plot of ground about 10 feet square. This was banked up with dirt around the bottom, and boards placed on top of the wire. Tanglefoot was then smeared both on the top and under the boards, to see if the weevil will try to fly or crawl in. No weevils were found in the tanglefoot and none were observed on the fence. Buds were not found cut within the enclosure until June 20th, when most of the blossoms had already opened.

The Sulphur Arsenical Dust.- Some recent experiments by Professor Headlee of New Jersey appear to have been successfully used as a repellent. It is planned to give this material a thoro test this spring by conducting a series of experiments in fields where the weevil is known to be very injurious.

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Britton, W. E.

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Brief notes on life history and habits. Injury reported from South Killingly and Huntington. Advises clean culture and the planting of pistilate varieties.

Caesar, L.

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Card, G. W.

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Compiled notes on methods of control. In 1899 a patch of wild blackberries near the College had 182 out of 291 buds destroyed.

Chittenden, F. H.

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Chittenden, F. H.

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Its injuries and bibliography. Correspondents report apparent success with Bordeaux and Paris green; clean cultivation and use of tobacco dust and fertilizers.

Close, C. P. and Ballard, W. L.

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Advises clean cultivation and profusely blooming varieties.

Fletcher, J.

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Report of injury at Clarkson, Ontario. Advises pistilate varieties; trap crops near outer rows. Covering of plants was found to keep out bees that aid in fertilization.

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More injurious than usual. 50 per cent loss reported often. Manhattan variety especially susceptible. Pistillate varieties not in favor by farmers.

Headlee, T. J.

1916 New Jersey Agricultural Experiment Station; 56.

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Herrick, G. W.

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Lime, ashes, dissolved bone, kerosene and plaster, and tobacco dust found wanting. Some growers report success with arsenate of lead.

Hitchings, E. F.

1906 First Annual Report of the State Entomologist.

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Houghton, C. O.

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Brief report. Found practically no weevils at Bridgefield where they were abundant the previous year. Slight injury to M. C. A. Betts of Cannon, Del.

Johnson, W. G.

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Morril, A. W.

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Murtfeldt, M. E.

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Compiled notes on life history and habits. Advises use of Paris green.

O'Kane, W. C.

1914 Injurious Insects; how to Recognize and Control Them. p. 337.

Recommends early spraying with lead arsenate and Paris green; also clean cultivation, burning over, and the use of pistillate varieties.

Patch, E. M.

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Found to be widely distributed, altho but a single large strawberry crop was destroyed, near Farmington. The weevils were also collected on wild raspberry.

Pettit, R. H.

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Economic notes. Advises clean culture, trap crop of staminate varieties, arsenate of lead. Blackberries found badly infested at Arcadia.

Quaintance, A. L.

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Reports 25 - 50 per cent injury - profusely blooming varieties proved satisfactory in escaping loss. Pistillate varieties not found satisfactory.

Quaintance, A. L.

1897 The Strawberry Weevil. Florida Agricultural Experiment Station. Bul. 42: 597.

Does not occur in Florida, but mentions its possible introduction.

Sanderson, E. D.

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Insect Pests of Farm, Garden, and Orchard. p. 456.

Advises pistillate varieties, trap crops, spraying with arsenate of lead, clean culture.

Sanderson, E. D.

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Report of the Entomologist for 1902, p. 150

Reported as injurious since 1898 at Bridgewater, especially noticeable on pistillate varieties and near woods. Suggests burning over of fields.

Sanderson, E. D.

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Slingerland, M. V. and Crosby, C. R.

1914 The Strawberry Weevil.

Manual of Fruit insects, p. 372.

Recommends pistillate varieties, trap crops, spraying with arsenate of lead, clean cultivation.

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Smith, J. B.

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Report for the year 1910, p. 308.

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Smith, J. B.

1912 N. J. Experiment Station; Report of the Entomologist for 1911, p. 412.

Reports injury in Burlington, Camden and Glouces-ted Co. Mr. Blake working on a resistent variety.

Smith, J. B.

