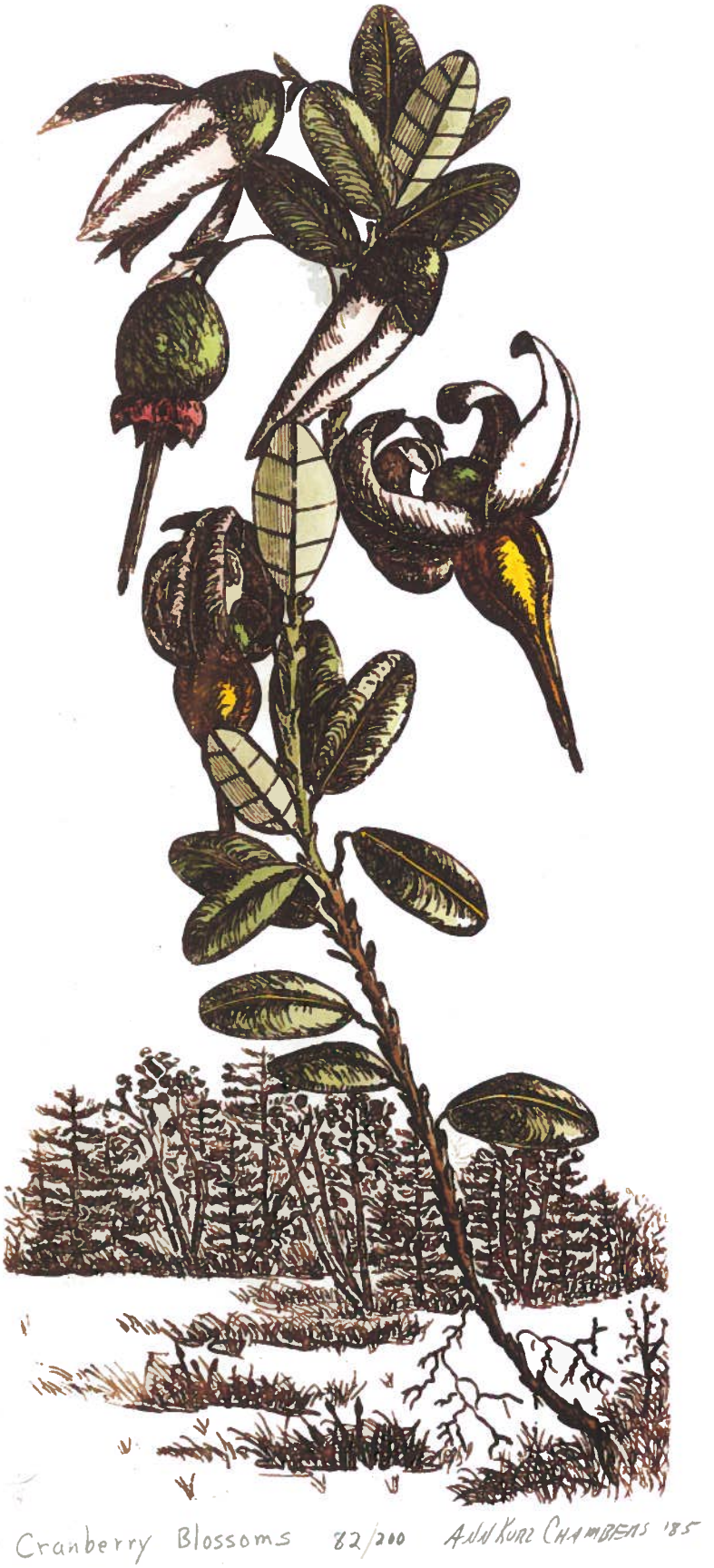

CRANBERRY INSECTS OF THE NORTHEAST

Anne L. Averill
&
Martha M. Sylvia

(Illus: Shear 1916)

CRANBERRY INSECTS OF THE NORTHEAST

A guide to identification, biology and management

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and Cranberry Experiment Station
University of Massachusetts at Amherst

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Cover artwork by Ann Kurtz Chambers

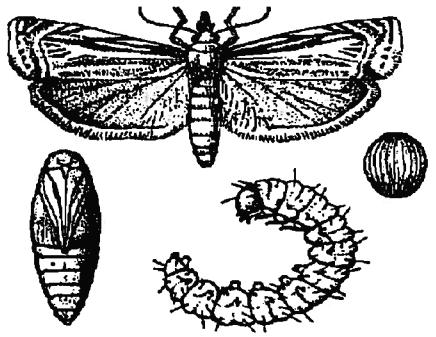
We are indebted to Henry J. Franklin (1883-1958) who devoted his versatile talents to many aspects of the improvement of the cranberry industry. His work on cranberry insects has lit the path for many who followed.

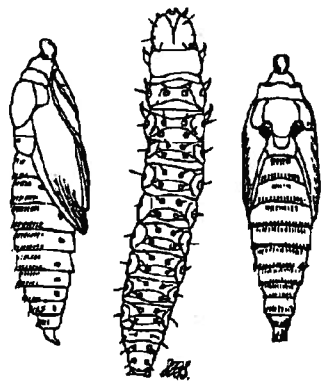
In Franklin's words:

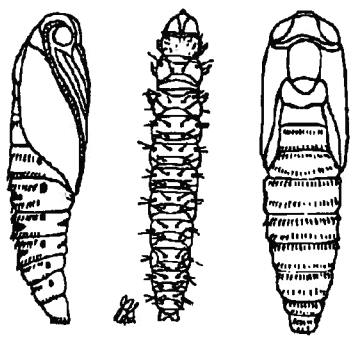
"Cranberry insect problems present so many conditions that it is hard to cover them all fully in bulletins...Bog managers should learn to gauge insect infestations in their early stages so as to know when attacks may be neglected. The insect net is as important as any other bog equipment. The bogs should be examined with it every few days from May 10 till mid-July. For practical purposes the sweeping with the net may be done at any time of day, though it usually collects rather more cutworms and gypsy moth larvae as soon as the dew is off in the morning and just as it begins to form in the evening. If fifty sweeps of a net eleven inches in diameter gather from the vines over eight gypsy moth caterpillars or cutworms of any kind, or more than thirty-two spanworms, the infestation should be treated, four spanworms equaling one cutworm in their capacity to do harm. As the worms of many of the species grow larger they cling more and more to the vines or hide under them and so are gathered by the net in smaller and smaller numbers." (Franklin 1928)

"Spray for a purpose. Do not spray 'on general principle' only, but when there is good reason to believe the bog really needs it...Do not be one of the ninety-nine out of every hundred who will look at this bulletin and then make no use of it. Be the hundreth man."(Franklin 1908)

PREFACE







(Illus: Smith 1903)

This guide is designed as a reference for growers as well as for cranberry consultants and researchers. This was a very large undertaking for us and we strove for accuracy. We would very much appreciate any mistakes being brought to our attention.

There has been change in insect management recommendations and we will see much more over the coming years. It is likely that the present line of insecticides utilized in cranberry will be fully modified and that new options will be introduced. A current insecticide recommendation could be obsolete tomorrow. As a result, in the management sections included here, only standard practices, particularly cultural approaches, that should remain applicable over the long term are discussed.

For the most up-to-date information regarding insect management (particularly spray recommendations), it is critical to consult the annual management recommendations provided by local or state Extension Services.

In cranberry, many of the concepts of integrated pest management were introduced decades ago owing to the leadership and scholarship of Henry J. Franklin of the Cranberry Experiment Station of the University of Massachusetts at Amherst. His comprehensive and authoritative coverage of the biology and management of cranberry insects was contained in a series of bulletins "Cranberry Insects in Massachusetts" vols. I-VII, published in 1948, 1950 and 1952. The materials presented in our new guide are built on Franklin's bulletins. We have adopted his format and we have freely utilized his descriptions of the insects and many details of their biology. We respectfully and candidly acknowledge that at numerous points, we have launched from his original material, often verbatim.

All photographs were done by James E. O'Donnell unless indicated otherwise. Thanks to Bruce Lampinen for some last minute pictures. Reference to CES (Cranberry Experiment Station, East Wareham, MA) photograph archives are largely the work of S. L. Roberts, C.F. Brodel, W.E. Tomlinson.

Special thanks to: William Simmons for moral support; Carolyn DeMoranville (University of MA) for guidance and advice; Revel Gilmore, Carla Healer, Greg Garnett, and Melissa Cannon for assistance in aspects of presentation; Charlie Armstrong (University of ME), Sridhar Polavarapu (Rutgers), Dan Schiffhauer and Tim Dittl (both Ocean Spray Cranberry) for sharing their observations and materials on cranberry insects; and to Joe Shoenfeld (University of MA) for his time and expertise regarding publications.

Partial funding for printing was provided by the National IPM Education Foundation, USDA-EPA Pesticide Environmental Stewardship Program, granted to the Cranberry Institute. Thanks to key players Jere Downing (Cranberry Institute) and Don Weber (Ocean Spray Cranberry, Inc.) for help in securing and disbursing these funds.

This volume is dedicated to the memory of Walter "Walt" Cannon, Cecil "Footie" Foote, and Irving "Dee" Demoranville, all of the University of Massachusetts Cranberry Experiment Station. We miss their unconditional support — provided in each man's own inimitable way — and hope they would have been pleased with our efforts here.

December 1998

For additional copies of this guide, send address
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UMass Cranberry Experiment Station
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INTRODUCTION

Along with Concord grape, cranberries and blueberries are the only commercially cultivated fruit crops that are native to North America alone. As pointed out by Dana (1990), the cranberry industry was developed through the manipulation of the native ecosystem in which the cranberry species evolved. The cultivars that are utilized in cranberry plantings are predominantly native selections of the species *Vaccinium macrocarpon* Aiton, the large or American cranberry (Dana 1990). This species is native to bogs from Newfoundland south to North Carolina and west to Minnesota.

According to Dana (1990), the cultivar Howes was selected from the wild by Eli Howes of East Dennis, MA around 1843. This is the dominant late cultivar in the Northeast. Early Black, the overall dominant cultivar in New Jersey and the dominant early cultivar in Massachusetts, was selected from the wild on Nathaniel Robbins' property in Harwich, MA around 1852. Of the other cultivars planted in the Northeast, Ben Lears (a native cultivar) is steadily increasing and Stevens (a hybrid of the native cultivar McFarlin and Potter) is currently favored for new plantings in New Jersey and Maine (see Caruso 1997).

A number of the insects presented here are reported to be specific to only cranberry or to cranberry and species of blueberry (e.g. *V. angustifolium* Aiton, *V. corymbosum* L). Cranberry and blueberry are both within the family Ericaceae and are both within the genus, *Vaccinium*. All of the species in *Vaccinium* are acidophilic (Hancock 1995). This genus also includes the small cranberry (*V. oxycoccus* L.) and the lingonberry (*V. vitis idaea* L.) (see Van Der Kloet 1988).

The cranberry plant

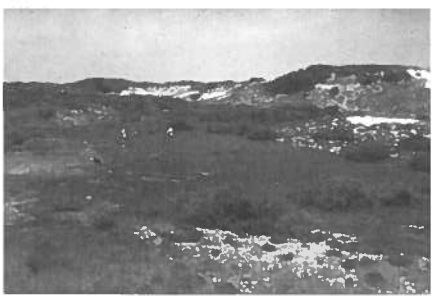
A woody and evergreen perennial, a cranberry plant is a low-growing, trailing vine. It typically grows in hummocks in acidic peat bogs and wetlands of pH 4.0 - 5.0 (Hancock 1995). The plants have fine, fibrous roots (and no root hairs) that grow in the top 10-20 cm (4-8") of soil. The horizontal shoots are called "runners" and the vertical shoots, which bear the fruit, are called "uprights." The plants flower in late June into July. Terminal buds on the plant contain either vegetative primordia or both vegetative and flower primordia. The buds form in late summer during the season prior to their growth.

Wild and abandoned bogs

Although fairly rare in Southeastern Massachusetts now, wild stands of cranberry were common centuries ago. We have studied the insect and spider fauna at a number of the "dune bogs" (Johnson 1985) on the Cape Cod, Massachusetts peninsula in the towns of Sandwich, Truro and Provincetown. Here, areas of cranberry vines are located in depressions between sand dunes. In addition to cranberry, other vegetation includes *Sphagnum* moss, bayberry (*Myrica pensylvanica* Loisel), bog orchids (*Habernaria* spp.), round-leaved and thread-leaved sundews (*Drosera* spp.), poison ivy (*Toxicodendron radicans* L.), various sedges, grasses, rushes, and other herbaceous and woody plants commonly found in undisturbed bog habitats in the region. While these bogs are considered wild, reportedly some sites were partly managed many years ago, perhaps starting early in the 1800's when ditches and dikes were constructed to improve water control. If so, no evidence of human activity still exists.

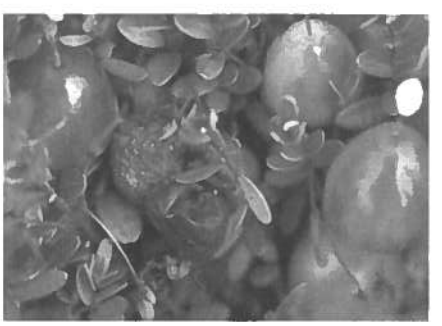
The insects and spiders we observed at the dune bog sites vary greatly from commercial bogs. While cranberry fruitworm, cranberry weevil, cranberry tipworm, Collembola, and flea beetles are found, all of which are common on cultivated bogs, cutworms, brown and green spanworms, Sparganothis fruitworm, leafminers and all species of soil insects are essentially absent. Common insects include blackheaded fireworm, fire beetles, cranberry spittle bugs, blunt-nosed leafhopper, and sharp-nosed leaf hopper.

Cape Cod barrel label



Wild bog in the dunes in Sandwich, MA

Developing cranberries



Cranberry fruitworm damage

The wild sites at Sandy Neck in Sandwich, MA, support a variety of spiders and insects.

Cranberry blossoms.

Cranberry water harvest. (Photo: F. L. Caruso)

Dry harvest at state bog. (Photo: B. D. Lampinen)

While the family Linyphiidae (small spiders that construct sheet webs) strongly dominates cultivated bogs, we found a more diverse group of families at a number of the dune bogs. Here, close to half of all spiders identified were hunting spiders in the family Lycosidae with the remaining half comprised of Araneidae, Clubionidae, Dictynidae, Salticidae, Linyphiidae, and Tetragnathidae (R. Young, unpublished data). The most common prey items recovered from spiders at the wild bog sites were Diptera (particularly midges — Chironimidae), Collembola, Homoptera (particularly leafhoppers — Cicadellidae), and small Hymenoptera (Bardwell and Averill 1997).

Abandoned bogs may have mats of *Sphagnum* moss interspersed with grasses, brambles (*Rubus* spp.), poison ivy, small flowering shrubs, and saplings of early successional tree species found in adjacent wooded habitats (including red maple, *Acer rubrum* L., white pine, *Pinus strobus* L., *Populus* spp., and *Betula* spp.). Over time, little cranberry remains, particularly on drier beds. Dominant insects include blackheaded and yellowheaded fireworm, cranberry spittle bugs, blunt-nosed leafhoppers, cranberry fruitworm, and cranberry weevil. Similar to the wild bog sites, cutworms, brown and green spanworms, Sparganothis fruitworm, leafminers and all species of soil insects are low or absent. Based on observations limited to two abandoned bogs, the spider fauna was comprised largely of Oxyopidae and Tetragnathidae (Bardwell and Averill 1997).

Winter flooding, insecticide use, fertilization, natural enemy pressure, and irrigation may all be key factors contributing to differences in the arthropod fauna between abandoned and cultivated sites.

Cultivated bogs

Many insect species are found feeding on cultivated cranberry in the Northeastern United States. The key insects found on cranberry are not too dissimilar between Maine and Massachusetts; there are greater differences between these two northern states and New Jersey.

For example, in both cranberry and highbush blueberry in New Jersey and Massachusetts, an interesting contrast occurs regarding the pest status of cranberry fruitworm and cranberry weevil. In Southeastern Massachusetts, cranberry fruitworm is seldom, if ever, reported as a problem in blueberry but carries a key pest status on cranberry. In New Jersey, the reverse is true: cranberry fruitworm is a pest of blueberry, but is seldom a problem in cranberry .

Now turning to cranberry weevil, similar patterns are seen: in Massachusetts, cranberry weevil is not a pest on blueberry, but it is a serious problem on cranberry. In New Jersey, weevil is a blueberry pest but is rarely found on cranberry.

Regarding these observed patterns, in her work on cranberry weevil, Mechaber (1992) found that there were distinct differences in patterns of weevil's use of cranberry, blueberry, and other host plants in each geographic region. The patterns of population abundance over time also varied between the regions. She speculated that one of many explanations for these patterns may be differences in crop abundance. Cranberry plantings are extensive in Massachusetts and not so in New Jersey. Blueberry plantings are extensive in New Jersey and not so in Massachusetts.

Regarding the other North American cranberry-growing regions, which include British Columbia, Oregon, Washington, and Wisconsin, the key insects vary a good deal from those found most commonly in the Northeast. Some of the most severe problems occur from infestations of blackheaded fireworm, black vine weevil, and cranberry girdler.

Contrasts between then and now

There are several insects contained here that do not appear in Franklin (1948a, 1950, 1952). These include humped green fruitworm, cranberry vinehopper, sharp-nosed leafhopper, *Coptodisca negligens*, an unidentified species we call

"serpentine leafminer," *Hoplia modesta*, black vine weevil, strawberry root weevil, and oriental beetle. Regarding the latter three species, transport of materials, particularly plant materials, from all parts of the world, as well as the urbanization of the land, may each contribute to the appearance of new insect species in an area. Nursery plantings are a fine source of introduced pests. Reforestation of previous farmland throughout portions of the cranberry-growing areas could also provide a very different reservoir surrounding cultivated beds.

Additionally, two species that were of so little importance that they appeared only as footnotes (Franklin 1948a) are included as more lengthy descriptions. These are spiny looper and *Sparganothis* fruitworm. *Sparganothis* is among the top five insect pests in cultivated bogs in New Jersey and Massachusetts, while spiny looper is observed increasingly in Massachusetts.

Insects that Franklin considered of some importance that we have not seen (or heard of) in the Northeast in the past decade are not included here. These are cotton spanworm [*Anavitrinella pampinaria* (Gn.)], cranberry black bug (*Plagiognathus repetitus* Knight), short-horned grasshopper [*Melanoplus femur-rubrum* (DeGeer)] mealybugs [*Phenacoccus flaveolus* (Ckll.)], several scale insects, and grape anomala (*Anomala luciola* Fab.).

Franklin (1948b) designated the worst insect problems in Massachusetts as cranberry root grub, cranberry fruitworm, blunt-nosed leafhopper, blackheaded fireworm, and cranberry girdler. Today in Massachusetts, we consider cranberry fruitworm to be the most serious and widespread pest. Sparganothis fruitworm, cranberry weevil, false armyworm, brown spanworm, cranberry root grub, and white grub are problematic on many beds. Oriental beetle, *Hoplia modesta*, and gypsy moth, are severe problems where they appear.

Sparganothis fruitworm, spotted fireworm, and cranberry blossomworm are among the most serious problems in New Jersey, with cranberry rootworm and white grub (*Phyllophaga*) increasing in numbers (D.Schiffauer, personal communication). Cranberry beds in Maine are too new to forecast key problems; currently cranberry tipworm has emerged as a key concern, reportedly owing to the short growing season (C. Armstrong, personal communication).

Cultivation has changed a good deal since Franklin's day. Because cranberries are grown in low-lying areas, they are susceptible to frost damage over a large portion of the growing season. Previously, water was held on bogs throughout the spring during high frost risk; bogs were also rapidly re-flooded when frost was forecast. Bogs were flooded for irrigation prior to sprinkler introduction and were flooded for short intervals for insect management. This practice likely had a large impact on populations of insects. In the late 1950's, sprinklers were introduced as a method of frost protection and spring flooding for frost was largely abandoned. Also in past times, late water (a reflood from April to May) was frequently held for insect management and to enhance keeping quality of fruit. Summer floods were also held for insect and weed management. Bogs were much weedier; in some archive photos, one cannot see the vines. Further, methods of harvest and sanding are entirely different. Taken together, it is not surprising that considerable contrasts exist between insect species in the early part of the century vs. now.

Format

In addition to insects seen on cultivated bogs, we also describe species that occur at wild sites and abandoned bogs. Some of these are seldom, if ever, seen on commercial bogs. This may change as management practices evolve. For example, when sprays are relaxed in some New Jersey beds, blunt-nosed leafhopper appears (Marucci and Moulter 1992a; S. Polavarapu, personal communication).

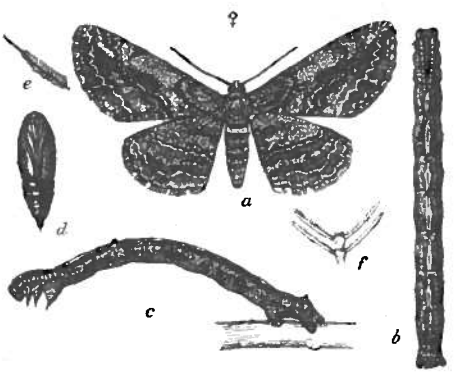
Insects are presented in groups, based either upon the type of insect (for example fireworm, cutworm, and spanworm families) or the type of plant part utilized by each: blossom and fruit feeders and root and stem feeders. For each species, a description of the life stages, its distribution and host plants, and a review of its seasonal history are presented.

Also included in this guide is a discussion of pest management principles and applications for cranberry. Finally at the end, we present a key to most of the insects discussed, a glossary of terms, and a listing of common and scientific names of host plants referred to in the text.

Many of the common names used by cranberry growers and researchers are not officially recognized by the Entomological Society of America. In the table of contents and at the outset of the description of each species, these unrecognized common names are in quotation marks.

Readers seeking current control recommendations must refer to the annual updates provided by their state and University extension programs.

Blackheaded fireworm moth. (Illus: Franklin 1948a)



Cotton spanworm, *Anavitrinella pampinaria* Gn. (Illus: Chittenden 1907)

INSECTS: BASIC FACTS

In cranberry production, before an attempt is made to manage any population of insects, one should first identify the insect and understand its life cycle. Insects and mites belong to the group of animals called arthropods. Relatives of insects within the arthropod group include crabs, lobsters, ticks, spiders, scorpions, centipedes and millipedes. The presence of jointed legs separates the arthropods from earthworms and their relatives. The presence of an external skeleton (exoskeleton) separates the arthropods from the chordates, such as mammals, fish, and birds, all of which have an internal skeleton.

