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THE CRANBERRY TOAD-BUG.

F. A. SIRRINE AND B. B. FULTON.

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SUMMARY.

Cranberry growers on Long Island have been troubled by a peculiar dying of the new growth of the vines, caused by the cranberry toad-bug (*Phylloscelis atra* Germ.) of the family Fulgoridae. The shape of the insect and its posture when at rest suggested its popular name.

The cranberry appears to be the only host plant of this insect. When it feeds on the new growth both branch and fruit are killed, but if it feeds on the old wood the berries and branches beyond the feeding point are shriveled and dwarfed. Many bogs are practically free from the insects, but on one at Riverhead and one at Calverton, the yield from certain varieties has been reduced to one-half or one-fourth of a normal crop.

There is but one brood of the insects during the year. The egg is elongate-oval in shape, with a short stalk at one end. The egg-laying period extends from September 1 to the middle of October. The female runs over the ground, dragging the egg by the stalked end, so that its viscid surface becomes covered with sand and dirt before it is dropped. Hatching begins on June 25 to 30 of the following summer, and a few may not hatch until early in August. Nymphs usually group together to feed, and may live a long time on the same branch if not disturbed. The insect has five nymphal instars. The first adults appear about the first of August, the males maturing first.

The nymphs secrete a white, cottony substance which adheres to the branch, and this, with the excrement and molted skins, is more easily detected than the insect. The first symptom of injury is the closing in toward the branch of the leaves on the new growth.

Tests were made of two methods of control, flooding and spraying. Of these, the former is recommended where it is possible,

and should be practised between August 1 and 15. All weeds on and near the bog should be cut. A cloudy period should be selected, and a good wind favors efficient control. Bugs on the surface of the water should be sprayed with kerosene. All grass, weeds, and drift on the shore should be burned with a burning torch-spray.

Spraying is the only possible remedy on " dry bogs." When the vines contain much old wood they should be mowed at the usual season for cutting and, between August 1 and 15, sprayed with soap solution, 1 pound to 7 gallons, making two applications, using 200 gallons per acre.

INTRODUCTORY NOTES.

Prior to and during the summer of 1911 a cranberry bog at Calverton, L. I., managed by Mr. R. C. Brown, of Riverhead, suffered from a peculiar dying of the new growth of the cranberry vines. This trouble was at first ascribed to " cranberry scald " and " cranberry rot," but the treatment recommended for the control of these diseases — mowing the vines, resanding, fertilizing with fish scrap and the use of other measures to promote new growth of the vines — did not afford any protection to the plants. Mr. Brown reported the damage as great in 1912, after using the above measures, as in the previous year.

The writers had no part in the above diagnosis of the trouble, nor in the recommendations given for treatment; but they assisted Mr. Brown in planning his stationary spraying outfit for preventing the supposed fungus troubles. Upon assembling the equipment they requested Mr. Brown to notify them the following year as soon as any of the injury was noticeable on the bogs. Early in July Mr. Brown reported that a diseased condition of the vines was again making its appearance. The vines were inspected July 10, 1912, and, after a careful search by the senior author, patches of a white, powdery substance were found on branches and on the ground. By using caution in moving the branches, and with the aid of a hand lens a small nymph of some hemipterous insect was found, which proved a very active jumper. The life history of this insect was followed in the field and in breeding cages until adults were obtained. These were kindly identified by Mr. E. P. Van Duzee as *Phylloscelis atra* Germ., which belongs to a group of homopterons known as the Fulgoridæ or Lantern-fly Family. The

shape of this insect and its posture, when at rest on the vines, remind one of a toad, and for this reason the popular name — " cranberry toad-bug "— is suggested for this species. However this should not be confused with the name " toad-shaped bug " which has been given to a group of hemipterous insects belonging to the family Galgulidæ.

NOTES ON THE INSECT.

HISTORY OF THE SPECIES IN THE UNITED STATES.

This species has in the past attracted but little attention from economic and systematic workers. The earliest published accounts of insects injurious to cranberries, by Dr. A. S. Packard,[1] include nothing relating to any of the homopterous bugs. Dr. Saunders[2] gives a "spittle insect" (*Clastoptera proteus* Fitch) as a cranberry pest. In 1884 Dr. J. B. Smith[3] collected a Fulgorid (*Amphiscepa bivittata* Say) on cranberry bogs. He says, " This little insect, while found on every bog, does little injury." Again in 1890[4] he mentions three leaf-hoppers as taken on cranberry bogs, of which he says: " These species puncture the vines and live upon the sap, but I have not seen any injury that could be attributed to them."

In the Annual Report of the New Jersey State Museum for 1909, Dr. Smith gives the Fulgorid *Phylloscelis pallescens* Germ. as taken on cranberry bogs. In the same publication he lists *Phylloscelis atra* Germ. and *Amphiscepa bivittata* Say, but does not state that they were taken on cranberry bogs.

The Wisconsin Agricultural Experiment Station has published three bulletins[5] on cranberry culture, in none of which is mention made of any injury to cranberry vines by either Fulgorids or Jassids.

In 1908 the Massachusetts Agricultural Experiment Station published Bulletin 126 on " How to Fight Cranberry Insects," by H. J. Franklin, but no reference is made to any of the above insects as attacking the cranberry.

[1] Rept. U. S. Geol. Surv. for 1876., pp. 521–531.
Trans. Wis. State Hort. Soc. 10:313–322. 1880.
[2] Ins. Inj. to Fruits, p. 374. 1883.
[3] U. S. Dept. Agr., Ent., Bul. 4, p. 30. 1884.
[4] N. J. Agr. Expt. Sta. Spl., Bul. K., p. 42. 1890.
[5] Wis. Agr. Exp. Sta. Buls. 35 (1893), 119 (1905) and 159 (1908).

Although the cranberry toad-bug was collected on cranberry bogs prior to 1900, and described as early as 1839, the indications from published accounts of cranberry insects are that the descriptions of this pest were made from migrants which were collected on other plants than the cranberry, leading therefore to the conclusion that the species was of no economic importance. In cases where it produced injury the trouble was, as in the foregoing outbreak, laid to other causes.

The wilting of new growth shown on Plate VI of Dr. C. L. Shear's work[6] on "Cranberry Diseases" resembles the characteristic injury of the cranberry toad-bug; though the same condition might result from the drying of the foliage before photographing, or, as indicated, from some disease.

ECONOMIC IMPORTANCE.

Unlike most species of the Fulgoridæ, this bug apparently confines its feeding to one plant — the cranberry. The insects do not appear to be widely disseminated, and many bogs are practically free from them; but on two Long Island bogs, one at Riverhead and one at Calverton, the crop of fruit from such varieties as Centennial, Matthews, Howe and Early Black has been greatly reduced, the loss varying from one-half to three-fourths of a normal crop during the past three years. Wherever the insects feed on the new growth both new shoots and fruit are killed outright; while if they happen to feed only on the old wood the berries on all branches beyond the feeding point are shriveled and dwarfed, as shown in Plate II, fig. 2, d; c shows normal fruit. Plate VIII, fig. 1, b also shows an uninjured branch with fruit.

The amount of damage these insects do can be expressed roughly by the loss in yield on bogs where the pests have become established. On the Brown bog at Calverton, L. I., the yield on an affected tract of Howes, of about 5 acres, for four years was as follows: 1910, 800 bushel crates; 1911, 500 bushel crates; 1912, 292 bushel crates, and in 1913, after treatment, 1,350 bushel crates. A small section of Early Blacks adjoining the Howes yielded as follows: 1912, 36 bushel crates; 1913, after treatment, 139 bushel crates.

Expressed in barrels, after sorting, and in money values these yields would be approximately as follows from five acres of Howes:

[6] U. S. Dept. Agr. Pl. Ind. Bul. 110 (1907).

1910	200 bbls.	$1,800
1911	125 "	1,125
1912	73 "	657
Average of 3 years before treatment		$1,194
1913	350 barrels after treatment	3,150
Gain by treatment		$1,956
Gain per acre		$391.20

On the small tract of Early Blacks adjoining the Howes the yields were as follows:

1912	9 bbls.	$81.00
1913	34¾ " (after treatment)	312.75
Saving due to treatment		$231.75

SYNONOMY

The generic name, Phylloscelis, was given to this insect in 1839 by Germar [7] who described two species from a collection of two specimens, both of which had short wing covers and abortive wings. In 1907 Van Duzee [8] described the alate forms of both species basing the distinction of the two on the venation of the elytra. Osborn [9] in 1904 described the alate form of *P. atra* illustrating the venation of the wings.

