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BLUEBERRY INSECTS IN MAINE.

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BULLETIN 244.

BLUEBERRY INSECTS IN MAINE.*

WILLIAM COLCORD WOODS.

Perhaps as unique and interesting an ecological community as may be encountered in the state of Maine is presented by the blueberry barrens of Washington County which comprise some two hundred and fifty thousand acres of unforested wild land in the eastern part of the state, extending roughly from Cherryfield in the west to Machias in the east and comprising more especially Deblois and the townships numbered 16, 17, 18, 19, 24 and 25. How the barrens originated is a matter of dispute and there are several theories as to their beginning, but at any rate this fact is clear: in this section of the country wherever the forests are removed and more especially when they are destroyed by fire, blueberry bushes tend to spring up in large numbers. The barrens or "plains" consist of great stretches of mostly level or slightly rolling land more or less broken up by lakes and swamps. Climatic conditions such as characterize the whole coast of Maine prevail here: short summers, which on the barrens are very hot, and very long cold winters during which, however, the plants are usually well protected by a thick covering of snow. The average annual rainfall is 45 inches; typically there is a heavy rainfall in the spring followed by a dry period in June, a condition which seems to be favorable to the growth of blueberry bushes. When tested the soil, which is a mixture of sand, gravel and loam, is found to give an acid reaction.

THE BLUEBERRY IN MAINE.

In Maine the blueberry blossoms about the middle of May, and on the barrens the berries begin to ripen quite generally by

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the end of July. There, the picking season lasts from the tenth of August until mid-September. The greater part of the barrens is owned by comparatively few individuals but for a moderate rental they lease the land to farmers and others living in the vicinity who, as will be explained shortly, take charge of the burning and picking and in general care for the property. The berries are picked with a rake somewhat similar to that used for gathering cranberries, consisting of a flat tray one end of which is prolonged into a row of 25 or 30 small steel teeth while to the opposite end a short handle is attached. When in use, it is swung with a forward-directed lifting movement More or less foreign material such as leaves and stems is gathered in this way together with the fruit, but usually the berries are given a preliminary winnowing in the field, and this removes the coarser dirt. With the rake, one man can pick on the average about 3 bushels a day and it is estimated that one acre yields about 60 bushels of berries. The land is valued at about 50 dollars per acre. After the berries have been winnowed, they are packed in half bushel boxes and driven to the canneries. During the picking season the pickers move out to the barrens with their families and live in tents, so that the plains appear not unlike an army encampment, for at this time there are some 1,200 or more people finding their employment there.

Although the blueberry stands transportation well, comparatively little of the fruit is shipped fresh on account of the high rates charged, and most of the berries are sold directly to the canneries and to the local markets. Washington County is the home of the blueberry industry in this state and 12 canneries are located in various towns in this county, as well as one in Amherst in Hancock County. Each cannery has a capacity of several hundred bushels per day and employs from 20 to 30 people. In 1886 when the first attempt was made to can the berries, 5,000 bushels were put up; whereas in 1912 some 90,000 bushels were canned and the industry valued at $2,000,000.

Every third year the barrens are burned over, although occasionally the land is allowed to lie unburned for as many as 5 years or even longer. As a rule, each owner divides his land into 3 approximately equal lots which are burned in rotation, one each year. No berries are produced on the "new burn" (by

which is meant the first year's growth of bushes) but the second year the bushes bear very heavily, and somewhat less heavily in succeeding years, the reason being that the fruit is produced on the new wood developed during the preceding year. All the stems and leaves are destroyed in the burning and only the tangled mass of roots remains, so that there is a very vigorous growth during the first year, but decidedly less the second year as so much energy must be expended in developing the berries. The fires are set on a clear morning in the spring and sweep across the barrens all day but are checked by the heavy dews in the evening. Mr. Bird and Mr. Cobb in their thesis on the blueberry presented to the faculty of the University of Maine in 1913 state that no free element except carbon is left when the bushes are burned, for the vegetable oils are converted into carbonates, sulphates, and phosphates, or into metallic oxides, all of which are soluble in the soil water. Nitrogen is lost, but is supposed to be returned by a symbiotic fungus which lives on the roots.

Not only does the burning restore the fertility but it tends to keep in check the trees and bushes which would otherwise spring up on the plains. Three species of blueberries occur on the barrens, *Vaccinium pennsylvanicum* Lam. (including var. *nigrum* Wood), *V. canadense* Kalm, and *V. vacillans* Kalm, but the first two very decidedly predominate. As *V. canadense* ripens about 10 days later than *V. pennsylvanicum,* the berry season is fairly long. Locally the mountain-cranberry *Vaccinium Vitis-Idaea* L. var *minus* Lodd forms a dense cover over the ground, especially along the sides of little ravines. Huckleberries *Gaylussacia baccata* (Wang.) C. Koch and chokeberries, *Pyrus melanocarpa* (Michx.) Willd. are in places very plentiful, while the other more characteristic plants associated with the blueberries are the sheep-laurel, *Kalmia angustifolia* L., sweet-fern, *Myrica asplenifolia* L, and young gray birches, *Betula populifolia* Marsh. Less characteristic but common on some parts of the barrens are the alder, *Alnus incana* (L.) Moench, meadow-sweet, *Spiraea latifolia* Borkh, and several species of *Aster* and *Solidago.*

Blueberries are widely distributed elsewhere throughout the state but they grow only in pastures and waste land, and there is no real blueberry industry outside of Washington County

(save for the one cannery already referred to in Hancock County), for the fruit is used only locally while fresh. As on the barrens the low bush blueberries and more especially *V. pennsylvanicum* and *V. canadense* are the ones most generally gathered. Two species of high bush blueberries, *V. corymbosum* L. and *V. atrococcum* (Gray) Heller occur in the state, usually in moister localities, but they are little used in any section of the state with which I am familiar.

Besides the low and high bush blueberries several other species of *Vaccinium* occur in the state. These are the bilberries *V. caespitosum* Michx. and *V. uliginosum* L. and the cranberries, *V. Vitis-Idaea* L. var. *minus* Lodd, *V. Oxycoccus* L. and *V. macrocarpon* Ait.

Insects Attacking the Fruit Directly.

The Apple Maggot *Rhagoletis romonella* Walsh.

Distribution. Most important of the insects affecting the blueberry and the one around which the chief economic interest centers is the ordinary apple maggot or railroad worm, *Rhagoletis pomonella* Walsh (Diptera, Trypetidae). In Maine this fly in so far as the blueberry is concerned apparently is restricted to the barrens of Washington County although as an apple pest this species is widespread and troublesome throughout the state. Mid-July is the time during which the adults begin to appear on the plains. Eggs deposited in the berries during August hatch into white maggots which become full grown in about two weeks and enter the soil to pupate, spending the winter as puparia and emerging as adult flies in the course of the succeeding summer.

Seasonal history and life history in the blueberry. The adult. Rhagoletis pomonella in the adult form is a beautiful little black fly with banded wings. Although the total number of individuals on the whole extent of the barrens must be very large they are nowhere very abundant and the writer has never captured more than 22 in any one day even when he has spent 8 or 9 continuous hours on the plains, while usually one sees but 12 or 15 or even fewer.

All of the writer's observations were made in the vicinity of Cherryfield, Maine, as this town offered the easiest access to the barrens. In 1913 two trips were made to the plains, the first on July 30 and the second on August 14. Adults were present on both dates. Rather more data are available for 1914. On July 2 the writer made his first visit to the plains for that year. No flies had yet emerged. An attempt to dig out puparia was partially successful for a few were obtained, but this is an impracticable procedure partly because, as the puparia are so scattered, much soil must be sifted to reveal only a few, and partly because the tangled mass of roots and underground stems renders digging very difficult. No flies emerged from any of these puparia and subsequent examination showed that all were dead, probably, as will be made clearer later, because they were dug on "new burn." On July 20 a few adults were captured and it seems fair to assume that they began to emerge about the middle of the month. On July 30 and August 12 the flies were fairly common, but they were decidedly more numerous on August 18-20. Imagos were still fairly common but noticeably fewer on August 25 and but one fly was observed on September 10. Adults were fairly common on August 26, 1915.

Under artificial conditions emergence covers a considerable period of time. Pupae obtained from material collected during the summer of 1913 were kept at room temperature through the following winter and spring. February 11, 1914 and May 8, 1914 were the extreme dates of the emergence of adults from puparia kept under exactly the same conditions in the laboratory. None emerged however between February 11 when a single female developed and April 3. 35 out of the total 54 emerged between April 14 and April 27.

As the puparia which were dug in the field failed to produce adults the writer was unable to determine the preoviposition period. No maggots were found on July 30, 1914 but on August 12 larvae at least a week old were fairly common. This would indicate a preoviposition period of at least 15 days and probably longer. Doctor Illingworth (Cornell Exp. Sta. Bul. 324, p. 143) records it as 24 days for specimens bred from apple. In this bulletin is published also a detailed account, with figures, of the development of the eggs in the female.

Presumably the habits of the fly in relation to the blueberry are in general similar to its habits on the apple. There is however one very striking difference. Whereas on the apple the flies are rather sluggish and very tame, so that it is easy to watch oviposition in the field, on the blueberry they are very alert and shy, and the writer has never seen oviposition in the field. The adults suddenly appear on the berries seemingly as if they had just sprung into existence, and are so suspicious that it is no easy task to take them captive, a decided contrast to the larger, less active, and easily taken apple flies.

The Egg. The writer observed copulation in the laboratory several times in early August, 1914. The male grasped the female with his prothoracic and mesothoracic legs, the metathoracic trailing unused behind. The female meanwhile wandered nervously and uneasily about. They may remain in copulation at least half an hour but from 15 to 20 minutes seemed to be the usual time.

The adults are restless in confinement and it is hard to keep them alive. The writer has never succeeded in keeping them much over 3 weeks although they were supplied with food daily and with water many times daily. They refused to oviposit in captivity and I have witnessed the process once only. Then it took place just as has been described for the apple maggot. The fly walked over the surface of the berry and finally stopped, head downward. Lifting her abdomen, she thrust out her ovipositor and made a slit at an angle of 45 degrees in which she deposited a single egg just below the surface. This occupied about 2 minutes. Unfortunately this egg did not develop. The writer has found eggs in the field half a dozen times, though without knowing when they had been deposited. All of these hatched within 24 hours and the egg period in the blueberry probably does not exceed 2 or 3 days.

At all events these data are sufficient to show that in the case of the blueberry maggot as with the apple maggot, the egg is deposited directly in the berry and not in the blossom as is the prevailing idea on the barrens, for the adults do not emerge until fully 6 weeks after the bushes have flowered.

The Larva. Maggots were fairly common on August 12, 1914, including some about a week old, but the writer failed to find any indication of them on July 30. On August 18 and 25

larvae were common in all stages from those just hatched to some ready to leave the berries. On September 10 they were decidedly less numerous and there were but few small maggots. About 30 puparia were obtained from material collected on July 30, 1913, and on September 5 of that year maggots were still common in all stages. The season 1913 was more normal than 1914, which was decidedly backward, and this doubtless explains the discrepancy in the records. In 1915 larvae in all stages were found to be common on August 25 and 26.

