The life history and control of the cranberry weevil
Anthonomus musculus Say (Coleoptera: Curculionidae) and other papers

Donald Sewall Lacroix

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The Life History and Control of the Cranberry Weevil and Other Papers

Donald Sewall Lacroix
THE LIFE HISTORY AND CONTROL OF THE CRANBERRY WEEVIL
Anthonomus musculus Say (Coleoptera: Curculionidae)
and Other Papers

Donald Sewall Lacroix, B. Sc.

A Thesis Submitted in Partial Fulfillment of
the Requirements for the Degree of
Master of Science

MASSACHUSETTS AGRICULTURAL COLLEGE
AMHERST, MASS.
1926
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III. The Pollination of the Cranberry by Honey Bees and Bumble Bees

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FOREWORD

This thesis consists of four separate papers, each the result of observations made during the writer's graduate work and which are here presented together for the degree of Master of Science.

The first paper brings together observations on the life history and control of the cranberry weevil *Anthonomus musculus* Say on Massachusetts cranberry bogs.

The second paper contains investigations on the life history and distribution of a scale insect (*Targionia dearnessi* Ckll.) occurring on the cranberry in Massachusetts, an insect about which little has been published.

The third paper is a brief resume of some preliminary experiments on pollination of the cranberry by bees.

The fourth paper presents the results of one season's work with Sodium Fluosilicate, an insecticide which has but recently come to the attention of economic entomologists. This material was used as a dust against two types of cranberry fireworms with good success.
I.

THE LIFE HISTORY AND CONTROL OF THE CRANBERRY WEEVIL
Anthonomus musculus Say (Coleoptera; Curculionidae)
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THE LIFE HISTORY AND CONTROL OF THE CRANBERRY WEEVIL

Anthonomus musculus Say (Coleoptera: Curculionidae)

by

Donald Sewall Lacroix

Introduction

The cranberry industry of Southeastern Massachusetts suffers considerable loss through the activities of insects. Many of these appear every year, and are combated more or less successfully by the application of sprays or by the timely flooding of the bogs. Others among the hosts of insect pests occur spasmodically at unexpected intervals and, although they may do but little damage in some years, they occasionally appear in such numbers as to cause much anxiety among some growers.

The Cranberry Weevil, Anthonomus musculus Say, is one of the latter class. So far as we know, it has never devastated great areas of cranberry bog in Massachusetts, but it becomes abundant here and there at intervals, causing much loss on individual bogs. This weevil's activities are rendered more acute because of its minute size and methods of procedure.
A serious infestation is not suspected by the average grower until the crop is well on the way to ruin. The bloom is observed to disappear rather rapidly in early summer and little or no fruit is found. The bog owner often endeavors to explain the loss by saying that the blossoms did not set well, or that a late frost killed them.

A thorough search through the literature has failed to disclose any records of a detailed study of the life history of this insect, either on the cranberry or elsewhere. Likewise, no methods of control seem to have been attempted, either experimentally or otherwise. Then too, the insect has been confused with several other similar species in many instances, as will be indicated below. It seem advisable, in view of the above mentioned facts, to bring together all available information and couple with this detailed observations made during the past two seasons.

The work presented in this paper was carried out under the direction of Dr. H. J. Franklin. To Mr. H. B. Scammell the writer is greatly indebted for his efforts
in attempting to locate specimens collected by other workers on this insect, and for observations on the activities of the insect in New Jersey.

The writer would take this opportunity to express his appreciation to Dr. H. T. Fernald for the instruction and helpful criticism extended in connection with this and other work.

**Historical**

Thomas Say (1)\(^1\) described *Anthonomus musculus* in 1831 from Indiana. Records of this insect next occur in literature in 1885 when Riley (2) stated that the weevil had become a serious pest of the strawberry during 1884 in several eastern states. Later, Dietz, who was a specialist on the Anthonomi, indicated (3) that the weevil which Riley thought was *A. musculus* was really *A. signatus* Say, the true strawberry weevil.

Packard (4) recorded for the first time the activities of a cranberry *Anthonomus* in Massachusetts and stated that the species involved was *A. suturalis* Le-

\(^1\)Numbers in parenthesis refer to Literature Cited.
Conte. Lugger (5) mentioned *A. suturalis* as a cranberry feeder. Hardenberg (6), who carried on some investigations of cranberry insects in Wisconsin, again recorded *suturalis* as being destructive to the cranberry. Franklin (7) applied the same name to a cranberry weevil found in abundance in Massachusetts in 1914. The writer found a cranberry weevil on the Cape Cod bogs during the summer of 1924 and was unable to make the species fit the description of *suturalis*. Specimens were sent to Mr. H. C. Fall and Prof. Blatchley for identification, and both agreed that the species was *musculus*. The writer has been unable to locate either Packard's specimens or those studied by Hardenberg, but an examination of Franklin's material revealed the fact that the weevil recorded by him as *suturalis* is identical with *musculus*. Hardenberg's descriptions are rather vague, but the meager report on the life history of his weevil leads the writer to suspect that his weevil was also *musculus*. In all probability, then, the cranberry weevil of literature has been *Anthonomus musculus* Say instead of *Anthonomus suturalis* LeConte.
Distribution and Food Plants

*Anthonomus musculus* is a native of North America, and is known to occur from Ontario and New England west to the Rocky Mountains and south to Florida.