In our collections of this insect we have obtained specimens that not only accord with the descriptions of *atra* and *pallescens* but others also that are intermediate forms between these species. We are not stating positively that only one species exists, but until more marked and constant characters can be found for separating the different forms we see no reason for listing them as separate species or for separating the insects into varieties. Since Mr. Van Duzee has pronounced the specimens sent to him as *P. atra*, we have retained that name.

[7] *Ztschr. Ent.*, 1839, pp. 191–2.
[8] *Proc. Acad. Nat. Sci. Phil.*, 1907, pp. 471–472.
[9] *Ohio Naturalist*, 4:93–4.

DESCRIPTION OF LIFE STAGES.

Description of egg: (Fig. 1.) The main body of the egg is an elongate oval, about .8 mm. in length and .4 mm. in width. One end is slightly narrower and bears a short slightly curved stalk or peduncle, which is from .16 to .19 mm. in length. The color is a distinct yellow when the egg is first deposited, but soon becomes a light yellow or straw-color. The surface is minutely roughened so as to appear only semi-glossy, and when first laid is somewhat viscid. When placed in water the eggs sink readily.

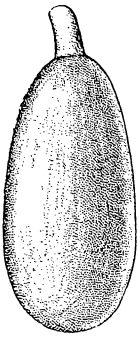


FIG. 1.— EGG FROM BODY OF FEMALE.

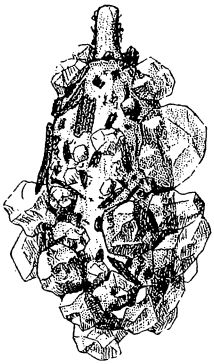
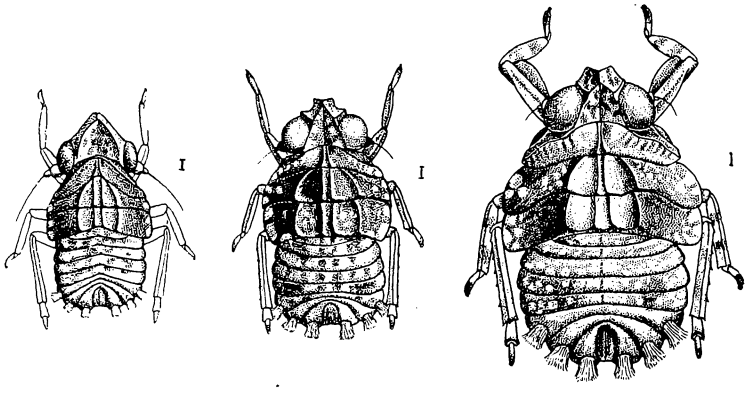


FIG. 2.—EGG COVERED WITH SAND AND DIRT (usual condition).

Description of nymph. First instar: (Fig. 3, a.) Vertex of head elongate; disk depressed and bounded by lateral carinae which unite at the apex. Front with a broad groove bounded by parallel carinae which also meet at the apex. Apex with a short median carina. Below, the head is prolonged posteriorly; beak apparently arises from between the anterior coxae. *Thorax* broad. Sides of pronotum with anterior edge bent abruptly downward behind the eyes, these parts in later stages becoming rounded lateral plates. Each segment of thorax with a pair of carinae close to median line, and the meso- and metathorax have another pair more widely separated. Abdomen rounded; with eight complete segments. The last three are strongly bent forward in the middle, the last being shaped like an inverted U, and each bears a small gland at the lateral edge, which develops a brush of white waxy filaments.

Color.— Head with pale ground color and brown markings. Thorax dark brown above; paler near median line. Abdomen mostly pale. The first five segments may be specked with brown or have white spots on a pale brown ground color. Legs white. Antennae pale brown.



a. b. c.

FIG. 3.— DORSAL VIEW OF NYMPH OF CRANBERRY TOAD-BUG. a, First instar; b, second instar; c, third instar.

Size.— Length about 1 mm.; width about .5 mm.

Second instar: (Fig. 3, b.) Vertex not so much prolonged. Median carina at apex reduced so that the paired carinae of vertex and front meet at nearly the same point. Front with another pair of carinae just in front of eyes, parallel to the inner pair and joining the carinae of the vertex above the eyes. Sides of pronotum bent downward so that the anterior portion appears as a lateral sclerite behind the eyes. Front femora and tibiae laterally compressed.

Color.— Head white with brown specks. Front with two fuscous lines between inner carinae. Thorax white between the outermost pair of carinae and thinly specked with brown. Outer part plain fuscous with a few white spots near the carinae and outer edge. Abdomen brown and white mottled. Under parts white, thinly specked with pale brown. Legs white with a few pale brown bands. Tips of tarsi dark.

Size.— Length 1.3 mm.; width .75 mm.

Third instar: (Fig. 3, c.) Vertex shorter. Front with a small median carina. Sides of meso- and metanotum directed posteriorly forming short wing-pads, the first barely overlapping the second. Fore femora compressed and with a rudimentary foliaceous extension on the upper and lower edge.

Color.— Head and thorax fuscous, with roundish white spots mostly clustered around median area and outer edge. Abdomen mottled; where fuscous predominates, the white takes the form of round spots. Underside mostly pale. Legs spotted and banded with fuscous.

Size.— Length 1.8–2.3 mm.; width 1.0–1.3 mm.

Fourth instar: (Plate I, fig. 1.) Sides of pronotum form roundish lateral plates back of antennae and above front coxae, and separated from dorsal part of pronotum by two oblique parallel carinae which run about in line with the edge of the meso-thoracic wing-pad. Wing-pads well developed, the first distinctly overlapping the second. Foliaceous extensions of the front femora well developed. Brushes of waxy filaments not as conspicuous as in previous instars.

Color.— Upper parts and sides of thorax fuscous marked with roundish white spots. Under side of abdomen pale. Tips of wing pads with large white spots, bases plain fuscous. White predominates on hind portion of abdomen. Legs fuscous, with numerous white spots. Tarsi white at base.

Size.— Length 2.8–3.2 mm.; width 1.7–2.0 mm.

Fifth instar: (Plate I, fig. 2.) Vertex relatively short. Outer pair of frontal carinae most prominent; median as prominent as inner pair. Front wing-pad laps over the second nearly to its tip. Secretion from abdominal glands inconspicuous.

Color.— Ground color of different parts varies from pale brown to fuscous or black; everywhere specked with numerous small white spots. Lateral lobe of pronotum with a large black patch covering the upper half and extending along the front edge of pronotum toward the median line. Hind edge of metathorax with a large transverse black blotch on each side of median line. Fourth abdominal segment with an ill-defined median black blotch. Fifth segment with a pair of black spots half-way between median line and sides.

Size.— Length 3.5–3.8 mm.; width 2.3–2.8 mm.

General characters of adult.— (Plate I, fig. 3). The adults are characterized by having a short vertex, prominent eyes and broad leaf-like front femora. The insects normally sit with the tip of the abdomen close to the branch and the head held away so that the long axis of the body makes an angle of about 45 degrees with the branch. The hind legs are doubled up tightly, the tibiae fitting into grooves in the distal part of the femora. The former are armed with a row of 4 to 6 spurs on the outer carina and a crown of eight stout spurs on the tip. These spurs give a firm contact with the

supporting surface, which, with the structure and position of the tibiae and femora, make the hind legs powerful jumping organs. The adults are extremely variable in size, structure, color and habits. (Fig. 4.) Our collections and notes show that the first individuals to reach maturity are males with abortive wings and short elytra. All the early maturing individuals, both males and females are dark colored, occasionally jet black and are sometimes without white markings. Late in the season males and females, both short- and long-winged forms, are lighter colored, some being even light brown. An occasional male and a larger number of females develop complete wings for migration, and these are the forms which are generally obtained by collectors on various kinds of vegetation. However, the major portion of the insects have abortive wings and remain on the bogs. As far as observed only the dark-colored alate forms were able to fly. The light brown females, with both pairs of wings well developed, but possessed of little or no power of flight, have very indistinct veins on the elytra.