The Insect Design

The typical adult insect has three pairs of jointed legs and three distinct body regions, the head, thorax and abdomen. The head contains most of the sensory organs, such as mouthparts, eyes, and antennae. The legs and wings are located on the thorax, which serves as the body's site of locomotion.

Metamorphosis

An insect begins life as an egg. Once it hatches, it goes through a series of stages called instars. As the insect eats during the first instar, it reaches a point where the exoskeleton must be shed, a process called molting, after which it reaches the second instar. The number of instars varies by species.

Most insects undergo substantial change as they grow and undergo a process called metamorphosis. There are different levels of metamorphosis. Some of the primitive insect groups undergo no change from one stage to the next, such as the silverfish. Others exhibit "incomplete" metamorphosis, including blunt-nosed cranberry leafhopper and cranberry spittle bugs. These insects are seldom seen on commercial cranberry, but are very common on the wild Cape Cod bogs.

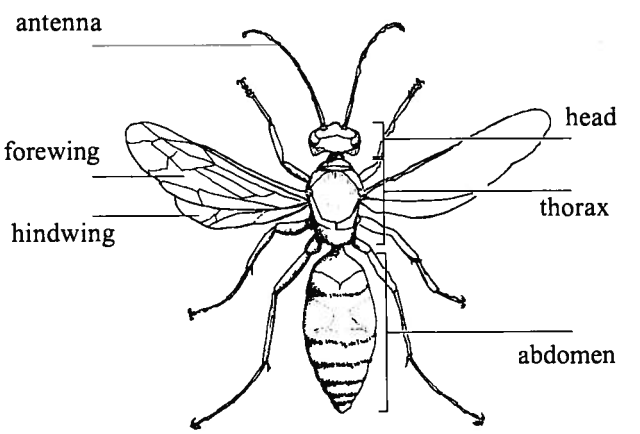
In insects that undergo incomplete metamorphosis, the immature stages are called nymphs, which resemble the adult stage. The nymph usually has eyes and antennae, and also has walking and feeding appendages that are similar to the adult. The nymphs have external wing pads that become larger over subsequent molts. Functional wings only appear when the insect undergoes the final molt to the adult stage.

Most of the key insects found in cultivated cranberry undergo "complete" metamorphosis, including the fireworms, cutworms, cranberry fruitworm, sparganothis fruitworm (all moths as adults), cranberry weevil and scarab grubs (beetles as adults). For insects that undergo complete metamorphosis, there are four distinct stages: egg, larva, pupa, and adult. Following egg hatch, the insect passes through several larval stages. The larva does not resemble the adult at all. Wing pads are never present. The larva eats large amounts of food and grows enormously in size; it may reach a size larger than the adult. Depending on the insect order, the larva may be a caterpillar (moth or butterfly), a grub (beetle or wasp), or a maggot (fly).

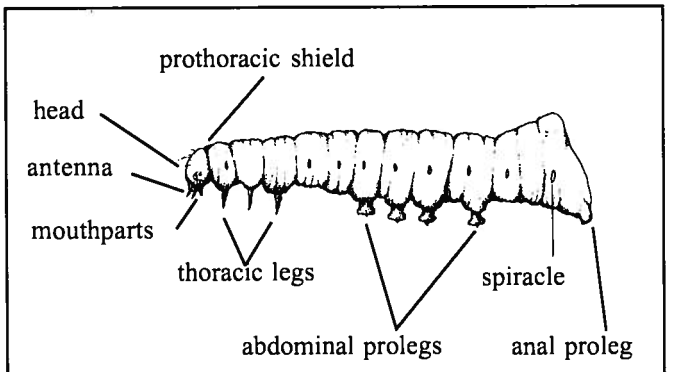
Following completion of the larval stage, the insect enters the pupal stage. The pupa does not feed and usually resides in a protected site or within a cocoon. The pupa undergoes sweeping transformation of the body, or complete metamorphosis. Structures are reorganized and the adult is formed. Adults may or may not continue to eat, but they no longer molt. The adults mate and reproduce.

Insect Mouthparts

The type of feeding that an insect does on the cranberry plant is dependent upon its type of mouthparts. Most insects found on cranberry have biting-chewing mouthparts. This includes the larvae of all of the cutworms, spanworms, fireworms, and leafminers, as well cranberry girdler and sparganothis and cranberry fruitworms. The chewing structures of these larvae are heavily sclerotized and possess teeth and grinding surfaces. The strength of these mouthparts is very apparent, when, for example, a set of gypsy moth or false armyworm larvae reduce a cranberry upright to a splinter. The chewing mandibles are responsible for the tearing and grinding of the cranberry leaf, stem,



Body parts of a typical adult insect, a wasp. (Illustration: Garnett)



Body parts of a typical moth larva, a caterpillar. (Illustration: Garnett)

and fruit tissues.

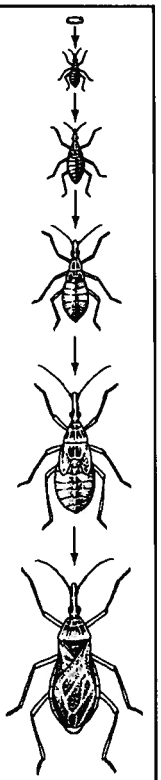
None of the adult moths that originate from these larvae do damage to the cranberry plant by feeding. All depend on liquid food and have siphoning mouthparts that are similar to a rolled suction tube that uncoils when in use.

All of the beetle larvae that feed on roots or leaves, as well as the cranberry weevil larva (that feeds on the contents of the blossom bud), have chewing mouthparts, as do the adult beetles. In some cases, such as striped colaspis or black vine weevil, both the larva and the adult feed on cranberry; in these two species, on the roots (larva) and on the leaves (adult).

The remainder of cranberry insects is separated into groups having various modifications of the primitive chewing mouthparts. The homopteran group, which includes the leafhoppers and spittle bugs, have piercing-sucking types of mouthparts that are characterized by a tubular, jointed beak. The beak is inserted into the plant tissue and plant sap and cell contents are sucked up. Both the nymphs and adults feed on cranberry.

Finally, for cranberry, the least common type of mouthparts is that of cranberry tipworm. As an immature, the maggot has mouth hooks that are used in a sickle-like manner to break and tear plant tissues. Once liquified and combined with the larva's salivary secretions, the plant tissues are sucked in. As an adult, the mouthparts of the tipworm fly are sponge-like, but we have not seen them feed.

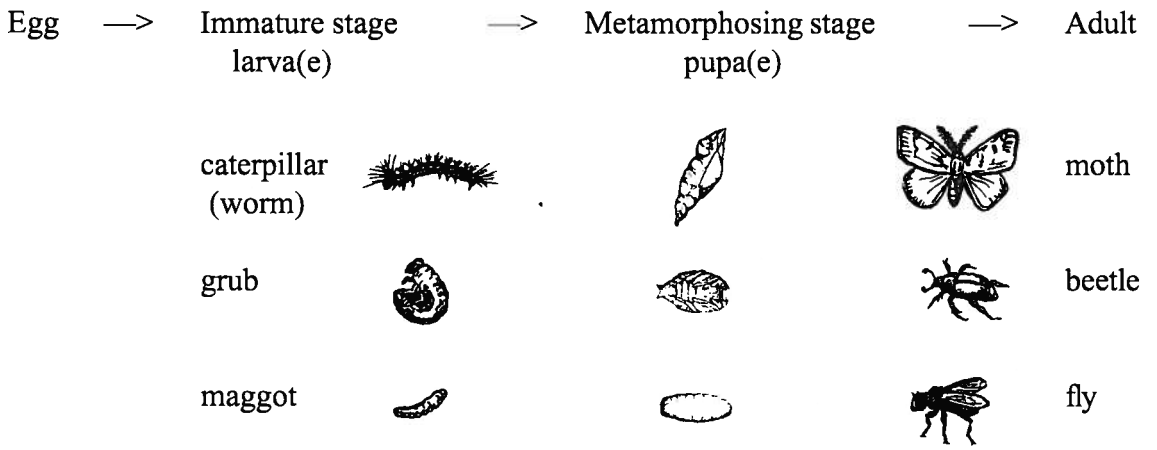
Life stages for insects undergoing incomplete metamorphosis. Some insects, including leafhoppers and grasshoppers, begin life as an egg but do not change structural form as they become larger and pass from immature stages (called nymphs) to adults. Wing buds enlarge with each nymphal stage until functional wings appear in the adult.



Insect Life Cycles

It is also important to understand the life history of each insect, which includes not only the life cycle, but also the number of generations per year, the point in the year when the life cycles occur, and the overwintering stage and location. If utilizing management measures, targeting the vulnerable life stage of the insect pest is very often vital. Some cranberry insect pests move into bogs from outside sites (e.g., cranberry weevil) while other pests remain in the bogs continuously (e.g., sparganothis fruitworm). For both cases, the pest insect population is usually vulnerable to management during a small window of time. To effectively manage pest populations over the long-term, one must not only carry out proper identification, but also be aware of the life stage or stages present at any given point in time.

Most insects in cranberry complete a single generation each year (e.g. cranberry fruitworm, cranberry weevil, the spanworms, false armyworm, cranberry girdler, black vine weevil), although several go through two or more generations (e.g. sparganothis fruitworm, yellowheaded fireworm, cranberry tipworm, blackheaded fireworm). Insects are inactive during the winter, and each species typically has one life stage that is adapted for survival through the winter. For example, blackheaded fireworm and gypsy moth overwinter as eggs, sparganothis fruitworm overwinters as a small larva, cranberry fruitworm and cranberry girdler as a full grown larva within a hibernaculum, brown spanworm as a pupa, and cranberry weevil and false armyworm moths as adults.



Life stages for insects undergoing complete metamorphosis. Most cranberry insects, including the moths, beetles, and flies, begin life as an egg and undergo a larval and pupal stage before reaching the adult stage. (Illustration: Albright + Garnett)

INTEGRATED PEST MANAGEMENT

HISTORY OF IPM

The philosophy of insect management in a crop setting has evolved over the decades, with a critical transition occurring from the "pesticide era" of the first half of the 1900's to the "integrated pest management (IPM) era" in the latter third of the century. Insect management lies within the IPM system, a system that also considers mites, diseases, and weeds. The IPM approach eliminates those treatments based solely on a schedule, such as the "pre-bloom, clean-up spray" in cranberry, and utilizes instead regular monitoring to determine the need and timing of a treatment. The approach utilizes all appropriate management procedures and blends them into an ecologically sound and coordinated program. The aim remains to maximize crop yield and quality.

By using several tactics to reduce a pest's numbers, an IPM program removes the singular reliance on a given pesticide. Reliance on pesticides can lead to the appearance of pesticide "resistance." This is a population phenomenon that occurs when pesticides are applied; with each application, some portion of the pest population may possess genetic traits that allow survival and their offspring appear in the next generation. Subsequent applications select mainly those organisms that are resistant. The fact that several insecticides were previously effective in management of brown spanworm, cranberry tipworm, sparganothis fruitworm, cranberry weevil suggest that these insects have become resistant.

Pesticide applications can also lead to pest "resurgence" where the pest's natural enemies are removed or reduced by spraying. The pest population can multiply without pressure from the natural enemies. Predators and parasitoids typically take much longer to rebuild high numbers. For insects such as cranberry tipworm or sparganothis fruitworm that 1) reach remarkably high numbers on some beds 2) were previously killed by a number of insecticides but now are not and 3) have very high natural enemy pressure on low-spray bogs, it strikes us that both resistance and resurgence phenomena are at work.

Finally, pesticide application often leads to the emergence of induced, or "secondary," pest outbreaks. For any host plant, there are often many different types of insects feeding. However, only a few typically are present in noticeable numbers and the remainder of species typically remain very low in numbers. These previously unnoticed insects can multiply with few restraints when their former competitors or natural enemies have been killed by insecticide applications. This phenomenon may account for the very high numbers of leafminers that we see on some bogs in Massachusetts cranberry. Plant vigor may be measurably reduced by these secondary outbreaks.

The term "management," utilized in theory and practice in an IPM program, is very different than the term "control" that was utilized throughout the pesticide era. In integrated pest management, one recognizes that 100% mortality of pest populations is not required to profitably grow a crop. A "management" approach implies that some level of pest activity may be essential to create a more stable system. The "control" approach not only eliminates pests, but also eliminates other non-target organisms in the bog ecosystem, for example, the diverse plants and animals that provide nectar, pollen, and alternate hosts for beneficial organisms, such as natural enemies and pollinators. As a result, the natural checks and balances that may have been impacting a pest population are disrupted. Dependence on very limited options becomes typical. Pest outbreaks may become increasingly common, as the simplified crop ecosystem becomes less and less stable. The IPM approach developed as a response to these challenging pest problems.

The First Stage of IPM Adoption

A key principle in the initial application of IPM is a recognition that disruptive, broad-spectrum chemicals should be avoided. Utilization of selective pesticides hinges on a sampling program that indicates when a pest has exceeded a tolerable limit. Monitoring methods include recording temperature and other weather data, using insect-attracting traps, observing plant growth stage, or regularly checking plants for pests or pest damage. The monitoring information is important for the tracking of populations, and over the years and through modeling, predictions regarding population patterns can be made. Pesticide applications are made only to prevent actual crop damage. Using this approach, pesticide applications per season likely will be reduced, but numbers may increase as well.

A good deal of work is required to develop insect management programs that are not largely driven by insecticide use. However, in most crops, including cranberry, we have seen factors that will foster substitution of harsh insecticides with alternative pest management strategies. Initially, broad-spectrum insecticides are quite effective. Over time, we have seen that spraying often leads to population resistance, pest resurgence, and secondary pest outbreaks. As a result, we become caught in a "pesticide treadmill" situation. Here, an upward spiral of increased-rate applications targets an uncontrolled pest problem, and it does not work.

IPM does not preclude the use of traditional pesticides. In certain situations and for some pest insects, an insecticide application may be the only effective alternative or may be the only cost- and labor-effective solution.

Program Development

The next stage in an evolving IPM program is the consistent substitution of alternative approaches to pesticides. This involves the integration of practices that could be considered ecological-agricultural, such as host plant resistance (selection of cultivars with qualities that allow the plant to avoid or tolerate insect attack), biological control (maximizing

impact of natural enemies such as predators, parasitoids and diseases), behavioral controls (e.g. mating disruption) and cultural controls (manipulation of the environment e.g. flooding and trash flows). This stage of IPM has been referred to as "bio-intensive" IPM. Folded into such a program could be target-specific "biorational" insecticides that do not upset the activity of beneficial organisms.

While the first stages of a pest management programs tend to focus on a single pest class, the higher levels of a fully mature IPM program integrate multiple management tactics across all classes of pests. For example, as a starting point along this line, in Massachusetts cranberry, the beneficial effects of a late water flood have been evaluated across all classes of pests, with agreement and mutual reinforcement among growers and researchers.

Regardless of management philosophy, the minimization of intolerable damage by arthropod (insects and mites) pests is key to successful cranberry production. Once a bog is in commercial production, failure to detect and manage pest insects properly can result in crop loss, vine damage, or in extreme cases, the death of large areas of the bog.

To summarize, at the outset, IPM depends on the accurate identification of pest problems through regular scouting. Anticipation of potential problems is maximized through consultation of records and bog maps that are scrupulously maintained from year to year. The most effective management program is founded upon a knowledge of the pest species and the crop, combined with an integrated approach that utilizes proper application of cultural, biological, behavioral, and where necessary, chemical controls. Regarding the latter, minimization of dependence on insecticides will take time, effort, and an enhanced level of understanding. These inputs will be greatest at the outset and will diminish over time.

The traditional chemicals (organophosphates and carbamates) will cease to be the first line of defense in cranberry insect management. These broad-spectrum insecticides will be replaced, typically by a multi-pronged approach. Environmentally friendly, biorational insecticides, such as BTs and insect growth regulators will be folded into management approaches (discussed below) such as reliance on natural enemies along with certain cultural practices.

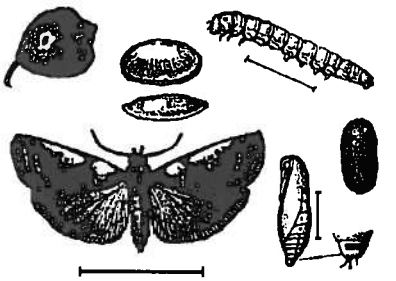
Success of insect management in the future will hinge on a number of points. First, an intensive knowledge of the target pest will often be essential. New management tactics are typically applied within a narrow window in the pest species' life cycle. Targeting this window may require an ability to identify very young stages and to adequately sample the population. New options will frequently be ineffective when applied through a large-volume chemigation system, thus requiring development of ground-rig applicators or a fine-tuning of the original chemigation approach to allow a low water volume application. Finally, the measurement of "success" of an insect management program in the next century likely will use a different yardstick. As synthetic insecticides are phased out, adoption of even multiple applications of our new options in combination with other strategies, may result in lowered levels of overall insect control. Acceptance of a higher percentage of crop damage by both growers and consumers may be inevitable.

MANAGEMENT METHODS

BIOLOGICAL CONTROL

Naturally-occurring predators and parasitoids often play an important role in the regulation of plant-feeding insects and mites in crop systems. In commercial cranberry production, a recent survey (Mahr 1998) suggested that there are considerable opportunities for a greater role.

A predator is a free-living generalist feeder that includes other animals in its diet. For example, birds may eat many moths. Predatory insects, which have been called the wolves and sharks of the insect world, include the lacewings, syrphid fly larvae, and ladybird beetles. Predatory spiders also may consume large numbers of pest insects.



Cranberry fruitworm is a challenging pest. (Illus: Smith 1903)

This ichneumonid wasp, *Pristomerus austrinus*, attacks the cranberry fruitworm larva in the berry.

This cranberry fruitworm egg has been parasitized by a tiny *Trichogramma* wasp and has turned a diagnostic black color.

A parasitoid is a natural enemy that kills its host. In insect parasitoids, the major groups occur in the Diptera (flies) and the Hymenoptera (wasps). The life cycle usually begins when the female lays an egg in or on another insect (= host). The stage of the host varies for a given species of parasitoid. One species may lay eggs in the eggs of the host, while another may lay eggs in the larval stage of the host. Parasitoids tend to be very host specific (attacking one or a narrow number of different species). The parasitoid eggs hatch and the larvae eat away at the host either internally or externally, eventually causing the host's death.

The role of natural enemies in cultivated cranberry can be enhanced by the avoidance of unnecessary broad-spectrum insecticide treatments. Under favorable conditions, this allows a build-up of the indigenous species of predators and parasitoids.

BIOLOGICAL OR BIORATIONAL INSECTICIDES

Microbial insecticides contain living microorganisms or the toxins that they produce. Along with fungi and viruses, this also includes bacteria and parasitic nematodes. These latter two are utilized widely in cranberry. These organisms are grown in vats, collected at the proper stage, and then formulated to allow application with standard spray equipment. The timing and precision of applications are usually far more exacting for microbials than it is for the synthetic insecticides (e.g. organophosphates). On the other hand, microbial insecticides are selective in action. They are highly effective against the target insect pests but are essentially harmless to non-targets — humans, wildlife, domestic animals, aquatic organisms, pollinators, and natural enemies.

Bacillus thuringiensis (BT)

BT products originate from bacterial species. As the bacteria multiply, the cells produce a spore and a crystalline toxin, called an endotoxin. Some formulations contain both the spore and the endotoxin, or the endotoxin alone. Many different strains have been isolated and each is toxic to a different group of insects. Properties of the endotoxin vary and this determines the insect range of toxicities.

BT must be eaten before it is toxic to the insect, in contrast to the majority of traditional synthetic insecticides. BT applications typically kill a lower overall proportion of the pest species than the chemical insecticides. A multi-pronged approach will probably be necessary to manage the most serious or abundant pests. For example, natural enemies, which are not affected, may play an important role in suppressing the remainder of the pest population that escaped. Chances of rapid development of resistance to microbial insecticides are unlikely.

BTs are stomach poisons and all have similar modes of action. When the crystal endotoxin is eaten by a susceptible insect, the crystal dissolves. A series of reactions occurs when the crystal components attach to the gut wall. The gut breaks down, allowing the gut contents to enter the insect's body cavity. The poisoned insect stops feeding. Bacterial spores may also invade the body cavity and this produces further septicemia.

The BT does multiply within the body of the insect but the BT-killed caterpillars do not serve as a source of infection. Thus, additional applications of BT may be required to manage the total population at an acceptable level. Other considerations may also be key, including adequate foliage coverage, protection of new plant growth, and washoff by rainfall. For cranberry, one of the most serious considerations is excessive water delivery during chemigation of the BT formulation. Poor systems or excessive purging can wash the BT off the foliage. Low-gallonage applications (aerial or ground rig) are frequently superior.

Nematodes

Nematodes utilized in cranberry management of root and stem feeders are tiny, microscopic roundworms in the phylum Nematoda. The parasitic nematodes kill their host by "infectious juveniles" entering openings, such as the mouth and spiracles. Some species may actually bore through the insect cuticle. Once inside the host, they feed on the host-insect tissues and release toxic bacteria. This results in rapid host mortality as a result of blood poisoning. The nematodes continue to live on the cadaver's tissues as well as feed on the bacteria. The juvenile nematodes complete development inside the host, mate, lay eggs, and continue to reproduce until crowding or unfavorable conditions result in juveniles exiting and seeking new hosts.

Nematodes are most effective when they are applied to moist soil, not only to enhance their longevity, but also because the juveniles actively search for hosts by swimming on a film of soil moisture to the target. It is widely reported that they do not establish long-term populations, so reapplication is required.

They are well suited to cranberry because they can be applied through the chemigation system and then watered in to maintain a soil moist enough to favor survival and infection of the soil pest.

Insect growth regulators

These compounds mimic or interfere with the hormones that are actually regulating the insects' development. IGRs are reportedly safe for non-targets that do not molt or metamorphose in the manner that insects do.

CULTURAL APPROACHES

Cultural controls in insect management rely on the purposeful manipulations of the agricultural environment to make it less favorable for pest species. The benefits of cultural control are that they often are cheap and long-lasting.