It has been found feeding on huckleberry, *Gaylussacia resinosa* Torr. and Gray, and black chokeberry, *Pyrus melanocarpa* Willd. Mr. H. B. Scammell, formerly of the United States Bureau of Entomology, informs me that he took this insect on the cultivated blueberry, *Vaccinium corymbosum* L., at Toms River, New Jersey, during the summer of 1924. As far as can be determined, this paper records *musculus* as a cranberry pest for the first time.

Description

**Egg.**—Oblong-ovoid, 0.4 to 0.5 mm. long and 0.29 to 0.32 mm. wide; pale lemon-yellow to almost white in color; glistening; viscid; smooth (no sculpturing).

**Larva.**—Full grown larva yellowish-white; a cylindrical, footless grub, 2.5 to 3 mm. in length; head pale yellow, margins of mandibles brown to black; body strongly
curved, so that anal segment and head are closely approximated.

**Pupa.**—A pupa libera, 2 to 2.5 mm. long, 1 to 1.4 mm. wide; naked, stout, yellowish to white in color; eyes showing as black spots after a few days; legs, beak and wing pads folded tightly against body, the wing pads covering in part the folded legs; beak lying along under side; several spines on head and abdomen; last abdominal segment prolonged into a process bearing two stout spines.

**Adult.**—1.5 to 2 mm. long, beak and head of old specimens black, elytra dark red, legs dark. Freshly emerged specimens much lighter in color, beak and head brown, elytra golden-brown. Older individuals may be entirely black. A few white scales scattered over the back give appearance of transverse bands of gray; scutellum covered with white pubescence.

**Similar Species**

As already indicated, musculus has been confused with suturalis and also with signatus. Hamilton (8) gives a very interesting discussion of musculus and
signatus (the strawberry weevil). He says that the true musculus is not very common (in Pennsylvania) and is usually found on huckleberry blossoms; a thorough search through strawberry plantations during several periods of the season disclosed a total absence of musculus on that plant.

Dietz (3) says, in writing on musculus versus signatus,

"Aside from the difference in length of the second joint of the funicle which is always evident in fresh and can be demonstrated on old specimens that have been relaxed, the present species (musculus) is less robust, thorax less round-ed on the sides, and suture always darker".

A. musculus Say is smaller than A. suturalis Lec., ranging from 1.5 mm. to 2.0 mm. in length while the latter ranges from 2.3 mm. to 3.0 mm. in length. In general shape, musculus is less oblong, somewhat widening behind while suturalis does not widen behind, the sides remaining parallel; the antennal funicle of musculus is stouter and club more abruptly formed than in the latter species; the sides of the thorax of musculus are more rounded and more transverse, apical constric-
tion shorter; upper side less shining, punctuations finer and denser, hairs coarser and longer; elytra distinctly shorter in *musculus*, widening behind; striae less impressed with puncture less coarse; pubescence coarser, usually forming two transverse bands, these bands never occurring in *suturalis*; color red, brown, or black (in *musculus*), with or without a black spot behind the middle, very rarely black with tip indistinctly dark red; color black (in *suturalis*) with a large usually well defined apical spot yellow or red.

*Suturalis* has been found to breed in Phylloxera galls on hickory leaves and is frequently found in such galls, while *musculus* has never been reported from galls or from hickory.

**Nature of Injury**

Although the over-wintering beetles do some feeding on the cranberry in late May and early June, most of the damage is done just before egg laying and again in July when the newly-emerged weevils attack the fruit, leaves, and terminal buds. The most severe injury done during late May and early June is caused by the weevils feeding upon the new terminal growth. They feed ravenously on
the new leaves and tender blossom-buds. In many cases they bore into the very basal portion of the new leader so that the latter dies back to the old wood, turning black in a few days and giving all the appearances of having been killed by frost. Within a few weeks a new shoot takes the place of the dead leader, but of course, bears no bloom that season.