Judging from measurements of the chitinous rasping hooks there are three larval instars. About one-fifth caudad there is a pronounced articulation, and measurements were made from the base of this angle to the tip of the terminal portion. In a recently hatched maggot this measurement was .035 mm., and in the succeeding instars .0625 mm. and .11[illegible] mm. (although in the two latter cases there was variation from .055 to .070 and from .090 to .120). The size of the larva offers absolutely no criterion as to the size of the hooks.

The writer has reared only a few larvae under such conditions that he was sure as to the exact number of days passed in the berry. One maggot which hatched August 18, 1914, was in the third instar on August 24, and formed its puparium on September 2. Two which hatched August 26, 1914, were in the last instar on September 2, were apparently full grown September 7, left their berries Sepember 8, and formed puparia September 9. One which hatched August 28, 1914, was in the second instar on September 2, and in the last instar on September 8; the puparium was formed on September 14. One which was in the second instar on August 26, 1914, was in the last instar on September 2 and formed its puparium on September 7.

These records indicate that the larva spends on the average about 14 days in the berry and that the period spent during the last instar is nearly as long as the time of the two preceding instars together.

Although when the maggots are small, an infested berry cannot be distinguished by sight from a sound one, in any case, even when the larvae are very small, fruit which has been attacked can easily be determined by the touch, for it feels soft and mushy, and this is the surest external indication of attack from *Rhagoletis*. The pulp becomes red and stringy and by the

time the larva is half grown, the fruit becomes much shriveled and shrunken. This condition is illustrated in figure 60 A. In every case which the writer has observed at all closely the larva has attained its full growth in one berry, which it leaves by an irregular and jagged exit-hole. Nor has he ever found more than one larva per berry under natural conditions. Usually the fruit falls off shortly before the larva becomes full-fed, but at times it may remain on the bush after the maggot has entered the soil. In such cases the larva doubtless works its way to the surface of the berry and then drops to the ground.

The Pupa. When ready to form their puparia, the larvae enter the soil which is of a sandy character on the barrens, but probably do not penetrate to a depth of much more than an inch. Under laboratory conditions they barely bury themselves beneath the surface in most cases. As is characteristic of this group of flies, pupation takes place within the last larval skin which is not molted but shrinks up and hardens, turning a light yellowish brown. Invariably the puparia are formed within 2 days after leaving the berry and usually within one. Transformation to the pupa takes place within 7 days after the puparia have been formed, usually about the fifth day.

The earliest date on which the writer obtained puparia in 1914 was on August 21, which would indicate that the first eggs were deposited about August 5. As has been stated previously, 29 puparia were found on August 22, 1913, in material collected on July 30, but, as has been explained, the difference in the climatic conditions easily accounts for the apparent discrepancy of the records.

Below is given in tabulated form the dates on which the writer removed full grown maggots which had left the berries, and puparia from the breeding cages, in 1913, 1914 and 1915. All material was collected in Cherryfield, Maine.

(1) MATERIAL COLLECTED AUGUST 18, 1913.

1913	Aug. 22	Aug. 23	Aug. 25	Aug. 27	Aug. 28	Aug. 30	Sept. 2	Sept. 4
Larvae	4	6	20	3	7	2	7	2
Puparia	7	4	4	33	7	22	38	10

1913	Sept. 8	Sept. 9	Sept. 13	Sept. 15	Sept. 22	Sept. 24	Sept. 26
Larvae	0	9	14	26	5	1	0
Puparia	50	20	16	12	15	18	4

(2) MATERIAL COLLECTED AUGUST 18, 1914.

1914	Aug. 21	Aug. 24	Aug. 27	Aug. 31	Sept. 14
Larvae	2	16	3	0	0
Puparia	2	20	11	2	3

(3) MATERIAL COLLECTED AUGUST 25 AND 26, 1914.

1914	Aug. 27	Aug. 28	Aug. 31	Sept. 4	Sept. 8	Sept. 14
Larvae	8	0	19	44	22	0
Puparia	0	1	16	104	30	4

(4) MATERIAL COLLECTED AUGUST 25 AND 26, 1915.

1915	Aug. 27	Aug. 28	Aug. 30	Aug. 31	Sept. 1	Sept. 2	Sept. 4	Sept. 5	Sept. 7	Sept. 9	Sept. 14	Sept. 18
Larvae ..	18	3	2	3	13	16	0	0	11	5	0	0
Puparia .	0	0	11	3	6	11	1	4	73	19	23	19

Generations. There is but one generation a year and the writer has not observed the slightest evidence of even a partial second generation.

DESCRIPTION.

No technical description of the stages of *Rhagoletis pomonella* Walsh is included in this bulletin because careful and accurate descriptions have already been published, especially by Doctor Illingworth in Bulletin 324 of the Cornell Experiment Station. (Egg, page 154; larva, page 154; puparium, page 155;

pupa, page 156; adult, male and female, page 151). The writer has compared his material with these descriptions and finds that larva, puparium, pupa and adult obtained from the blueberry exactly correspond down to microscopic detail, except that they fall much below the normal size of individuals bred from apples. The writer has also compared pinned specimens of adults bred from apple with individuals bred from blueberries, under the binocular, but can find no essential differences. The gray thoracic stripes are much lighter in the blueberry flies, even in fresh specimens, and the average difference in size between male and female is greater, but otherwise they are exactly like the apple flies except in size.

Specimens of the flies bred from blueberries were submitted to Mr. C. W. Johnson of the Boston Museum of Natural History, who very kindly determined them as undoubtedly *Rhagoletis pomonella* Walsh. It is interesting to note in this connection that the adults bred from huckleberries in Connecticut by Doctor Britton which Mr. Johnson showed the writer were of about the same size as those bred from blueberry, and Professor O'Kane states in his recent bulletin on the apple maggot that the flies which he bred from blueberries in New Hampshire were under the normal size of this species.

Below is printed a table showing the comparative size of a series bred from apples in Maine, and of a series bred from blueberries; measurements mere made from 10 males and 10 females of each race in the case of the adults, and of 10 larvae and of 10 puparia of each race for the rest. All measurements are expressed in millimeters.

	Apple Maggot		Blueberry Maggot	
	♂	♀	♂	♀
Average wing	4.80	5.20	3.55	4.25
Shortest wing	4.55	4.75	3.25	4.00
Longest wing	5.25	5.80	4.00	4.60
Average length adult	4.60	5.80	3.60	4.20
Minimum length adult	4.25	5.00	3.10	4.10
Maximum length adult	5.50	6.50	4.00	4.45
Average tibia mesothoracic leg	1.55	1.60	1.10	1.30
Minimum tibia	1.45	1.50	0.90	1.20
Maximum tibia	1.70	1.85	1.30	1.45

Average length larva	7.75*	4.75
Minimum length larva	7.00*	4.50
Maximum length larva	8.50*	5.50
Average length puparium	4.25	3.35
Minimum length puparium	4.00	2.80
Maximum length puparium	5.25	4.00

The measurements of the adults were made by means of a compound microscope and camera lucida under a magnification of 20 diameters. The larvae and puparia were measured by means of a simple dissecting microscope under a magnification of 12 diameters. The length of the wings was measured along a hypothetical line drawn from the angle formed by the union of R and C at the basal portion to the costal margin of R_{4+5} at the apical. The length of the adult was measured along a hypothetical line from the convergent bristles slightly in front of the ocelli to the tip of the abdomen. Only specimens in which the abdomen was straight and in which the ovipositor was withdrawn into its sheath were used in this last measurement. It will be noted that the largest female bred from the blueberry is but .2 mm. longer than the smallest male bred from the apple.

METHODS.

Infested berries were placed under breeding cages on cheesecloth spread several layers thick over moist dirt, and the full grown larvae as they left the berries and the puparia removed daily. The writer found the most satisfactory way to keep the puparia through the winter was in jelly tumblers on cheese cloth over sand which was moistened approximately once a month. However, in one tumbler which was inadvertently overlooked and not watered between October and April the adults developed normally. The writer experienced no difficulty in carrying his 1913 material through the winter at room temperature but unfortunately all of his 1914 material—not only of *Rhagoletis* but of other blueberry insects as well—become overheated and completely failed to develop. For this reason it has not yet been possible to determine the exact preoviposition of *Rhago-*

*From Illingworth, Cornell Exp. Sta. Bul. 324, p. 155. No Maine material measured.

letis in connection with the blueberry, nor does the writer know whether as a general rule adults emerge earlier from the puparia that are formed first. Further collections were made during the past summer (1915) and it is hoped that these points may be ascertained later.

In the laboratory the adult flies were treated in accordance with the suggestions given the writer by Dr. H. H. P. Severin engaged in special work for this Experiment Station. They were kept in glass jars about five inches high and five inches in diameter in which a layer of moist sand was placed on the bottom. Absorbent cheesecloth was fastened over the top, and moistened with water every few hours. The adults were fed with banana once a day, inserted through a hole in the cheesecloth which at other times was filled with a cotton plug. Through this same hole flies could be removed or introduced at will. They were supplied with a fresh blueberry twig daily.

HOST-PLANTS.

The writer has bred *Rhagoletis pomonella* Walsh from the three species of low blueberries, *Vaccinium pennsylvanicum, V. canadense* and *V. vacillans.* Professor O'Kane has recorded it from *V. corymbosum* (N. H. Exp. Sta. Bul. 171, p. 18). This species has not been found at work in the mountain cranberry, *V. Vitis-Idaea* var. *minus,* locally common on the plains. The huckleberry, *Gaylussacia baccata* is also common on the barrens and is subject to attack later in the season. The writer has never found maggots in huckleberries in August but when the blueberries are becoming scarce in early September, then the huckleberries are quite generally infested. Twice before the apple maggot has been reared from huckleberries (*Gaylussacia* sp.): once in Connecticut by Doctor Britton (Rpt. Conn. Sta. 1905, p. 200); and once in New Jersey by Doctor Smith (Insects of N. J., 1909, p. 802). Chokeberry, *Pyrus melanocarpa,* is locally abundant on the plains but a careful search has failed to reveal any larvae in them. The writer did succeed in making successful transfers and very small larvae removed from huckleberries and blueberries attained their growth and formed puparia when placed in chokeberries. Puparia were also obtained

in limited numbers from haws, *Crataegus* sp., collected in the vicinity of Orono.