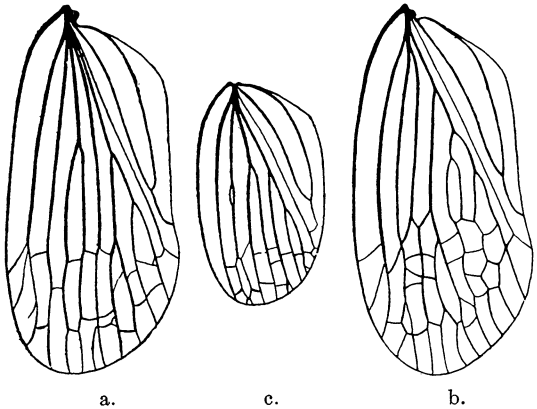


FIG. 4.—CRANBERRY TOAD-BUG. Diagrammatic drawings of elytra, showing variations in size and venation. a and b, alate forms; c, abortive-winged form. (10 diameters.)

The following is a detailed description of the adult:

Adult.— Vertex short and broadly rounded; disk depressed but slightly raised in center; side and hind margins elevated; bounded in front by a pair of carinae which meet at the apex in an obtuse angle. Front prominent; sharply separated from the genae by parallel carinae; with distinct median and an obscure inner pair of carinae. Beak extends downward and backward between the front coxae. Eyes prominent, usually brownish, revealing at times whitish markings.

Pronotum short; sides extended downward to base of front coxae and expanded into large rounded lobes. Scutellum broadly triangular. Front wings coriaceous. In short-winged forms they are convex or spoon-shaped, but in long-winged forms are more flat. Veins run parallel and branch mostly near the base and with two or three series of cross veins near apex. There is however no constancy in the venation of either long- or short-winged forms. Median portion of space between

veins slightly elevated, more prominently in abortive-winged forms where it appears like a supernumerary vein. Hind wings thin and delicate. In long-winged forms they reach nearly to tip of fore wings, and in short-winged forms are abortive. Front femora broad and foliaceous. Hind femora grooved on the distal part to receive the tibiae. Tibiae all triangular. Hind tibiae with a row of four to six spurs on the outer carina and a row of eight stout spurs across the apex on the under side. Tarsi three jointed; with two claws or hooks. The front and middle tibiae are covered with stiff hairs.

Color.— Dark forms: Ground color fuscous or black. Head, thorax and legs specked with small, round white spots. Face with an oblique white band extending from base of beak up and back across gena and lateral lobe of pronotum. Elytra entirely black and generally with scattered translucent spots along the veins. Early in the fall some of the short-winged males show no white markings except a trace on the face, but the major portion of them have the white face bands and at least one white spot on front femora. Elytra of alate forms have fewer translucent spots.

Light forms: Ground color medium to dark brown with numerous whitish spots and face bands as above. Elytra pale to dark brown; translucent spots may be present but are not conspicuous.

Size.— Length 4.0–5.5 mm.

LIFE HISTORY NOTES.

Under the conditions of confinement in breeding cages, the females during the period of oviposition were very uneasy, dropping to the ground, running over it to another branch of the same plant, or even to another plant, dragging an egg by the stalked end, so that small particles of sand would adhere to it, often completely covering it. (Fig. 2.) Generally the egg was lost on the ground. If not, the female rubbed it from the ovipositor against a branch or a leaf, from which the egg soon fell to the ground. The particles of sand undoubtedly aid in preventing the floating of the eggs when bogs are flooded, which generally covers the period from November 15th to May 1st. Studies conducted by means of breeding cages indicate that the eggs may be deposited over a period beginning with about the first of September and lasting to the middle of October. Under natural conditions the insect baffled all attempts to study its habits during the egg-laying period.

As far as observed, none of the eggs hatch until about June 25 to 30. The earliest date on which nymphs have been found was June 29, while the occurrence of nymphs of the first instar after August 1, combined with the fact that the bogs became pretty well infested after flooding as late as July 20, would indicate that a large portion of the eggs hatch after July 15. On sections of bogs where the vines are very heavy and shade the ground the eggs do not hatch as early as in more open spaces; the difference in time

is from one week to ten days. A few eggs, moreover, do not hatch until early in August.*

As soon as hatched, the young nymphs crawl to the cranberry vines, insert their beaks into the bark and commence feeding. Sometimes a single nymph will be found on a branch, but usually from two to six are grouped near together to feed. Not infrequently as many as three cast skins have been observed in the immediate vicinity of one insect, which indicates that individuals of the species may remain feeding on one branch for considerable portions of time unless disturbed. The cast skin may be easily mistaken for the bug itself, and when numbers of them are massed together they present the appearance of a colony of the living insects. In 1912 the first winged specimens, all of which were males, were observed on August 1, while in 1913 winged specimens were obtained on August 2. Mating of the insects was first observed during 1913 on September 14 and insects in copula were detected as late as October 15. In the observation cages, the males died a short time after mating, while the females disappeared soon after the conclusion of the period of egg-laying.

SOME HABITS OF THE INSECT.

As the nymphs feed and grow they secrete a pulverulent, cottony substance, so that the bodies of the insects appear to be covered with small tufts of white hairs. This secretion, instead of forming long tufts as is natural with some species of bugs, breaks away as a powdery substance which adheres to the branch where the insects feed and to surrounding objects, or may even appear on the ground. This substance is secreted from glands on the body and is not the excreta of the insect. The latter looks like fly specks when it occurs on the leaves, even on the old dead leaves. It resembles the perithecia of the cranberry-rot fungus and may quite easily be mistaken for them.

The molted skins adhere to the branch where they are shed. Usually it is easier to find the cottony secretion and molted skins than to find the nymphs themselves (Plate II, fig. 1), as the latter have a habit of dodging around to the opposite side of a branch

* Bog No. 1 was flooded June 13 and 14, before blossoming, for cranberry worms, and left under water forty-eight hours. No toad-bugs in any stage of development came ashore at this time.

Bog No. 2 was flooded July 23. On August 6, young nymphs were found on it.

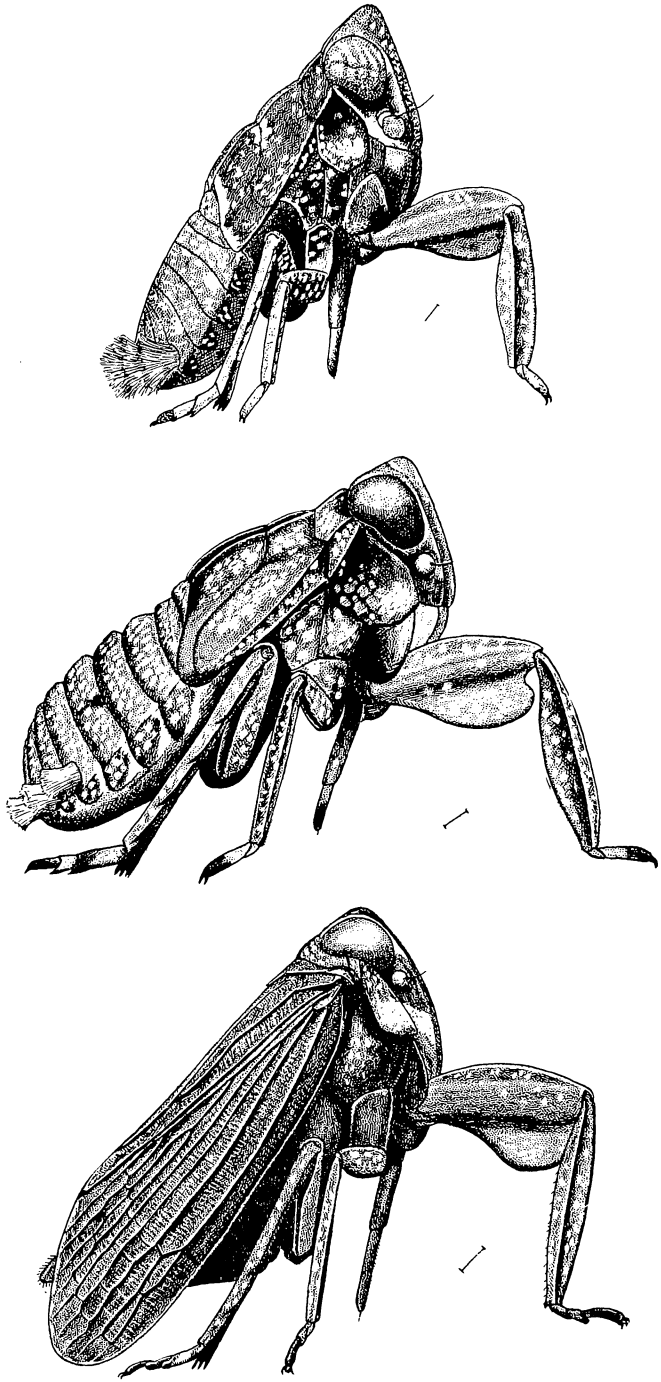


PLATE I.— STAGES OF CRANBERRY TOAD-BUG.
1 (upper), Fourth instar; 2 (center), fifth instar; 3 (lower), adult.