Flooding

Cranberry cultivation typically utilizes water as a management tool to a greater degree than just about any other agricultural crop. Regarding insect management, in the past, flooding during the growing season was heavily relied upon, such as a short 10-hour flood in May for cutworms or in early June for blackheaded fireworm and green spanworm. Whereas these floods are no longer used, the following floods are still used, but to varying degrees.

—Late water "Spring reflood"

This was a prevalent water management practice historically in Massachusetts and utilization has increased somewhat in recent years. Late water is a flood that refers to the practice of removing the winter flood in March and then reflooding the bog for one month, starting about mid April (see p. 89).

Late water floods suppress false armyworm, cranberry blossomworm, gypsy moth, and Southern red mites (Averill et al. 1994). It also suppresses cranberry fruitworm (Averill et al. 1997), but owing to high levels of moth movement, care must be taken to observe late-held bogs that may have uncontrolled populations nearby.

—Summer flooding
Holding of a flood from 12 May to about 20 July effectively eliminates cranberry root grub and cranberry white grubs. It probably would also be effective against the other species of scarab grubs as well, but this has not been evaluated. Most species of insects are eliminated by a summer flood (see p. 87).

The crop is lost for the season that the flood is held. Some growers have reported low yields in the year following as well.

—Fall floods
These are fairly short floods that target specific insects. Cranberry girdler can be managed by a week-long flood held between 20 September and 30 September (but beginning no later than 25 September). A two-week flood after harvest is effective against black vine weevil and strawberry root weevil.

—Detrashing floods
Yearly sanitation of the bog can aid in insect management. Trash floods at harvest remove the accumulation of leaves, fallen berries, and twigs on the bog floor. This debris is floated, collected, and disposed of at a distant site. If the debris is not removed, it can serve as an ideal habitat for overwintering insects, particularly cranberry girdler.

Sanding
Sanding in Massachusetts is a key cultivation practice (see DeMoranville 1997). Here, a layer of sand is spread on the surface of the cranberry bed every 3-4 years. It covers the leaf trash. It also covers the old stems, which promotes formation of new roots and uprights — similar to pruning.

Sanding is important in the management of cranberry girdler and is discussed above under that insect. Fall or winter sanding is reported to be more effective than spring sanding in girdler management (DeMoranville 1997).

Sanding is also reported to be important in reducing populations of green spanworm and blackheaded fireworm. Further, Franklin (1914, 1915) showed that when entire bog areas were sanded, cranberry tipworm populations were reduced.

BEHAVIORAL CONTROLS

Mating disruption
Synthetically-produced female sex pheromones have been used as a control strategy for some moths in other crops. Synthetic pheromone is used in the crop to permeate the field or to provide numerous point sources of pheromone. The treatment reduces the frequency of successful mating, most likely as a result of an interruption of the normal in-flight location of females by searching males. The mechanisms of how disruption works are not fully understood. Overall, in a successful operation, fewer viable eggs are laid.

In cranberry, sparganothis fruitworm is the first candidate in the Northeast. Much work has been ongoing for blackheaded fireworm in the other growing regions.

This strategy is usually most successful under low to moderate pest densities. As population densities increase, the distance that a male must go prior to finding a mate decreases. Thus, the probability that mates will locate each other by chance increases with moth density. For this reason, for insect pests at high populations, it may be necessary to utilize one or more additional approaches, in addition to mating disruption, to significantly reduce numbers.

Additionally, if the area where mating disruption is attempted is near unmanaged beds or is near other host plants of the target insect, there can be a constant invasion of mated females.

Beneficial nematodes are particularly effective against black vine weevil (shown above).

The fall flood. (Photo: B. D. Lampinen)

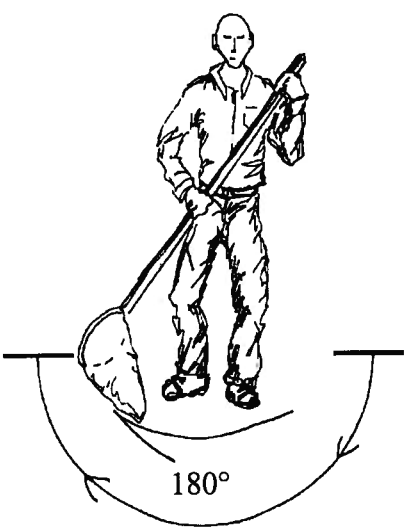
The bottom of this plastic pheromone grub trap is full of oriental beetles after just a week. Thousands are caught on badly infested bogs.

Winter sanding on the ice is a key cultural practice.

IDENTIFYING PEST PROBLEMS

A 10X magnifier may be used for closer inspection of insects. It is also required to determine presence and status of cranberry fruitworm eggs.

Sweep netting should be done on the bog at least once a week from mid-May through the end of June.



When sweeping, a full 180° arc should be used with each sweep pass. (Illustration: Garnett)

SAMPLING FOR PESTS

What is the pest insect?

The success on any management strategy depends on the correct identification of the arthropod pest. Damage caused by the pest may often be indicative of the species that caused it, and in some cases, will allow immediate identification. However, care must be taken when management decisions are under consideration because damage may not appear until the pest has already completed development.

There are many arthropod species that are known to occur on cranberry, but only about two dozen insects and a single mite species are known to be of economic importance. It is usually advisable to be highly familiar with these pest species and not to be overly distracted by small numbers of non-pest insects that are picked up during scouting.

Sampling and monitoring

Sampling and monitoring of acreage allows recognition of a pest problem. 'Scouting' of acreage is an essential activity in insect management in cranberry. The point of the sampling exercise is to accurately determine the presence or estimate the density of a pest as well as the pest's life stage. Two keys to this activity are to establish a regular schedule and to maintain accurate records. Detection of pests utilizes visual assessments of the bed as well as sampling with a sweep net. The condition of the crop should also be assessed while walking the bog.

Sweep net sampling

Sweeping is a sampling method that allows an estimate of insect pressure over an entire bed. Because it is not possible to examine the entire bog, selected areas are sampled while walking across the bed using a sweep net. Different areas are evaluated and then the total counts of insects collected for each sweep set are averaged to estimate the insect population.

When to sweep

—Over the season

Weekly sweeping activity typically begins the second week of May and continues through bloom. Although sweeping may be terminated when fruits appear, perhaps even earlier, we recommend continued sweeping and visual inspections through August, particularly if cranberry weevil, Southern red mite, black-headed fireworm, flea beetle, or brown spanworm problems are suspected. At least a reduced level of examination is mandatory.

Fears of money loss because berries/blossoms are crushed/lost during mid- to late-season sweeping activity cannot be supported. Take the most impossible, nightmare scenario: Assume 50 blossoms or berries are crushed with each step (given that Godzilla is sweeping), and 50 steps are taken per acre for the required sweep set and 500 blossoms or fruits are picked up in the net. We know that there are 440,000 berries in a barrel (100 lbs.) and in a good year, each barrel may net $60. For a sweep set taken per acre of bog under these assumptions, 41 cents is lost each time an acre is visited and swept.

In the early spring there may be caterpillar activity. Pest levels of insect caterpillars should be evaluated in their early stages. As the caterpillars of many species grow larger, they cling to the vine or hide in the daytime. Thus, they are less likely to be gathered in the sweep net over time.

—Within a day

The hours of activity may vary among the different species of insects. However, the majority feed up on the vines during warm, calm days and it is clear that bogs should be swept under such conditions to maximally assess insect populations.

Night sweeping in June and July is valuable for suspected infestations of black vine weevil or strawberry root weevil. The adults feed up on the vines following completion of larval development in the soil.

How to sweep
Sweep-netting involves sweeping back and forth across the vines. A single 'sweep' is a 180-degree arc, dragging across the vines with a 30 cm (12") diameter sweep net. A sweep set consists of 25 sweeps. Sweeping should be done in a line across the bog, using a large stride to move across as much area as possible.

Minimum number of sweep sets for a given acreage when the pieces are single and continuous. Greater numbers of sweep sets allow more accurate estimation of insect populations.

1-10 acres.....	1 sweep set/ acre
10-20 acres.....	at least 10 sweep sets
more than 20 acres.....	1 sweep set per 2 acres

The net should be dug into the vines to pick up caterpillars that are clinging to the lower portion of the stem. After completing the last sweep of the set, the net should be knocked so the insects fall down into the net. The contents should be inspected carefully. The insects must be accurately identified (using a 10X magnifier), counted, and recorded.

Where to sweep
On large pieces, a zig-zag pattern among sweep sets could be used when walking across the bog to allow coverage of as much area as possible. Different routes should be taken on the next sweeping visit, allowing a greater overall coverage within a season. Some pests (particularly cranberry weevil, gypsy moth, brown spanworm, big cranberry spanworm, spiny looper, black-headed fireworm, flea beetle, southern red mite) may be very patchy within the central areas of a bog. Thorough assessment of total acreage is essential.

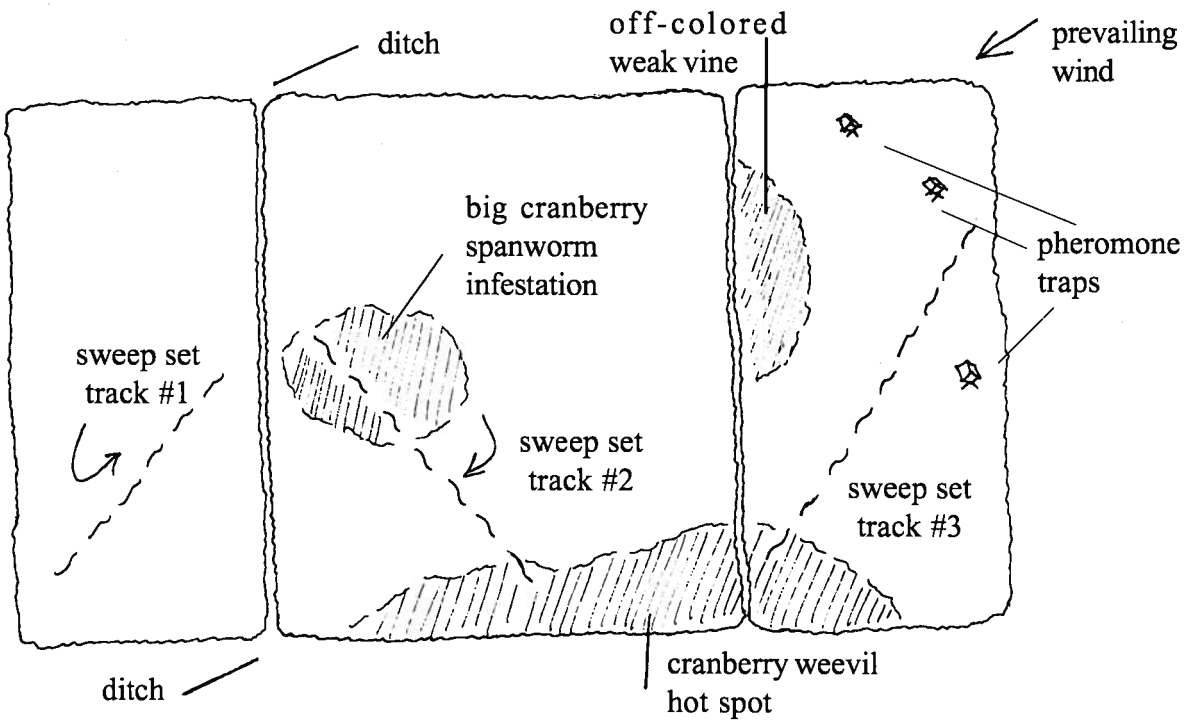
Weed patches and bare spots should be avoided. While sweeping to sample the bog, one should start at least 10 feet in from the bog edge. Bog edges, which typically have higher numbers of some insects, should be assessed separately.

Many of these same insects may aggregate in "hot spots" in bog coves (narrow areas at the margin of the bed) and the bog margins. Checking known hot spots may help establish the first occurrence of a pest. It is important to sample these areas, but management decisions for a bed should be triggered by the average level of insect activity over the bed's entirety. In the best-case scenario, hot spots should be treated separately, rather than blanket treating a large acreage, particularly if a broad-spectrum insecticide is utilized. A view to the future dictates that methods for managing problems in small areas of a cranberry bed are developed.

Large bogs may be subdivided and managed as smaller units depending on chemigation design or ability to treat aerially. In these instances, specific data should be collected and management decisions evaluated for each of these management units.

WHERE AND WHEN TO MANAGE INSECTS

Treatment of a pest population is often based on scouting. When pest insect numbers are evaluated by sweep-netting, management treatments should be considered when the insect numbers exceed an established action threshold (see Table below) — but keep in mind that these numbers are not set in stone, as discussed below. Cranberry thresholds



Map of a bog following a visit to a bed, showing path of sweeping, pheromone trap placement, and "hot spots" of insect activity. (Illustration: Garnett)

are based on the average number of insects in sets of 25 sweeps. The average number of insects at a bog site is calculated by adding up all counts in all sweep sets and dividing by the number of sets conducted. This average number should be compared with the threshold values listed below. If the average number of a given pest on a bog is greater than or equal to the threshold, management measures should be considered.

However, the threshold values should not be considered as hard and fast numbers. The numbers we have used for decades are closer to a "rule of thumb" indication of when a given pest insect is being sampled at numbers that we consider to be high and worthy of attention. We use the same numbers that Henry Franklin recommended in the early 1900's. These threshold levels for pest insects have been shown to be effective in cranberry production for many decades.

In traditional agriculture, an economic threshold was the point at which control measures were taken such that the amount of damage/loss to a crop did not reach and exceed the cost of management measures. In past days, this simple equation of determining the economic damage to a crop, based on yield levels and market returns, made a decision to treat more straightforward. Now, costs and benefits are far harder to fit into an equation, and the number of external factors that impact a spray decision are far higher.

The decision whether to treat when a threshold is exceeded, particularly with synthetic insecticides, should not be made without bringing many other external concerns to bear. Example are natural enemy conservation, insecticide resistance of a key pest, neighbor concerns, and resistance management. Overall, regulatory scrutiny and the values and expectations of adjoining neighbors and communities where cranberries are produced have changed tremendously.

Using BT's and growth regulators

When utilizing a biorational option, it is often advisable to start to treat a pest population when low numbers are sampled. If past records are consulted and show an annual trend of damaging numbers, or if there is reason to believe that numbers will progressively increase to intolerable levels over the season, better control may be realized if applications are not delayed until higher numbers are sampled.

Correct timing has been proven to be crucial in the application of the "biorational" insecticides such as microbial formulations and growth regulators. *Bacillus thuringiensis*, known as BT, and sold as Dipel, Mattch, Xentari, and several others, targets caterpillars. The BT's and growth regulators must be eaten by the larvae. Applying a BT formulation while the population is in the moth or pupal stage is worthless. Further, smaller instar caterpillars frequently tend to be the most susceptible.

Record keeping

Good records are an integral component of any IPM program. The identification and number of insects sampled (recorded for each individual sweep set), environmental conditions, treatment records, including approach, material used, rate used, target pest, timing of application, and an evaluation of efficacy are among the important subject headings.

Scouting information should also be recorded (i.e. yearly observations of cranberry weevil moving into the bog over time, presence or absence of southern red mite, etc.). These observations should be recorded for each bog separately, preferably by cultivar.

Mapping the bog

Making a map of scouted beds can be useful and serves several purposes. Overall, a yearly history of the cranberry bed is assembled. Many pests accumulate in "hot spots" or will first appear in the same part of a bog from one year to the next. For example, this is often true of

ACTION THRESHOLDS FOR COMMON CRANBERRY PESTS, BASED ON AVERAGE NUMBERS OF INSECTS IN SETS OF 25 SWEEPS.
Keep in mind that these numbers serve as a "rule of thumb" indication of where insect numbers can be worthy of attention.

Black-headed fireworm	1 to 2	Action should be considered relative to a past history of infestation.
Sparganothis fruitworm	1 to 2	Visual search for webbed vines or leaves should also be carried out.
Cranberry weevil	4 to 5	These small, reddish snout beetles may play dead; thus, the net should be left undisturbed for awhile. Sweeping picks up higher numbers when it is warm and sunny.
Cutworms (false armyworm, cranberry blossomworm) humped green fruitworm gypsy moth caterpillar	4 to 5	Add up numbers for these caterpillars as if they are the same kind of insect. Do not include cranberry sawfly in your cutworm counts.
Green spanworm Brown spanworm	18	Small caterpillars will cling to side of the net.

blackheaded fireworm and cranberry weevil. Areas where vines are discolored can be noted on a bog map. Mapping keeps a record of these spots. To direct attention to problem or suspect areas, copies of such maps can be transferred to new scouts or consultants working on the bed.

The sampling pattern for sweeping can also be recorded and varied on the next visits, allowing coverage of different parts of the bog. This insures the fullest coverage of the overall acreage during routine visits.

USING PHEROMONE TRAPS
Detecting and Monitoring Insects with Pheromone Traps

What is a sex pheromone?
Pheromones are chemical signals emitted by organisms that allow communication among members of the same species. Sex pheromones have been called "naturally-occurring perfumes" because they are used to attract members of the opposite sex for mating. In the majority of cases, it is the female that emits the pheromone, usually from a gland on the tip of the abdomen. Most sex pheromones have multiple components and are highly volatile. They elicit a response at incredibly low concentrations and are picked up by the male by specialized receptors on the antennae — this often accounts for the larger or more hairy antennae observed on males when compared to females of the same species.

The odorous molecules of the pheromone are carried downwind and, when detected by the attracted sex, the insect (usually the male) exhibits oriented movement to the site of pheromone release. The distance of attraction is difficult to quantify but has been estimated to be up to 100-1000 meters.

Sex pheromones in IPM
The sex pheromone is identified and synthesized in the laboratory. In most cases, the pheromone is placed on a rubber septum. The pheromone volatilizes and the septum must be regularly replaced (within 2-4 weeks, depending on type). The pheromone is used as a lure within a cardboard or plastic trap. Sticky or another technique, such a funnel trap, is used to capture the insect. Because the female-produced pheromone is used, only males are captured in these sex pheromone traps.

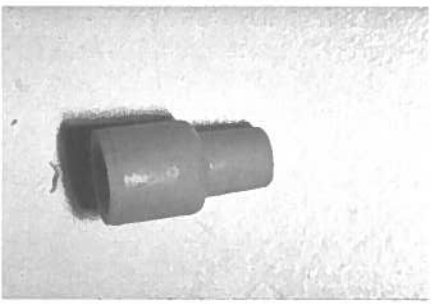
Pheromone traps for moth species
Traps are available for cranberry girdler, blackheaded fireworm, or sparganothis fruitworm. Guidelines are being developed for pheromone trapping of spotted fireworm in New Jersey.

The trap style used for sparganothis fruitworm is a wing type (e.g. 1C) and for blackheaded fireworm and cranberry girdler is a diamond-type trap (e.g. Pherocon II).

At this point, we do not have sufficient information to correlate trap captures with the need for a treatment. Pheromone traps have been called "chemical searchlights," meaning that they allow us to see when the insect pest is present and reaches peak flight activity. In cranberry, timing of management measures are based on weekly counts of captured moths; for example, nematodes may be applied against cranberry girdler based on moth flight. Here, the strategy is to target the larval population once all eggs have hatched. Thus, the recommendation is to apply the nematodes two weeks after the end of moth flight.

How to use pheromone traps
For moths, adult populations should be monitored with pheromone traps starting about 1 June. Traps should be checked weekly and the moths removed, counted, and recorded. The sticky portions of the trap should be kept free of debris and be changed if necessary. Further, the pheromone bait should be changed every 3 weeks, or as recommended. For every 10 acres, at least one trap should be placed on the upwind side of the bog so that the volatilized chemical can be carried downwind and across the vines.

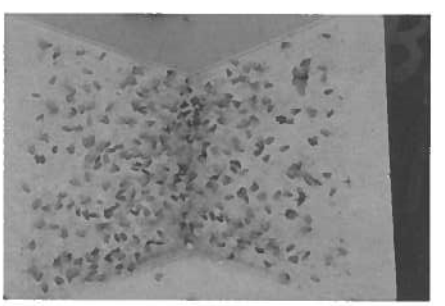
Although captures are typically highly specific, sometimes non-target and non-pest species are caught in fairly



A pheromone-treated lure or rubber septum is the part of the pheromone trap that mimics the odor of the female insect.

1C wing traps can be used for *Sparganothis* fruitworm.

Smaller Pherocon II traps can be used for cranberry girdler and blackheaded fireworm.



The bottom of a pheromone trap is covered with sticky that holds the moths to be counted.

significant numbers in both the cranberry girdler and blackheaded fireworm traps. Recognition of the adult moth is important before monitoring begins.

For these species of moths, the risk that the trap will attract a pest to the bog and establish a greater level of infestation is not apparent. Nonetheless, this is a concern for some. First, only males are attracted to the pheromone traps containing a female pheromone, so providing a scenario where pheromone traps play a key role in the onset or enhancement of an infestation is difficult. There is no evidence that presence of males attracts females. Perhaps, one could reason that if males are attracted to the area, but are not captured in traps, the mating frequency for on-bog females when the population is low could be enhanced. For sparganothis fruitworm, this seems unlikely, because although it feeds on plants in addition to cranberry, we do not find moths in the uplands and moth numbers are low on abandoned bogs. Thus, moth captures likely originate in the bog that is being trapped.

Such an argument cannot easily be made for the remaining two moth species. Blackheaded fireworm is specific to cranberry but can be very abundant on abandoned bogs. Such unmanaged areas (which are rare except for Cape Cod bogs, and perhaps Maine) could be a constant source of not only colonizing females but also males attracted to a pheromone source. Cranberry girdler larvae are reported to prefer to feed on some grasses over cranberry, so males and females could move to cranberry following adult emergence.

If attraction of males is a concern, rather than choose not to use traps, the blackheaded fireworm and cranberry girdler traps could be placed a few meters off-bog, or ideally, two traps could be placed far apart, off-bog and on-bog. If few moths are caught off-bog, fears of an invading moth population are not supported.

Pheromone traps for beetle species

For scarab beetles, pheromone traps are also available for cranberry white grub/ common June beetle (*Phyllophaga anxia*) and oriental beetle. For both species, a Japanese beetle standard funnel trap can be used. The white grub trap is above ground hanging about 15-30 cm (6-12") above the vine. The oriental beetle trap should be sunk into the bog with just the funnel above ground level.