For one very peculiar fact of distribution the writer can offer no very satisfactory explanation. In Maine, although as an apple pest *Rhagoletis pomonella* is widely distributed throughout the state, and although blueberries are found commonly everywhere in the state, as an enemy of the blueberry *Rhagoletis pomonella* seems to be entirely restricted to the blueberry barrens of Washington County. The writer has made a great many careful collections of blueberries around Orono during the past 3 summers without finding so much as a trace of the work of this insect. In the orchard in the rear of his home in Orono are 2 sweet apple trees which for years have served as a trap for the apple maggot, the fruit being so badly infested as to be worthless, and two pastures full of blueberries lie within an eighth of a mile of these trees, yet the blueberries are entirely free from any attack by *Rhagoletis,* nor has the writer seen any indication that *Rhagoletis* was at work on the blueberry elsewhere in Penobscot County. Careful collections at Auburn, and in the Katahdin region, and more hasty ones at Kineo, Searsport, Mount Desert, and elsewhere, bear out the conclusion stated in the first part of this paragraph. Moreover, the same would appear applicable to the huckleberries; it is true that they are not common in the State, yet they seem to be infested by *Rhagoletis* only on the blueberry plains.

Owing to the frequent burning of the barrens, the soil does not become exhausted and the berries there are much larger and juicier than elsewhere in the state. It is not impossible that only in these larger berries does the maggot find sufficient food for its growth and thus is restricted to this region. The writer's observations have been entirely confined to the low bush blueberries, and he has not had an opportunity to examine the high bush blueberries which are naturally somewhat larger; it is not improbable that when the high bush berries in different parts of the state are examined they will be found more or less abundantly infested with *Rhagoletis* elsewhere than in Washington County.

It will be recalled that the flies bred from blueberries were so much smaller than those bred from apples that at a glance they could be distinguished readily. Although the apple maggot was

very troublesome in the orchards of Cherryfield in 1914 neither there nor elsewhere did the writer observe any flies on the apples that were subnormal in size. These observations are in perfect accord with those made by Professor O'Kane in New Hampshire.

The writer has not succeeded in inducing the fly of the apple maggot to lay eggs in blueberries. This experiment has been tried a number of times both in the laboratory and in the field. A large cage was placed over a healthy blueberry plant, and about 20 adult *Rhagoletis* just captured on apple introduced, but they refused to oviposit. This was done twice in the field and on a smaller scale several times in the laboratory and insectary, always with negative results. At various times during the past summer the writer introduced some 20 or more half-grown blueberry maggots into apples of various kinds, inserting them beneath the skin in such a way that they could burrow into the pulp before drying up, but not a single one developed sufficiently to form a puparium. Likewise flies taken on blueberries refused to oviposit in apples, but as they also showed so much reluctance in the laboratory to oviposit at all one should not lay too much stress on this point.

At any rate the writer is inclined very strongly to believe that biologically at least there are two distinct strains or races of *Rhagoletis pomonella* Walsh, the one breeding in the apple and related fruits and the other in smaller fruits such as the blueberry and huckleberry. There does not seem to the writer to be any other conclusion which will explain the data given above. Certainly in so far as *Rhagoletis* occurs in Maine the form on the apple and the form on the blueberry are entirely independent. The "oldest inhabitant" of the barrens cannot remember a time when there were not maggots in the blueberries, while the introduction and spread of the apple maggot in the state is a matter of record and is discussed by Professor Harvey in the Annual Report of this Experiment Station for 1889 and subsequent years. In Maine the blueberry maggot apparently did not migrate to the apple nor vice versa and the two races have lived on independently side by side.

The original host plant of this insect is as much a matter of theory as ever. Professor O'Kane has shown that it must have been some species of haw, or else the blueberry or huckleberry

(Bul. 171, N. H. Exp. Sta.). Since the blueberry and huckleberry flies are so much below what must be considered the normal size of this species, and since apparently they are decidedly restricted in their breeding habits, it does not seem probable to the writer that any species of either *Vaccinium* or *Gaylussacia* was the original host of the insect in question. This would seem to leave the haw as the only remaining possibility. Professor O'Kane has suggested four species (l. c. pp. 16-17) whose range and fruiting habits would be suitable in this connection. These are *Crataegus coccinea, C. punctata, C. macracantha* and *C. mollis.* Since *Rhagoletis pomonella* Walsh has now been bred quite extensively from haws and since adults so bred are about normal in size, the writer would suggest that some one of the four species of *Crataegus* listed above was the original host, and that the species has spread on the one hand to the apple and related fruits, and on the other to the huckleberry and blueberry, in which an independent and quite different strain has arisen.

It is tempting to try to include the chokeberry in the above scheme since it belongs to the genus *Pyrus*, especially after it has been demonstrated that successful larval transfers may be made to this fruit; but if the chokeberry were really an acceptable home to *Rhagoletis pomonella*, occurring abundantly as it does on the plains, it would certainly be heavily infested.

NATURAL ENEMIES.

A hymenopterous parasite, *Biosteres rhagoletis* Richmond, (Braconidae) was bred in considerable numbers from puparia obtained from blueberries in 1913. Under laboratory conditions the adults emerged at various times between February 25, 1914, and April 21, 1914, from the pupae of *Rhagoletis pomonella.* Specimens of this species were swept on the blueberry barrens of Washington County during the summer of 1914. Apparently they had considerably reduced the number of maggots as compared with the preceding season, and certainly must render very efficient aid in holding the maggot in check.

Adults were observed quite commonly on the barrens hovering about the blueberry bushes on August 26, 1915. They were rather slow moving and not very shy. In one case the writer

was fortunate enough to witness oviposition. The long ovipositor was thrust its full length into the berry. The larva selected formed its puparium on September 11, 1915, so it could not have been more than a day or two old when the egg of the parasite was deposited in it. It is, therefore, a larval parasite although the parasitized larva grows normally and forms its puparium. In the field the parasite doubtless passes the winter protected within the puparium of the host and does not emerge until mid-summer or later.

These parasites belong to the family Braconidae and to the subfamily Opiinae. Specimens were submitted to Mr. E. A. Richmond of Cornell University, who determined it as a new species and named it *Biosteres rhagoletis*. The original description which appeared in the Canadian Entomologist for September, 1915, v. 47: 293-295, pl. 12, is here reprinted with Mr. Richmond's permission:

Biosteres rhagoletis (description of adult by Mr. Richmond)

"Fulvous (xanthine orange); antennae, except scape in ♂ (partly in ♀), terminal joints of pro- and mesothoracic tarsi, entire metathoracic tarsi and tips of mandibles, brown; eyes and ocelli black; wings with membrane colorless, nervures and stigma brown; sheath of ovipositor brown; inner stylets fulvous. Length 3 mm.; ovipositor 3 mm. Habitat—Cherryfield, Maine.

"*Head* shining, closely tessellate, punctulate, pilose (including mouthparts); ocellar elevation impunctate and not pilose; face with a median longitudinal elevation, almost a keel; *clypeus* with sparser punctures in center; *flagellum* 36-41-jointed; scape a little longer than first joint of flagellum, pedicellum globular. *Thorax* shining, sparsely punctulate and pilose; parapsidal furrows converging and ending in a median V-shaped, impunctate impression, which lies in the posterior third of the mesonotum; mesonotum (including scutellum) margined; propodeum not flat but rounded, more pilose and punctulate than the rest of thorax, irregularly rugulose and tending to have poorly-defined areoles, which are more especially prominent in ♀ ♀; r (first abscissa of the radius), a little more than 1-6 as long as r-m; shorter than the petiole of M_4; M_4 petiolate, petiole about 1-5 as long as m-cu. *Abdomen* finely punctulate, shining, very sparsely pilose; 1st segment margined laterally, finely and closely striated with some of the elevations often more prominent at basal half; 2nd segment with a little more than its basal half finely and closely striated (or sometimes almost entirely striated,) except at sides; ♂ and ♀ similar, except as noted above." The female is illustrated in figure 62, A, B and C.

METHODS OF CONTROL.

While the actual number of maggots in 250,000 acres literally blue with berries when they are ripe must be very large, ordinarily only an insignificant proportion of the fruit is infested. This was the case in 1913, when the crop was fairly large, and though the maggots were abundant only from 1 to 2 per cent of the crop had been attacked. But in 1914, though the larvae were far less numerous so small was the yield that from 8 to 10 per cent of the fruit was maggoty. Conditions were much the same in 1915, owing to a short berry crop, although as *Rhagoletis* is more or less locally distributed on the plains, it is very hard to make even an approximate estimate.

No measures aimed at a complete control of this pest would prove really practicable and in an ordinary yield no elaborate system of control is needed. The maggot could never be exterminated in so vast an area of wild land, most of it remote from any town and broken up by swamps, lakes and occasional forest tracts, even if concerted efforts were made, for of necessity there would always remain many places in which the flies would breed uninterruptedly and from which they would spread again over the rest of the barrens. Nor does it seem practicable to advocate poison spray and volatile oils for an area of 400 square miles, even if there were no doubt as to the efficiency of these agents.

Burning the plains as is commonly done is a practice highly to be commended. Besides restoring the fertility of the land, it undoubtedly destroys the puparia in the soil for they lie near the surface, and it must be a very material help in keeping down the numbers of the fly. It also serves to kill many other insects for wherever there is "new burn" the bushes are conspicuously free from leaf-feeding insects of all kinds. As approximately only one-third of the plains is burned yearly, the fly is not exterminated, and this probably could not be accomplished even if an attempt were made to burn over the whole extent of the barrens at one time.

When the berries are winnowed in the field the maggots can be found abundantly. A great many of the larvae are blown out with the lighter dirt and can be caught in one of the trays in which the berries are packed. Frequently a good many larvae

remain in the trays after the berries have been poured out. The writer has never seen any attempt to kill the maggots at the time of winnowing but if this were done it should help not a little in reducing the numbers of this pest. The older larvae doubtless pupate *in situ* and because of the many berries necessarily scattered about in the process of winnowing probably many of the smaller larvae are able to work their way to a new berry and complete their growth.

As the maggots usually are not troublesome until the end of the season when the berries are scarce, and as the parasite *Biosteres* seems to be doing excellent work fortunately none of the more elaborate control measures are necessary for it would be impracticable to apply them on such a large scale on wild land so far from any centre of supply; and the common practice of burning together with the destruction of such maggots as can be caught and killed conveniently after winnowing will doubtless serve to hold *Rhagoletis pomonella* in check so far as Maine blueberries are concerned.

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1914. *O'Kane, W. C.* The apple-maggot. N. H. Agr. Exp. Sta. Bul. 171, pp. 1-120, pl. 1-8.

1914. *Woods, William C.* A note on *Rhagoletis pomonella* in blueberries. Journal of economic entomology, v. 7:398-399.

These are the most recent publications dealing with the apple maggot and both contain a full bibliography of earlier articles.

A Blueberry Cecid *Lasioptera fructuaria,* Felt n. sp.

DISTRIBUTION AND HOST-PLANTS.

Rhagoletis is not the only dipterous insect which has adopted the blueberry as its habitation. A tiny Cecidomyid, *Lasioptera fructuaria* Felt was found in the fruit in considerable numbers. It is not of economic importance, however, because it infests only decayed or decaying berries. It seems to be generally dis-

tributed through the state, for the writer has found it wherever he has collected berries at Orono, Cherryfield, Auburn and Searsport. The writer has bred it from *Vaccinium pennsylvanicum* and *V. canadense*.