PLATE II.— CRANBERRY TOAD-BUG AND ITS WORK ON PLANTS.

[illegible] of plant; c, normal cranberry branches and fruit; d, branch and fruit injured

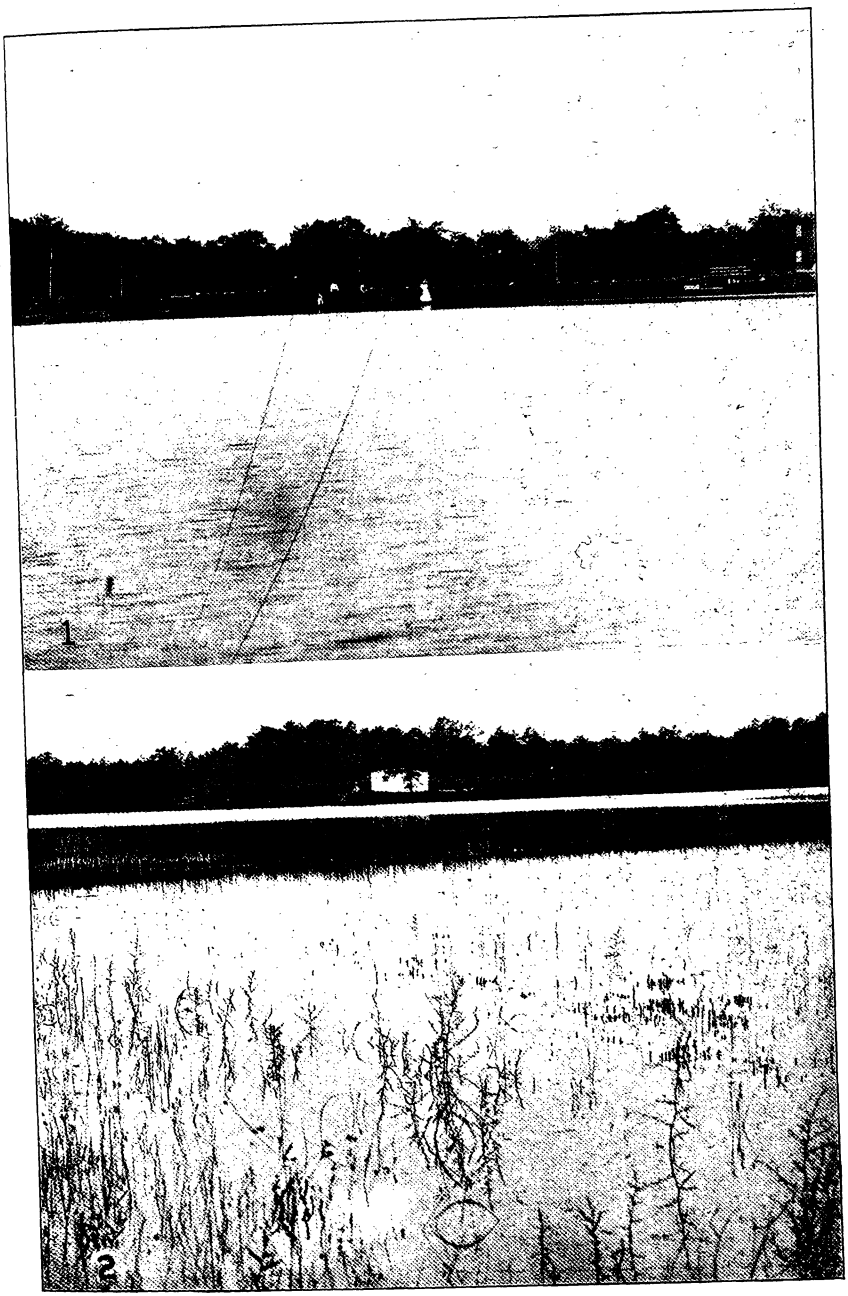


PLATE III.— FLOODING FOR CONTROL OF CRANBERRY TOAD-BUG.
1, Properly flooded bog; 2, improperly flooded bog.

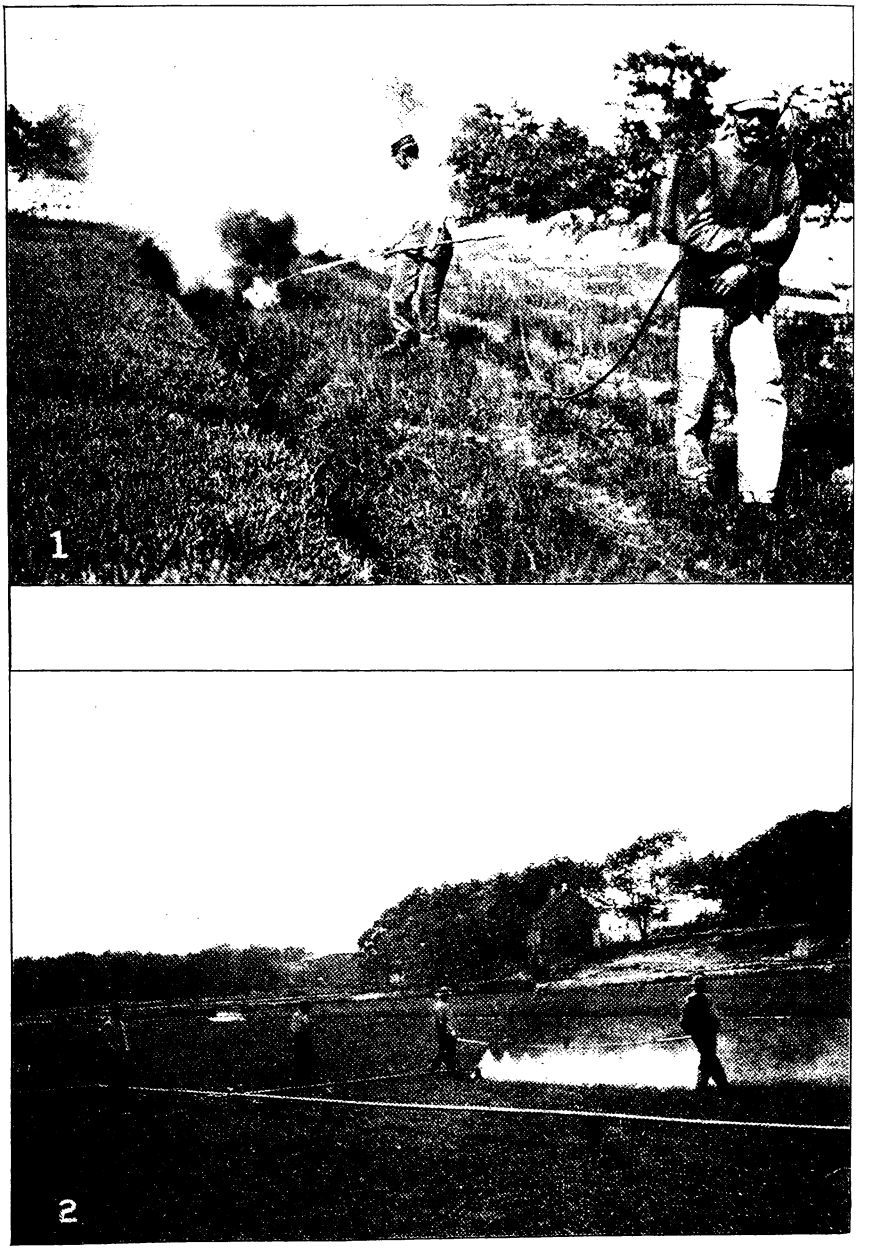


PLATE IV.— CONTROLLING CRANBERRY TOAD-BUG.