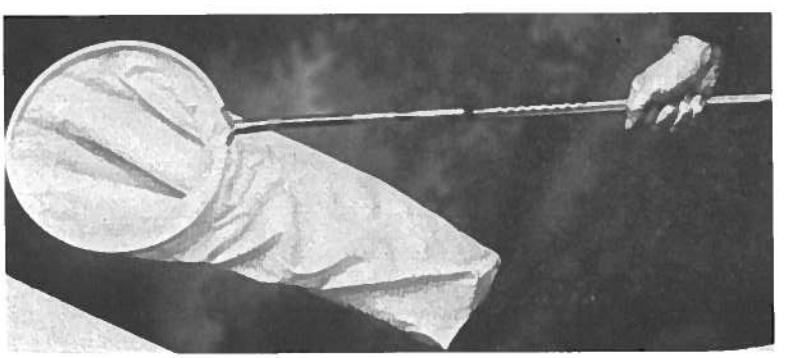
Because these species move throughout the bog and surrounding habitats, for monitoring purposes, the traps can be placed along bog margins and dikes. There will always be difficulty in determining the origin of adults. This makes verification of species identity through examination of larvae in infested bogs highly advisable.

There is no evidence that the sex pheromone traps for oriental beetle and cranberry white grub enhance the probability of infestation in the vicinity of where they are deployed. This is a concern because it is well known that such is the case for Japanese beetle traps; these contain both floral attractants and sex pheromone. Both males and females are attracted and there is evidence that instead of entering the trap, Japanese beetles may establish in higher numbers in the vicinity of the trap.

Even half a century ago, when several treatments were available that now are not, Franklin (1950) noted that "no complete control for this pest [cranberry white grub] has yet been found; but it may be lived with" if a series of treatments are applied. This statement will likely hold true for all of the scarab beetle grubs. One treatment that may be useful for grub management is mass trapping of adult males. Using synthetic pheromone in conjunction with traps, this approach relies on the removal of sufficient males from the population to limit the proportion of females that is able to find mates.

Mass trapping has been applied for control of some moth species with variable results. Initial population levels of the pest species and the number of traps that can be reasonably placed per area are two of the most important factors contributing to success. Regarding the number of traps utilized in moth control, 50-100's are employed per acre. Success may also be linked to the level of competitiveness of the sex pheromone bait as compared to virgin females. Here, adequacy of the initial identification of the components in the pheromone blend, the accuracy of the ratios utilized, and the release rate of pheromone may each figure importantly. Trap design may also be key. For many of the moth species targeted in other crops, infestation was reduced when compared to the control plots, so the mass trapping approach for the scarab beetles can be seriously considered.

For cranberry scarabs, we have some limited work ongoing to evaluate mass trapping in Massachusetts cranberry, focusing on cranberry white grub and oriental beetle, where the pheromones are already identified. These two species are highly polyphagous, so reinfestation from external sources may always be problematic. However, in the absence of other controls, the approach is a viable one.

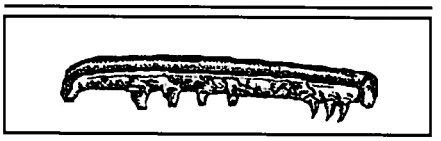


Franklin used an 11" sweep net while today a 12" sweep net is used. (Franklin 1935)

CRANBERRY INSECTS: BIOLOGY, IDENTIFICATION, AND MANAGEMENT

CUTWORMS

CUTWORMS
Lepidoptera: Noctuidae



A mature cutworm has three pairs of thoracic legs just behind the head, four pairs of fleshy abdominal prolegs towards the middle of the body, and a single pair of anal prolegs at the very end of the body.

These large-bodied larvae feed openly, never webbing the vines. They are 38-51 mm (1 1/2-2") long when mature and without noticeable hair. When they become large, they feed mostly at night. The large larvae usually hide among the vines, in the litter on the bog floor, or under pieces of board if such are present. The moths are robust and measure 38 mm (1 1/2") or more across their outspread wings. Their eggs are round, slightly flattened, and marked with many ridges radiating from the summit. Larvae appear as a typical caterpillar in shape, with a cylindrical body, and a series of legs, shown above. For all pests included here, Franklin (1948a) recommended poisoned baits. See Glossary, p. 97.

"FALSE ARMYWORM"
"American (red) swordgrass moth"
***Xylena nupera* (Lintner)**
Lepidoptera: Noctuidae

This species has appeared consistently for nearly a century in Massachusetts, and is frequently found in high numbers. It never infests bogs on which late water is held and seldom appears on bogs that are not winter flooded. The moths seem to prefer damp locations for egg-laying. It is found occasionally in New Jersey and Maine.

Distribution and Food Plants
This insect ranges throughout northeastern United States and southern Canada, south to the District of Columbia and west to Nebraska, Oregon, and Alberta. It feeds on various weeds, grasses, iris, wild cherry, and apple as well as cranberry.

Character of Injury
The young larvae often do great damage by eating out the hearts of the terminal buds before new growth starts. They develop with the new growth and feed more and more intensively as they mature, eating leaves, buds, and flowers until sometimes little is left of the new shoots but the stems. They seldom eat the old foliage. Their feeding is more like that of gypsy moth caterpillars than that of any other cranberry pest. They feed freely in the daytime when small.

Description and Seasonal History
There is a single generation each year. The moths overwinter and the females lay about six hundred eggs apiece in late April and very early May, placing them in masses of sometimes over a hundred on the stems or the backs of the leaves of cranberry. They hatch during the second and third week of May, the egg stage lasting 15-20 days.

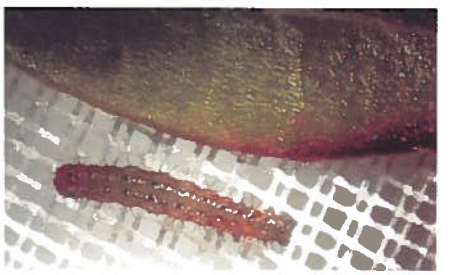
The larvae mature in late June and go into the ground to remain dormant two to six weeks before pupating. They pupate mainly in late July and early August. The moths emerge from mid-August until late September.

The Egg
The eggs are whitish at first, soon turn light yellow and ultimately become reddish-brown. They are about 0.8 mm (1/32") in diameter.

The Larva
Newly hatched larvae are whitish and marked with many black spots. Each spot bears a slender black spine that is inconspicuous unless magnified. The tiny larva does not have 4 abdominal prolegs until later instars. In the middle photograph (right), development of the more anterior prolegs can be seen in the later instar larva.

Small larvae loop much like spanworms

Egg mass of false armyworm.

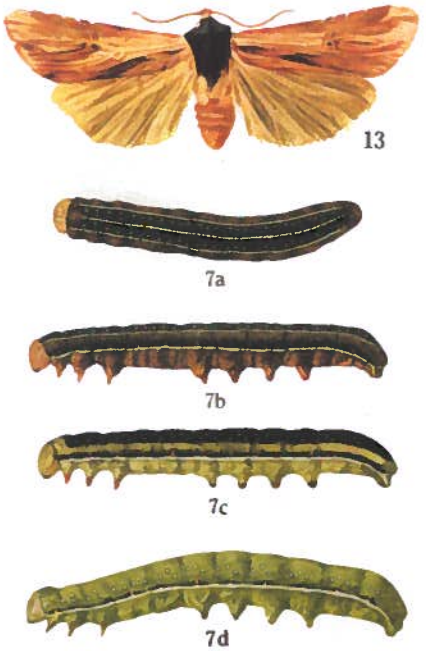


Tiny first-instar false armyworm is whitish and has black dots bearing spines and moves with a looping crawl. The larva does not have 4 abdominal prolegs until older.

Notice still undeveloped abdominal prolegs toward center of body and continued looping crawl.

Medium-size false armyworm larva.

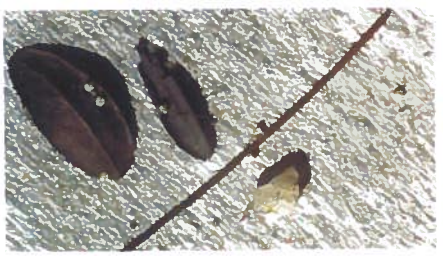
Full-size false armyworms may be up to 51 mm (2"); notice color differences.



The moth of false armyworm (at top) and the different color variations of the mature false armyworm caterpillar. (Illus: Franklin 1948a)

Blossomworm larvae have a distinctive reddish-brown purple color.

Blossomworm moths fly during harvest. Females lay eggs that overwinter and hatch the following spring.



Blossomworm eggs are scattered on the bog floor where they overwinter (Photo: W. Z. Fort).

but gradually drop this movement and become green with whitish lines along the back and sides, being somewhat darker above than below, and retain this pattern until over a 1/3 grown.

The mature caterpillar is about 51 mm (2") long and its head is uniform greenish yellow. Though the arrangement and relative width of the various stripes and lines along the body are the same in all specimens, the general color varies greatly from grass green to dark brown to black. The stripes are as follows: a broad band of varying color runs the length of the back and is divided in the middle lengthwise by a light line; below, this band is bordered on each side by a yellowish line; below this line on each side is a much wider stripe extending nearly down to the spiracles; across the spiracles passes a blackish line that is bordered below by a sulfur yellow line. There are light dots at intervals along the back. The body is greenish or flesh colored beneath. The spiracles are orange, ringed with deep brown.

The Pupa

The pupae are stout, dark brown, and about 25 mm (1").

The Moth

The upper wings are light coffee brown with reddish sooty brown below and on the back between the wings. The top of the head, the collar, and the abdomen above are pale yellowish brown. The forewings are variegated, with brown, gray, and sooty streaks above and are a light brown color. A diagnostic trait is the series of three dashes across the forewing, which are not readily apparent in the figure above. These dashes are black and transverse, the first originates at the wing base, the second is in the middle of the wing, and the last extends from the reniform spot toward the margin of the wing. The reniform spot is almost kidney shaped and lies in the outer part of the wing, at the 2/3 point from the base. The hindwings are pale brown with a conspicuous dark spot somewhat before the middle and toward the base on the other side. The wings expand 50 mm (2") or more.

Management

Late water controls false armyworm. A historical control was also a quick reflood about 18 May for 10 or as much as 14 hours. Seven hours was enough in windy weather; the treatment was put off until late May or very early June if the infestation was only moderate. This later flood was thought to check other pests also, but is considered more risky.

"CRANBERRY BLOSSOMWORM"
"Pointed sallow "
Epiglaea apiata (Grote)
Lepidoptera: Noctuidae

This cutworm appears commonly in Massachusetts, but typically in small numbers. It is more important in New Jersey. In the days of Franklin, it often destroyed the crop promise entirely on small areas on the Cape. It was confined to bogs not reflooded regularly in late May or June or after picking. Some growers called it the "bud worm."

Distribution and Food Plants

This insect ranges through the Northeastern States from Maine to Illinois. It feeds on blueberry and is said to feed on leatherleaf also. Tomlinson (1948) found that in New Jersey, larvae fed in large numbers on leatherleaf, which provided a source of invading moths for the majority of bogs.

Character of Injury

The young larvae first nibble the leaves, especially at the margin, or bore into the buds and so spoil them for fruit production. As they grow, they nip off blossom buds. They rarely cut off the leaves, differing in this from spotted cutworm and armyworm. They are night active and work very little in the daytime after they are half grown. Each larva that matures destroys many cranberry blossoms.

Description and Seasonal History

There is a single generation each year. Most eggs are laid in October and these overwinter. They are fastened singly to fallen leaves or pieces of dead vine littering the bog floor. They usually begin to hatch after the middle of May on bogs drained in April, and hatch

mostly in late May and early June following a late water flood.

The larvae mature early in July on the bogs where winter water was removed in early spring. They soon enter the ground or deep trash to remain dormant two to four weeks before pupating. Pupation normally occurs in late July and early August, usually in a cell slightly below the surface of the ground. The moths emerge during September and are active, especially the males, until late November. On late water bogs, pupation may take place in August or early September and the moths emerge in late September to October. The females lay from one hundred to two hundred eggs.

The Egg
They are pale yellow at first but soon turn dingy brown.

The Larva
Young larvae are usually green on much of the front half of the back. Somewhat older larvae are reddish-brown, with the head light mottled brown and with a whitish stripe along each side of the smooth and well-rounded body. Large larvae become pale brown, often look somewhat bloated, act torpid, and are nearly 38 mm (1 1/2").

The Pupa
The pupa is brown and about 16 mm (5/8") long. It is enclosed in a loose and indefinite cocoon of silk and sand.

The Moth
The moths vary greatly in color. Some are brownish gray; others are fox red above and somewhat lighter below. The front wings are crossed by a few fine lines and there are two characteristic subcircular markings placed lengthwise on the middle of the front part of each. The main part of the body is tufted heavily with hair. The wings expand about 38 mm (1 1/2").

Management
Late water floods control blossomworm. Historically, flooding for ten hours about 10 June was also done. Tomlinson (1948) reported that a 12 hour reflow in about the last week of May, when almost all eggs had hatched, was highly effective, if the winter flood had been drained from April until the first week of May. On earlier drained bogs, hatch would also be earlier so the flood could be moved up to 15-20 May, reducing the danger to developing flower buds. See also Flooding Appendix, p. 87.

"HARVEST CUTWORM" species unknown

An unidentified brown or rust-colored caterpillar appeared on Massachusetts bogs in 1996 and 1997. They are usually seen in the harvest waters or along the edge of the bog. Some growers have reported hundreds of these caterpillars. The larva has the typical cutworm body type and has a velvety look to it. We have not successfully reared this insect to the adult stage.

There are no control recommendations at this time. The caterpillars apparently do not sink in the harvest flood and will probably not be drowned if a flood is held for several extra days. In the lab, the larvae eat cranberry vines but prefer maple leaves and foliage of other common trees. They may feed on weeds on the cranberry bog. Similar caterpillars were not found in sweep sets in the spring, even where there were remarkable numbers the previous fall. There are many explanations for this observation: for example, they are night active (typical of other cutworms, see below); they are active only later in the season, or they do not overwinter on cranberry bogs. Further study will be required, if populations continue to be observed.

UNCOMMON CUTWORMS

Excepting spotted cutworm, which is occasionally reported in New Jersey, these cutworms are not seen. If flooding as a management tool is readopted, frequencies of observation may increase for some of these species.

Cutworms often appeared after fireworm floods. For management of black-headed fireworm, it was recommended to hold the winter flood until about 1 June and reflow three weeks later (Franklin 1928). Franklin found that "the chances are two to one that some of these [cut]worms will infest a bog if the winter flood is held until June". Infestations were rare if spring floods were not held. In Massachusetts, he observed that the cutworms tended to appear within ten days to two weeks after flood removal.

Females of these species prefer damp areas as egglaying sites, as observed in other crops. For example, black cutworm moths lay eggs in low spots of a corn field. Bogs drained during the time of moth flight may provide favorable conditions for egg survivorship. Flood removal in late spring may also favor larval survivorship in that these bogs will produce new growth at a point later in the season when larvae of these species appear.

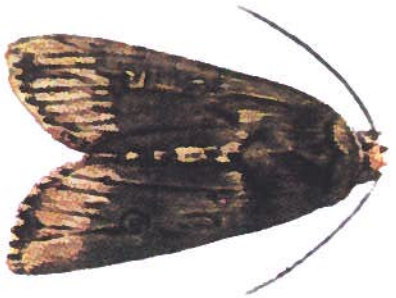
All of these cutworms have very wide distributions over the United States, feed on an extensive list of host plants, and are notorious pests, particularly on vegetables and grasses.

The moths are nocturnal and difficult to distinguish from several other species of cutworm moths.

The larvae look like typical garden cutworms and are cylindrical. The cutworms are difficult to identify in the early instars because all are whitish to greenish. Older instars can be identified by their more distinctive markings. Franklin also used the color of the spiracles to distinguish among the species as larvae. Using a 10x magnifier, one can see that the armyworm and black cutworm have dark spiracles, the spotted cutworm have clear yellowish-white rimmed with deep brown, blossom worm have reddish-brown to dark brown rimmed with darker brown, false armyworm have yellowish-white as medium larvae and deep brown in mature larvae, and fall armyworm have pale brown with the rim dark brown.

Because the cutworm larvae are hidden during the day in the soil, a suspected infestation would be evaluated by examining the soil 7.5 cm (3") in areas where damage is seen. Night sweeping is also reported to pick up some larvae.

Black cutworm. (Illus: Franklin 1948a)



Black cutworm moths have rarely been seen in Massachusetts or New Jersey in recent years. (Photo: CES archive)

BLACK CUTWORM
"Ipsilon dart"
***Agrotis ipsilon* (Hufnagel)**
Lepidoptera: Noctuidae

This pest has not been observed recently in Massachusetts or New Jersey. In the past, it often infested Massachusetts cranberry bogs when the winter flood has been held until late May or later. It overwinters in southern North America and Central America and migrates northward in March and April (Showers 1997). It primarily feeds on grasses and is a serious pest of vegetables, particularly corn. In Massachusetts, black cutworms would commonly appear in late July and early August after removal of a long late-spring and early-summer grub flood. Also in the past, in both Massachusetts and Washington, it sometimes attacked new plantings and girdled vines in the hills at the surface of the ground. The small larvae usually begin to appear eleven or twelve days after the water is let off. The black cutworm was sometimes found in mixed infestations of the spotted cutworm, fall armyworm and armyworm. It has also been called "greasy" cutworm in North America.

Character of Injury
Feeding by the larva is similar to that described for armyworm.

Description and Seasonal History
This insect does not overwinter in this region. The life history on cranberry is irregular and has not been traced thoroughly. The moths are active from late May until late October. Chapman and Lienk (1981) reported that in New York, the moths arrive from southern overwintering sites in mid-April and undergo two generations. Peak moth catches in light traps occurred in mid-July and September. Franklin observed two generations in Massachusetts, the moths of the first being most abundant in June and July and those of the second in August and September.

In the Midwest, the eggs take 5-10 days to hatch. The larvae undergo 6 or 7 instars and require 28-35 days to mature. The pupal stage lasts 12-15 days.

The Egg
The eggs are laid in masses of 10 - 30. Individual eggs are circular and are slightly wider than tall. When first laid, they are white and then darken as they develop.

The Larva
The young instars are greenish-brown or grayish in color, the green color is due to the food in the larva rather than to pigmentation.

When more mature, the larva is mostly dark brown or sooty gray on the back and sides and grayish below. An indefinite and inconspicuous broad stripe of somewhat lighter brown usually runs along the back. The head, the neck shield, and the spiracles are mostly black.

They are about 38 - 51 mm (1 1/2 -2") long when mature. They are often very active in the afternoon.

Under magnification, the cuticle of the black cutworm differs from the other cutworm species in that it has convex, rounded, distinctly isolated coarse granules with smaller granules interspersed between the larger granules.

The Pupa
The pupae are brown, about 19 mm (3/4") long, tapering to the posterior and blunt at the anterior. They are found in the soil.

The Moth
The moth expands to nearly 45 mm (1 3/4"). The head is mostly reddish brown. The collar is sooty gray with a transverse line of black. The front part of the back is sooty gray. The underside of the thorax is light gray. The hind body is pale brownish above and light gray below.

The forewings are mostly sooty and are lighter colored toward the outer third. A dagger-shaped marking appears just beyond the center of the forewing near the outer margin. There are a few other inconspicuous black markings on the forewing. They are pale brownish underneath. The hindwings are pale with brown shades toward the margins.

Management
In the past, if an infestation was anticipated, it was advised to drain the winter water before 20 May. In cases where water was held late in the spring and infestations ensued, flooding for ten hours at night was advised.

SPOTTED CUTWORM
Black-letter dart
***Xestia* sp. Franclemont**
Lepidoptera: Noctuidae

Currently, we do not see this insect in Massachusetts, but it has appeared in New Jersey bogs occasionally. In the past, it appeared in outbreak numbers on a number of bogs on Cape Cod. For example, in 1923, Franklin noted a striking case where the winter flood had been removed from a Cape bog but where water subsequently backed up from an adjoining flooded bog. Here, larvae were abundant only at low sites where standing water had occurred and then drained. In contrast, when the water was drained from the adjoining flooded bog, it became totally infested.

It feeds on many plants and crops, such as apple, corn, barley, clover, and maples. *Xestia adela* Franclemont and *Xestia dolosa* Franklemont were separated from the European species *Amathes c-nigrum*, based on subtle differences (Franklemont 1980). Further work is required to arrive at the correct species name for cranberry spotted cutworms.

Character of Injury
In the past in Massachusetts, infestations were most common on Howes bogs where the winter flood was drained between 26 May and 8 June. The larvae are most active at night and during bloom. They nip off buds, leaves, flowers, and small berries, severing the stem near where it joins the ovary. They are most active during bloom. They also partially excavate grown berries. Fallen green leaves are seen near bog ditches and later everywhere under much infested vines. Severe infestations in small areas may result in such severe defoliation that the bare uprights give the vines a brown tinge.

Description and Seasonal History
According to Franklin, the larvae live through the winter and pupate in May. The moths emerge in late May and early June and soon lay eggs. The eggs are laid in rows or compact masses, with each moth laying two hundred or more. The larvae mature in late July and early August. They pupate in the soil at depths of 2.5 - 10 cm (1-4"), usually from the last of July to late August. The pupal stage averages about nineteen days. The second generation of moths emerges from mid-August to mid-September. The majority of eggs are laid in early September, hatching in about two weeks to produce the overwintering larvae.

The Egg
The egg is 0.6 mm (1/40") and is nearly spherical. It is fluted and each fluting is finely scalloped.

The Larva
The young larvae are pale at first, but they assume their mature coloration before they are half grown. The mature larva is about 38 mm (1 1/2") and dull gray or brown with greenish or olive-brown tints. It has a whitish stripe along each side and two to four rather conspicuous angular, blackish spots in a row on the back. There are large wedge-shaped markings on the seventh and eighth abdominal segments. The head is light yellowish-brown with a color network of darker brown. The spiracles are whitish or yellowish.

The Pupa
The pupa is mahogany brown and about 19 mm (3/4") long.

The Moth
The moth expands about 38 mm (1 1/2"). Its back between the wing bases is reddish sooty gray, with a pale gray or whitish collar in front. The upper side of the abdomen is light brown. The under side of the body is dark gray, with light gray or even whitish sometimes prevailing on the sides and hind part of the chest. The forewings are mostly dull brown above, usually tinged slightly with a reddish or bluish color. Each has a conspicuous triangular pale patch reaching back from near the middle of its front margin and nearly dividing an equally noticeable dark brown area, also some blackish markings toward the base and a blackish spot toward the outer end and running back from the front margin. The under side of the forewings is light brown. The hind wings are whitish with brown shadings.