SEASONAL HISTORY AND LIFE HISTORY IN THE BLUEBERRY.

Apparently the delicate little midge hibernates as an adult, emerging from her winter quarters at least by June. She is unable to puncture the skin of the berry and deposits her eggs in cavities which already exist in the fruit from other sources. Quite frequently she seems to make use of the egg puncture of a weevil, *Pseudanthonomus validus* Dietz; certainly this would be a natural inference, for one may frequently find cecid larvae in the same fruit as weevil larvae. Usually but 3 or 4 eggs are deposited in a berry, but the writer has found as many as 6 larvae in a single one.

The exact duration of the egg-stage was not determined. Eggs collected on June 18, 1915, hatched on June 21. Probably not more than 4 or 5 days is required. Recently hatched cecids are quite common after June 20. When the larva leaves the egg it is whitish and nearly transparent; the older larvae are pinkish orange. It is impossible to keep one individual under continuous observation for the larvae are very delicate; they cannot be transferred from one berry to another and dry up if left in an opened berry.

In an ordinary season most of the larvae are full grown about July 20 and begin to leave the berries to pupate. In a late season, such as 1915, the majority do not leave the fruit until about July 30. However, a few individuals are full fed even as early as the first of July. The dates on which the berries were picked and the dates on which the larvae left the fruit were recorded in 1913 and 1914. In the majority of instances the larvae have been ready to leave 8 or 9 days after the collection. From July 12 until August 4, 1914, 23 days, was the extreme length; and from 15 to 20 days would probably be a fair estimate of the larva life.

As was stated above, the larvae leave the berries before pupating. The writer does not know where they pupate in nature; Doctor Felt has suggested that they may seek grass

stems. In the laboratory a part pupated on the cheesecloth in the berry dishes but the majority entered the sand or dirt. On the cheesecloth they spun cocoons before transforming to pupae, while in dirt no cocoon seems to be spun, but a little cavity is hollowed out by contorting the body. The silk appears to be secreted from glands opening on either side of the penultimate segment, but no detailed study was made of this point. From 12 to 14 days are required after leaving the berry before the adult midge appears. About half the time is spent as a pupa and half as a prepupa.

Only a very small proportion of the larvae that left the fruit ever emerged as adults. The pupae are extremely delicate and die unless conditions are exactly suitable. July 18, 1914, is the earliest record for the emergence of an adult.

There is probably a partial second generation as the writer has found eggs in early August and small larvae at various times through the month.

Technical Description.

Adults were submitted to Dr. Ephraim Porter Felt of the State Museum, Albany, N. Y., who determined them as a new species, *Lasioptera fructuaria.* In the key which he has prepared it runs near *L. michellae* Felt from which he states that it can be easily separated by colorational characters and by the presence of well developed hooks upon the ovipositor.

Doctor Felt described the adults of both sexes as well as the larva and has very kindly given me permission to publish his descriptions which are printed here for the first time.

Adult male. (Description by Doctor Felt). Length 1.5 mm. Antennae yellowish brown, the two basal segments yellowish; 15 or 16 segments, the fifth with a length one-half greater than the diameter, the terminal segment roundly conical, with a length one-fourth greater than its diameter. Palpi: the first segment narrowly oval, with a length three times its diameter, the second a little longer than the first, slender, the third two-thirds the length of the second, more slender, the fourth about as long as the third. Mesonotum shining dark brown. Scutellum yellowish brown, postscutellum fuscous yellowish. Abdomen: basal segment yellowish or whitish, the other segments dark brown, narrowly margined apically with yellowish or whitish. Genitalia fuscous yellowish. Wings hyaline, the third vein uniting with the costa just beyond the basal half. Legs a nearly uniform fuscous yellowish; claws slender, strongly curved, the pulvilli as long as the claws. Genitalia: dorsal plate deeply and triangularly emarginate, the lobes obtusely and irregularly rounded; ventral plate indistinct in the preparation. Harpes long, slender, the apices slightly divergent, subtruncate.

Adult female. (Description by Doctor Felt). Length 1.75 mm. Antennae dark brown, the 2 basal segments yellowish; 16-20 segments, the fifth with a length about three-fourths its diameter, the terminal segment globose. Palpi: yellowish, the first segment short, sub-quadrate, the second with a length twice the first, the third one-half longer, more slender, the fourth about as long as the third, more slender. Mesonotum dark brown. Scutellum, postscutellum and abdomen dark brown, the segments of the latter narrowly margined posteriorly with yellowish white, the ovipositor nearly as long as the body, fuscous yellowish, the terminal lobes with a length 4 times the width and with a group of heavy, chitinous hooks. Halteres and legs fuscous yellowish, otherwise nearly as in male. Type Cecid a 2641 in the New York State Museum, Albany, N. Y.

Egg. Shining white, oval, comparatively long and slender, slightly more pointed at one end. Length 0.20 mm. See figure 56 B.

Larva. (Description by Doctor Felt). Length 2.1-2.5 mm., orange pink, moderately stout, tapering at both extremities, the skin coarsely shagreened; head moderately stout, broad apically, the antennae divergent, with a length 3 times the diameter and apparently uniarticulate; breast-bone distinct, the shaft stout, the apex broadly bidentate; terminal segment broadly rounded, almost subtruncate and with 4 sublateral pairs of stout, tapering, spinose processes. See figure 56 A.

Pupa. Thorax and abdomen pink; head, eye and appendages colorless and transparent. Thoracic segments closely fused together; wings appressed to body, folded over to ventral side and partly covering the legs; the base of the antenna forms a projection on the anterior end; antenna extends back over the eyes bordering the lower margin of the wing; legs closely appressed to body, with the tips free. A dark brown spine on the suture between head and thorax. A brown spiracular opening above the eye from which a long flexuous seta projects. See figure 56 C.

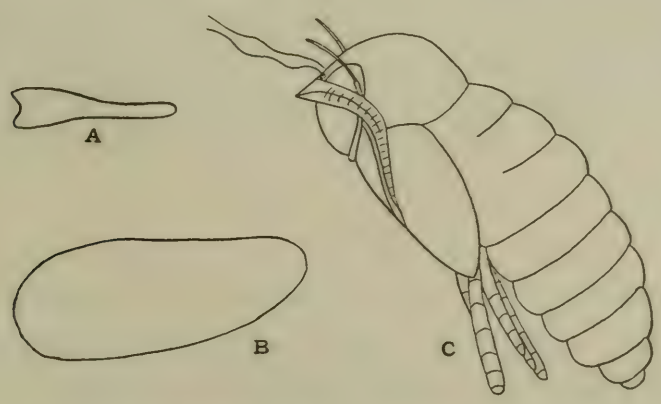

Fig. 56. *Lasioptera fructuaria* Felt sp. n. A. breast bone of larva about 100 times natural size; B. egg about 100 times natural size; C. pupa about 20 times natural size.

A Pomace Fly *Drosophila ampelophila* Loew. *et al.*

Pomace flies of various species were bred in great numbers from blueberries placed in cages in the insectary, as soon as the fruit became a trifle old and had lost its firmness. Unless stored berries were packed securely and guarded against the attack of these flies they might prove to be a very serious pest.

In two cases in fresh berries brought in from the field the writer has found white dipterous larvae which he believes were *Drosophila* sp., but it is seldom, if ever, that *Drosophila* attacks the fresh fruit.

Care should be taken not to confuse this insect with *Rhagoletis*. Fortunately larva, puparium and adults are all very much unlike. This species is figured in Bulletin 3 of this Experiment Station.

The Currant Fruit-Weevil *Pseudanthonomus validus* Dietz.

DISTRIBUTION AND HOST PLANTS.

The currant fruit weevil (Coleoptera, Curculionidae) is quite widely distributed in Maine as a blueberry pest for it occurs both in Orono and Cherryfield, the only places in which extensive collections of berries have been made for the study of their insect enemies. Mr. R. A. Cooley of the Montana Experiment Station has bred this species from the currant and reports it as a serious currant pest in that state. Dr. H. H. P. Severin, who has been engaged in a special investigation for this Station on the currant fruit fly during the past 2 seasons, states that he has seen no indication of the work of this species on the currant in Maine. So far as the writer knows, in Maine this species is confined to the low blueberries, *Vaccinium pennsylvanicum* and *V. canadense*.

SEASONAL HISTORY AND LIFE HISTORY IN THE BLUEBERRY.

The Egg. Hibernation takes place in the adult stage. Egg deposition begins about the middle of June, while the berries are still small and green. Usually the female chooses one of the calyx lobes in which to lay her egg. The sepals are hollow

with just enough space between the two walls to receive the egg, and in the majority of cases it is simply deposited within one of the sepals. In other cases the puncture is longer and the egg lies in the berry itself near the surface, at the end of a short curved passage leading from one of the calyx lobes. The opening left after the puncture has been made is rather irregularly circular; the edges soon become dry and turn brownish. Frequently punctures of a similar nature are to be found continuing straight through both walls of the sepal. To make exactly the right puncture must be a rather delicate operation and presumably these represent unsuccessful attempts, for the writer has never found any eggs in connection with them. Occasionally an egg is deposited just beneath the skin at the stem end of the fruit, the puncture appearing as before. In a short time the surrounding skin becomes purplish and later hard and brownish.

The earliest date on which the writer has found the egg of this species is June 15, 1915; and they are to be found quite generally by June 18. The duration of the egg stage was not exactly determined for the overwintering adults are scarce and none were swept in the field until after the egg laying period was passed. Of 3 eggs found June 18, 1915, 2 hatched on June 21 and 1 on June 22. The egg stage probably does not last longer than 4 or 5 days. The latest date recorded for a first instar larva is July 9, 1914, so for the most part oviposition is probably over in early July. The writer has no data as to the number of eggs which one individual may deposit.

The larva. The newly emerged grub appears slightly larger than the egg and is pure white except for the proportionately large head which is very light yellow brown. Recently hatched larvae were common on June 22, 1915, and as the writer found one on June 16 eggs are evidently deposited at least as early as June 12.

As soon as the larva hatches it tunnels to the center of the berry, typically leaving behind it a hardened reddish trail which is very conspicuous in the green pulp. This seems to be the case no matter where the egg has been deposited. But from this point on the fruit is eaten irregularly. All through its larval life the weevil lives in a little cavity which is just the size of its strongly arcuate body. The grub is sluggish, moving but little and very slowly and filling up the trail behind it with

frass. One berry furnishes sufficient nourishment for one weevil with little or none to spare. All parts of the fruit are eaten except the outer coat of the seeds, and the berry is left just a shell around a mass of fine brown frass. Where the weevil has burrowed near the surface, the skin often appears discolored.

The writer has not found it possible to keep one larva under continuous observation for they are unable to enter the uninjured fruit when once removed, and a green berry when punctured dries up very rapidly. Not infrequently larvae may be found which have been crushed by the growth of the berry.

There are 4 larval instars. The head of the newly hatched weevil measures .095 mm. and the succeeding instars measure approximately .11, .13 and .15 with slight variation, especially in the fourth instar. The ratio is 1.16 and the theoretical measurements .110, .1275, and .148 agree very closely with the actual. All measurements were made under a magnification of 20 diameters by means of a camera lucida.