1, Burning drift and grass with kerosene-spray torch on margins of bog after flooding; 2, piping and aluminum sprayboom, for use on large bogs

PLATE V.—CONTROLLING CRANBERRY TOAD-BUG.
Burning debris and toad-bugs on surface of water with a kerosene-spray torch; an unsatisfactory method.

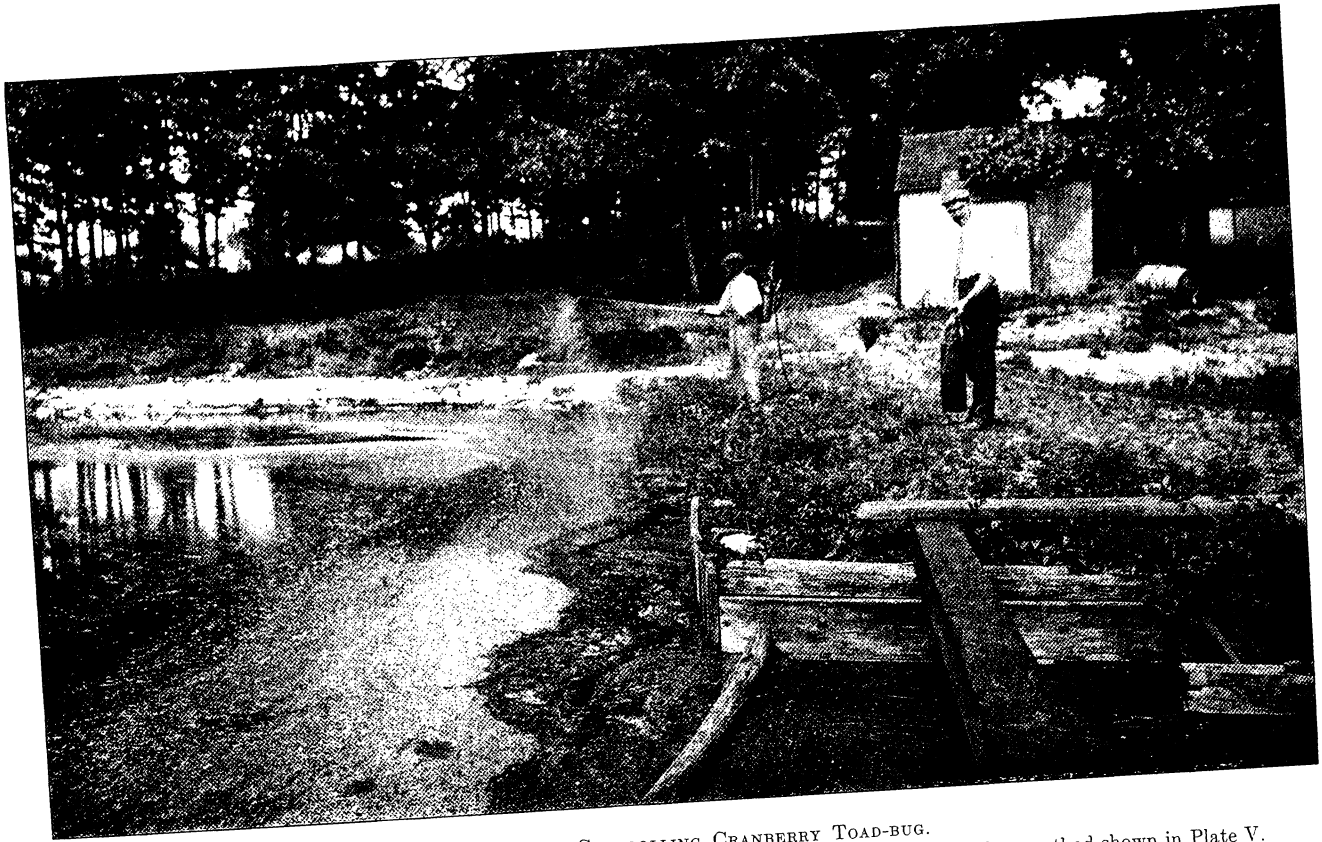


PLATE VI.— CONTROLLING CRANBERRY TOAD-BUG.

Spraying kerosene on weeds and floating debris covered with toad-bugs; much more effective than method shown in Plate V.

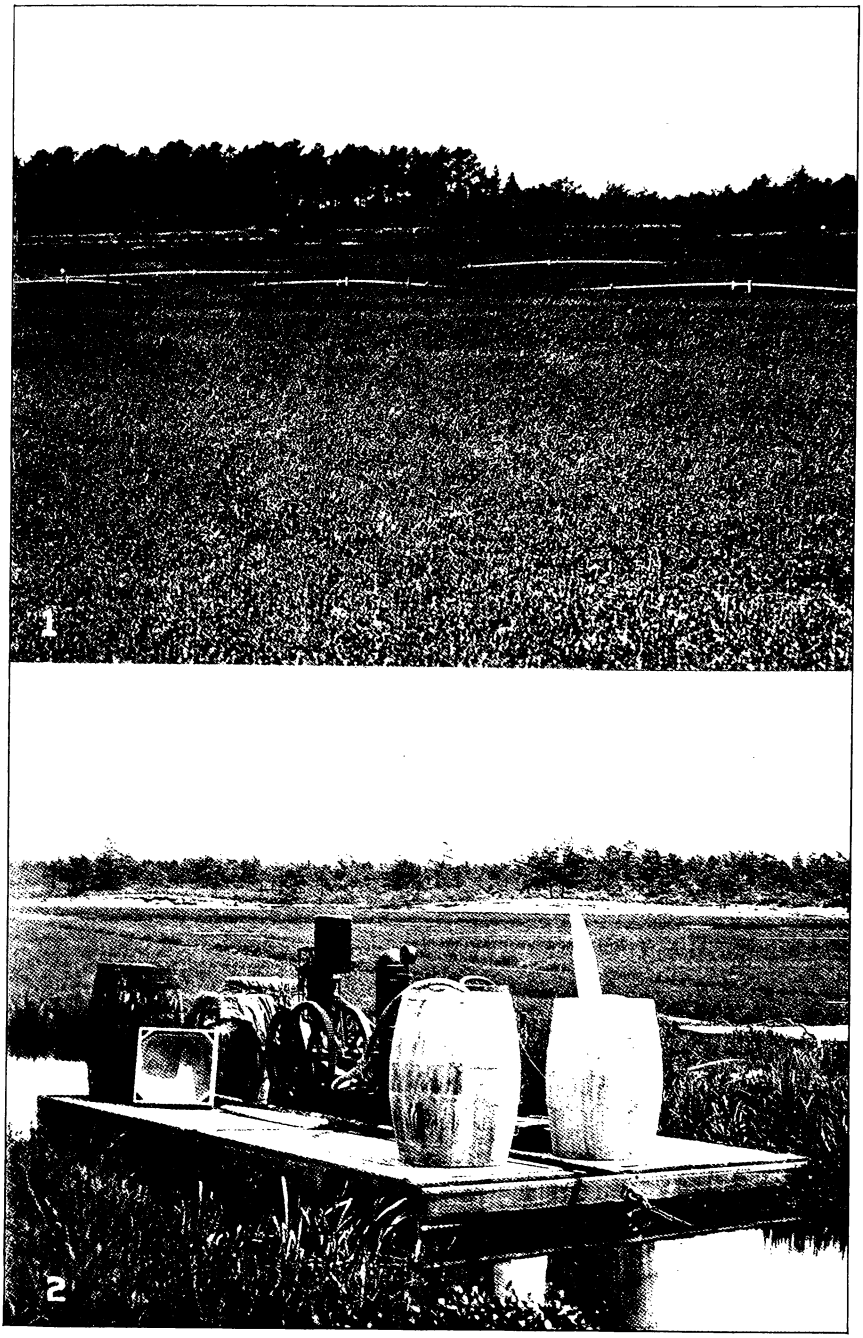


PLATE VII.— PIPING (1) AND SPRAYING OUTFIT ON FLOAT (2) FOR SPRAYING A LARGE BOG FROM ONE CANAL.
(Used primarily for cranberry diseases.)