Management
Since this insect only appears on bogs where the winter flood is removed about June 1st, the standard approach of removing the winter flood in March may have essentially eliminated this insect in Massachusetts cranberry. It is unclear what factors favor its occasional appearance in New Jersey.

Ten-hour floods at night carried out in June were done in the past under pressing population levels.

Franklin observed very high (65-70% of larvae) parasitism in this species.

11

Spotted cutworm moths appear on a bog two times during the season (late May to early June and again mid-August to mid-September). (Illus: Franklin 1948a, Photo: CES archive)

2a

2b

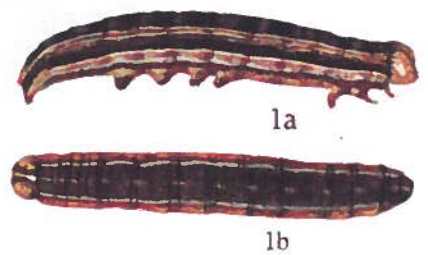
Spotted cutworm larvae. (Franklin 1948a)

ARMYWORM
***Mythimna (=Pseudaletia) unipuncta* (Haw.)**
Lepidoptera: Noctuidae

In the past, this cutworm species appeared more commonly on bogs after a late spring flood was drained. Infestations were reported within eight days after the removal of this flood if the water was let off any time between about 20 May and about 10 July. It never was a problem on a bog drained early unless there were abundant grasses on the bog or if the bog was reflooded for ten days or longer in late May.

The moths are reported to fly with the prevailing winds for many miles in great numbers and alight to lay their eggs in a place favorable to larval development. This accounts for the sudden appearance of this insect in regions remote from any known source of infestation. According to Franklin, "swarms of the moths often appear about streetlights shortly before an outbreak of the worms. Cranberry men sometimes may be warned by this and should know the moth at sight." A few of the moths appear every year over most of the area in which it occurs, but this does not explain the sudden great invasions that come from time to time. It was very abundant in the Cape cranberry region in 1914 and 1919. They were more common after a cold and late spring. The armyworm feeds mostly in low meadows and among rank-growing grasses.

Armyworm moths. (Photo: CES archive)



Armyworm larvae. (Illus: Franklin 1948a)

Distribution and Food Plants
This species occur commonly in the United States east of the Rocky Mountains. Its primary larval hosts are grasses, and is especially abundant in moist areas. It is a known pest of corn and wheat. When these are not available, the larvae will feed on a broad range of hosts, including vegetables and ornamental plants.

Character of Injury
The larvae nip off the cranberry leaves more freely than blossom worms and spotted cutworms do, sometimes nearly defoliating the vines. They also commonly cut new uprights nearly off, so that they break over and hang by a thread. They feed mostly at night and on cloudy days, but also move and feed in clear weather.

"Invasion" behavior of the larvae where they migrate in large numbers from areas of exhausted resources to new stands of plants led to the name armyworm. This is not a common behavior. The armyworm is known to invade grass in wet areas and become most abundant after flooding has occurred (Tashiro 1987).

Description and Seasonal History
This insect is reported not to overwinter in this region. It overwinters in the southernmost regions of North America and migrates northward each year to recolonize the temperate regions. The life history of the armyworm varies widely in different parts of the country. It is reported to undergo five generations in the South and two in New England.

In light trap captures in New York, two peaks of moth activity occurred in late May to early June and again in mid July to early August (Chapman and Lienk 1981). Eggs hatch in a week to ten days. Larvae are predominantly night active. Mature larvae go 25 mm (1") or more into the soil to pupate. The pupal stage lasts two weeks or longer in an earthen cell, and the moths emerge from the ground and fly at night, laying eggs for the next brood. The summer larvae are thought to be more destructive when compared to spring generation. The larvae mature in about a month, go into the ground, pupate late in July, and moths appear in August. The females lay their eggs, and the caterpillars from these probably are killed by the first frosts.

New spring infestations result from migration of moths from the south.

The moths live on the nectar of flowers and the honeydew of certain insects, and sometimes many may be caught with sweet baits at night. They rarely lay eggs near where they have developed and may often fly many miles before doing so.

The Egg
The eggs are laid in rows or groups of ten to fifty, mostly in the leaf sheaths of grasses and grains or on stubble or straw, usually in moist or shaded spots, and are covered with a gelatinous substance. Each moth commonly lays a total of five to six hundred. They have been reported to lay up to 2,000 eggs (Tashiro 1987).

The Larva
The young larvae loop like spanworms and spin down on silken threads but soon lose these habits. The maturing caterpillar is smooth and rather dark. A broad dark brown stripe runs the length of the back and usually is divided by a broken pale line running along its middle. At each side of the dark back stripe is a narrower reddish yellow one, then a dark one, and lastly, there is a subspiracular stripe that is pale orange to reddish yellow that is bordered by a narrow white line. These colors vary somewhat. Pale yellow lines separate the stripes. The underside of the body is a pale greenish brown. The spiracles are black. Each proleg of the four anterior pairs has a noticeable deep brown stripe across the middle of its outer side. The head is yellowish brown with a color network of darker brown. The mature larva can reach 38 mm to 50 mm (1 1/2 - 2").

The Pupa
This is reddish or chestnut brown at first, becoming blackish before the moth emerges.

The Moth
The wingspan usually spreads about 38 mm (1 1/2") and the resting moth is about 23 mm (<1") in length. It is plain light brown. A diagnostic feature of the forewing is a white diamond-shaped speck near the center of the upper surface and a dark shade running back obliquely from the outer angle.

Management
See black cutworm on page 18.

FALL ARMYWORM
***Spodoptera frugiperda* (J.E. Smith)**
Lepidoptera: Noctuidae

This insect is not seen in Northeast cranberry currently. It has a past history of great damage. Devastating infestations in New Jersey occurred in 1916 on several bogs when summer floods were drained in mid-July. In Cape Cod bogs, it appeared in damaging numbers at several widely separated sites in late July and early Aug. 1948, after removal of summer floods for cranberry root grub. This species forms infestations later than the other cranberry cutworms and is the only one, except the black cutworm, likely to seriously infest a bog when a summer flood is drained. It will not attack a bog that has been drained much before July.

Distribution and Food Plants
This pest occurs yearly in Central and Southern U.S. and in the past, its worst outbreaks may have originated in those regions. It is evidently a native of tropical or subtropical America and does not survive the winter north of the Gulf Coast. In the years of its great abundance in the South, great numbers of the moths fly northward, sometimes for hundreds of miles, and lay their eggs. These hatch, the larvae develop, and the moths fly northward again before egglaying. Under favorable conditions, the insect may temporarily colonize most of the eastern two-thirds of the United States and even part of Canada before fall frosts halt it. Fall armyworm sometimes does immense damage to crops throughout this range.

In the past, it sometimes seriously attacked grasses on Cape Cod. Its host plants are grasses such as quack or crab grass, Bermuda grass, blue grass, Johnson grass, and it is a major turfgrass pest in the United States. It seriously injures alfalfa, clover, corn, cotton, cowpea, kafir, millet, oats, rice, sorghum, sugar cane, and wheat. It sometimes attacks beet, bean, buckwheat, cabbage, grape, pecan, pepper, peanut, potato, sweet potato, strawberry, spinach, tobacco, tomato, turnip, and other plants. In greenhouses, it is destructive to gladiolus, chrysanthemum, geranium, and dahlia.

Character of Injury
The feeding done by this insect is like that of the armyworm.

Description and Seasonal History
This insect is reported not to overwinter in this region. It overwinters in the southernmost regions of North America and migrates northward each year to recolonize the temperate regions. The moths move north from overwintering sites and the largest numbers arrive from mid-summer to fall. In New York, light trap captures showed a single peak of moth flight in mid-September (Chapman and Lienk 1981), suggesting a single arrival of females that laid eggs. The moths are strongly attracted to lights.

The moths lay their eggs mostly at night, preferably on grass blades, though they may place them on any plant suitable for larvae. Low-lying fields of grass or small grains often are chosen for this, so the outbreaks usually begin on bottom land. Sometimes the eggs are laid on lawns. They hatch after a week or more. The larva matures in about four weeks. They are cannibalistic. They feed in the daytime, even in sunny weather. There usually are five generations a year in the Gulf States, but probably only one full generation is seen in the northeast. The pupa is formed in a cell 25 mm (1") or so in the ground and last 10 days to two weeks.

Any larvae present into the fall will die after the first killing frost.

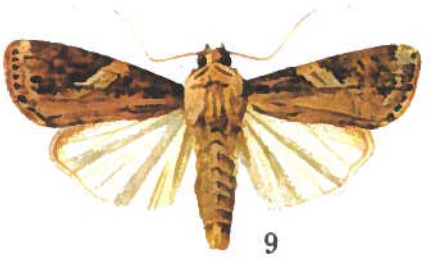
The Egg
The eggs are laid in masses of from fifty to five hundred. They are spherical, light gray and always are covered with grayish hairs from the female's body. Each egg is much flattened at the base.

The Larva
The newly hatched larva has a black head and whitish body. As they mature, the larvae resemble armyworms and vary greatly in color. The body is striped lengthwise on a ground color varying from buff to dull gray or nearly black. A pale yellow line divides lengthwise the broad mottled-buff stripe covering most of the back. On each side of this broad stripe is a light line, then a dark stripe, and lastly- down toward the legs- a light yellow stripe mottled with reddish. The underside is pale, varying from buff to green, and often tinged with red, especially toward the sides.

Tubercles, each with one hair, appear plainly as dark dots, particularly along the back. The head is rather light brown to almost black, is mottled with pale yellow, and always has an inverted, though not conspicuous, white "Y" on the face. The prothoracic shield varies from light brown to nearly black. They are 32 mm (1 1/4") long when mature.

The Pupa
It resembles the armyworm and is 13-19 mm (1/2 - 3/4") long. It is light green at first but soon turns light brown and finally dark brown. The spiracles with areas partly surrounding them usually appear as dark spots along the sides.

Fall armyworm larvae are usually only seen on summer-flooded bogs.



Fall armyworm moth. (Illus: Franklin 1948a)

The Moth
The wingspan of the moth expands from 25 - 43 mm (1 - 1 2/3") and the moth is 20 mm (3/4") long at rest. The male usually is plain gray with brown shading and obscure lines and spots. The forewings of males are mottled brown. The female has a pale-brown body. A white spot occurs near the tip of the forewings. Another whitish area runs back obliquely from near the middle of the front margin; those of others are uniformly dark grayish brown. The hindwings are whitish with a pearly or pinkish luster and edged with smoky brown. An erect tuft of scales on each side of the hind end of the dorsum of the thorax and a similar tuft on the middle of the base of the dorsum of the abdomen are noticeable. A row of dark spots runs along each side of the venter.

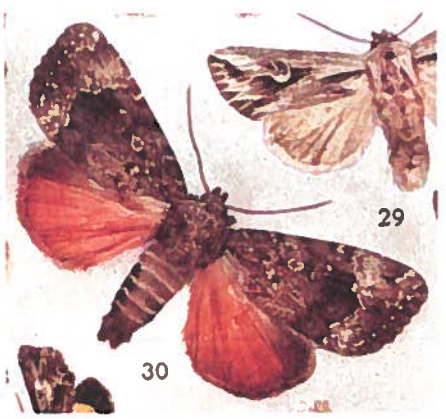
Management
In the past, if infestation was a critical problem or expected to be a problem, it was advised to avoid summer flooding. In cases where a summer flood was held late in the season and infestations ensued, flooding for ten hours at night was advised, as soon as infestation was detected.

OTHER EARLY SEASON FOLIAGE FEEDERS

A medium-size humped green fruitworm larva.

In the later instars, the hump on the humped green fruitworm caterpillar is very prominent.

Humped green fruitworm pupae are found on the bog floor.



Humped green fruitworm moth #30 (Illus: Holland 1905)

"HUMPED GREEN FRUITWORM"
"PYRAMIDAL FRUITWORM"
"Copper underwing"
***Amphipyra pyramidoides* (Guenée)**
Lepidoptera: Noctuidae

This insect was not previously reported in cranberry. It is an early season foliage feeder and does not eat cranberry fruit. It is in the group of "green fruitworms" found in other fruit crops such as apples, grapes and blueberries where they eat holes into the fruit (Rings 1968). The insect is also known as the 'pyramidal fruitworm.' It is a stout-bodied green caterpillar. It is in the same family of moths with the cutworms and armyworms, but lies in a different subfamily. Unlike the cutworm subfamily, the green fruitworm stays on foliage continuously during the larval stage. In contrast, true cutworms rest in the soil or trash on the soil surface during the day and when large do most of their feeding at night (Chapman and Lienk 1974).

Character of Injury

Our observations indicate that the humped green fruitworm will feed on cranberry vines in a manner similar to blossomworm and false armyworm. Thus, these larvae should be included in cutworm counts when determining action thresholds during scouting.

In other crops, members of the green fruitworm group are direct pests of the fruit. However, fruit damage has not been associated with the humped green fruitworm on cranberries.

Host Plants and Distribution

The larvae will eat the foliage or fruit of many host plants. Rings (1968) collected larvae from apple, plum, peach, black cherry, flowering almond, and crab apple in his studies in Ohio. It was also found on 20 deciduous trees and shrubs in collections in Canada; basswood, elm, oak, white birch, and willow were favored. It has also been collected on grape, maple, oak, poplar, rhododendron, raspberry, hickory, redbud, hawthorn, strawberry, Virginia creeper, blackberry, lilac, pear and walnut (Rings 1968). Rings (1968) reported no economic importance of this insect in crops.

According to Chapman and Lienk (1974) the species has been collected most commonly in the northeastern quadrant of the United Sates and the adjoining provinces of Canada. Limited records also place the species in British Columbia, Washington, California, Arizona, New Mexico, Kansas, Texas, and Georgia.

Seasonal History and Description

The insect completes one generation per year. The humped green fruitworm is different from other green fruitworms found in apples and pears in that it overwinters as an egg. Egg hatch and larval development begin in early spring. Pupation occurs on the ground and the cocoon is made of silk and debris (Rings 1968). Adults are present from July into November in field sampling in Ohio, but egg-laying may not start until September.

Working with an Ohio population in the lab, Rings (1968) found that females laid an average of 276 eggs and the highest number observed was 635 eggs per female. The eggs are laid singly or in masses.

The following descriptions are freely taken from Chapman and Lienk (1974) and Rings (1968).

The Egg

Eggs of green fruitworms are small, 0.70 mm (1/35") diameter and 0.48 mm (1/50") height, and oval when viewed from above, but appear slightly flattened when viewed from the side. Distinct ridges radiate from the top of the egg. The eggs are white or cream-colored when first laid but after a few days become red-violet.

The Larva

The caterpillar is robust. The arrangement of the legs on this species appears the same as the cutworms. The caterpillar is most easily recognized by

the prominent hump that occurs on the eighth abdominal segment, but this hump is present only in instars three through six. A continuous white line runs down the back, as do lateral lines that angle toward the hump. The spiracles are black and there is a line that runs along the spiracles that is white and yellow. This spiracular line is bold on the first two thoracic segments, then is quite faint on the third thoracic segment and first abdominal segment. The spiracular line then reappears as a bold line on the third abdominal segment and continues to the body's end above the anal proleg.

Average measurements of the six instars

Larval instar	Total length (mm)	Head capsule (mm)
1st	3.1	0.34
2nd	4.0	0.57
3rd	7.5	0.96
4th	10.0	1.44
5th	23.0	2.19
6th	40.0	2.80

The Pupa

The pupa resembles that of the typical leafroller, and is about 17-20 mm (3/4") long x 5.5 mm (more than 3/16") wide and is dark reddish-brown.

The Moth

The forewings are abruptly divided into a dark proximal two-thirds and a lighter distal third. In the former instance, most of the scales are dark fuscous, but some blackish areas are also present. In the distal portion, the grays are lighter on average and include some quite light gray-white areas.

The adult is also known as the "copper underwing," which aptly describes the coloration of the hind wings. The adult moth is very large with a wingspan that is on average 38 to 47 mm (1 1/2 to 1 3/4"). The hind wings are a characteristic coppery orange with the costal area fuscous.

GYPSY MOTH
***Lymantria dispar* (L.)**
Lepidoptera: Lymantriidae

This introduced species was brought into Massachusetts in the late 1860's by a French biologist interested in commercial production of silk. It escaped in the Medford, MA area and although it is established in many areas of southeastern and midwestern states, the northeastern states remain a stronghold of its infestation. It has defoliated millions of acres in the U.S. It did not infest the Cape cranberry region seriously until 1913 and it has increased vastly there. It continues to be a serious cranberry pest. The populations are highly variable from year to year and tend to be cyclic.

Distribution and Food Plants

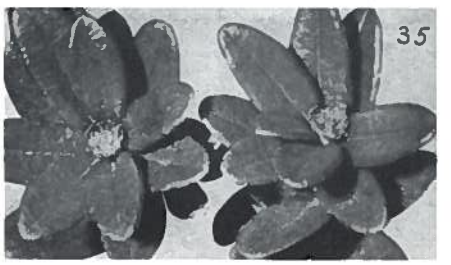
This species ranges widely through the world and is found throughout a large portion of the United States. It feeds only on foliage, and in the Northeastern U.S. has 300-400 food plants. Preferred plants include oaks, alder, some birches, aspen, linden, willow, box elder, Lombardy poplar, apple and apricot. Less preferred are chestnut, pine and spruce, and even less preferred are cherry, cottonwood, elm and spruce. Newly hatched larvae must feed on preferred host plants to survive, but older larvae are able to feed on less preferred food plants.

Character of Injury

On cranberry, the young larvae commonly attack the terminal buds first, eating all but the outer scales, and often causing great loss before detected. As the new growth develops, the caterpillars devour the leaves, flower buds, and blossoms and often sever the new part of the stem. They attack the old foliage severely when they are very abundant and once they have destroyed the more attractive growth, will sometimes even gnaw bark from the vines.

The feeding done by this insect on cranberry vines is much like that of the false armyworm in all stages. This is true of no other pest. An infestation of two

Gypsy moth larvae vary in color by age. Young larvae are black (right) and intermediate size larvae are black with a chain of orange dots (left).



An old Franklin photo shows the "cabbage-head" feeding damage done by gypsy moth larvae. (Photo: Franklin 1948a)

Gypsy moth life cycle with enlargement of a first instar larva ballooning from trees on a silken thread. Because females do not fly, wind drift of newly hatched larvae from adjacent trees can be a major source of bog infestation. (Illus: Wood 1885)

On large gypsy moth larvae, blue and red dots are prominent along the back.

Gypsy moth pupae.

first-stage larvae to the square foot often develops so as to destroy nearly all the new growth, and one larva to the square foot usually reduces the crop materially. Bogs often do not yield well until the second year after severe injury by this pest.

Description and Seasonal History

There is a single generation each year. Eggs overwinter. They usually are placed within a few inches of the pupal case from which the female moth emerged. The young larvae become fully formed inside the unhatched egg within three weeks after the eggs are laid. They cannot endure a temperature lower than -25°F and often are winter-killed extensively in northern New England.

Larvae normally hatch from eggs during the last of April to mid-June, according to ambient temperatures and their location. Those in sunny places hatch earliest, while those in cool, shady locations emerge much later, most of them usually hatching between the 12th and the 25th of May.

When conditions are favorable for dispersal, the larvae climb up trees leaving a continuous silk trail as they move. When they reach the outer branches or tops of trees, they drop on a silken thread, reclimbing the strands until carried by the wind to a new location. Both the silk and long lateral hairs provide buoyancy to the windborne caterpillar.

Male larvae undergo five instars and females undergo six. The number of days between instars varies, depending on instar as well as temperture. Fourth instar behavior is different from the previous instars. While younger larvae remain sheltered at night and feed in the open in the day, older larvae feed during the night and seek protective locations during the day where they rest in concealment.

The caterpillars spin much silk in their first stages and commonly drop and hang by a thread when disturbed. They do not do this when they get larger, but they spin a few threads for support before pupating and often make a scant cocoon.

Pupation becomes general toward mid-July on the Cape, but some caterpillars remain until mid-August. When the larvae abound in the uplands, they commonly collect in masses on tree trunks to pupate.

The moths emerge in late July and August. The males are slender-bodied and fly actively by day with a zigzag flight, but the females are heavy bodied and sluggish. The female is completely flightless. She produces a sex pheromone that attracts males.

The Egg

The eggs are smooth, globular, about 1.5 mm (1/20") in diameter and pale pinkish brown when first laid. They grow darker within three weeks when fertile, owing to the development of the larvae within. They are laid soon after the moths emerge, mostly in oval or rounded masses of 75 up to a thousand. The egg mass is 13-18 mm (1/2 - 1 1/2") long and 9-13 mm (1/3 - 1/2") wide. They are covered with yellowish hairs from the abdomens of the moths, which insulates the eggs from desiccation and low temperature. The egg mass with its tannish hair covering looks like a piece of sponge.

The Larva

Immediately after hatching, the larva is buff colored but within hours turns black. They are covered with very black long hairs that provide a buoyancy and they are borne easily by the wind; they may be carried twenty miles or more.

The larvae first grow rapidly during late May and June and mature early in July. The slightly older larvae are black with a chain of orange dots along the back. After their first stages are past, they appear as follows: the head is mostly sooty black, this color being much broken up by irregular light yellow markings. A long triangular stripe runs down the middle of the face and there are two converging curved lines on the top that are cream-colored and conspicuous. Its surface bears many yellow hairs. The underside of the body is mostly yellowish. The back and sides are dark brownish-gray, with a light line down the middle of the back. There are eleven prominent tubercles in a row along each side of the back, the first five being blue and the last six red. These bear slender black spines and a few short pale yellow hairs. Tubercles on the sides have more and longer hair, most of which is pale yellowish. Two small tubercles without hair or spines, some distance apart on the mid-line of the back toward the hind end, and a conspicuous dark hairy tubercle on each side just behind the head are distinctive. The female larvae are often 50 mm (2") when mature, but the male larvae seldom much exceed 25 mm (1").

The Pupa

The male pupae are 15 - 23 mm (3/5-7/8") long and the female from 15 - 36 mm (3/5 - 1 2/5"). The female is usually much larger than the male pupa because it passes through an additional larval instar. Pupae are deep brown and bear considerable yellow hair. They usually are found on the sand of cranberry bogs, often covered with litter, but they also occur up among the vines. The pupal stage lasts 7 to 17 days, on average about 2 weeks.