All larvae found in the berries were preserved in alcohol with a record of the date of collection and the date of removal, and their instar determined by head measurements. A part of this data is given below in tabulated form.

		1st	2nd	3rd	4th			1st	2nd	3rd	4th
1914	June 30			1		1915.	June 21	1			
	July 6	1	1	3	2		June 22	7			
	July 7		1	1			June 25	1			
	July 9	1			2		June 26	1			
	July 10			2	5		June 30		3		
							July 11			1	4
							July 13			1	6
							July 17				3
							July 18			1	3
							July 20			1	1
							July 23				1
							July 24				3
							July 29				1

Very few first instar larvae are to be found after the last of June. Second instar larvae occur mostly in early July before the seventh of that month. Third instar larvae were found on quite scattered dates but mostly between July 6 and 11. Fourth instar larvae are occasionally met with as early as July 6 but

they are most abundant from July 13 until about July 24, occurring, however, through the rest of the month.

From his data and observations the writer would infer that each instar lasts about a week, except the fourth which (including the prepupal period) extends over 10 days, and that consequently 30 or 31 days is a fair estimate of the average length of the larval life. The majority hatch about June 22 and pupate from July 23 to July 30.

The pupa. This insect does not leave the berry in order to pupate, but the pupa is formed in the same little cavity in which the larva lived. The young pupa is pure white, with transparent legs and wings. It is able to move rather freely when disturbed. The cast larval skin usually adheres to the tip of the abdomen. Two days before emerging the beak, coxae, and femoro-tibial joints are brownish. About 24 hours before emergence, these parts are darker brown and the tips of the elytra appear dark; 12 hours before, in addition the dorsal part of the prothorax is brownish, and the eyes are black. The beak, head and prothorax of the newly emerged beetle are dark brown, the eyes deep black, the legs white except for the dark brown femoro-tibial joints and the black tarsi; the abdomen is practically white, the elytra are soft and colorless, and the wings are not yet folded beneath them. The legs are at first closely appressed to the body. The pupa lies with the ventral side uppermost and the adult remains on its back for several hours. The weevil stays in its cavity within the berry until the cuticula becomes fully hardened and colored, a matter of some 24 hours. Often the pupal skin is caught on the end of the beak which is used in pushing off the old cuticula.

Only once was the writer able to determine the pupal period exactly. From a pupa formed on July 20, 1914, the adult beetle emerged on July 29 and was fully colored on July 30. Less definite observations would indicate that 9 days might safely be considered the normal time spent as a pupa. Reckoning the duration of the egg stage as 5 days, the period of larval life as 31, and the pupal instar as 9, gives 45 days as the average length of the period of development.

Adults. The adults began to emerge in mid-July and emergence continued a month or more. Below is given in tabulated form the emergence of adults in 1913 and 1914.

1913		1914	
10 on	August 1	1 on	July 18
3	2	2	23
11	4	2	24
1	5	3	25
22	9	5	27
17	11	3	28
6	16	7	August 3
8	22	1	4
		3	5
		7	10
		4	17
		1	21
		1	28

The majority emerge in early August which further bears out the conclusion that the greater number pupate in late July and that the pupal period is about 9 days.

The adults feed very greedily on the berries, eating off the skin and sucking up the juices. This condition is illustrated in figure 60 C. They refuse to eat the leaves even when there is no fruit available. These weevils enter into hibernation shortly after they emerge. In the spring the over-wintering beetles will eat the leaves quite readily leaving them punctured with small dots.

Generations. There is probably but one generation in Maine for the writer has found no tendency to pairing and no tendency to lay eggs in weevils reared from the berries and confined in the laboratory. On the other hand, the writer occasionally has found larvae even in August as shown in the table printed below.

		1st instar.	2nd instar.	3rd instar.	4th instar.	Pupae
1914.	August 10		1			1
	14	1	1	1		3
	15			1		
	17		1			1
	21				1	1

The writer is inclined to believe that these individuals hatched from eggs deposited much later in the season than is usual by the overwintering weevils of the preceding summer. It is

possible, however, that they represent a partial second generation.

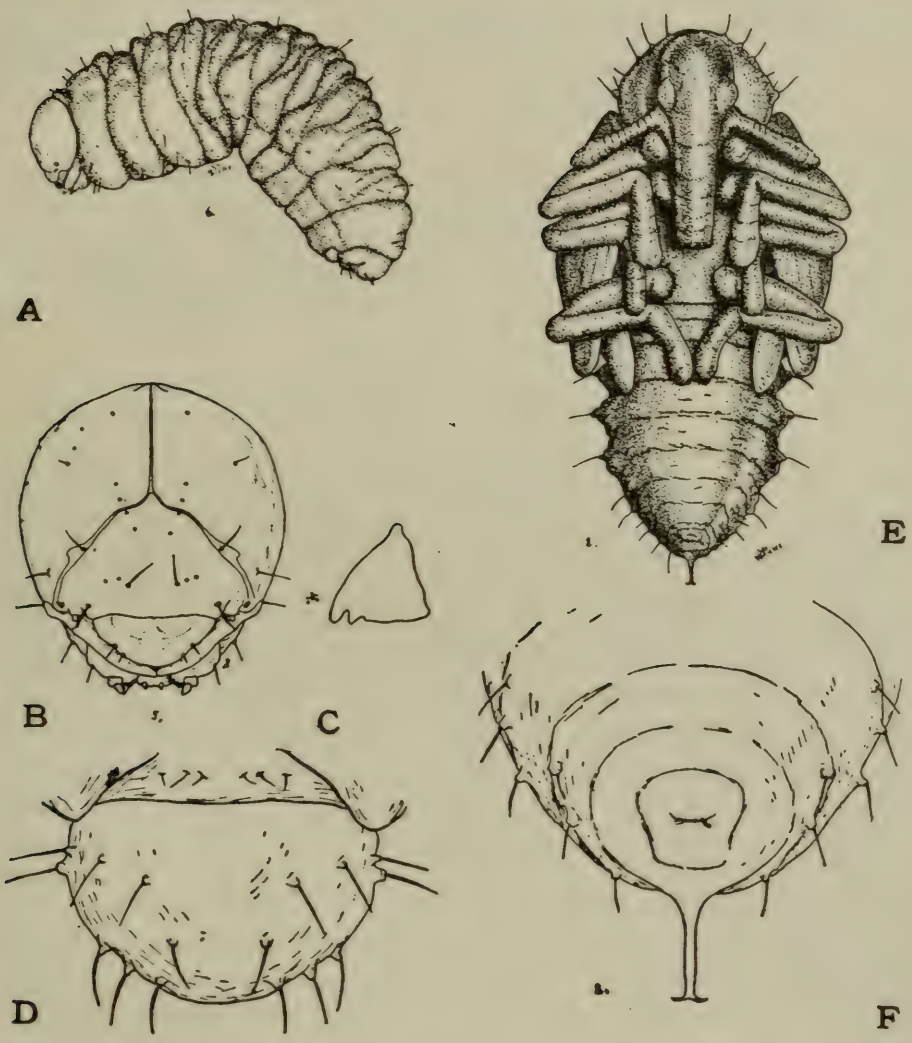

Fig. 57. *Pseudanthonomus validus* Dietz. From drawings by W. Dwight Pierce. A. larva; B. head of larva; C. mandible of larva; D. pronotum of pupa; E. pupa, ventral aspect; F. caudal portion of pupa, ventral aspect. All enlarged.

Description of the Stages.

Specimens were submitted to Mr. W. Dwight Pierce of the United States Bureau of Entomology, who determined them as *Pseudanthonomus validus* Dietz. He has very kindly supplied me with a description of the larva and pupa, which is published in the next section. All of the drawings for figure 57 were made by Mr. Pierce and are reproduced here with his permission.

Egg. Nearly oval, very pale translucent green, with a very thin and delicate shell. The egg becomes whitish before hatching and the weevil can be seen distinctly curled up inside. The shell is smooth.

Adult. The adult is a reddish brown weevil somewhat less than one-fourth of an inch long.

The immature stages of Pseudanthonomus validus Dietz.* The species *Pseudanthonomus validus* Dietz belongs to a genus of reddish weevils which breed in the buds and fruit of various plants. This genus is placed in the tribe Anthonomini,—a very characteristic group in the Curculionidae.

Very little has yet been done toward differentiating the immature stages of weevils and it is, therefore, very difficult to present characters for the separation of species. Ultimately we will find characters in the arrangement of the folds of the body of the larvae as well as in the spiracles. The descriptions given herewith, used in connection with the illustrations, will serve to identify this weevil.

Larva. White, 3-4 mm. long. Head yellowish. The location of the pits and hairs on the head is of considerable importance. These are indicated in the drawing of the head. The labrum and clypeus seem to be fused and are so transparent that the mandibles can be seen through them. The ocelli are tiny and black. The antennae are single-jointed. The mandibles have two strong teeth and are slightly asymmetrical. The maxillary palpus is but 2-jointed and the labial palpus 1-jointed. See figure 57 A, B and C.

Pupa. White, 3.5 mm. long. The pupae of the tribe Anthonomini are characterized by having a chitinous apical process from the ninth dorsal abdominal segment. The genus *Pseudanthonomus* is characterized by having this process slender with the apex abruptly bifid, the 2 processes almost at right angles to the axis of the process, apex sinuate. Otherwise the pupa must be recognized by its tubercles. The prothorax is provided with 8 pair of setigerous tubercles, more or less cone shaped, 3 pair apical, 2 pair lateral, and 3 pair dorsal. The mesothorax and metathorax each have 3 pair of little setae. The first 5 abdominal segments are laterally provided with prominent setigerous tubercles, 1 to a segment, and with 2 pair of dorsal setae. The sixth, seventh and eighth segments are provided with 3 pairs of inconspicuous setigerous tubercles arranged in a row on the dorsum. The beak is comparatively short. See figure 57 D, E and F.

NATURAL ENEMIES.

Mr. Cooley has recorded that a species of *Catolaccus* parasitizes the beetles quite abundantly in Montana. The writer has bred several adult Hymenoptera which he believes were parasitic on this species, but none of them were reared under such conditions as to furnish positive data.

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*By W. Dwight Pierce.

Both in field and laboratory, at least the adult occasionally succumbs to a fungus *Sporotrichum globuliferum* Speg. which was kindly determined by Dr. Roland Thaxter of Harvard University.

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A Fruit Caterpillar *Epinotia* (?) sp.

DISTRIBUTION AND HOST PLANTS.

The blueberry maggot excepted, the insect most commonly found in the fruit is a little lepidopterous larva, the adult of which the author has not yet succeeded in rearing. He has swept quite commonly on the blueberry bushes in late June and early July a little moth which seems to correspond to our specimen of *Epinotia fasciolana* Clemens. Although no conclusive data are at hand to establish his opinion, the writer believes that this is the species in question since it is of approximately the right size and no other little moth is common on the bushes at the time when the eggs are being deposited. The life history of this species is apparently unknown, but a member of the same genus has been reared from the fruit of the apple (*E. pyricolana* Murtf. U. S. Ent. Bul. 80, p. 46).