1909 Insects Injurious to Strawberries,

N. J. Agricultural Experiment Station, Bul. 225.

Life history, habits and control measures. Recommends

Bordeaux and Paris green. Just before blossoming (4 lbs. of copper sulphate, 4 lbs. of lime, 50 gals. H_2O with 1 lb. of Paris green. 25 lbs. of arsenate of lead to every 125 gal. of Bordeaux; also mowing and burning of vines as soon as picking is over, covering of beds, pistillate varieties, clean culture, trap crop and profusely blooming varieties. Does not advise mulching.

Smith, J. B.

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Notes prevalence. Abundant at Atlanta Co. and Southern States.

Smith, J. B.

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Reported as injurious at Burlington and Cumberland Co.

Smith, J. B.

1898 N. J. Experiment Station. Report of the Entomologist for 1897, p. 402.

Report of injury.

Sherman, F., Jr.

1909 Notes of the year. Journal of Economic Entomology, Vol. 2; 201 - 206.

Reported as again serious; pistillate varieties not popular because they are not early enough.

Sherman, F. and Collet, R. W.

1904 N. Carolina, Department of Agr., Div. of Entomology, Circ. 12.

Notes on appearance, life history and habits. Recommends the planting of imperfect varieties, the mowing and burning of fields immediately after picking, clean culture, trap crops, and spraying with Bordeaux and Paris green. No results were obtained with carbolic acid, and water, and whale oil soap.

Symons, T. B.

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Report of injury.

Washburn, F. L.

1904 Ninth Report of the State Entomologist, pp. 52 and 78.

Advises spraying with Bordeaux and Paris green; burning over of fields; planting of pistillate varieties.

Washburn, F. L.

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Report of injury. Advised the planting of pistillate forms.

Webster, F. M.

1902 U. S. Department of Agriculture, Division of Entomology Bul. 31: 85.

Very injurious in Scioto County, Ohio. Half of crop destroyed.

Webster, F. M.

1901 Report of Committee on Entomology, Ohio Horticultural Society, Report of 1901, p. 878.

Reported as injurious near Scioto, Ohio, and Portsmouth, Ohio, at the farms of Mr. Walters and Mr. Kenney. 50 per cent of crop destroyed.

PLATE I.

Fig. 1. The Strawberry Weevil at work cutting a bud in which it had laid an egg; in order to protect the future grub.

Fig. 2. Pedicel of Strawberry showing all of the buds cut off by the Strawberry Weevil.

Plate 1

S. Marcowitch.

PLATE II.

Fig. 1. Work of the Strawberry Weevil on Raspberry buds showing the buds cut in a similar manner as on Strawberry.

Fig. 2. Same as Fig. 1 - showing also work of the Raspberry Byturus on leaf.

Plate 2.

S. Marcowitch.

PLATE III.

Fig. 1. Work of the Strawberry Weevil as it appears in the field, showing a number of buds cut on a single plant.

Plate 3.

S. Marcovitch.

PLATE IV.

Fig. 1. The Strawberry Weevil: Dorsal aspect of the adult, enlarged about seven times.

Fig. 2. The Strawberry Weevil: Lateral aspect of the adult.

Fig. 3. The Strawberry Weevil: Antenna, (greatly enlarged)

Fig. 4. The Strawberry Weevil: Secondary sexual characters as indicated in the snout; female snout at left and male snout at right, which is shorter and stouter than that of the female.

Fig. 5. The Strawberry Weevil: Hind wing (greatly enlarged).

Plate 4.

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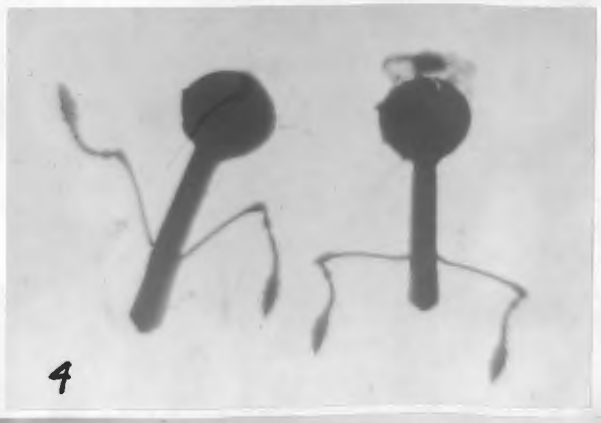