The Moth

The sexes are very unlike. The ***male's*** wings expand about 38 mm (1 1/2"). Its

antennae are plumose (bushy). The upper side of the body and wings are dingy brown and the forewings have irregular dark brown markings. The head and the underside of the body are yellowish white. All the wings are light brown underneath.

The ***female's*** wings expand about 51 mm (2") across. Its antennae are dark brown and much less bushy than the male's. The hind end of the abdomen is dingy reddish-brown. The rest of the body and wings are nearly white. The forewings are marked irregularly with different shades of brown and all of the wings have dark brown spots at regular intervals along their outer margins.

Management

Early detection is key. The larvae are often very patchy, so thorough sweeping in the spring in affected areas is essential. The winter flood of bogs does not harm the eggs much as long as it is cold, for they hatch readily afterwards if it is let off early in April.

On the other hand, late water is an excellent managemet tool for gypsy moth. If the flood is held until mid to late May, hatching is negligible and most of the small instars that arrive on-bog do so through wind drift.

Franklin (1928) also recommended reflooding on about 29 May for about 36 hours. If it was among the earliest of springs, the flood could go on ca. 24 May; if it was among the latest of springs, the flood could be delayed until 3 June. At the time of the reflood, most of the airborne first instars should have arrived on the bog. Unless they are very numerous, up to the time of the flood, they cannot do much vine damage. If the larvae are a 1/3 grown, a 14 hour flood kills them. If the larvae are abundant, delay of the reflood was not advised, probably owing to the great damage potential of the larvae. The small larvae often cling to the vines as the flood water rises and never come to the surface, and this actually enhances survivorship; larger larvae do go to the surface where they thrash themselves to death. The other insects impacted by a late May flood are false armyworm, cranberry blossomworm, black-headed fireworm and green spanworm.

How Bogs Become Infested with Gypsy Moth

Bogs become infested in the four following ways:

1. By the hatching of eggs laid on the bog the year before. Larvae originating from these infestations usually defoliate rounded, patchy areas. Each patch represents larvae from an overwintering egg mass.

2. By wind drift of the newly hatched larvae. This is the main cause of infestation. The uplands around the cranberry bogs, often from 3-12 meters (10-40') high and usually wooded, furnish ideal conditions for wind dispersion. Infestations from wind drift often are the thickest near bog margins and diminish towards the center. They seldom, if ever, develop in round patches.

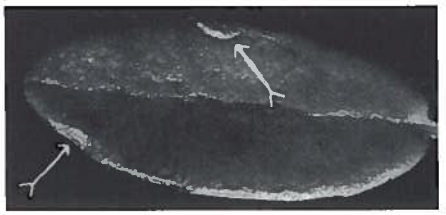
3. By the larvae falling on the bog margin from the overhanging trees. The uplands from most bogs are now being cleared of trees and brush well back from the margin, so the chances of this are generally small.

4. By the larvae crawling across the ditch in their later stages. When the surrounding upland is heavily infested, complete defoliation of the trees commonly occurs, and then hungry larvae may crawl onto the bog.

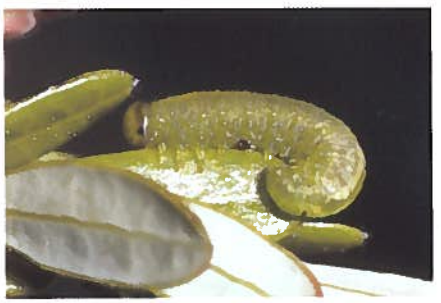
The eastern tent caterpillar (*Malacosma americanum* F.) should be properly identified, and thus, not mistaken for gypsy moth. It has a continous white stripe down its back and is densely hairy. Young larvae form white silk tents in crotches of trees. Upon completing development, full-grown larvae may wander extensively before forming a whitish cocoon.

Gypsy moth adults. The male and female moths are very different. The male (top) is darker and smaller. The female (bottom) is mostly white. She cannot fly and here, is pictured producing an egg mass. She covers the egg mass with hairs from her abdomen.

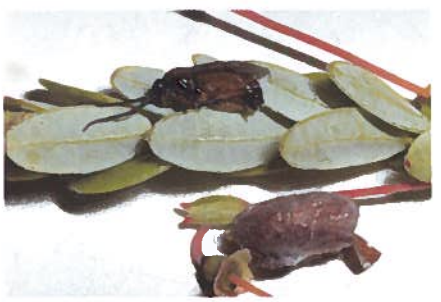
Compare the gypsy moth larva (above) to the tent caterpillar (below). The tent caterpillar is <u>not</u> a cranberry pest, but may wander onto bogs when searching for pupation sites.



Eggs are laid into pockets in the cranberry leaves. (Photo: Franklin 1948a)



Cranberry sawfly larva. It is somewhat similar in color to the false armyworm larva but has a rounded head capsule, more legs, and a distinct curling behavior.



A cranberry sawfly adult (top) and a pupal case (bottom).

The sawfly adult is black with yellow areas.

Another species of sawfly (not cranberry sawfly), that along with other unknown species, may be common on some bogs.

"CRANBERRY SAWFLY"
Pristiphora idiota (Norton) ?
Hymenoptera: Tenthredinidae

The adult is wasp-like. In the past, it occurred in numbers only on bogs where winter water was not held and on bogs that were not reflooded regularly. It is found in small numbers on many bogs in Massachusetts and occasionally in high numbers. It is currently not thought to be a pest.

This species identification is questionable, and even if correct, likely has been revised. Neilson (1958) provides a description and biology of a sawfly identified as *P. idiota* on low bush blueberry. There are few parallels between that sawfly and our cranberry sawfly. However, there are close parallels with another unidentified species of *Pristiphora* that he studied.

Other species of sawflies are also found; in some instances, these unidentified species may be found in high numbers. The sawfly group in cranberry requires study.

Distribution and Food Plants

Cranberry sawfly has been found in Massachusetts, New York, New Jersey, Illinois and Wisconsin. Cranberry is its only known food plant, although low bush blueberry has also been reported (Neilson 1958).

Character of Injury

The larvae feed on the edges of the cranberry leaf, resulting in an irregular scalloping.

Description and Seasonal History

Cranberry sawfly is multivoltine. The larvae overwinter in rather tough cocoons of coffee-brown silk among the trash on the bog floor, unharmed by the winter flood. They pupate early in May and the adults usually emerge soon after mid-May and lay eggs so that new larvae appear on the bogs early in June.

The female may be parthenogenic (see Neilson 1958). She always perches on the edge of a cranberry leaf to oviposit. She puts her eggs in pockets that she makes between the upper and lower leaf surfaces. The pocket opens at the margin. The pockets usually are placed singly, but sometimes two or more are near together. One or, rarely, two eggs are placed in a pocket and often protrude a little. They hatch about a week after they are laid.

About five generations occur, the last larvae usually entering their winter cocoons in mid-October. The larvae develop so irregularly that the generations are mixed by late summer.

The Egg

The eggs are elliptical, watery greenish brown, and a little over 1 mm (1/25") long.

The Larva

At first the larvae are light yellowish-green with the head dark brown. They grow darker with age. When mature, they are 10 mm (3/8") long, smooth, green and without noticeable markings except a narrow internal stripe of whitish pigment running the length of the back on each side of the heart which is visible inside. The head capsule is brown with black dots on either side. It is distinctly round. They have six pairs of prolegs on the posterior portion of their body.

The Adults

The adults are 5 mm (1/5") long and 12 mm (1/2") across expanded wings. They are mostly black, but have yellow areas: a broad band across the middle of the upper side of the abdomen and all of its underside but the tip.

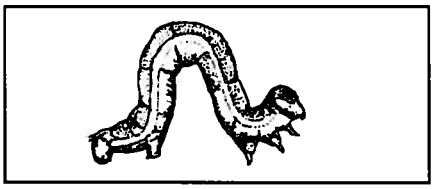
Management

This species is of importance in the spring when sweep counts of the very damaging species, false armyworm, are made. Care should be taken to distinguish and ignore cranberry sawfly when management decisions are made. Upon examination, the sawfly larvae are clearly curled, have a greater number of legs on the abdomen, and have an obviously rounded head when compared to false armyworm.

Franklin (1928, 1948a) felt that sawfly could be a "minor drain" and recommended refloods about 8-10 June for 10-15 hours. In his earlier works, he also suggests fall flooding, for 18 days in late September and early October.

SPANWORMS

SPANWORMS
Lepidoptera: Geometridae



Typical spanworm larval form. There are three thoracic legs in the front of the body. The posterior part of the caterpillar's body has only two pairs of fleshy prolegs.

These insects, known also as loopers and inchworms, have a striking way of crawling. They stretch out to full length, take hold with the front legs, and then bring forward the hind end close to the front pairs of legs, the body between bending well up out of the way. This habit is due to the lack of several legs that other caterpillars have to support the middle of the body.

These larvae are more slender than most caterpillars, and are thin and cylindrical. They are hairless and feed openly, never sewing leaves together. When disturbed, they cling to their support by the hind pairs of legs and remain straight and motionless, thus assuming a twig or branchlike posture. They usually are colored to harmonize with their habitual surroundings and often resemble short or broken twigs. This habit tends to save them from their enemies (Bardwell and Averill 1996).

The moths, called "geometers," are small to medium-sized with angular wing margins. Growers should know the moths of green and brown spanworm, for their abundance may be an indicator of coming trouble — either in the present year or the following year.

Interestingly, a few new species of spanworm, not presented in Franklin, have appeared. Some of these have not been reared out to a moth as yet and remain unidentified (see figures at right).

"GREEN SPANWORM"
***Itame sulphurea* (Packard)**
Lepidoptera: Geometridae

This species usually occurs in limited numbers on many Massachusetts bogs and recently has been seen in very high numbers on a few bogs. It can do considerable harm. In Franklin's day, he found it in limited numbers on most Cape bogs and he believed that it was found on bogs since at least 1900. It broke out on many bogs in 1920 and 1921, destroying the entire crop promise on a large acreage.

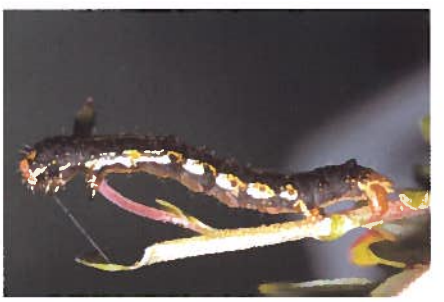
Distribution and Food Plants
This moth ranges from Nova Scotia to British Columbia and has been found in Massachusetts, New York, New Jersey, and Wisconsin. No food plant other than cranberry is known.

Character of Injury
They usually feed like the blossom worm, nipping off flower buds and blossoms by severing the stem near where it joins the ovary. When extremely abundant, they attack the leaves and sometimes brown a small area. When late water is held, some of the larvae hatch in time to eat into terminal buds like false armyworms. They seldom do much harm in this way.

Description and Seasonal History
There is a single generation each year. The eggs overwinter and there is often a very long hatching period. When the winter flood is removed in early spring, hatching begins from about 15 May to about 1 June, depending on the advancement of the season, and may continue until about 1 July. The larvae mature from about 10 June to about 22 July, becoming 25 mm (1") long. The larvae pupate in the litter under the vines. The pupal stage lasts about ten days.

The moths emerge irregularly from late June until early August, the males tending to appear first. Although the males are more active than the females, they still rest often among the vines.

An unknown species of spanworm larva found in increasing numbers on Massachusetts beds.



Another unknown species of spanworm larva found in increasing numbers on Massachusetts beds.

Spanworm larva, called the saw-wing geometer, *Euchlgena serrata* (Dru.). It feeds on apple, blueberry, and maples, also. It is found occasionally.

The saw-wing adult, with wingspan of between 36 - 50 mm.

Green spanworm eggs are scattered singly in the trash layer of the bog.

Geen spanworm larva. It has only two pairs of hind legs.

Green spanworm pupae.

Green spanworm moths are yellow. They fly mostly in July.

Green spanworm moths fly less than the males of the brown spanworm. They are flushed up easily and sometimes rise in large numbers from a badly infested area. The period of activity of the moths coincides with that of the brown spanworm, and when both species abound on the same area, they could be confused. The species are obviously different in appearance so a moment should be taken to properly identify each.

The female moths scatter eggs singly among the litter under the vines, laying about 125 each. They usually stick to the bog trash.

The Egg

The eggs are greenish white, elliptical, and about 0.7 mm (1/37") long. They are surprisingly rigid and unyielding as they come from the moth's body. When examined with a microscope, they are thickly studded, except more or less on a central area above and below, with minute round smooth white tubercles. They often become somewhat sunken in the middle as hatching approaches.

The Larva

During most their life, the larvae are green with several white lines along the back and sides and a narrow light yellow stripe along each side. In the last instar, the green has a yellow tinge and the whitish lines are obscure except for a pair of lines along each side of the back that often are more marked.

The Pupa

It is pale greenish at first but later becomes dark brown. It is about a 8.5 mm (1/3") long.

The Moth

The male is pale yellowish. Its head bears long pectinate (having teethlike projections) antennae. Its wings expand 25-26 mm (a little over 1").

The female is sulfur yellow and its wings expand about 21 mm (7/8"). Its wings have noticeable brown spots that vary, but commonly are arranged as follows: the upper surface of each front wing with three against the front margin, one against the hind margin, one in front of the center, and five to seven small ones along the outer border; the underside of the front wing with one in front of the center, some spots along the outer border, and a streak toward the outer end and parallel with the outer border; the upper side of each hind wing with a spot in front of the center, another against the hind margin, and several toward and on the outer border; the under side of the hind wing with one near the center and often a series running parallel with the outer border. All the wings have brown sprinklings on the under side, and the outer borders on fresh specimens have brown fringes. The moths brush off many of their scales, often losing their markings and even their yellow color. The antennae are threadlike.

Management

This species is not affected by late water. However, a 10-15 hour flood on 30 May reduced the earliest portion of the population. A heavy layer of sand covers the overwintering eggs and is known to reduce the population.

"BROWN SPANWORM"
"CRANBERRY SPANWORM"
***Ematurga amitaria* (Guenée)**
Lepidoptera: Geometridae

This insect appears on some Massachusetts bog in high numbers almost every year. In some years, more serious infestations have been observed, for example, in 1919 and the early 1980's, such that it was one of the most important cranberry pests.

Distribution and Food Plants

This insect inhabits Nova Scotia, the New England States, New York, Michigan, Wisconsin, Colorado, Alberta, and Alaska. Its known food plants beside cranberry are : chokeberry, arbor vitae, steeple bush, running bramble, black huckleberry, highbush blueberry, sheep laurel, leather leaf, sweet pepperbush, swamp honeysuckle, bearberry, red maple, scrub oak, willow, wool grass, cotton grass, Juncus rush, lance-leaved violet, swamp loosestrife, marsh St. John's-wort, bugle weed, sawbrier (*Smilax* spp.), loosestrife, gray birch, and bayberry, the twelve first-

named being more favored host plants.

Character of Injury
Moderate populations feed much like the green spanworm, nipping off the blossoms and small berries, but they feed on the leaves more and chew into and eat holes through the flower buds and often excavate the partly grown berries. A severe infestation sometimes results in loss of all blossoms and in highest numbers, may turn a whole bog section brown. Infestation is most often very patchy.

This species of larva feeds so late in the season that where abundant, it destroys all chances of a crop in the following year, and sometimes patches of vines fail to recover fully for two years.

Description and Seasonal History
There is a single generation each year. The pupae overwinter. If the winter flood is let off before May 1st and the season is warm, a few of the moths often appear late in May, but they tend to emerge mostly during the first half of June and are active until its end. Where late water is held, they emerge mostly in late June and fly into July. As the moths emerge, males appear noticeably earlier. The males fly freely, often swarming in clouds over badly infested areas; but the females, heavy with eggs, can only fly along the ground.

The female moths lay about three hundred eggs each. They hide them among the litter on the bog floor, mostly in irregular clusters of sometimes as many as twenty. If the winter flood has been let off early, they usually begin to hatch about 1 July, but sometimes in advanced seasons by 20 June. The larvae mature in late July and early August and change into the pupae that pass the winter.

The Egg
The eggs are elliptical and about 1 mm (1/27") long. They are light green at first but turn yellow.

The Larva
In its early stages, the larva is rather light brown with a whitish stripe along each side and another along the middle of the back. The latter tends to persist but becomes obscure as growth proceeds. The mature larva is over 25 mm (over 1") and is grayish brown, varying greatly in shade, the under half being lighter than the back and the back often having various indefinite markings of darker brown. A whitish stripe often runs along each side just below the spiracles. The spiracles are orange-brown, rimmed with dark brown. The body has no noticeable tubercles or nodules and is covered with fine whitish or sometimes partly brown flakes, seen only with a good lens. The head is indented only slightly and is chestnut brown, commonly marked with darker brown across the top.

The Pupa
The pupae overwinter among the litter under the vines, enduring the winter flood even when it is held until June. They are brown and somewhat over 9.5 mm (3/8") long and have no cocoon.

The Moth
The *female* is a finely sprinkled grayish or yellowish-brown. The wings have vague and variable brown and whitish markings and the hind ones much yellow also on their upper surfaces. They are mostly yellow or yellow and white underneath with liberal general sprinklings of brown. On both their upper and lower surfaces, they usually have two or three poorly defined and often more or less broken markings running from the front to the hind margin. The back, especially between the bases of the wings, is mostly dingy brown, and the scales on the under side of the body and on the legs are mainly pale yellow. The antennae are threadlike. The wings spread nearly 25 mm (1").

The *male* spreads somewhat over 25 mm (1"). The body and head above and the large bushy antennae are dingy brown with a sprinkling of pale yellow. Underneath, the body, head, and legs are clothed mostly with light yellow hair and scales. The front wings are coffee brown above with two or three indefinite and irregular darker brown markings running from the front to the hind margin of each and often with touches of

Brown spanworm eggs are laid in irregular clusters amongst the trash layer.

Small brown spanworm larva.

Brown spanworm larvae. This shows various instars. Older larvae have less pronounced striping. (Photo: CES archive)

Brown spanworm pupae overwinter in the trash layer of the bog.

Areas of no flowers may indicate brown spanworm feeding activity on a bog in July.

Brown spanworm moths: female on left, male on right.

Brown spanworm larvae use cryptic behavior of: "I'm a stick".

Brown spanworm damage on berries. Previous feeding by larvae has resulted in brown, scarred-over areas on the fruit.

Big cranberry spanworm larva.

Big cranberry spanworm moth. (Photo: CES archive)

white. The hind wings are mostly deep yellow above with a strong general sprinkling and three rather vague cross markings of brown and with the outer border brownish. Beneath, the wings are deep yellow with a general sprinkling and usually two irregular cross markings of brown.

Management

If the moths have been flying in great numbers, the vines should be examined with an insect net daily from about 20 June until the larvae begin to hatch. Net count may be very high.

On some pieces, small, newly-hatched larvae may continue to be picked up in the net for several weeks.

Franklin (1948a) noted that the early June refloods interfere with the egglaying enough to prevent the development of infestations, if flooding is carried out regularly. Complete reflooding of the bog for 36 hours when the moths reach peak flight activity may sometimes eliminate an infestation. Because the larvae are active so late in the season during bloom, floods against larvae are not practicable.

"BIG CRANBERRY SPANWORM"
"Curve-toothed geometer"
***Eutrapela (=Abbotana) clemataria* (J. E. Smith)**
Lepidoptera: Geometridae

This species can be extremely destructive in small areas of bog, but on a small number of bogs. A patch of bog infested with a large number of larvae results in fairly circular areas of damaged vines. They prefer to sever the flower buds and blossoms.

The eggs of this species were used as a surrogate host for lab rearing of a beneficial parasitoid in a biological control program for the fall cankerworm (Fedde et al. 1982). *E. clemataria* was selected because the researchers found that, at least for southern populations, the moths are light trapped from spring to fall, the larvae "thrived" on an established artificial diet, it did not diapause in the lab, and pupated with no special medium. Egg numbers produced were high, which was also observed by Payne (1919).

Distribution and Food Plants

The insect ranges from Canada to Florida and Missouri. It feeds on apple, clematis, false dandelion, hickory, maple, pear, live oak, and white oak.

Description and Seasonal History

There is only one generation a year. This species overwinters as a pupa. The moths emerge late in May and soon lay their eggs. The eggs are laid in clusters, often of as many as 432. These hatch toward mid-June. The larvae mature and pupate in July.

The Egg

The eggs are green at first but turn reddish, then black—the last color only two or three days before hatching.

The Larva

The caterpillars are almost black at first, but as they grow they become chocolate brown. The mature larva is fully 64 mm (2 1/2") long. Most of its surface is very smooth. A noticeable dark ridge bearing a few low tubercles crosses the back opposite the second pair of legs. The back, in front of this ridge, and the head are lighter brown than most of the body. The under side between the legs at the hind end is lighter still. The spiracles are yellow, rimmed with black. On the back are a pair of noticeable tubercles somewhat behind the middle and a moderate double tubercle toward the hind end. The top of the head is rounded and not much indented.

The Pupa

The pupa is about 19 mm (3/4") long and 6 mm (1/4") thick. It is coffee brown and, with the exception of the wing cases, has an irregular sprinkling of dark brown. The spiracles and their surroundings appear as conspicuous black spots along the sides. The surface is dull and rough. This pupa never gets hard and firm as most pupae do, but always yields to the touch.

The Moth

The moth is light gray, dully variegated with rusty brown. The wings, the

abdomen, and the legs are sprinkled lightly with black scales. The thorax is whitish beneath and pale brown above. The head is light rusty brown, the tip between the bases of the antennae is pure white.

The wings spread about 51 mm (2"). Their outer edges are gently scalloped and the tips of the front ones are sharp-pointed. A nearly straight line running from near the tip of each forewing diagonally across its upper surface to the hind margin is whitish on the outer side and brown on the side toward the body. A similar line runs part way across the upper surface of each hind-wing from beyond the middle of the hind margin. All the wings have a conspicuous dark brown speck somewhat back from the middle of the front margin on each surface.

Management

These spanworms become far larger than the other two common species of spanworm. Because of this, during sweep counts, they should be counted as if a cutworm.

They often appear in the same areas within the same bog year after year, and are almost always patchy. Intensive sweeping to identify affected bog areas is required. Larvae are capable of consuming all new foliage and blossoms.