Immediately prior to and during egg-laying, the adults drill into unopened buds to devour the contents (immature floral parts), and, in so doing, often make several holes in one bud. The bud naturally never opens, but dries up on the pedicel and eventually drops off. Each blossom in which an egg is deposited becomes the food of the hatching larva and therefore never matures.

As soon as the young beetles emerge from the pupa stage they at once attack the immature cranberries and riddle them in short order. The hungry weevils drill anywhere from one to thirty holes in a single berry, gouge out the interior, and then attack another. Such fruit as may escape drilling continues to grow, and apparently becomes too tough for the beetles, for they soon turn their attention to the terminal buds and new
leaves, riddling them also. During the first part of August, they gradually cease eating, and, by the middle of the month, no trace of recent feeding can be found.

**Life History and Habits**

The over-wintering adults make their appearance soon after the coming of warm weather, usually about the middle of May. By sweeping over the cranberry vines with an insect net on warm sunny days in mid-May, many specimens can be taken on infested bogs; but, during cold, windy, or cloudy weather, at that time of year, only a few beetles can be thus obtained. On such days they may be found, however, on the bog floor, inactive and often apparently lifeless. On hot days the beetles appear to be at the maximum of activity, running up and down the vines, often taking flight. When disturbed, they may "play 'possum" and drop to the ground with their legs folded tightly against the thorax and abdomen, or may spread their elytra and fly off a few yards.

Towards the end of May the weevils start feeding upon the old leaves, unopened terminal buds, and such new growth as may have started. Most of the eating
on the old leaves is done on the lower epidermis, but
the injury resulting from this is of little account.
The most serious damage at this season of the year is
generated by the beetles drilling into the buds and base
of the terminal growth. They exhibit no fixed manner
of feeding as do many species of weevils (some weevils
of the same genus have been observed to feed head down-
ward), but drill into the edible parts of the plant
while standing at any angle. As they feed on the new
leaves and blossom-buds, they leave small spots of ex-
creta, which under a lens appear as moist, dirty-green
drops.

By the first of June the beetles start mating.
The writer, in collecting them, placed several speci-
mens in a single vial. When a male and female met, cop-
ulation began at once. Beetles in captivity were
found in coitus at any time of the day and apparently
under any conditions. If disturbed, they separated,
only to mate again in a few minutes. Copulation last-
ed from a few minutes to several hours, usually less
than a half hour.

Egg deposition.-- The eggs of this insect are deposit-
ed singly, one to a bud, and in the majority of cases are placed by the female in the blossom-bud at the bases of the anthers. The process of depositing the egg is interesting. The female drills a hole by first chewing an opening through the petals. She then slowly bores a passage into the interior of the flower by rotating her whole body on her beak as a pivot, until she has drilled to a depth equivalent to the length of her beak. This process requires from ten to fifteen minutes. Upon completing the hole, the female withdraws her beak, turns around and feels over the surface of the bud with the tip of her abdomen until she locates the hole just drilled, inserts a short ovipositor, pushes an egg into the opening and walks away.

It has been reported (6) that the female cuts off the blossom after depositing the egg, but the writer has observed this only in a few cases.

Egg-laying may extend over a period of three or four weeks, depending upon the development of the cranberry bud and upon weather conditions. Eggs have been found in the "pod" stage of blossom development, i.e., when the blossom-buds are just beginning to show
pink, before they have become advanced enough to droop over. This period necessarily varies with the season and with the time of removal of winter flowage, and may occur at any time between the first of June and the third week in June.

Females reared in the laboratory deposited as many as thirty-nine eggs in a season, and the average number of eggs laid per female was twenty. The period of greatest activity in laying seems to be dependent on temperature to a considerable extent, as on the very hottest days (shelter maximum temperature of 93° to 100° F.) females laid three or more eggs, while on cooler days only one, and on cold days none.

**Larval habits.**—The eggs hatch in from three to nine days, also depending on temperature. In June 1924 (the spring of 1924 was cool and wet) eggs hatched, on an average, seven days after they were deposited. During 1925 eggs hatched on an average of four days after having been deposited during the very hot period mentioned in the previous paragraph.

The young larvae at once begin to gnaw through the anthers, then devour the stamens and pistil, and
finally eat away the interior of the immature ovary. The petals and outer skin of the ovary are left intact throughout larval life. It is very interesting to note that the petals, instead of curling away from the pistil and stamens (as they normally would do on an injured blossom), remain tightly closed together, in time becoming stiff and dry in this position, so that a protective cell is formed enclosing the larva and pupa.

Pupation.-- Pupation takes place within the above mentioned cell from ten to fourteen days after the hatching of the larva. The pupa is at first white throughout, but in a few days the eyes become dark. Pupal life extends over a period of from five to seven days. When disturbed or jarred vigorously, the insect in this stage twists and turns by rotating the last few segments of the abdomen in rapid, jerky gyrations.