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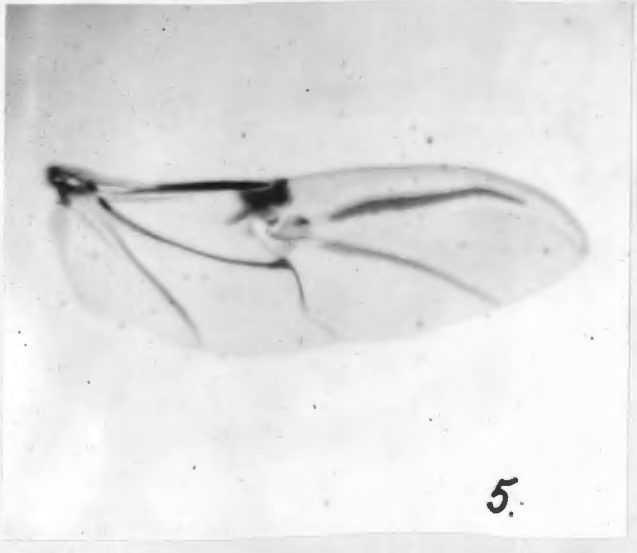

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S. Maravitch.

Plate V.

Fig. 1. The Strawberry Weevil: Bud opened showing egg (enlarged about seven times).

Fig. 2. The Strawberry Weevil: Young grub just after hatching from egg (left). Egg (on right).

Fig. 3. The Strawberry Weevil: Bud opened showing the mature curved grub. Pollen and contents of bud eaten up.

Fig. 4. The Strawberry Weevil: Grubs getting ready to pupate, being about 22 days old.

Fig. 5. The Strawberry Weevil: Pupa.

Fig. 6. The Strawberry Weevil: A dried strawberry bud showing emergence hole of the adult.

Plate 5.

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S. Marcowitch.

PLATE VI.

Fig. 1. The Strawberry Weevil: Leaf of strawberry showing feeding punctures on the under side (August 1915).

Fig. 2. The Strawberry Weevil: Strawberry leaf showing parts of leaf fallen out where feeding punctures have been numerous.

Fig. 3. The Strawberry Weevil: Work on fruit.

Plate 6.

S. Marcovitch

PLATE VII.

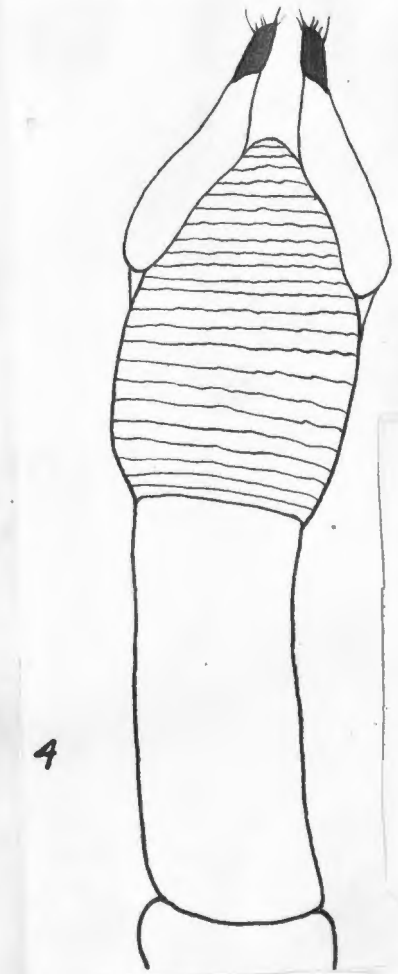
Fig. 1. The Strawberry Weevil: Head of larva, Dorsal aspect with parts named. (Much enlarged).

Fig. 2. The Strawberry Weevil: Ventral aspect of Maxilla and Labium of the larva with parts named. (Much enlarged).