"SPINY LOOPER"
"HALF-WING GEOMETER"
Phigalia titea (Cramer)
Lepidoptera: Geometridae

This species did not appear in Franklin's 1928 manual, but in 1948, he referred to it in a footnote. He believed that the species was unimportant. He noted it was 38 mm (nearly 1 1/2") long when mature, and rather common during the first half of June on dry bogs and bogs that are not reflooded. Because forest trees are primary hosts, it is possible that as some growing areas have become increasingly forested over the past century, populations in cranberry have been seen with greater frequency. The populations are apparently cyclic in forest stands.

Distribution and Host Plants

This species occurs in southern Canada westward to Saskatchewan and in several Eastern states. Its host include various hardwoods, especially red oak, red maple, basswood, hickory, and elm. Numerous outbreaks have been recorded in mixed oak and maple stands in the Northeastern States. According to Butler (1985a), this defoliator of hardwood forest is a native species of geometrid that occurs in outbreak numbers, at least in West Virginia, where significant defoliation has been observed in outbreak years.

Character of Injury

On cranberry, the larvae feed on the leaves of new growth, down to the old growth and then move to adjacent areas of new growth. Some larvae nip the stem of the new shoots, which fall over. In areas of older feeding, browned tips are obvious. Patchy areas of feeding and larval aggregation are highly characteristic.

Seasonal History and Description

The seasonal history has not been studied on cranberry. On forest trees in Virginia and West Virginia, there is a single generation and winter is spent in the pupal stage in the soil. Adults emerge in the early spring and climb vertical surfaces. Males appear several days to a week before females and rest on tree trunks. Mating occurred on tree trunks, after which females climbed upward to locate oviposition sites, usually dead twigs. In western Massachusetts, the typical light colored male moth (which is cryptically colored when resting on birch trees) occurs as well as a melanic form, which is entirely blackish (Sargent 1985).

The larvae are reported to be active in May and June. To date, in an accelerated year (1998) we observed a dense aggregation on a bog edge in May. At such high densities, we could only conclude that the overwintering pupal stage was able to survive on the bog.

Spiny looper larva.

Male spiny looper moth. In western MA, there are both light-colored and dark moths. (Photo: T. D. Sargent)

Spiny looper larval feeding on new growth.

Spiny loopers damage to vines. Tips have browned as a result of larval feeding on new growth.

Spiny looper feeding. On the left, larvae have completed feeding on new growth and have moved towards the right to a new area.

Patches of larvae within a bog have also been observed by growers on bogs. Females do not fly, so it is possible that, in these cases, each patch is made up of the progeny of a single female. She would have ballooned to the bog from the uplands as a first instar larva, completed larval development, overwintered as a pupa, attracted a male for mating, and laid her eggs.

Larvae feeding on cranberry were observed to complete larval development and burrow into sand to pupate in the first week of June.

Females are cryptically colored and are virtually wingless. The females do not fly. According to Butler (1985a, b), survey of oviposition sites in the field revealed that eggs were laid under loose flaking bark of dead twigs of hardwoods such as maples and oaks or loose bark in the crotches of dead twigs. Oviposition site is unknown in cranberry, but one would suspect that eggs will be deposited on the bark of the uprights. At 24° C, development time of the egg was 7 to 8 days. (Butler 1985a)

In forest studies, the first instars were observed to actively balloon, and ride the air currents to new sites. They hang on silk lines below the dead twigs on which eggs had been laid. As noted above, this would be the most likely way that a cranberry bog would become infested. There are five larval instars. In lab studies, approximately 4 days passed per instar when the larvae ate young leaves of sugar or red maple or red oak. On more mature leaves, more days elapse between instars. (Butler 1985a).

The Egg

Butler's (1985a) description is as follows. Eggs are slightly rounded and have reticulate sculpturing. They are oval with one end of the egg more flattened or broadly rounded and the opposite end more conical; heaviest sculpturing occurs at the broad end. According to her measurements, eggs average 0.91 mm (1/24") long and 0.52 mm (1/49)" wide; these sizes are about half of those reported by Talerico (1968), who noted that the eggs were not much bigger than salt crystals.

When first deposited, eggs were greenish yellow when observed by Butler (1985a) or pinkish-red by Talerico (1968). Butler's (1985a) observations follow. As eggs developed, pink coloration appears at the blunt end of the egg and the eggs become darker pink over several days. When mature, dark red to black spots appeared at the blunt end. At about 24 hours prior to hatch, the eggs appeared dark purple as a result of the dark head capsule and body of the larvae being visible through the egg chorion. Following hatch, the empty chorion was conspicuous and was irridescent lavender.

The Larva

Full-grown larvae are violet, pinkish-gray brown with many blackish longitudinal lines and are about 37 mm (ca. 1 1/2") long. The thoracic segments are thick, and there are hairy tubercles on all body segments. There is black mottling on head capsule. Some larvae have yellow or orange patches along the side of the body.

The Pupa

The pupa is brown, appearing in general form quite similar to other spanworm pupae. The mean length was 13.5 mm (range 11.0-15.5 mm), (ca. 1/2 inch).

The Moth

The male moth has a wingspread of 37 mm (1 1/2"). The thorax is whitish and the abdomen is marked with two rows of black dots on the dorsum. The forewings are dotted with dark brown specks and are marked with three blackish lines and a row of black spots along the outer margin.

The female is ash gray with no obvious markings. Her wings, which are ca. 3 mm (> 1/8") long, are vestigial and functionless. Females are seldom detected.

"CHAIN SPOTTED GEOMETER"
Chain-dotted geometer
Cingilia catenaria (Drury)
Lepidoptera: Geometridae

This species is seen occasionally in New Jersey. We do not see it on Massachusetts cranberry and as a matter of fact, it appeared on the Massachusetts endangered species list as a special concern species. This means that a documented decline in numbers has occurred. Franklin reported that a few larvae appear on most bogs where no winter flood is held. He wrote that on neglected bogs with a dense growth of birches on the surrounding upland or on areas that never are flooded, the larvae would occasionally crawl onto the beds in such numbers that the vines would be browned for some distance from the margin. These larvae were often highly parasitized or diseased. Severe local outbreaks occurred on cranberry in Cape Cod in 1927 and 1934, and local outbreaks have been recorded in the northeastern United States over the years.

According to Baker (1972), the species prefers blueberries, huckleberries, and small trees growing in pastures or cut-over areas.

Distribution and Food Plants

This species ranges through the Atlantic States and southeastern Canada and west to Colorado. Gray birch is a favored host plant, but it often feeds on alder, ash, low blueberry, dwarf blueberry, highbush

blueberry, maleberry, wild black cherry, bayberry, sweet fern, black huckleberry, dangleberry, wild indigo, red maple, white maple, sheep laurel, black scrub oak, meadow-sweet, poplar, red spruce, tamarack, white pine and willow. It also feeds on raspberry, blackberry, beach plum, locust, goldenrod, sweet gale, hazelnut, poison ivy, juniper, apple, pear, cranberry, rhodora, sedges, grasses, and other plants. Reader (1979) examined feeding on Labrador tea, leatherleaf, and bog laurel in Ontario bogs. It has sometimes been reported as an important pest in cultivated blueberry (Phipps 1928, 1936).

Description and Seasonal History
The egg overwinters. They hatch about the first of the following June. The larvae appear in early summer and develop slowly, maturing in late July and early August. When full grown, they are 38 mm (1 1/2") long. As they mature, they have the habit of hanging straight and still, head downward, during the day. They seem to feed mostly in the early evening or at night. The pupa is formed in a slight but well-made net of yellowish threads among twigs, leaves, or grass. The pupal stage lasts about a month.

The moths appear in September and very early October. They are day-active, but the males may come to street lights in clouds. The females fly little if not disturbed. One female may lay as many as 368 eggs. The eggs are attached to the lower surfaces of leaves or scattered indiscriminately on the ground, mainly in the latter half of September.

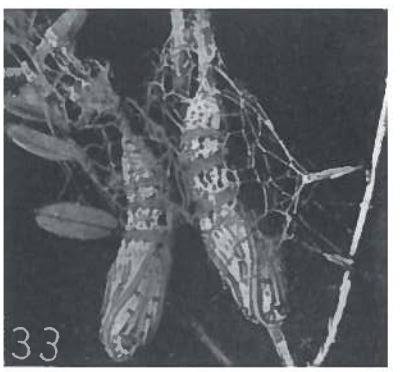
The Egg
The eggs are greenish-yellow at first but become brownish lavender in a few days. They are 0.8 mm (1/32") long and are broadly elliptical with one end flattened or somewhat cupped.

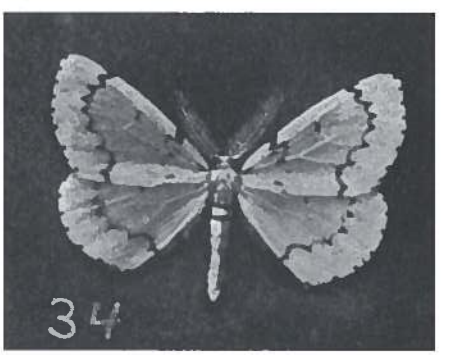
The Larva
They are yellow to straw-colored with round black spots on the head, the prothoracic shield, the outer sides of the prolegs, and the very hind end. About thirty-two deep rusty-brown lines run along the body, some above, some below. There is a row of conspicuous white spots along each side, mostly above the spiracles. Most spots are bordered with one black spot in front and another behind. When full grown, the larva is 55 mm (2 3/16") long.

The Pupa
The larvae pupate in early and mid-August. The pupa is white, marked with black and yellow, and is about 20 mm (4/5") inch long.

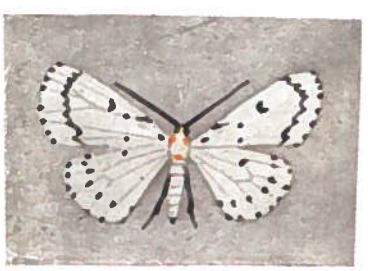
The Moth
Both sexes have snow-white wings marked with zigzag lines and dots of black. The face is deep yellow to orange-yellow and there is a patch of yellow in front of the base of each forewing. The antennae of the male are very bushy and those of the female are threadlike. Male wings expand across to about 38 mm (1 1/2"), female 35 mm (1 3/8").

Treatment
Franklin recommended keeping the marginal ditch cleaned out and partly full of water to keep a bog from infestation.





Chain-spotted geometer, larva top, pupa middle, and moth bottom. (Franklin 1948a)



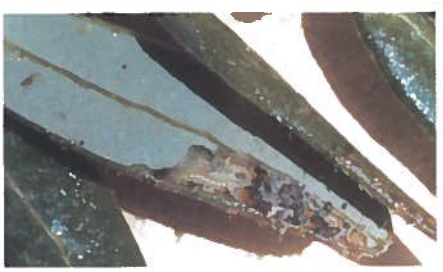
Larva (left), moth (center), and pupa (right), of chain-spotted geometer moth (Illus: Hardenberg 1908)

FIREWORMS

Blackheaded fireworm eggs are laid singly on the underside of cranberry leaves.

A small blackheaded fireworm larvae has the distinctive black head.

If the eggs hatch early in the season, tiny blackheaded fireworm larvae initially mine inside last year's leaf.



The tiny blackheaded larvae can be seen inside the leaf if the mine is dissected under a microscope. (Photo: W. Z. Fort)

Small blackheaded fireworm larvae will web together 3 or 4 leaves to make a feeding shelter. (Photo: W. Z. Fort)

These are relatively small larvae, measuring 9-19 mm (3/8" - 3/4"), that wriggle spasmodically when first disturbed. Using silk from glands in their mouth, they sew together plant material which they feed on and form nests. This barrier likely protects them from parasitoids and other natural enemies. They usually begin this webbing soon after they hatch, and many in the group sew together three or more leaves at the tip of a single upright. The later webbing varies somewhat but usually draws several uprights together finally. The larvae of all but hill fireworm often injure the foliage so that it turns brown and looks as though a fire had burned the vines — hence the name fireworm.

BLACKHEADED FIREWORM *Rhopobota naevana* (Hübner) Lepidoptera: Tortricidae

Blackheaded fireworm is among the most serious pests of cranberry in all growing regions except the Northeast. Previously, it was one of the most prevalent insects in Massachusetts cranberry. However, with the introduction of insecticides, this insect is seldom a problem in Massachusetts. Certain hot spots have blackheaded fireworm every year, as do spotty areas where vines are rank, where winter flooding has been truncated, or where trash on the bog floor is piled up. On Cape Cod, it is common on wild bogs and may appear within a few years when a bog is abandoned.

Why it remains a key problem on flooded Wisconsin beds, where insecticides are also applied, remains an interesting question.

Distribution and Host Plants

This insect is found in all growing areas of North America. In the eastern states, its only known host is cranberry. On the west coast, in addition to cranberry, it feeds on a related species of *Vaccinium* known as the evergreen blueberry, also called "florists' greens".

Character of Injury

If the larva hatches from the egg in the early spring prior to appearance of new growth, it may act as a miner in the cranberry by burrowing into the underside of an old leaf. The first instar larva casts frass out on the lower surface of the leaf like a small mass of refuse. An area on the upper side immediately over these castings is lighter colored than the rest of the leaf, and the first hatching of the insect often may be detected most easily by these light patches.

As new shoots appear the larvae proceed to sew three or four tip leaves together. If the larvae hatch after the new growth develops, they usually go directly to the new tips without mining the old leaves. The webbed tips generally are the first work noticed by growers. The larva usually leaves the sewed tip within a few days and either webs leaves farther down on the shoot or moves to other new growth and commonly webs one or more uprights together. If the larvae are very abundant, two or three larvae join efforts to silk several uprights together into a nest. They feed freely on the new leaves and flower buds in their nests, and the infested area of the bog looks brown.

The feeding activity of the second generation varies more than that of the first and may be more or less severe than the first generation. If egg hatch begins while the vines are in flower, the small larvae may feed mostly in the blossoms, especially in the ovaries, which they excavate to form tiny cups, and web the foliage only in their later stages. Usually they go to the tips when they hatch and silk the leaves together, but this tip-webbing is more gradual than that of the early spring generation. They usually silk together several uprights at last and may make nests even larger than those of the first generation.

Whether they web much or not, they reduce the crop in proportion to the amount of infestation by scoring the berries or excavating the fruit flesh in them somewhat as the cranberry fruitworm

does. Sometimes they feed almost exclusively in the berries. This generation may greatly reduce the crop possibilities for the next year, for the tips of the injured uprights usually fail to form normal fruit buds. Many of the chewed leaves soon drop and the vines recover somewhat into the fall, mainly by putting out some tip growth, but the uprights are often rather bare.

Blackheaded fireworm prefers Howes and Smalley Howes to Early Blacks. It tends to flare up in areas of trash accumulations, rank vines, or where nearby abandoned bogs support dispersing populations.

Description and Seasonal History

Blackheaded fireworm has two generations. If a bog is heavily vined, hatching is much extended giving the appearance of more than 2 generations.

This species winters as an egg. Hatching normally begins about the middle of May. Sometimes it starts the first week in May, or occasionally is delayed until the first of June. The hatching period often lasts three weeks on thinly vined bogs if the weather is warm, but it may continue for six weeks among rank vines in cool weather.

The black head of the larva may be seen through the eggshell for a day or two before hatching occurs. When the larva emerges, the eggshell is left as a thin shiny whitish scale on the leaf.

First-generation larvae generally take two and a half weeks to mature with an additional pupal period of nearly two weeks. The first generation of moths lay their eggs in late June and July.

The female may lay eggs within a day after it emerges. Many of these first generation eggs are reported to delay hatch until the next spring. Because of this, the hatching period of the second generation of larvae on any given bog may last little more than a week. If late water is held (until mid to late May), a delayed hatch of the entire population may occur. The moths fly little during the day unless it is warm and very cloudy, but they are flushed up easily. At dusk, they fly and hover freely just above the vines.

The eggs hatch during bloom, mostly in early July. The larvae of this second generation complete development in about 12 days. The pupal period is about a week and a half. The moths of the second generation lay the overwintering eggs in late July through much of August.

The second generation larvae sometimes feed into August, even when removal of the winter flood has occurred before April.

According to Franklin, some of the eggs would have been laid by second-generation moths and perhaps some by first-generation moths, the hatching of the latter having been suppressed. The eggs are laid singly, nearly always on the backs of the leaves of the new growth. Often several are placed on one leaf. The leaves of delicate uprights deep among the vines are somewhat preferred for egg laying.

Franklin also asserted that eggs on the leaves in late fall often vanish while under the winter flood. These may die, because the infestation always is reduced the next spring when this happens. Usually, however, most of the eggs stick to the leaves until spring and hatch. In the rare event that an infested bog is left unflooded for the winter and the vines are winterkilled, the dead leaves drop in the spring and the fireworm eggs on them usually dry up and fail to hatch.

The Egg

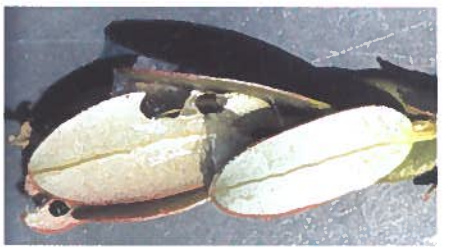
The eggs are very flat, disk-like, light yellow, and about 0.8 mm (1/32") in the longest diameter.

The Larva

The larva is greenish or pale yellowish, with a shining black head and is about 8-9 mm (1/3") long when full-grown.

The Pupa

The pupa usually is in a light case of silk and sand or fallen leaves. It is light brown at first, but becomes almost black before the moth emerges.



Small blackheaded fireworm larvae feed within leaf shelter. (Photo: W. Z. Fort)

Blackheaded fireworm damage. Significant damage can be seen early season on foliage. Vines turn brown after a week or two as shown.

Blackheaded fireworm damage. Significant damage can be seen later in the season when berries are scored.

This blackheaded fireworm pupa is webbed within the upright.

Even a fully size blackheaded fireworm larva isn't that big. (Photo: W. Z. Fort)

Cranberry bed with vines browned by feeding by blackheaded fireworm larvae.

Sex pheromone traps can be useful in blackheaded fireworm management.

The moth of blackheaded fireworm. (above illus: Smith 1903)

The Moth

The moth is dark grayish brown and quite small. The wings expand somewhat over 9-10 mm (3/8"). The forewings are marked with gray-brown and silver-gray bands.

Management

Parasitoids of blackheaded fireworm have been investigated in British Columbia. Li et al. (1993) looked at the egg-parasitizing Trichogrammidae and Fitzpatrick et al. (1994) reported on larval parasitoids. Fitzpatrick et al. (1994) reported an interesting escape behavior. They found that when disturbed by a parasitoid or predator, the larva drops though a pre-cut hole in the bottom of the webbed tent. Using a silken thread, the larva returns to the original tent.

In Massachusetts, the traditional blackheaded fireworm flood was advised for 24-48 hours in mid-May when little harm to the cranberry vine is expected. Perhaps this recommendation did not coincide with complete egg hatch (Cockfield and Mahr 1992), and the current Massachusetts flooding recommendation is for two 10-hour floods, timed about 1 June and 12 June. At this point in the season, the plants are actively growing and there are risks of increased fruit rot and crop damage.

Franklin (1928) stated that complete flooding early in June was long the standard control for the first generation. He noted that this reflood was also effective against several other pests as well. The reflood must be done before blossoms begin to open much. When the winter flood has been removed before 8 May, then 7 June is usually about the right date. Crop injury was a key concern, however. See Flooding Appendix, p. 87, for more information.

Spring reflooding has been studied in the lab and field in Wisconsin by Cockfield and Mahr (1992). In the lab, they found that larval mortality was very high after 2 days under low dissolved oxygen levels. Under conditions of high dissolved oxygen, the larvae could survive for days; their silken shelters likely trapped air when the vines were submerged. In Wisconsin field trials, a 1-2 day flood in mid-May showed variable results, but there was a reduction of the population. This suggested that under conditions of known egg hatch, plant development, water temperature and water dissolved oxygen, such a flood could be of utility (Cockfield and Mahr 1992).

Sex pheromone traps are used in blackheaded fireworm management (McDonough et al. 1987, Slessor et al. 1987). A three component blend of (Z)-11- tetradecen-1-ol acetate, (Z)-11-tetradecen-1-ol, and (Z)-9- dodecen-1-ol acetate was shown by Fitzpatrick and Troubridge (1992) to be highly effective in field trials.

For low to moderate populations, pheromone-mediated mating disruption (discussed in IPM section) has been evaluated in Wisconsin and British Columbia. This should be considered as a management tool.

YELLOWHEADED FIREWORM
***Acleris minuta* (Robinson)**
Lepidoptera: Tortricidae

Yellowheaded fireworm occurs very rarely on cultivated bogs where a winter flood is held. It is very occasionally found on the bog edge where the winter flood did not cover adequately. Its feeding activity in cranberry is much like the blackheaded fireworm, but the larva gathers more uprights into its webbed tent, not only browning the bog but often leaving only bare uprights in the fall. Three quarters of a century ago yellowheaded fireworm was well known in the central states as a pest of apple and plum nursery stock (Chapman and Lienk 1974). Currently, it is a minor pest of apple and may feed as a leaf tier on huckleberry and blueberry.

Yellowheaded fireworm moths are considerably larger than moths of blackheaded fireworm. Larvae are attacked by parasitoids much more than the blackheaded fireworm. These natural enemies do not reduce the first generation much, but they decimate the later ones so that, however large the population, the

first generation of the next year usually is small. The species is multivoltine. There are three generations in Massachusetts, four in Iowa, and three or sometimes four in New Jersey. In New Jersey, the gray moth (the overwintering color morph, also referred to as the "cinderella form") was found flying by the middle of April. The first summer moth flight began in early June, the second summer moth flight in August, and the winter or gray moth flight in October (Smith 1884).

Distribution and Food Plants

This fireworm appears throughout the United States and southern Canada. It has been an occasional but serious pest on midwestern nursery plants and apples. It also feeds on pear, plum, wild rose, huckleberry, highbush blueberry, glaucous willow, and sweet gale. It feeds on the terminal leaves of small rosaceous plants, expecially Malus and Prunus, tying the leaves together as they feed (Schwarz et al. 1983). In earlier literature, it was also referred to as "lesser apple leaf-folder" and "lesser apple leaf-roller". Franklin noted in 1948 that, over the years, yellowheaded fireworm had been much less generally destructive on the Cape than the blackheaded fireworm.