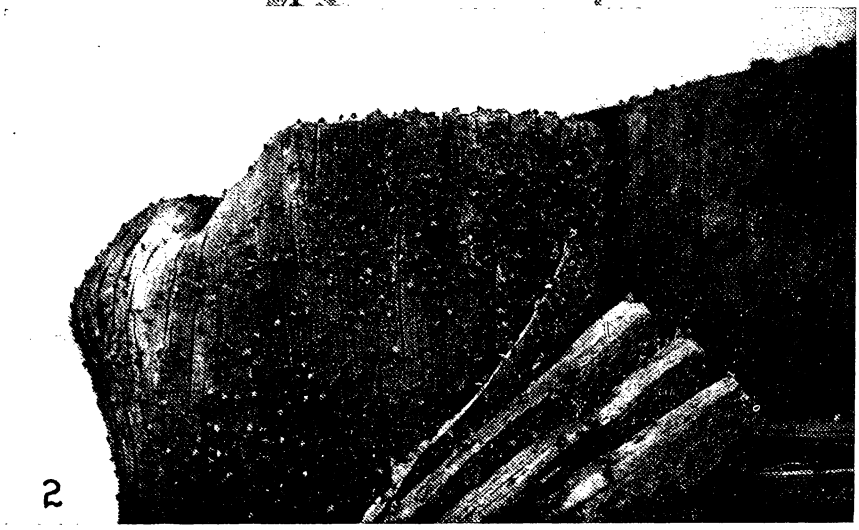


PLATE VIII.— CONTROLLING CRANBERRY TOAD-BUG.

1, a, Plant injured by soap spray; b, uninjured plant; 2, toad-bugs that have come ashore from the flooded bog; on woodwork of flume.

when disturbed. After the third and fourth molts the insects are more active and are found more frequently on the new growth of vines.

Early in September some of the females reach maturity, when pairing begins. This function does not, as far as observed, interfere with the feeding of the females. In fact, it appears probable that the females feed until they commence to deposit eggs. In no stage of their development have they been observed, either in breeding cage or in the field, to feed on the leaves or leaf-petioles. Like the nymphs, the adults are shy creatures and when disturbed dodge to the opposite side of the branch on which they have been resting or feeding. When in their characteristic positions the long forelegs of the insects hold the anterior portions of their bodies well away from the branch on which they happen to be sitting, while their prominent eyes apparently enable them to see in all directions. Moreover, the posterior legs, which have spined tibiæ and tarsi, give a good anchorage and serve as powerful springing organs. The adults are able to jump at least a yard, but the distance they project themselves is not so remarkable as the velocity with which they are able to move under such circumstances. Because of the position in which they rest on a branch, the insects, when in the act of jumping, convey the impression that they are moving backward rather than forward.

EFFECT ON VINE AND FRUIT OF FEEDING OF TOAD-BUG.

The feeding of this pest on the vines of the cranberry produces apparently the same effect as that of the squash bug on vines and leaves of the squash; that is, the parts attacked wilt; but the evergreen leaves of the cranberry do not show wilting as plainly as the leaves of the squash. The first symptom of injury is the closing in, toward the branch, of the leaves on the new growth, while the leaves on the wood of the previous year's growth appear normal. (Plate II, fig. 2, c and d.) The second stage of the injury is the change in color of the new growth, which takes a reddish tinge and finally a brown straw-color. Usually the work of the insects will first attract attention from a distance by a reddish tinge over the bog in July, similar to the fall-ripening effect of frost. Close examination of a plant will show a branch here and there on which all the leaves on the new growth are turning brown. This is followed by the dying of the branch, as if broken from the plant. Where the

insects feed only on the old wood, a condition that occurs frequently with the nymphs, the berries are dwarfed, as shown in Plate II, fig. 2, d. Sometimes the berries shrivel or grow one-sided, but as a rule they remain miniature berries and ripen as such; but where bugs feed on the new branches, or a number of them on one old branch, the berries shrivel up and the branch dies. In cases where the insects feed on old wood, or wood of the previous year, all the new branches beyond the feeding point may produce dwarfed berries. It has been observed in the field that where one insect is feeding alone on new growth, this branch will wilt and change color. The plants usually start new buds below the point where the insects are feeding.

The amount of injury to the vines is considerable, as can readily be measured by the amount of fruit the affected plants produce. There is always a very characteristic difference between injured and uninjured portions of bogs, which could not be better illustrated than in the Brown bog at Calverton, L. I. In this planting there is a ten-foot drainage ditch which cuts a tract of Early Blacks into two parts. The portion south of the ditch has been infested for several years, while very few of the insects have reached the area north of the ditch. In the fall of 1911 the difference between these two tracts could be distinguished at a distance of a quarter of a mile. The affected side was brown and unhealthy in appearance, while on the opposite side of the ditch the vines were normally green and vigorous. The differences were noticeable in 1912, although, after the flooding operations in July, the affected portion threw out new growth and improved rapidly in appearance by fall.

HOST PLANTS.

The host plants listed by collectors of this species convey the impression that *atra* is a general feeder, but so far as observed by the writers this insect finds its subsistence only on the cranberry. Careful observations have failed to detect this species feeding on other marsh plants. After flooding of the bog the insects have been collected from weeds and willows on the sides of the marsh, but at no other season of the year have they been observed on these same plants.

ENEMIES.

The ladybird beetle (*Hippodamia 13-punctata*) and the soldier bug (*Coriscus inscriptus*) occur in abundance in bogs overrun with *atra*.

While we have not observed these attacking this pest, their presence under infested vines suggests that they prey upon the cranberry toad-bug. The spined soldier-bug, *Podisus spinosus*, occurs also in similar situations, but usually in much less abundance than the foregoing species. A number of undetermined ground and jumping spiders are generally quite common on the bogs, and these, we observed, were persistent enemies of the cranberry pest.

During 1913 a fungus disease was very conspicuous in the breeding cages and destroyed many specimens of the insects which were being used for breeding purposes. Evidences of this same disease were occasionally found in the field.

EXPERIMENTS WITH METHODS OF CONTROL.

TESTS OF FLOODING, 1912.

Bog No. 1.— This bog is located at Calverton, Long Island, on the Peconic River, and is owned by R. C. Brown. It contains about 25 acres and is divided by dams into five sections so arranged that they can be flooded separately by beginning at the upper section. As the importance of the cranberry toad-bug was not really understood until late in the season of 1912 it was decided not to attempt any spraying tests, but to try flooding in order to check further injuries by the insect. This experimental effort is of interest since it is contrary to general practice. While many of the cranberry growers flood their bogs before blossoming to combat such pests as the fruit and vine worms, the majority of them avoid flooding after the fruit is set because of the danger of "scalding" the berries. Selecting a day during a cloudy period, flooding was begun on July 20 over the entire section of the bog and the water allowed to remain for forty-eight hours to determine the effects on both the insects and the vines. It was soon discovered that the bugs would not remain under water or in the water if they could escape. They were driven to the tops of the vines, and as the water rose they would float off and climb the taller plants, generally weeds, or unsubmerged rubbish. A strong wind favored the flooding so that the bugs were all floated to one side of the bog, where they crawled to all available weeds, grass and willows in such numbers as to weigh the plants down. Judging from their activities, the insects were unaffected by this unusual experience. As they were driven ashore Mr. Brown sprayed them with pure kerosene, using a

compressed-air sprayer. He also tested the use of Vreeland's insecticide soap, using it at the rate of one part to six parts of water. This strength killed the bugs readily, but it did not penetrate the drift and rubbish as completely as did the kerosene.

Results on the insect.— Forty-eight hours after the water was drawn off an examination was made of the bog. The vines for the most part were free of the insects. In a few spots where the plants had not been completely submerged by the water many insects were observed, and a few specimens of the pest were also noticed along the margins of certain portions of the marsh, which indicated a re-invasion of the vines by bugs which had managed to escape from the treatment with kerosene because of protection by weeds and rubbish.