Fig. 3. The Strawberry Weevil: Mouth parts of the adult, ventral aspect with parts named. (Much enlarged).

Fig.4. The Strawberry Weevil: Ovipositor as dissected out.

Plate 7.



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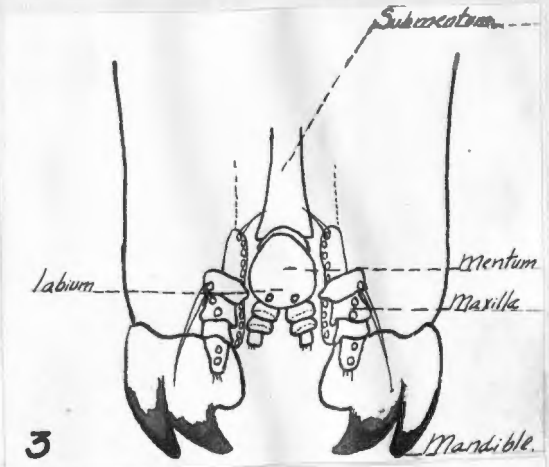

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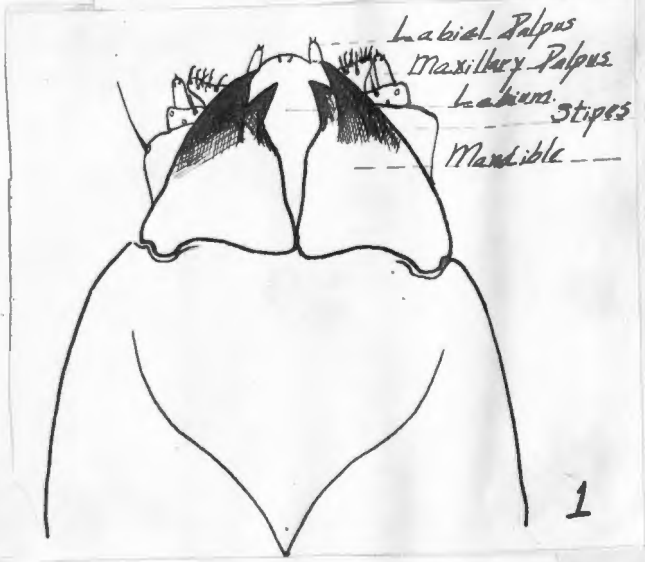

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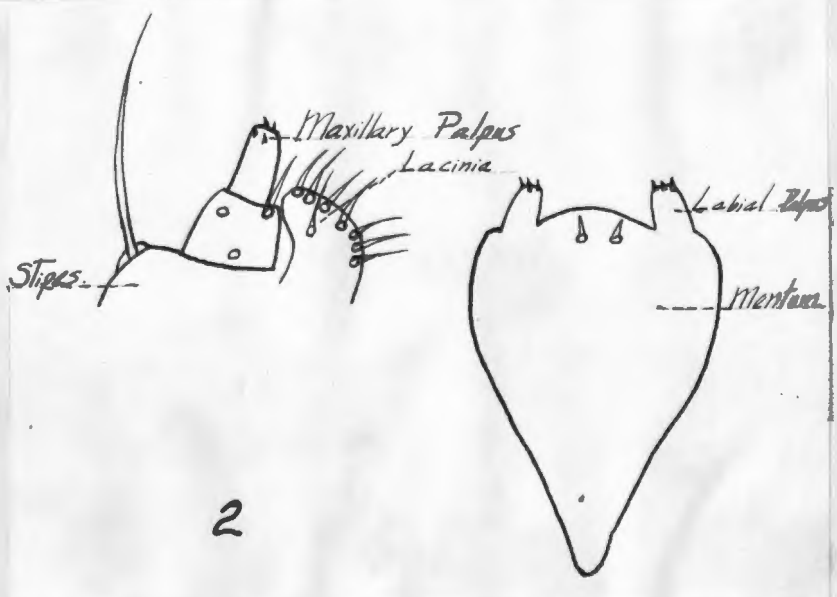

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S. Marcovitch.