The structure of the larva found in the blueberry agrees very closely with the careful figures of the larva of *E. pyricolana* published by Mr. E. Dwight Sanderson in the Canadian Entomologist for 1903, V. 35:158-166.

This insect was rather abundant in 1913 but was very extensively parasitized, which so reduced its numbers that it was quite rare in 1914 and had not appreciably reestablished itself in 1915. During the past summer the writer has collected material from which he hopes to succeed in obtaining adults and thus definitely determining the species. He has bred the larva from the berries of *Vaccinium pennsylvanicum, V. canadense,* and *V. vacillans.* It is generally distributed through the state so far as the records of this Experiment Station show.

SEASONAL HISTORY AND LIFE HISTORY IN THE BLUEBERRY.

The egg. The eggs are deposited singly on the outside of the blueberry, usually somewhere around the calyx lobe; they may be found on either side of the sepal or on the floor of the calyx cup. Oviposition takes place while the fruit is still green, for the eggs are deposited during the latter part of June and early July, and the larva is usually at least half grown before the berry in which it is living ripens.

The larva. As is the case with most of the insects that live in the fruit itself, it does not seem possible to keep one larva under continuous observation, for they cannot stand continuous transferal from one berry to another while young, and a green berry dries up very rapidly after it has been picked.

There are 4 larval instars, and head measurements are typically .29, .43, .62 and .90. The greatest variation is in the last instar. Measurements were all made under a magnification of 20 diameters with a compound microscope by means of a camera lucida. Larvae were preserved in alcohol as they were found in dissecting the berries with a record of the date of removal and the date of collection. Head measurements were made of all specimens as obtained and thus their instar determined. A partial summary of these data is given in the following table.

Date	Instar				Date	Instar		
1914	1st	2nd	3rd	4th	1915	1st	2nd	3rd
June 20			1		June 22	1		
July 6				1	25	5	2	
7	1	2	3	2	26	2		
9		1	2	1	30	4		
13		3	1	2	July 7	1	3	2
15			4	3	12	1		
20		2						
23				3				
28			3					
Aug. 1				1				
3				1				
14				1				

From such observations as he has been able to make, the author would infer that 25 days is a fair estimate of the time spent in the berries. The earliest data on which a larva was

found was June 22, 1915, and, in the laboratory material, July 17 was the first date on which a caterpillar was recorded as leaving the fruit that year, a period of about 25 days. About 12 days are required for the last 2 instars; this has been verified several times, as the berries have begun to ripen by the time the larvae are half grown, and they can be raised easily. As the instars are probably of about equal duration this is what one would expect if the duration of larval life is 25 days.

First instar larvae were common by June 25, and most were still in this stage at the end of the month. The majority leave the fruit about the twentieth of July in a normal season or around the thirtieth in a backward season such as 1915. A few straggle along up to mid-August. Probably most of them pass through the second instar in early July and nearly all have molted to the third instar at least by the tenth, though a few first instar larvae may be encountered even as late as July 7.

In most cases the larva when it hatches enters the berry near the calyx end usually on the outside of the berry at the base of one of the sepals, but some enter by the calyx cup and a few near the stem end. Most commonly the larva enters beneath a sepal and tunnels around the circumference of the calyx cup in a complete circle, just beneath the surface; then it burrows down to the stem end, sometimes through the center and sometimes close to the surface. Often the skin is discolored where the trail runs beneath it. From this point on, the fruit is irregularly eaten. Merely a shell of skin filled with dried pulp, the coat of the seeds and fine brown frass all woven together with silk, is left when the larva is full grown. Frequently 2 berries are webbed together. The first one is usually small and dry, full of frass webbed together; the second is larger and fresher. They are firmly attached together by silk and the larval trail leads from one into the other, at the point of attachment, usually on one side of the fruit. Rarely 3 or even 4 berries are thus united.

When full grown, the larvae leave the berries. In the laboratory they entered rotten wood in preference to sand, or earth. They spin silken cocoons in which they pass the winter as prepupae. A natural inference would be that they pupate in the spring and emerge as adults after a short pupal period, but there are no data at hand on this point.

Below is given a table showing the dates on which larvae left the fruit in the laboratory in 1913, 1914 and 1915.

1913		1914		1915	
7	on July 10	1	on July 13	1	on July 17
7	14	4	23	1	20
16	19	2	24	1	24
11	21	1	25	2	26
9	23	3	29	1	28
6	24	2	Aug. 5	3	29
2	25	4	1	1	31
3	26			3	Aug. 3
6	28			2	7
8	Aug. 2			2	9
4	4			1	11
				1	21

The extreme dates are July 10, 1913, and August 21, 1915.

Technical Description.

Egg. Oval, translucent, whitish.

Larva. Length 6-8 mm.; width 1.25-1.50 mm. Elongate, sub-cylindrical; color pinkish orange above, lighter beneath, pro- and meso-thorax almost white; tubercles light brown, spiracles brown; head either dark or light brown, shining, the suture lines darker or almost black; anteclypeus and labrum brown, mandibles dark; palpi and antennae colorless; a conspicuous white line on the head on either side of the suture between the clypeus and epicranium, fusing above the clypeus and extending nearly to its base, thus forming two sides of a triangle; ocelli 6 on each side. Head often partially withdrawn under the transparent cervical shield which is straight on its cephalic margin and curved outward on its caudal. Body widest at abdomen 4, but all segments about the same size except abdomen 8, 9, and 10, which are conspicuously smaller. Legs brown, tips of prolegs brown, ninth abdominal tergite chitinous, dark brown; caudal setae prominent; 4 or 5 stiff brown setae around anus. See figure 60 G.

The above applies to the fourth instar. In the first 3 instars (rarely only in the first 2) the head is deep shining black and the cervical shield blackish, as is also the chitinized ninth abdominal tergite; the legs are almost black; the body is white, sometimes more or less orange above; the head is never withdrawn beneath the cervical shield.

Setae. The arrangement of the setae on the fifth abdominal segment, the head and the antenna is shown in figure 58. The drawing of the lateral aspect of the fifth abdominal segment was made from the right side. All drawings were made by the aid of a camera lucida.

HABITS.

Several times the writer has had an opportunity to watch half-grown larvae removed from the fruit burrow into a fresh berry, and the process seemed to be practically the same in all cases. When the larva is first put on a new berry, it leaves it and wanders around uneasily for half or three-quarters of an hour, finally returning to the fruit. For a few minutes it

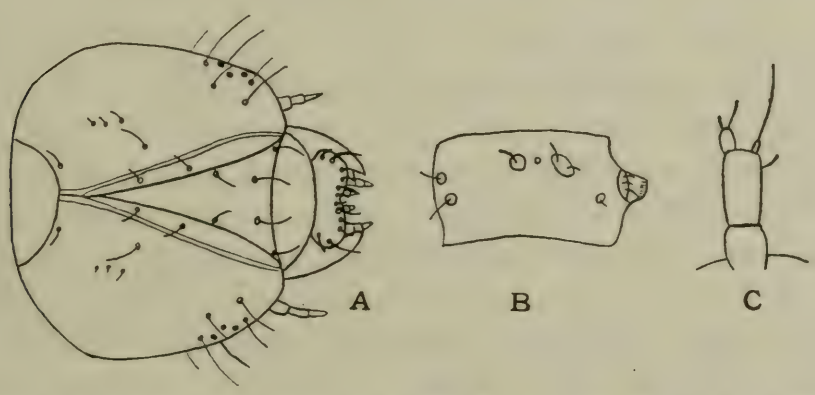

Fig. 58. *Epinotia* (?) sp. A. head of larva; B. 5th abdominal segment of larva, right lateral aspect; C. antenna of larva. All enlarged.

wanders about the outside, apparently eating something from the surface although the bloom is not rubbed off. Invariably the larva goes to the calyx cup in order to enter the fruit. If the berry is of small or medium size, before starting to burrow, the larva spins a web over the entire calyx cup, first standing right side up on the bottom, spinning a few strands across one diameter and following these with guide lines to the sides; then standing wrong side up and clinging to the under surface of the threads, it spins a dense network of silk enclosing the cup completely except for a little hole about the size of its body left diagonally opposite the point where the entrance hole is to be made. If the berry is an especially large one, frequently the larva spins over only half of the calyx cup, making in this case two silken walls at right angles to one another. Here too a hole is left in the silk. While spinning the caterpillars cling to their support by their prolegs, waving the head and thorax back and forth and from side to side. The silk appears to issue from the labium.

Ten minutes are required for the process noted above, then for some 5 minutes the larva wanders round and round in the calyx cup, occasionally pausing to peer out through the hole in the side. Finally it stops this meandering and starts work diagonally opposite the opening left in the silk, through which the latter abdominal segments project. The entrance hole is always made on the floor of the calyx cup, never in the center but always on one side, usually between 2 sepals. The caterpillar burrows in head first but wrong side up, clinging with its prolegs to the silken web which it has just spun. 10 minutes usually have elapsed before head and thorax are out of sight, for the entrance is gradual and occasionally the larva draws itself wholly out. But after this it works more rapidly and by the time another 10 minutes have passed, the entire body has disappeared. One can see the blood very plainly as it is driven forward in the heart, and the pulsations, though rapid, are regular and rhythmical, averaging quite constantly 79 per minute in all the cases counted. The last 4 segments of the abdomen contract and expand synchronously with the dorsal vessel. Approximately every 5 minutes the feces are voided, semi-fluid, dark, soon hardening into a dry frass.

No sooner has the larva entered the berry than it turns around and appears head first a minute or two later. By means of a row of stout setae on the labrum it rolls the excreta up into the silk where they stick fast. Then it disappears again into the berry for 2 or 3 minutes. The caterpillar does not feed at this time but simply chews up the pulp, soon reappearing and ejecting it as little balls which almost immediately harden into dry pellets. These balls are plastered into the silk in much the same manner as was the frass. Chewing and plastering intermittently in the course of 15 minutes it has usually covered the silk half over with dry ejecta. Now the larva seems to be tired, working more slowly with frequent resting spells, but the calyx cup is densely covered over with pellet lined silk within an hour after the insect starts to plaster.

The general habit of the caterpillar after entering the berry seems to be to tunnel straight down through the center and make another hole near the stem end. In this trail the larva lies with its caudal end projecting toward the calyx cup into which the feces are voided. When ready to leave the fruit the larva bur-

rows out a tunnel at right angles to the other, starting from the center and ending at some point on the circumference. If one berry does not contain enough food and 2 are webbed together, invariably the larva makes its way to the surface of the first one by a trail precisely similar to this, and fastening the second very securely to this point by silk attachments, continues the trail into it.

NATURAL ENEMIES.