One week later young nymphs were found scattered in spots over the section of the bog that had been infested before treatment. These increased in number so much that by August 19 they were quite plentiful. However, it is of interest to note that one could readily distinguish between the insects on the bog before flooding and those that appeared later, since the older bugs were always larger than those that hatched after the treatment and were for the most part grouped along the margins of the bog or on the unsubmerged areas, while the others were scattered about the vines generally. From the better results secured by later flooding in 1913, and from the completed life-history studies, it is evident that this flooding was made too early in the season; so that not over three-quarters of the eggs were hatched when the bog was overflowed. After the flooding, the nymphs from the unhatched eggs, with those that escaped the oil through lack of thorough spraying when they floated ashore, reinfested the bog. The appearance of so many young nymphs after this flooding, joined with the fact that many eggs must have passed through the earlier flooding of June 13 and 14, proves that the eggs of this pest can stand quite an extended immersion in water.

Bog No. 2.— This bog, which is owned by S. H. Woodhull & Son, is located near Riverhead, Long Island, on Little River, and contains about 30 acres. It is so situated that the entire bog must be flooded together. Arrangements were made to flood as soon as the fruit was picked, the object being to determine as far as possible how late such a procedure could be carried out with advantage. It was also hoped that the late flooding would facilitate the studies

on the egg-laying habits of the pest, as the turning on of the water would compel the insects to live on the margins of the bog, where they would be more readily observed. The water was turned on October 2, 1912, and left on for 48 hours. Large numbers of the adults came ashore on drifting leaves and rubbish. The workmen hauled this rubbish up on the banks with rakes and later, as it dried, burned it. Part of the adults were dead as they floated ashore, but enough live ones came with them to blacken the weeds and grass on the margins. (No oil was applied to the rubbish on this marsh at the time of this flooding.)

TESTS OF FLOODING, 1913.

The experiments conducted during the preceding year demonstrated conclusively that the bugs could be driven from an infested bog by means of flooding. As both of the bogs previously described showed, early in July, 1913, that they were still infested, it was decided to flood both. Aside from the desirability of protecting the cranberries from the insects, it was also felt that more information was needed as to the most efficient use of the water as a means of control, as well as the most effective methods of disposing of the insects as they floated ashore.

Bog No. 2.— Since Bog No. 2 began growth a trifle earlier than No. 1 and was also through blossoming sooner, it was the first to receive attention. After waiting for a cloudy period in order to avoid scalding of the fruit, and a favorable wind, the water was turned on in this bog at 6 p. m. of July 23. At noon the next day part of the vines on one side were not entirely submerged, and many sedges, "three square," and weeds on part of the bog were not covered. (Plate III, fig. 2.) Fortunately the direction from which the wind blew was such that the insects from the worst infested sections were not carried to the portions not entirely submerged. The water was left on all day the 24th. Three men with knapsack and compressed-air sprayers worked a good share of the day spraying the weeds, grass and margins of the water with pure kerosene, kerosene emulsion (one part to seven of water), and homemade fish-oil soap (one part to seven parts water). The men also waded out and sprayed the bugs that were found collecting on sedges and weeds not submerged. All three substances used killed large numbers of the bugs, but for penetrating the rubbish that floated ashore and for spread-

ing over the surface of the water, kerosene proved the best. Many millions of the bugs drifted ashore and were killed by the treatment.

The water was drained from the bog during the night of July 24, beginning at 8:30 p. m., and by morning was back in the ditches. The men began raking the drift rubbish from the vines on the margin of the bog where the receding waters had left it, after which the rubbish was sprayed again with kerosene. On the next day it was found that a few living bugs were coming from the masses of rubbish and the thick grass and were working back to the bog. A knapsack was rigged with a ten-foot rod and " Mistry Jr." nozzle for spraying kerosene and burning it at same time. (Plate IV, fig. 1.) With this outfit the bugs contained in the thick grass and wet rubbish were destroyed.

The items of expense in disposing of the insects along the margins of this 30-acre bog are as follows: 65 gals. of kerosene, $7.50; labor, 3 men for one day, $5.25. This makes a total cost of $12.75 for the final spraying and burning operations.

Results on insects and plants.— On August 6 the bog was carefully examined to note the effects of the different operations on the numbers of the bugs. All portions entirely covered with water were generally completely free of the pest. As in former experiments, varying numbers of the insects could be found near unsubmerged weeds, grass, sedges and vines. Only a few nymphs of the first instar were detected, indicating that but few eggs were not hatched at the time of flooding or that small numbers of the insect in the very immature stages may withstand immersion. There were no indications of scalding of fruit as a result of the flooding.

Bog No. 1.— Profiting from the experience during the previous year on this bog and from the experimental operations just completed on Bog No. 2, as described above, an effort was made to have all the sections of the bog to be flooded clean at the time of overflowing. Besides removing all weeds and sedges from the beds, the margins of the ditches as well as those of the bog were mowed. The effects of these operations in facilitating the submersion of the marsh is shown in Plate III, fig. 1.

On August 1, at 5 p. m. during a rain storm, the water was turned on, and by 6 a. m. the next day the flooded sections of the bog were well covered. Unfortunately the wind dropped and proved hardly strong enough to compel the bugs to drift ashore. As the

prospects were slight that the remainder of the floating insects would be driven to the land, spraying and burning operations were undertaken. The burning torch-spray was used with great advantage on the grasses and weeds, while the oil applied as a spray proved a most efficient treatment for the insects floating on the water. (Plates V and VI.) Besides spraying the surface of the water within reach of the shore line, applications of oil were made to cover floating insects and debris of all sorts which passed through a flume as the water was drawn off. (Plate VI.) In these spraying operations 65 gallons of kerosene were used, while two men were employed for a half day, making a total cost of eight dollars for this operation.

Results on insects and plants.— An examination of this bog on August 9 showed no trace whatever of the bugs on the flooded section. It should be noted, however, in the flooding of an upper section some insects may find their way to a lower section, probably by jumping over the intervening dam, and in this experiment a few individuals managed to escape by such means. The submersion of the vines did not produce any scalding of the fruit.

TESTS WITH VARIOUS INSECTICIDES, 1913.

As Bog No. 2 was flooded very late in the season of 1912, a close watch was kept during the following summer to determine if the insects would appear in injurious numbers. In July there were indications that the bugs were very plentiful and that they might do considerable damage by the time flooding could be safely attempted, with assurance of satisfactory results. It therefore appeared desirable to postpone the turning on of the water, and in the meantime to resort to other methods to keep the insects under control, until all of their eggs were hatched. Spraying with contact insecticides seemed to be the most promising procedure, and, moreover, tests along this line were desirable, since it was important to know if spraying would be, in any way, of more advantage than flooding, and, if so, what substances were best adapted for the treatment of cranberries. There are some bogs which are known as " dry " bogs where flooding is impracticable, and in the case of such a pest as the cranberry toad-bug spraying would probably have to be relied on as the chief means of defence. To this end the following tests were made.

Bog No. 1.— On July 4, Mr. Brown tested spraying with resin-

potash soap, 1 pound to 6 gallons of water, on plants that were in full bloom, and other vines that were well infested with the insects.

Results on insects and plants.—As far as could be determined very little if any of the spray reached the young nymphs and little or no protection was afforded the vines. An examination on July 27 showed that the set of fruit had been reduced at least 75 per ct. as the result of injury to the blossoms.

Bog No. 2.— On this bog the following insecticides were tested: Vreeland's insecticide soap, Good's resin potash soap, homemade fish-oil soap[10] and "Black Leaf 40." The first application was made July 9. The spraying plats were arranged as shown in Chart 1.

	canal				
3 rods	Fish-oil Soap 1 to 7 1 bbl. used twice sprayed	Insecticide Soap 1 to 5 1 bbl. used	Resin Potash Soap 1 to 5 1 bbl. used	Black Leaf 40 1 to 800 1 bbl. used	B.L.40 1 to 400 1 bbl. used
	3 rods	6 rods	6 rods	5 rods	3 rods

CHART 1.

These materials were applied with a cluster of three "Mistry Jr." nozzles at a pressure on pump of 180 lbs., the engine and pump being mounted on a float in the canal. (Plate VII, fig. 2.) By examining the vines as fast as sprayed, it was found that many of the nymphs had been disturbed and were working up towards the tops of the vines. Hence, on the plat where homemade fish-oil soap was used, a test of respraying was made as soon as it had been sprayed over once.

Results on insects.— Two hours after spraying, all the plats were examined again, and no dead nymphs of the toad-bug were found except where the double spraying with the fish-oil soap was given.