Adult life.-- The beetles emerge from about the 26th of June to the 10th of July and at once commence their feeding activities. At this period of their life, they
are most voracious, attacking the immature fruit, the new leaves, and the terminal buds. Through the early part of July, vines on a badly infested cranberry bog may be overrun by the young beetles. After the first week in August, little or no eating is done and the adults begin searching for their winter quarters. By the middle of September, few or no beetles can be found on the vines. Adults were found during October on the bog bottom under the trash and fallen leaves, only after careful and prolonged searching. It may be possible that some migrate to the surrounding upland and hibernate, but no beetles have been found on the upland to prove this. There is, then, but one generation a year in Massachusetts.

Natural Enemies

A chalcid fly, determined by Mr. A. B. Gahan of the Bureau of Entomology, U.S.D.A., as Habrocytus sp., was reared from the cranberry weevil. No other natural enemies have been observed.
Control

Late holding of winter flowage is a common practice in attempting to control many cranberry insects. This measure was tried on one bog, but apparently had no ill effect upon the weevils as they appeared in abundance three days after the winter water was drained off. The bog in question was held under water until May 25, 1925.

Another control measure was tried in connection with sanding. Cranberry bogs are usually sanded every few years to keep down moss and weeds, and to keep the root system of the cranberry well aerated. Usually a coating about one inch in depth is spread on the bog early in the winter. In the control work, one plot was left unsanded, another sanded in the customary way, and a third sanded very heavily. This was done during November 1924. Late in May 1925 an examination of the unsanded and sanded areas showed that the beetles were twice as abundant on the sanded plots as on the unsanded. This may be accounted for by the presence of a comparatively rank growth of tender, new
uprights on the sanded plots, a condition which always exists after re-sanding. This growth of fresh food undoubtedly attracted the weevils. Then too, "sanded bog" is usually several degrees warmer than "unsanded bog", and the warmer areas might be attractive to the weevils during the cool spring nights.

Field tests were conducted with several insecticides and spray mixtures. Nicotine sulphate (both as a dust and as a spray) was tried and proved of no value as a control. Lead arsenate spray, calcium arsenate dust, sodium fluosilicate (as a spray and as a dust), cryolite spray, and a mixture of Bordeaux, calcium arsenate, lime and fish-oil soap were each used in an attempt to combat the insect. The latter gave promise of being most effective during the first season and was recommended in 1925 as a practical spray. In every case where it was used, either experimentally or commercially, very satisfactory results were obtained. The table on the following page brings together briefly the results of the various insecticides used in experimental control.
Comparison of Effectiveness of the Several Insecticides Used in Experimental Control of the Cranberry Weevil

<table>
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<tr>
<th>INSECTICIDE</th>
<th>% KILL</th>
<th>REMARKS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bordeaux mixture, calcium arsenate, and fish-oil soap mixture.</td>
<td>100</td>
<td>This combination sticks to the foliage very well, does not burn, and is not costly.</td>
</tr>
<tr>
<td>Same as above</td>
<td>91</td>
<td>Applied too late in the season.</td>
</tr>
<tr>
<td>Calcium arsenate and lime dust, 1 to 5 (500 lbs. per acre)</td>
<td>100</td>
<td>To get good control it is necessary to dust very heavily. Cost prohibitive.</td>
</tr>
<tr>
<td>Lead arsenate and &quot;Sunoco&quot; spray oil (for spreader).</td>
<td>81</td>
<td>Only fair control.</td>
</tr>
<tr>
<td>Lead arsenate and &quot;Kavo&quot;.</td>
<td>66</td>
<td>Not satisfactory.</td>
</tr>
<tr>
<td>Cryolite, 1 lb.; lime; 2 lbs.; water, 25 gals.</td>
<td>78</td>
<td>Only fair control.</td>
</tr>
<tr>
<td>Same as above, twice the strength and 1 lb. fish-oil soap.</td>
<td>72</td>
<td>Only fair control.</td>
</tr>
<tr>
<td>Same as above, no soap.</td>
<td>72</td>
<td>Only fair control.</td>
</tr>
<tr>
<td>Sodium fluosilicate and lime dust (1 to 4).</td>
<td>65</td>
<td>Some injury where dust lodged heavily.</td>
</tr>
<tr>
<td>Sodium fluosilicate, 2 lbs.; lime, 4 lbs.; soap, 1 lb.; water, 25 gals.</td>
<td>55</td>
<td>Considerable injury by burning foliage.</td>
</tr>
<tr>
<td>Nicotine sulphate sprays and dusts of all grades.</td>
<td>0</td>
<td>Of no value against this pest.</td>
</tr>
</tbody>
</table>
It has been found advisable to apply the Bordeaux spray just before the buds begin to show pink. It is then that the weevils are very active and it controls them before they have an opportunity to lay their eggs for the summer generation. The pink stage (known as the "pod" stage) varies with the season and according to the length of time the winter flowage may be held on the bog, but usually is during the early part of June.