In 1913 this insect was attacked by parasites to a very considerable extent, which greatly reduced its numbers. Mr. E. A. Richmond of Cornell University kindly identified this for me as an Ichneumonid, *Pimpla sp.* near *P. indagatrix* Walsh from which it differs in coloration. Adults emerged between July 28 and August 22, 1913, and at corresponding dates in 1914 and 1915.

The larva is white or slightly pinkish and emerges from the caterpillar when the latter is nearly full grown, but before it has left the fruit. If 2 berries have been webbed together the larva of the parasite, if present, will always be found lying in the trail between the 2, half in one and half in the other. The pupa is pure white. In 7 instances the writer has been able to determine the pupal period exactly; it varied from 5 days to 11 days, and averaged nearly 8 days. A larva found in the fruit on August 11, 1914, formed its pupa on August 14 and emerged as an adult on August 21. This may be considered as fairly typical.

Often the head or shriveled skin of the caterpillar may be found in the same berry as the larva of the parasite. A careful examination usually shows a minute puncture in the skin of the fruit; this is probably made by the ovipositor of the adult female and, therefore, this is beyond reasonable doubt a larval parasite. A female is illustrated in figure 62 D.

The Blueberry Damsel-Bug *Nabis rufusculus* Reut.

DISTRIBUTION AND HOST PLANTS.

The writer has taken this species (Hemiptera, Nabidae) in Orono, Cherryfield and Unity; it is probably distributed through-

out the state. While the nymphs and adults live upon the blueberry bushes, they are predaceous in their habits. In nature they probably prey upon the little psocids and spiders which abound on the bushes; in the laboratory they ate all species of aphids that were fed them. They also ate one another with equal readiness. Fresh leaves and fruit were supplied them in the laboratory, but the writer has no evidence that they take any vegetable food. The eggs are deposited in the fruit of the blueberry, but this seems to be the only way in which this plant is directly concerned in their life cycle, and it is possible that the eggs may be laid elsewhere as well. The writer has found the eggs in the berries of *Vaccinium pennsylvanicum* and *V. canadense*.

SEASONAL HISTORY AND LIFE HISTORY IN THE BLUEBERRY.

This species hibernates in the adult stage. Oviposition begins at least by June 15. The eggs are deposited indifferently in any part of the berry, which may be either green or ripe. They are inserted beneath the surface and only the perfectly round white lid of the shell is visible from the outside, fitting snugly into the oviposition puncture and lying in a very slight depression. The egg itself is elongate-cylindrical, and is slightly curved. The exposed end is a sort of lid which fits closely into the rest of the egg; when ready to emerge, the insect pushes off this cap and crawls out, the lid remaining fastened to the egg shell by a sort of hinge. The egg is about 2 mm. in length. Rarely 2 eggs are placed in the same berry.

Eggs may be found from mid-June through the middle of July. Occasionally they are met with in August; these probably represent a partial second generation. An egg found on June 16, 1915, hatched on July 5, and the embryonic period is probably about 3 weeks.

The writer was unable to rear through to the adult stage any of the individuals which hatched from the eggs that he collected, for sooner or later they died in molting, becoming hopelessly entangled in the old cuticula. But young nymphs were swept on the blueberry bushes and from these adults were bred which were very kindly determined by Mr. H. G. Barber of Roselle Park, N. J.

When first hatched the nymphs are colorless except for their red eyes and the femoro-tibial joint, which is at first red, but sooner becomes blackish. The distal border of the first antennal segment is black. The caudal half of the abdomen is dark. In the second instar, three white dots appear on the abdomen. In the third instar the eyes are red; the legs are practically colorless; the second and third segments of the antenna are black; the dorsal part of the abdomen is brown, the cephalic border of the first segment being dark brown; there is a round white spot in the middle of each of the abdominal segments 1, 2 and 3.

The older nymphs are light brown in their general color as is also the adult. The writer is not sure of the exact number of nymphal instars. In general the early instars last 5 days, the later 7 to 8, and the pre-adult 10 or more. A young nymph, (probably second instar), a nymph two molts before the imago, and an adult are shown in figure 61.

The young nymphs especially are very neat and frequently clean beak and antenna. This is usually accomplished by holding out the prothoracic legs in front of the body with the tarso-tibial joints brought together, and drawing the antenna or beak through the point of union.

The later nymphal instars and the adults may be swept quite generally on the bushes in late August and early September, the only time when they seem at all numerous.

A Scale Insect *Pseudococcus* sp.

Occasionally a little scale insect was found in the calyx end of the berry. None of these mealy bugs were sufficiently mature to render a specific determination possible. Doctor Patch kindly determine them for the writer as *Pseudococcus sp.*, closely related to, if not identical with *P. citri.*

Insects Which are Primarily Leaf Feeders.

The writer paid only slight attention to any except fruit insects until the summer of 1915. There is a large variety of insects which feed on the leaves of the blueberry, but for the most part they are neither particularly common nor injurious. The list includes principally Geometridae and Noctuidae among the Lepidoptera, Tenthredinidae among the Hymenoptera, and

Chrysomelidae among the Coleoptera. Collections were made rather extensively in 1915 but from most of this material the writer has not yet obtained adults or else the adults have not been determined, so that any detailed discussion is reserved for future publication. The only leaf-feeding insect seriously injurious to the blueberry which the writer observed in Maine was a Chrysomelid beetle, kindly determined by Mr. Eugene A. Schwartz of Washington, D. C., as *Galerucella decora* Say, to a brief discussion of which the remainder of this paper is devoted.

A Leaf Beetle *Galerucella decora* Say.

DISTRIBUTION AND HOST PLANTS.

Galerucella decora Say is the only leaf feeding insect which the writer has observed to be decidedly injurious to the blueberry in Maine. It is widely distributed through the state and has been found wherever collections have been made on the blueberry for this Station. In the vicinity of Orono this species has been very abundant during the past 3 seasons and has killed a considerable number of blueberry bushes. Doctor Smith records it on willow (Insects of New Jersey, 1909, p. 347) as does also Mr. Blatchley (Coleoptera of Indiana, p. 1170) and Mr. Chittenden (U. S. Bureau of Forestry, Bul. 46, p. 78) but the writer has not found it anywhere except on the blueberry in Maine. It breeds on *Vaccinium pennsylvanicum, V. canadense,* and *V. vacillans.*

SEASONAL HISTORY AND LIFE HISTORY ON THE BLUEBERRY.

The egg. This species hibernates in the adult stage. The overwintering beetles may be swept up abundantly by June 15 and probably appear much earlier as even then the foliage was conspicuously eaten. The first eggs were deposited on June 16, 1915, and oviposition continued about a month. One female deposits about 25 eggs, usually within 3 or 4 days after pairing. Twenty-nine is the largest number the writer has recorded for any one female. In the laboratory the eggs were mostly deposited in the cheesecloth on the bottom of the dishes in which the beetles were kept. The writer has not succeeded in finding the eggs in nature, but feels sure that they are not fastened to the leaves.

The larva. None of the several hundred eggs deposited in the laboratory hatched although they were kept under the same conditions as *Haltica* eggs, nearly all of which developed; and even when the eggs were placed on moistened cheesecloth they dried up and shriveled. Larvae were swept abundantly in the field on August 6, 1915. Nearly all were in the last instar on this date. There are probably 3 larval instars as is the case with the various species of *Haltica* which the writer has reared. In the next to the last instar the head measures .55-.60 mm. across, and in the last .75-.825 mm., .80 mm. being the normal. The ground color of the larva is very light greenish gray; the tubercles are a darker gray; the prothoracic shield is grayish; the legs brownish black; and the head brown. Immediately after molting the entire body, including head and legs, is light creamy yellowish, except the eyes which are nearly black.

A larva which molted on August 9, 1915, to the last instar entered the soil as a prepupa on August 21, a period of 12 days. This is probably but little, if any, longer than the other instars, and 30-35 days is the probable length of larval life.

The insects are voracious feeders and the larvae eat the leaves very rapidly and in great amount. The leaves are skeletonized, and only the brown ribs and upper epidermis is left. They soon wither and fall off. Bushes which are defoliated 2 or 3 years in succession usually are killed.

The pupa. The larvae enter the ground before transforming to pupae, burrowing to a depth of an inch or more. Both in 1914 and in 1915 the majority entered the soil about August 10, but the writer has swept larvae as late as September 1. The prepupal period varies from 4 to 6 days, but averages about 5. The pupal period lasts 8 or 9 days. When first formed the pupa is straw yellow, with black eyes. Gradually the wings become gray, and the legs, antennae and mandibles dark.

The adult. The adult is yellowish when it emerges but colors up reddish brown in about 20 hours. These beetles can be swept abundantly on the blueberry all summer. The adults of the new generation emerge principally in the latter half of August and in early September. There is but one generation each year.

Like the larvae, the adults are very voracious and eat the leaves greedily in exactly the same way as do the larvae so that the work of the 2 stages is indistinguishable. Occasionally the

beetles also eat into the fruit from the outside. They feed both in the fall before entering their winter quarters and after they have come out of hibernation in the spring.

The egg, larva, pupa, and adult are illustrated in figures 59 A, 60 D, E, F, respectively and the work of the larvae on blueberry leaves in figure 59 B.

NATURAL ENEMIES.

Under conditions favorable to the growth of this fungus, larva, pupa and adult are subject to the attack of *Sporotrichum globuliferum* Speg. Diseased specimens were not infrequently found outdoors and in the laboratory these insects seemed very susceptible to *Sporotrichum*. This fungus was determined for me by Dr. Roland Thaxter of Harvard University.

MEANS OF CONTROL.

If this insect were to occur in sufficient numbers in any accessible locality so as to make remedial measures seem economically practicable, without doubt if could be controlled by any of the ordinary arsenical sprays.

ECONOMIC BIBLIOGRAPHY.

The writer has found only one reference to this species in the literature of economic entomology.