On July 11, a second attempt was made to kill the cranberry toad-bug by spraying. In this effort a different section of the bog was used, which is devoted to the Centennial variety. As the bog is laid with galvanized piping, for spraying all portions from the canal, this equipment was used for the treatment of the experimental plats. (Plate VII, fig. 1.)

[10] N. Y. Agr. Exp. Sta. Bul. No. 257, p. 434.

The following chart shows the size and arrangement of the different plats and methods of treatment.

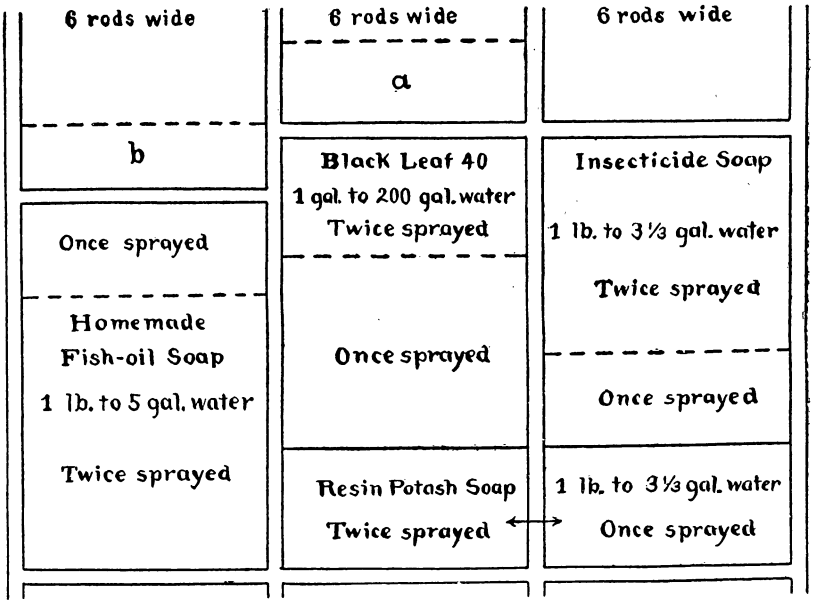


CHART 2.
(Parallel lines, except those at right, indicate ditches.)

Results.— One hour after spraying, a rough estimate of the effects of the different treatments was made, which was based on the number of insects moving as compared with those dead on the ground. In general, where the vines were thin and scattered, the soap solutions killed the majority of the nymphs, but on the heavy vines the applications were quite ineffective. The estimated percentages of insects destroyed by the different mixtures are as follows: By two applications of insecticide soap, resin-potash soap and homemade fish-oil soap, 70 per ct. of the insects were killed, and by one application 20 per ct.; by two applications of "Black Leaf 40" 1 per ct. were killed, and by one application, none were killed.

Since there was no apparent injury to vine or fruit from the treatment of July 11, and as there was still some soap stock on hand and the insects were very numerous, it was thought best to make a third series of tests. Accordingly, on July 15 all that portion of the bog sprayed July 11 was resprayed as follows:

The middle section and the small plat marked "a" (Chart 2) were sprayed with homemade fish-oil soap, 1 lb. to 5 gallons of water, while the remainder of the plats and the section marked "b" were sprayed with insecticide soap, 1 lb. to $3\frac{1}{3}$ gallons of water. All plats were twice sprayed as follows: A strip about 12 ft. wide was sprayed across each bed, then resprayed immediately before starting on another strip, and so on until each section was sprayed. From the experiments that were conducted, it was estimated that on an average approximately 200 gallons of mixture would spray one acre twice. On this basis, without including labor, "Black Leaf 40," used 1 gallon to 200 gallons of water, would cost $12.00; insecticide soap, 1 lb. to $3\frac{1}{3}$ gallons water, would cost $5.40; resin-potash soap, 1 lb. to $3\frac{1}{3}$ gallons water, would cost $2.00.

Results on insects and plants.— Without resorting to an actual count of the numbers of dead and living insects, it appeared that this method of spraying did not give as marked results as the one followed on July 11 where a longer interval of time was allowed between each application. The explanation for this marked difference in results is not clear. Apparently the effect of the first application was to force a good many of the insects into the tops of the vines, where they would be more quickly dried by the sun and the air. If sufficient time was allowed, many of the insects would occupy positions which would render them quite exposed to the second treatment. Then, moreover, it proved a difficult matter to do thorough spraying. In some instances it was almost impossible to reach all of the young nymphs feeding on the undersides of the branches, as the heavy growth interfered with the spray, preventing complete wetting of the foliage and wood.

Early in September, it was discovered that wherever the soap solutions were used stronger than 1 lb. to 7 gallons of water, not over one-third of the berries were perfect. Of the affected berries very few were shriveled or showed injury to one side. In most cases they were dwarfed, as shown in Plate VIII, fig. 1, a; b is normal fruit collected one foot from the sprayed section. Another characteristic of the soap-treated sections appeared later in the plants themselves. As the vines took on a natural reddish tinge late in the fall, the sprayed sections remained dark green as if recently given an application of nitrate of soda. It appeared that the vines bearing stunted fruit had put all their energy into a new growth of wood instead of fruit.

This injury was more marked where insecticide soap was used, apparently due to the fact that more of it would dissolve in a given amount of water, whereas with homemade soap, used 1 to 5, some of the material always remained undissolved in cold water.

CONCLUSIONS AS TO METHODS OF CONTROL.

The experiments herein described indicate plainly that of the two methods of control — flooding and spraying — the former is to be preferred if submersion of the bog is possible. Spraying the plants proved in the main less satisfactory as measured by the numbers of the bugs destroyed and the injury to the plants. Damage to cranberries may apparently arise from the use of too strong mixtures of soap, by too liberal applications of the spraying materials or by early treatments when the vines are in blossom. Further experiments with contact insecticides are desirable in order to determine conclusively the practicability of combating this pest by the application of spraying mixtures.

DIRECTIONS FOR CONTROLLING THE CRANBERRY TOAD-BUG.

From the knowledge of the life history and habits which has been so far ascertained, flooding should be deferred until from the first to the middle of August for sections in the same latitude as New York City. If submersion is practiced earlier than August 1 some nymphs may make their appearance after the water is removed, while if postponed until after August 15 eggs may be deposited in the bog which would permit reinfestation of the vines in the following summer. In selecting a date, some allowance should also be made for seasonal conditions. On the basis of the experiments previously described a cloudy period should be selected for flooding. The water should be turned on in the evening so that the bog will be completely covered by the next morning. Advantage should be taken of a favorable wind in order that the bugs may be floated ashore. Grass and weeds should be removed from the bog before flooding, while similar growth about the margins of the marsh should be mowed. Kerosene oil should be applied as a spray to all insects and debris floating on the surface of the water. Thick grass, weeds and drift on the shore should be burned by means of the burning torch-spray. If these precautions are carefully followed practically all of the insects can

be killed. Such complete extermination is not often met with in the control of an insect pest.

In flooding a bog to destroy this pest a word of caution is urged. A study of the life cycle of the bug and of its different forms and habits indicates that only the long-winged forms migrate under natural conditions; and it appears more than probable that even this form does not migrate very long distances. Carelessness in flooding during the summer would undoubtedly distribute them faster than any other method. It seems very doubtful if they are ever distributed by the transportation of the vines; because, first, the eggs rarely, if ever, remain on the vines; and second, the vines for transplanting are usually taken before the eggs hatch.

On what are known as " dry " bogs, where no method but spraying can be adopted, the following suggestions are offered: First, in cases where the vines are heavy and contain much old wood, mow the vines off at the usual season for cutting. Second, between August 1 and 15 spray thoroughly with a soap solution made with any of the three soaps — insecticide soap, resin-potash soap, or homemade fish-oil soap — 1 pound to seven gallons of water, applying at least 200 gallons of solution to the acre at each application and making two applications. By this method there would be no fruit to be injured with the soap solution, as cutting eliminates a crop of fruit for one year. In plantings where vines are very thin the cutting might be dispensed with, but would probably be a good cultural method even in such cases.

ACKNOWLEDGMENTS.

The senior author wishes to thank Messrs. Brown and Woodhull for their assistance in furnishing materials, apparatus and men free of charge for carrying out the tests made; for taking all the risk of damage to the crop by treatments tested; and for general assistance which has helped to round out this report.