The Bordeaux mixture, lime, calcium arsenate, and soap mixture should be made up as follows:

<table>
<thead>
<tr>
<th></th>
<th>Gallons</th>
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<tr>
<td>Lime (slaked)</td>
<td>4</td>
</tr>
<tr>
<td>Bordeaux</td>
<td>3</td>
</tr>
<tr>
<td>Copper sulphate</td>
<td>3</td>
</tr>
<tr>
<td>Water to make</td>
<td>50</td>
</tr>
<tr>
<td>Calcium arsenate</td>
<td>3 pounds</td>
</tr>
<tr>
<td>Fish-oil soap</td>
<td>2 pounds</td>
</tr>
</tbody>
</table>

Slake carefully the desired quantity of stone line. Dissolve three pounds of copper sulphate (blue vitriol) in three gallons of water. Dilute the lime mixture and copper sulphate solution with water to twenty-five gallons each, and pour together into spray tank.

Add three pounds of calcium arsenate to a gallon or so of the above mixture in a pail, and stir well. Pour this into the spray tank and add a quart or two extra.
of the lime water.

Mix two pounds of fish-oil soap in a little water and add to the spray mixture immediately before spraying. Agitate the whole thoroughly. This should be applied at the rate of 300 gallons to the acre.

The Bordeaux acts as a sticker (9), and "body" or "carrier"; the soap as a "spreader". It has been found by extensive experimentation that the above described mixture is one of the best "stickers" and "spreaders" that can be applied to the cranberry. The mixture will spread exceptionally well over the waxy cuticle of the cranberry leaf and fruit, and will withstand the washing effect of many rains without materially losing its toxicity. Furthermore, no trace of foliage injury could be found after spraying.

It will be observed that an excess of lime is present in the above mentioned mixture (instead of using the regular 4-4-50 formula, only 3 gallons of copper sulphate are used so that there will be a considerable excess of lime). This will take care of any arsenic rendered soluble by the addition of soap to the calcium
arsenate. Otherwise foliage injury might occur through the presence of soluble arsenic. As a rule, the use of soap with an arsenical is not recommended, but in this case it is quite safe, provided more lime is added as stated and that the soap is put in the mixture last. A quart or two extra of lime should be added to every fifty gallons of the mixture as a precautionary measure.

Cost of materials:

Bordeaux, Calcium Arsenate, and Soap.
Copper sulphate........ 18 pounds at $.10 ........ $1.80
Lime (lime stone)........ 24 " " 0.014 ........ 0.36
Calcium arsenate......... 18 " " 0.18 ........ 3.24
Fish-oil soap........... 12 " " 0.08 ........ 0.96
Water..................... 300 gallons
Total cost of material necessary to spray one acre..........................$6.36

There are some growers who during early summer make weekly or semi-weekly examinations of their cranberry property, sweeping with a collecting net here and there over the bog to get some idea of the abundance of insect life inhabiting it. Even then the minuteness of the cranberry weevil serves to prevent the casual observer from detecting its presence unless the insect is there in great abundance. The importance of a weekly, or better, semi-weekly examination of a bog cannot be
over-emphasized, and a careful scrutiny of the contents of the collecting net during such expeditions should be emphasized still more.

Observations made on a large number of bogs indicate that the cranberry weevil occurs in relatively small numbers on bogs that are subjected to regular spring and fall re-floodings. This fact in itself suggests that where possible a bog should be re-flowed in early June for a day or so and again in late September for two weeks.
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II.

MISCELLANEOUS OBSERVATIONS ON A CRANBERRY SCALE

Targionia dearnessi (Ckll.) (Homoptera; Coccidae)
MISCELLANEOUS OBSERVATIONS ON A CRANBERRY SCALE
Targionia dearnessi (Ckll.) (Homoptera: Coccidae)

by Donald S. Lacroix

During the fall of 1924 the writer found a peculiar scale insect on the cranberry in the town of Sandwich, Massachusetts. The insect at once became of interest because of its apparently solitary mode of existence, an unusual trait among the Coccidae. The full-grown females could be found scattered here and there over the bog, only one scale to an upright, though in rare cases two were found on the same stem. Further investigations indicated that the insect occurs on many widely separated cranberry bogs and under a variety of conditions. It appears to be fully as abundant on bogs subjected to regular flowages as on dry bogs and it infests the Early Black, Howe, and Chipman varieties with no apparent preference for any one of the three kinds. No injury of any importance could be traced to the activities of the scale. A similar insect was found on bearberry (Arctostaphylos uva-
Figure 1. Scale of Adult Female ($\times 10$)

Figure 2. Scale of Adult Male ($\times 10$)

Cranberry Scale, *Targionia dearnessi* (Ck11).
around the edges of cranberry bogs.
Specimens from both food plants were identified by Dr. Harold Morrison of the Bureau of Entomology as *Targionia dearnessi* (Ckll.)