1904. Chittenden, Frank Hurlbut. U. S. Bureau of Forestry, Bul. 46, p. 78, fig. 23.

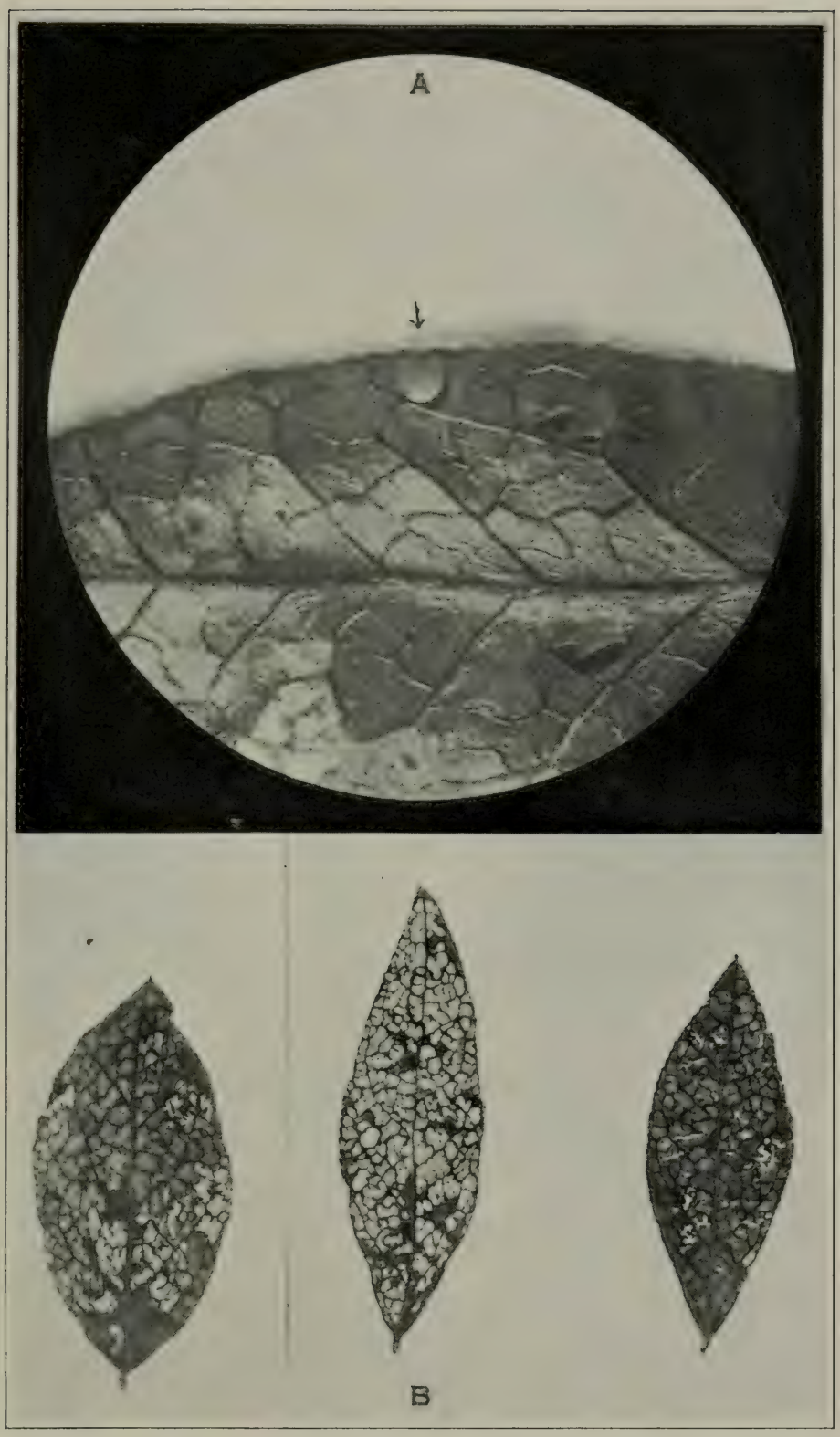

Fig. 59. *Galerucella decora* Say. A. egg near margin of leaf; B. work of larvae on leaves of *Vaccinium pennsylvanicum.*

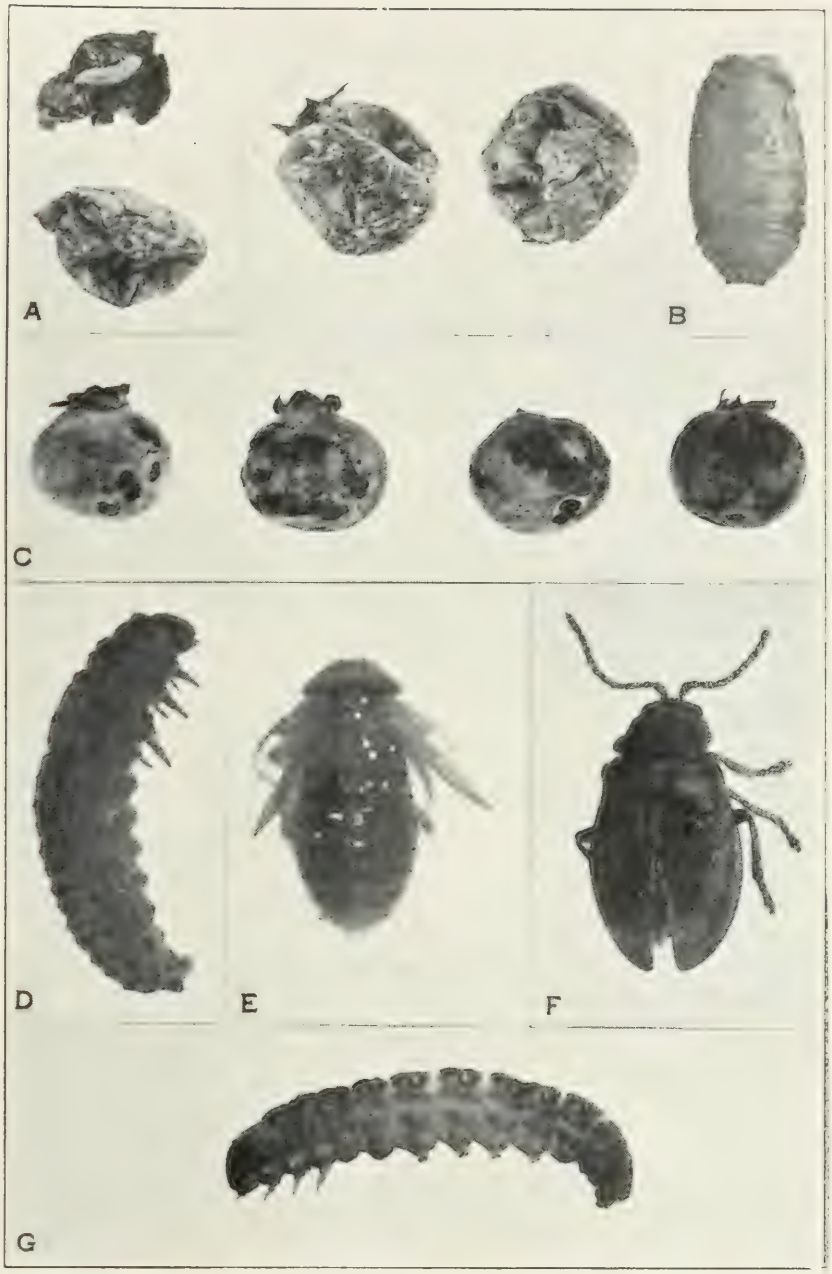

Fig. 60. A. four blueberries showing the work of the larva of *Rhagoletis pomonella* Walsh, the maggot exposed in the first berry; B. puparium of *R. pomonella,* enlarged; C. work of adult of *Pseudanthonomus validus* Dietz on blueberries; D, E, F. *Galerucella decora* Say, enlarged, larva, pupa, and adult; G. *Epinotia* (?) sp. larva enlarged.

Fig. 61. *Nabis rufusculus* Reut. A. young nymph; B. insect in next to last nymphal instar; C. Adult. All enlarged.

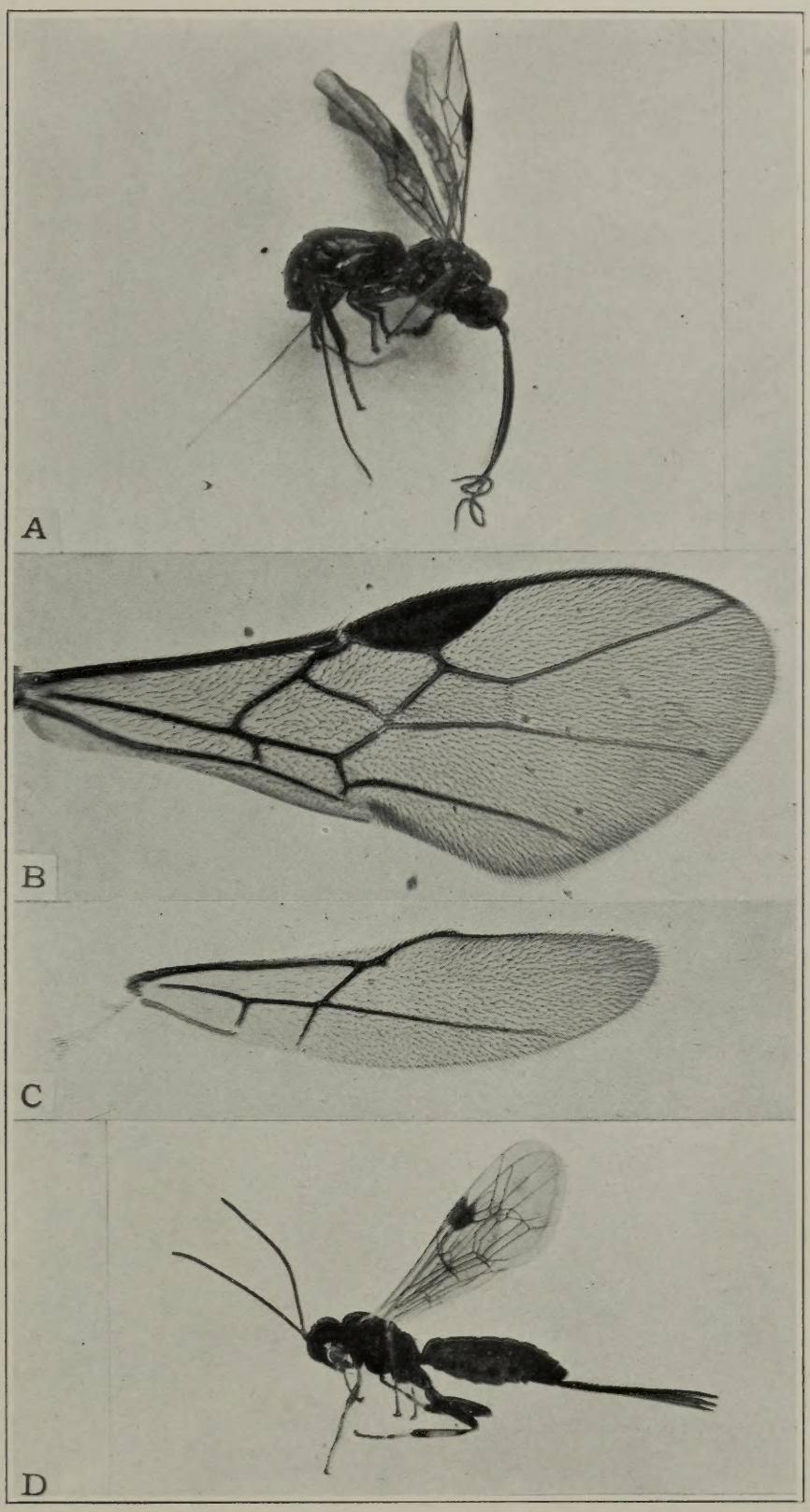

Fig. 62. A, B, C. *Biosteres rhagoletis* Richmond, enlarged, a parasite of *Rhagoletis pomonella* Walsh. A. female; B. upper wing; C. lower wing; D. *Pimpla* sp. female enlarged, a parasite of *Epinotia* (?) sp.