This species occurs throughout the United States from Wisconsin to Florida, west to California, and north into Canada. Food plants listed are bearberry, cranberry, summer farewell (*Kuhnistera pinnata*) and "several unknown weeds".

**Description**

*Scale of adult female* sub-oval, 2 mm. long; moderately convex; color dirty white to pale gray; exuviae subcentral, yellow; ventral scale thick. *(Fig. 1).*

*Scale of adult male* elongate, parallel-sided, 1 mm. long and 0.5 mm. wide; color white; exuvia at one end, color yellow; covered with a white secretion. *(Fig. 2).*

*Adult female* --

"Dark yellowish-brown, after prolonged boiling in K.H.O. becoming
transparent and almost colorless, except that the lobes remain dark brown. No circumzenital grouped glands. Only one pair of lobes, these short, parallel, very close together, practically contiguous at the tips, their ends broad and obliquely truncate, breadth of a lobe greater than its length beyond the general margin. Apparently no squames. Margin irregularly bluntly serrulate; a small projection near the lobes, and two much larger ones at considerable distances beyond, much in the style of A. bigeloviae. Anal orifice oval, a considerable distance from the hind end. Surface striated, with rows of small round dorsal glands, much in the manner of A. bigeloviae. Mouthparts large.

Adult male -- 0.5 mm. long; reddish brown in color; legs light yellow, with sparse hairs; tarsi terminated with single, slightly curved sharp claw; wings hyaline; antennae 8-segmented, each segment

1Cockerell, Can. Ent., XXX, 266-267, 1898. A. bigeloviae refers to Aspidiotus bigeloviae, the genus in which dearnessi was originally placed.
with numerous hairs; stylus one-half the length of body, ending in a sharp pointed elongation.

**Life History**

Adult females live over winter beneath the scale covering. Eggs become evident within the body of the female late in the spring and were found in one female in the laboratory in early winter, December 24, 1924.

The first crawling young hatched June 16, 1925, and three days later most of the young which hatched on that date had settled down on the fresh growth of cranberry and had started to secrete a covering. The first stages of this secretion resemble filaments of absorbent cotton, but finally become matted together and the outlines of the individual strands are lost.

The tendency of the crawling young is to settle down at the base of a leaf stem or a bract, and in the majority of cases on new growth. Some settled
on old wood. The young also exhibit a "wanderlust" and move away from the upright bearing the parent to search for new uprights where the females live the rest of their lives. Only occasionally did the writer find more than one female on an upright. The males, on the other hand, tend to colonize, and anywhere from one to ten may be found to an upright.

On July 13, 1925 the first second-stage female was found.

On August 5, 1925 the first male pupa was found beneath its scale covering, and males were emerging August 20-24, 1925. By September 1, 1925 practically all the females were full grown. Judging from these observations, it would seem that the length of life of the female from hatching to the attainment of full growth is about seventy-five days.

The stem of the cranberry becomes somewhat swollen where the female is attached to the upright. This swelling is first noticeable about six weeks
after the female has started feeding.

Parasites

This scale is subject to parasitism to a considerable extent. Possibly one-third of the scales found on a bog in the fall will show exit-holes of parasites. Two species of Hymenoptera were reared from the scales and were determined by Mr. A. B. Gahan of the Bureau of Entomology, as *Coccidencyrtus ensifer* (How.), and *Signiphora* sp. probably new.
III.

THE POLLINATION OF THE CRANBERRY BY HONEY BEES
AND BUMBLE BEES
Pollination of the Cranberry by Honey Bees and Bumble Bees

By Donald S. Lacroix

The efficiency of the honey bee as a cranberry pollinator has been at one time or another either over-rated or on the other hand under-estimated. Many cranberry growers maintain that without honey bees the blossoms cannot be fertilized while others believe that the honey bee is not essential. Franklin has brought out the fact that bees are necessary to properly fertilize the cranberry flower and that without them a very small yield is the result.

During the blossoming season of 1925, experiments were carried out on the Station Bog at East Wareham to determine the relative efficiency of honey bees and bumble bees as cranberry pollinators.

Mosquito-netting tents were placed on the bog before any blossoms had opened, and all insects were excluded from these tents. During the period of bloom some of the tents were lifted from the bog.

1Mass. Agricultural Experiment Station Bulletin 150, p. 48, 1914.
and the plots they had covered were kept under careful observation. Bees were allowed to work blossoms on these plots and each blossom visited was marked with colored yarn (red indicating bumble work and white, honey bee work). The tents were replaced at the close of observations each day.

Later in the season when the fruit was well developed, the plots were examined, and counts made of the berries set and of the blossom-stems which bore no fruit. Table I will serve to bring out the results.

From this study, it would seem that the bumble bees were more effective as pollinators since 55 4/5% of the blossoms visited by them set fruit, as against 43 1/5% of the blossoms visited by honey bees.

**TABLE I**

<table>
<thead>
<tr>
<th></th>
<th>Bumble Bees</th>
<th>Honey Bees</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Set</td>
<td>Not set</td>
</tr>
<tr>
<td>Small tent No. 1</td>
<td>11</td>
<td>10</td>
</tr>
<tr>
<td>&quot;        No. 2</td>
<td>10</td>
<td>13</td>
</tr>
<tr>
<td>Big tent No. 1</td>
<td>12</td>
<td>20</td>
</tr>
<tr>
<td>&quot;        No. 2</td>
<td>44</td>
<td>18</td>
</tr>
<tr>
<td>Totals</td>
<td>77</td>
<td>61</td>
</tr>
<tr>
<td>% set</td>
<td>55 4/5</td>
<td>43 1/5</td>
</tr>
</tbody>
</table>
Further observations were made to determine the number of blossoms visited per minute by various species of bumble bees and by honey bees. The results of these observations are tabulated in Table II.

**TABLE II**

<table>
<thead>
<tr>
<th>Species</th>
<th>No. of blossoms visited per minute</th>
<th>Average</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>July 6, 1925</td>
<td>July 7, 1925</td>
</tr>
<tr>
<td>Honey bees</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Bumble bees</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. affinis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>B. bimaculatus</td>
<td>9 4/5</td>
<td>12 1/10</td>
</tr>
<tr>
<td>B. impatiens</td>
<td>7</td>
<td>10 2/5</td>
</tr>
<tr>
<td>B. perplexus</td>
<td>11 3/5</td>
<td>11</td>
</tr>
<tr>
<td>B. ternarius</td>
<td>8</td>
<td>13 2/5</td>
</tr>
<tr>
<td>B. terricola</td>
<td>13 1/2</td>
<td>10 1/10</td>
</tr>
<tr>
<td>B. vagans</td>
<td>9 2/5</td>
<td>10 3/5</td>
</tr>
</tbody>
</table>

Time counts were made on several other dates during the blossoming period and under various weather conditions. In every case the bumble bees visited a larger number of blossoms per minute than did the honey bees. The bumble bees were the earliest arrivals in the morning and the last to leave the bog at night. After a rain the bumble bees arrived fully half an hour before the honey bees and gingerly worked the
top blossoms.

It was discovered that bees would work a flower but once, and that another bee would not work a blossom previously visited. To secure further data on this, stems bearing fresh blossoms taken from beneath tents free of insects were placed in vials of water. Bees of both kinds were induced to work these blossoms, and the latter were marked with colored yarns. These were kept in the insectary over night and were brought into the field on the succeeding day. Bees would often visit these blossoms but in only a single instance did one stop long enough to work. It was realized that in cutting off the uprights and placing them in water, that the natural environment of the cranberry vine was materially changed, and that the secretion of nectar may have been interrupted if not inhibited. Therefore careful observations were made on the experimental plots to determine if bees would work a blossom more than once. Even under natural conditions on the plots no bees were observed working a blossom a second time. They would often hesitate near a flower previously worked, but in
no case were they observed to stop and probe into the nectaries of such a flower.

After carefully watching bumble bees and honey bees as they worked, it was observed that the latter did not always come in contact with the stigma of the cranberry flower. It is of course necessary that the pollen-carrying hairs of the bee touch the stigma and leave a pollen grain before fertilization of the blossom can take place. The honey bee has a moderately short tongue, so that in order to reach the nectaries below, it is necessary to crawl around the sides of the blossom. Thus the stigma, which is above, is not always touched. On the other hand, the bumble bee has a much longer tongue and can readily reach the nectaries from above. In working a flower, species of *Bombus* grasp the whole blossom, standing on it in such a manner as to hug the stigma against the hairy ventral portions of the insect, and thus insure the deposition of pollen on the stigma. It would appear then that the bumble bee is the more efficient pollinator in this case.
Summary

I. The percentage of fruit which set as the result of bumble bee work was greater than the percentage set as the result of honey bee work.

II. The bumble bee is a faster worker than the honey bee, working more blossoms per minute than does the latter.

III. Through the advantage of possessing a longer tongue, the bumble bee is able to reach the nectar from above, and in so doing accidentally rubs pollen on the stigma of the blossom. The honey bee, on the other hand, having a shorter tongue necessarily must stand on one side of the blossom to reach the nectar, thereby lessening the chances of rubbing against the stigma.

IV. The honey bee may actually be a hindrance in fertilizing the cranberry flower since a blossom once worked is not worked by another bee. The honey bee may visit a flower and fail to deposit any pollen on the stigma. A bumble bee working in that vicinity at any time thereafter will not touch this blossom. In
this manner it is possible that many flowers escape pollination.

Judging from these observations, it would seem that the bumble bee is more efficient as a pollinator of the cranberry.
IV.

EXPERIMENTS WITH SODIUM FLUOSILICATE DUST
AGAINST CRANBERRY FIREWORMS
EXPERIMENTS WITH SODIUM FLUOSILICATE DUST AGAINST CRANBERRY FIREWORKS

By Donald S. Lacroix

Sodium fluosilicate has been recently brought to the attention of economic entomologists as a chemical of considerable value for insecticidal purposes. The irritating action of this material on the appendages of an insect causes the latter to clean the irritated parts by drawing them through the mouth, thereby giving the poison access to the alimentary tract. With careful use, sodium fluosilicate is not dangerous to handle, as a comparatively large dose is necessary to poison men or animals. This does not mean, however, that it should be looked upon as harmless. The cost of this insecticide is not great. It is a by-product of the fertilizer industry, and can be procured in a fine, powdery form for about eight cents a pound in small lots, and considerably less in wholesale quantities.

This new insecticide was used experimentally during the summer of 1925 as a control measure against
several cranberry insects. It was used in the dust form, being diluted with hydrated lime, and was applied to the experimental plots with a Niagara hand duster.

On April 16, a dry cranberry bog having a heavy infestation of the yellow-head fireworm (*Peronea minuta* Rob.) was found, and two plots (each about 1,000 square feet in area) were staked out. At that time the over-wintering adults were flying and were depositing eggs on the leaves. In a few cases, the eggs were developed to the point where embryo larvae could be seen beneath the chorion.

Two lots of dust were made up as follows:

1. 90 pounds hydrated lime
   10 pounds sodium fluosilicate

2. 40 pounds hydrated lime
   10 pounds sodium fluosilicate

Each lot was carefully mixed in a "roll-your-own" mixer (a barrel rolling on its long axis). The dust was applied at the rate of fifteen pounds to each plot, a rather heavy dosage. Plot A was dusted with the 1 to 9 mixture and Plot B with the 1 to 4.

Observations made six days later (April 22)
indicated that the adults were less numerous on the dusted areas. On May 6, an examination of the bog showed that larvae were active and abundant on the untreated part, while on the dusted plots but one living larva could be found.

Because of its habits and of the very nature of growth of its host plant, the insect's abundance cannot be accurately estimated, but when it is possible to find many larvae feeding on an untreated section of bog and only one on an adjacent dusted area, it is fair to say that the dust has satisfactorily controlled the pest.

Further tests were made with sodium fluosilicate and lime dust against the blackhead fireworm (*Rhopobota naevana* Mbn.), one of the most destructive of all cranberry pests. In these tests, two lots of dust were made up, 1 to 4 and 1 to 9 by volume, not by weight, as was the case in the previous experiment.

Two plots, each a rod square, were staked out on a bog in South Carver, Mass., and two on a bog in South Hanson, Mass. Both bogs were heavily infested
with larvae in all stages of growth, some just hatched and others nearly full grown. The dust was applied June 24 on the South Carver bog, and on the day following it rained. An examination of the bog on June 29 indicated approximately a 95% kill on both plots. Injury to the foliage was apparent only where the 1 to 4 dust had lodged heavily in thick masses.

On July 2, the same strengths of dusts were applied on the South Hanson bog. Rain followed two days later. The plots were examined July 5, and it was estimated that 80% control had been secured. Full grown larvae as well as younger ones were found dead in the webbed-up tips, on the leaves, or hanging halfway out of their webs. Some injury to the vines could be found on the plot dusted with the 1 to 4 strength, and some blossoms were injured on the 1 to 9 plot in places where the dust had lodged heavily.

From the last two tests it would seem that the 1 to 9 (by volume) strength is sufficient to satisfactorily control the black-head fireworm, and that if the dust is applied carefully no injury should re-
sult. It is recommended that, if this insecticide is to be used, it is well to dust before blossoming.