Character of Injury

The small larvae in the spring feed on the old leaves at first, usually sewing the surfaces of two adjacent ones together and feeding between them. Otherwise, this species feeds much like the blackheaded fireworm, but it tends to gather more uprights into the webbed area and often does more intensive injury, not only browning the bog but often leaving only bare uprights in the fall. The larvae feed in the berries and score them as blackheaded fireworms do.

Description and Seasonal History

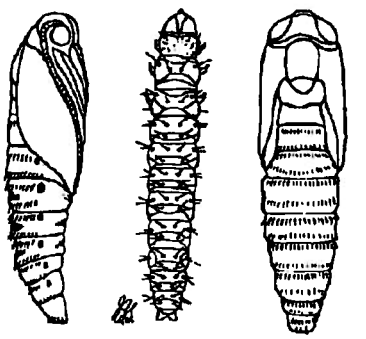
Tomlinson (1982) carried out light trap catches and showed that there are three generations of moths in Massachusetts. An unusual aspect of this species is that moth color is dependent on generation: the two summer generations are gold-orange moths and the third generation of moths that overwinters is slate-gray in color. The moths remain on the bog and surrounding upland, hidden in the vines or other shelter, but fly on warm days.

In Iowa, Weatherby (1982) found that there was a marked difference in mating behavior between the two color morphs. The orange morph female releases sex pheromone and is receptive to mating at the first dawn after emergence from the pupal stage. In contrast, the gray form females apparently require a cold weather diapause before mating occurs. Females produce a sex pheromone to attract males. (E) 11, 13-tetradecadienal is used in traps to capture males (Schwarz et al. 1983). Traps placed at either 0.30 m or 1.22 m (1-4') above ground captured similar numbers of insects (Weatherby and Hart 1984). Initial work by Weatherby (1982) showed that daily flight activity in Iowa occurred between 5:00 and 6:00 AM.

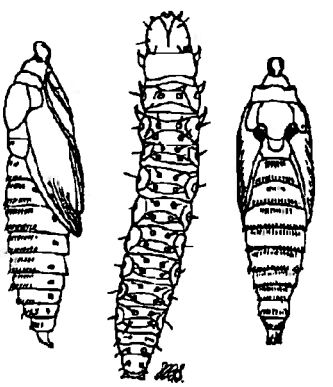
Eggs of the first spring generation are laid during April. Larvae pupate in silken cells among the webbed uprights, mostly early in June. The summer moths appear in June and a flight is seen for about three weeks. These moths morphologically are clear orange, but otherwise, are like those of the winter generation. They may be flushed up in clouds on badly infested bogs. They lay eggs during most of their flight and generally disappear about 10 July. The eggs usually begin to hatch about 8 to 10 July. The larvae complete development, more slowly than the first generation, and a second generation of moths appears in August. Eggs of the third generation are laid, larvae develop into the fall, and the gray winter moths appear in September and October.

Weatherby and Hart (1986) worked on apple populations in Iowa where 4 generations prevail and in the lab found that the larvae go through five, six, or seven larval instars. The five-instar mode was most common in the first three generations while the prevalence of the six and seven-instar modes increased in the fourth generation. Factors that result in greater instar numbers were decreased growth rates as a result of nutritional quality of the leaves, temperatures above

Yellowheaded fireworm larva. (Photo: W. Z. Fort)



Blackheaded fireworm pupa and larva. (Illus: Smith 1903)



Yellowheaded fireworm pupa and larva. Notice knob on top of pupa in comparison to black-headed fireworm pupa. (Illus: Smith 1903)

Yellow or summer form of yellowheaded fireworm moth. (Photo: W. Z. Fort)

Gray or winter form of yellowheaded fireworm moth.

Yellowheaded fireworm damage can be substantial.

Red-striped fireworm eggs. (Photo: Scammell 1917)

or below an optimal 22°C, and apple cultivar differences, but not photoperiod.

They also showed that, in the laboratory, individuals exposed to a fall photoperiod during the first and second instar and then for the duration of their immature lives emerged as grey moths. Following exposure to summer photoperiod, exposure to fall photoperiods from the beginning of the third and fourth instar resulted in the emergence of both color morphs.

The Egg

The eggs look like those of the blackheaded fireworm and are laid singly, mostly on the backs of the leaves. The eggs are very flat, oval, light yellow, and about 0.8 mm (1/32") in the longest diameter.

The Larva

Newly hatched larvae usually have dark heads but they soon change and are distinguished from the blackheaded fireworm by the yellow color of the head. The body is pale yellowish. The mature larva is about 12-13 mm (1/2") long.

The Pupa

The pupa is light brown at first, but it grows blackish as the moth develops. It is about 7 mm (1/4-1/3") long. The principal feature of the pupal stage is a prominent and distinctive knob on the head, which is forward projecting.

The Moth

This description is derived from Chapman and Lienk (1974). The ground color of the forewings in the summer form is rather uniformly golden throughout. There are small patches of shining pale rose tipped scales. In the winter form, the general color is a moderate rosaceous gray overall, but this includes sparse flecking of blackish scales, occurring singly or about four scales together. At first emergence, the winter moths are reddish grey, turning a slate grey as they age. The wing expanse is 14-19 mm (9/16-12/16") and the moth is about 8.5 mm (1/2") long.

Management

Complete winter flood, especially if the water is held until May, is known as an effective control (Franklin 1948a, Tomlinson 1948). We speculate that standard late water, where water is removed in March and the bog reflooded for a month in April to May may be less effective than "late holding" where the flood is held continuously through the winter until spring. Suspicion arises that the moths may overwinter throughout the bog habitat and then lay eggs in April.

Smith (1903) found that a 48-hour reflood when the larvae were half-grown in the spring was highly effective. He detailed the practice in his report and notes that it was widely adopted in New Jersey at the turn of the century.

"RED-STRIPED FIREWORM"
Aroga trialbamaculella (Cham.)
Lepidoptera: Gelechiidae

This New Jersey and Massachusetts species has not been recorded on cranberry elsewhere. It is very seldom seen on Northeastern bogs.

Distribution and Food Plants

It ranges from Maine and Quebec to Virginia and western Texas. Highbush blueberry and low bush blueberry are preferred food plants, which usually harbor large numbers of the larvae in the fall everywhere in the eastern part of Maine. It was recently reported as a pest in low bush blueberry in Maine, largely because of larvae that are jarred during picking and then appear in processing lines during harvest (Collins and Forsyth 1994). It also feeds on deerberry, dangleberry, black huckleberry, dwarf huckleberry, male berry, fetter bush, leather leaf, and trailing arbutus.

Character of Injury

Some of the newly hatched larvae go directly to the tips of the new growth, but many first mine the basal part of the blade of the old leaf, entering it from the upper surface and covering the entrance with a mass of green frass.

The webbing begins among the terminal

leaves but is not very conspicuous there. As the season advances, it is extended farther and farther down the shoot and often two or three uprights are sewed together. This species webs its nests more closely than the other fireworms do, and forms in them a characteristic irregular tubular case of silk covered with brown frass. The larvae are parasitized considerably, but their nests are a better protection than those of other fireworms and they keep much more concealed in them.

Description and Seasonal History
The full-grown larva overwinters. Most of the larvae leave their silked feeding sites during late September and October and go down into the trash and surface sand of the bog floor to remain dormant until the next spring. A few remain in their nests, many of which break off and drop during the winter. In the following spring, they pupate one after another during most of May and June.

The moths usually appear soon after mid-May and begin laying eggs in late May. Egglaying may extend over an extended period. Hatch begins in mid-June. The summer generation of females lay eggs from July to early August. The egg stage lasts about sixteen days in early June and about nine in late July.

All the larvae that hatched from eggs in June pupate in their nests after mid-July and moths emerge at the end of July and early in August. Most of those that hatch after the first of July continue as larvae until the following May as already noted. The insect is therefore partly univoltine and partly bivoltine.

These moths usually keep quiet among the vines during the day, but they flush fairly easily. They have a darting and agile flight and hide even more nimbly than those of other fireworms, often going into the litter under the vines when pursued.

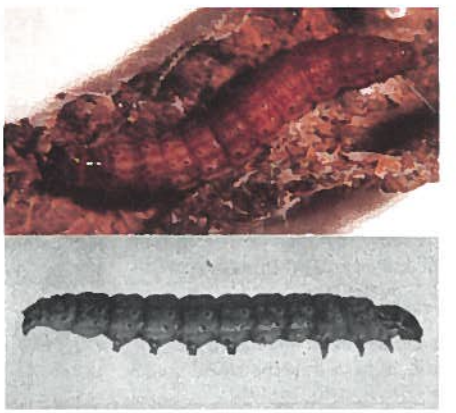
The Egg
The eggs are irregularly ellipsoid and small, 0.6 mm (1/40") long. They are very plastic and pearl-white when laid, but turn pinkish or yellowish before hatching. They usually are wedged in between the vine and the petiole or the base of the leaf blade, or are placed among the bracts of an opening terminal bud, but are deposited also under loose bark.

The Larva
The newly hatched larva is pale greenish yellow, with the head and prothoracic shield brown. As it grows, its head becomes yellowish to light tan, and dull reddish lines appear running the length of the back and sides. The red is more pronounced in older instars. The mature larva is fully 9.5 mm (3/8") and is more slender and agile than other fireworms. It is very active when disturbed.

The Pupa
The pupa is reddish brown and is small, about 8 mm (5/16").

The Moth
The adult is mostly dark brown, but has a white face, large rusty palpi, white dots on the forewings and white spots on the legs. It expands about 14 mm (9/16").

Red-striped fireworm moth. (Photo: UMaine)



Red-striped fireworm larva. (Photo: UMaine 1994 above, Scammell 1917 below)

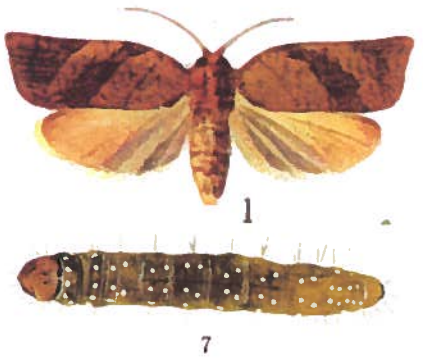
"SPOTTED FIREWORM"
Choristoneura parallela (Robinson)
Lepidoptera: Tortricidae

Spotted fireworm is one of the most important pests in New Jersey cranberry but has not been reported as a pest for more than 10 years in Massachusetts. In the past in Massachusetts, this fireworm was harmful only occasionally and on rather small bogs. It seldom infests bogs that are reflooded regularly. It feeds like the yellowheaded fireworm and silks together even more uprights. It can cause a characteristic browning of a bog when populations are high (Stuart and Polavarapu 1998).

Distribution and Food Plants
This species has been found from SW Ontario to Florida, reported in Maine, Massachusetts, New Jersey, New York, Illinois, Wisconsin, and Minnesota. It has been recorded on cranberry in Massachusetts, Minnesota, New Jersey, and Wisconsin. It also feeds on chain fern, sensitive fern, marsh shield fern, common brake, flowering fern, sawbrier, apple, hardhack, chokeberry, coarse bramble, winterberry, St. John's-wort, sweet pepperbush, highbush blueberry, sheep laurel, loosestrife, sweet melilot, willow, strawberry, and aster. Loosestrife and marsh St. John's-wort are preferred host plants of the larvae and, when abundant, may be responsible for infestations in cranberry. It is also sometimes a rose pest in greenhouses.

Description and Seasonal History
There are two generations. The larvae overwinter in trash on the bog floor and appear on the bogs from the third week of April to the first of June. They mature in late June or early July and pupate in early or mid-July. According to Polavarapu and Lonergen (1998), in New Jersey, onset of adult flight occurred in the first week of June. The second generation larvae complete development and the moths emerge in early August to lay eggs.

The eggs hatch in about ten days. Egg-hatch during the second generation begins towards the middle of August. Larvae feed on berries in the second generation and diapause as second instars.



Spotted fireworm moth and larva. (Illus: Franklin 1948a)

Spotted fireworm moth and larva. (Photo: W. Z. Fort)

According to Polavarapu (1996), at constant 25°C (77°F) in the laboratory, most larvae underwent 6 larval instars and the average time for larval development from egg hatch to pupal formation was 39 days for male larvae and 41 days for females. The duration of the pupal stage was 8-9 days.

Under lab conditions, Stuart and Polavarapu (1998) observed the majority of females calling 4 to 6 hours after the onset of scotophase and the peak period of mating occurred between 4-5 hours after the beginning of scotophase. Oviposition was observed within 24 hours after mating. In the field, eggs are laid late in June during the first generation and in August for the second generation.

Also in NJ, egg masses were found predominantly in areas with weed species and rarely were observed on cranberry foliage. In one case, under high populations, a few egg masses were seen on cranberry leaves. Favored weeds for egglaying were red maple, green-brier, leatherleaf, loosestrife, red root, St. John's wort, several species of ferns and grasses, *Smilax* and *Clethra*.

The Egg

The eggs are circular, flat and partly overlap one another, being laid in flat shiny masses containing up to 350 eggs. Egg masses are typically laid on the upper surface of the leaves. They are lemon yellow at first, but later become orange; and as they near hatching, the brown heads of the larvae show plainly through the shell.

The Larva

Larvae frequently disperse onto cranberry by ballooning. The small larvae are yellowish white with brown heads. As they grow, the head becomes amber and the body for a time may be somewhat reddish. As they mature, the head changes to light reddish brown and the body becomes more or less olive green on the back and sides, with conspicuous and somewhat elevated white spots along the whole length and usually one pale hair rising from each spot. They grow to be fully 19 mm (3/4") long and pupate among the webbed uprights.

The Pupa

The pupa is ca 13 mm (1/2") long and mostly chestnut brown, but its back is somewhat darker, being almost black toward the front. There is a prominent transverse ridge at the head end, and several rows of small backwardly directed teeth run across the top of the abdomen. Some of the pupae squirm vigorously when disturbed, but they are more often inactive.

The Moth

The moth expands ca. 19 mm (3/4"). It is brown with two chocolate-colored stripes crossing each forewing diagonally, one near the middle and the other shading the tip.

Management

Polavarapu and Lonergan (1998) examined sex pheromone production by females. They found that a 100:4:5 ratio blend of (E)-11-tetradecenol, E-11 tetradecenyl, and (Z)-11-tetradecenol was highly effective in traps. In New Jersey field tests, they observed a comparable or higher trap catch using this blend when compared to a series of other blends or when compared to a 4-component blend reported by Neal et al. (1982).

High parasitism has also been reported (Polavarapu, unpublished). A key larval parasitoid is the braconid *Meteorus trachynotus* and the egg parasitoid *Trichogramma* sp. was found in significant levels, particularly toward the completion of the season.

Franklin (1928) found that flooding for 30 hours about 6 June was effective against spotted fireworm.

HILL FIREWORM
***Tulsa (=Tlascala) finitella* (Wlk.)**
Lepidoptera: Pyralidae

In the past, outbreaks of the hill fireworm occurred with fair regularity on bogs that were flooded during the winter. The larvae in most of these historical cases attacked vines in the hills of new plantings for a year or two after they were set. Sometimes they seriously infest old, heavily-vined areas, and such infestations continue year after year unless they are treated effectively.

In Massachusetts, we have seen a single infestation of hill fireworm in a new stand of vines. The vines originated from Wisconsin. It is sporadically seen in New Jersey. This species was renamed by Heinrich (1956).

Distribution and Food Plants

This species ranges from Canada to Florida but is more common in the South. It has been reported as feeding on cranberry only in the Northeast. It also feeds on the foliage of highbush blueberry.

Character of Injury

The young larvae often begin their work by channeling the cranberry stems towards and to the tips, so causing them to drop over. Some of them silk up cranberry tips like other kinds of fireworms, but include more frass. As they grow, they often completely defoliate the hills of new plantings, leaving a thick

mass of their frass and dropped leaves on the sand around the base of the plants. One to three larvae work on a hill, and they make very extensive loose tubes of silk and frass, producing these materials in remarkable abundance and incorporating sand freely with them on and near the ground. These tubes are formed mainly on and around the lower parts of the plants, and the larvae hide and work in them. Runners in sand between the hills can also be attacked.

The larvae are sometimes abundant in the thicker clusters of vines of a heavily vined bog, mostly in their tubes of silk and frass, well down among the vines but in a zone 7.5-15 cm (3-6") above the bog floor. They may do rather serious damage there by feeding on leaves and blossoms.

Description and Seasonal History
We suspect that there is a single generation each year and that eggs primarily overwinter.

The larvae feed in June and July until mid-August. Most larvae mature and many pupate by 1 August. All of them pupate before 25 August. They envelop themselves in a cocoon of silk and sand, generally on the bog floor, and soon pupate in it.

The moths emerge from about 8 August until about 5 September and lay eggs that overwinter. Franklin (1948a) also reported that some of the pupae live through the winter, their moths coming out very late in May and during the first half of June and being somewhat larger than the others. These moths lay eggs in the first half of June on the stems of the new cranberry growth.

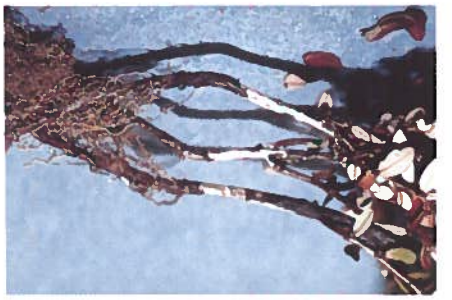
The Egg
They are oblong-oval and yellow or reddish at first, the largest being very nearly 1 mm (1/25") long. They become bright crimson within a day and a half and remain so up to within half a day of their hatching.

The Larva
The larvae have blackish heads and reddish bodies when newly hatched. As they grow larger, the head is black; the prothoracic shield with a much-broken pale-yellow stripe along its front margin; the body dark brown, marked lengthwise on the back and sides, except toward the hind end, with about eight narrow and brown pale-yellow stripes; these being most conspicuous toward the head end; the venter without stripes; the back and sides with noticeable scattered pale hairs. The full-grown larva is from 16 -21 mm (10/16- 13/16") long.

The Pupa
The pupa is slender and a little over 10 mm (2/5") long. Its head end and wing covers are dark olive green. The abdomen is mostly chestnut brown, the caudal segment is dark brown and has a small hook on each side of the apex, recurved ventrad.

The Moth
These moths hide well among the cranberry vines and in the litter under them, but are strong and quick in flight when flushed. They are 10-11 mm (6/16-7/16") long to their wing tips and have a wing expanse of 19-24 mm (12/16-15/16"). Their further description is as follows: Forewings dark gray above, with cross tufts of black or black-tipped erect scales near the base, about a third of the length from the base and somewhat beyond the middle of each; uniformly smoky below; hindwings pale with smoky front and outer margins; head (except eyes), palpi, and basal parts of antennae dark gray; thorax dark gray above, light gray below; legs dark gray; dorsum of abdomen dark gray with fringes of pale yellow along the hind margins of the middle segments; venter colored similarly but with pale marginal hind fringes on all the segments.

Management
Franklin (1928) noted that flooding did not prove practicable for this fireworm.

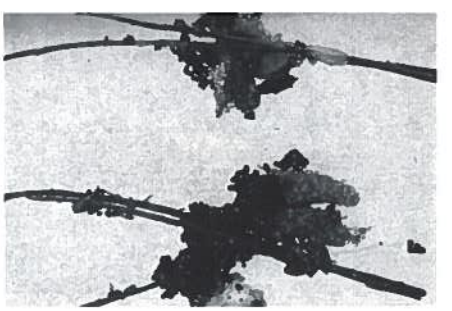


In the recent Massachusetts infestation, feeding at the base of the upright was obvious and significant.

The larvae of the hill fireworm are reddish or brown with a black head.

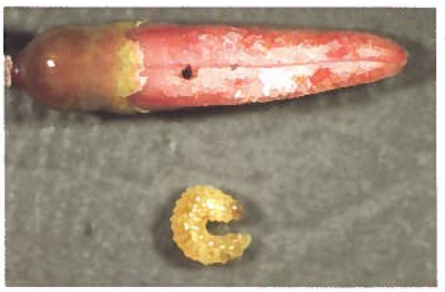
Hill fireworm moth.

The hill fireworm pupa is within a sandy hibernaculum.



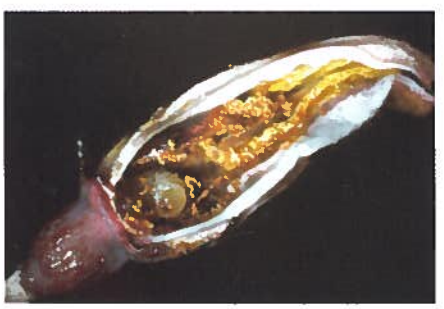
Hill fireworm tubes and frass. (Photo: Franklin 1948a)

FRUIT AND BLOSSOM FEEDERS



Female cranberry weevils lay eggs into the developing flower buds. An egg has been inserted (above) in the hole in the bud. The larva develops inside the bud.

Pearly-white, oblong-ovoid egg shown in center of blossom bud, which has been cut away for photo.



The larva of cranberry weevil is feeding within the blosssom bud.

Buds containing weevil larvae turn brownish-orange and are often severed from the upright.

CRANBERRY WEEVIL
***Anthonomus musculus* (Say)**
Coleoptera: Curculionidae

Distribution and Food Plants

This native North American beetle ranges from Ontario and New England to the Rocky Mountains and Florida. It is found commonly on black huckleberry and the flowers of chokeberry. The larvae develop in the flower buds of cultivated blueberry. It is also called the "blueberry blossom weevil." In New Jersey, weevil occurs in significant numbers on high-bush blueberry flower buds from mid-April to early May. Weevil rarely occurs on cranberry in New Jersey but is a serious problem in Massachusetts cranberry. This phenomenon is discussed a bit more in the Introduction.

According to Mechaber (1992) weevils use an extensive list of cultivated and native plants. This group of plants, all closely related to cranberry, grow in habitat surrounding cranberry bogs: on grassy areas adjacent to bogs, in woodlands, and in wetlands. Weevil use of multiple plant species, along with relative longevity of adult weevils (up to 13 months under lab overwintering conditions), and documented weevil flight capability (single flights of up to 75 feet) suggests that adults move onto new plant species seasonally, following the availability of flower buds. However, until more research is done, it is not possible to say whether plants surrounding the bog add to bog weevil populations by creating a reservoir of weevils, or act as trap crops, drawing weevils away from the bog.

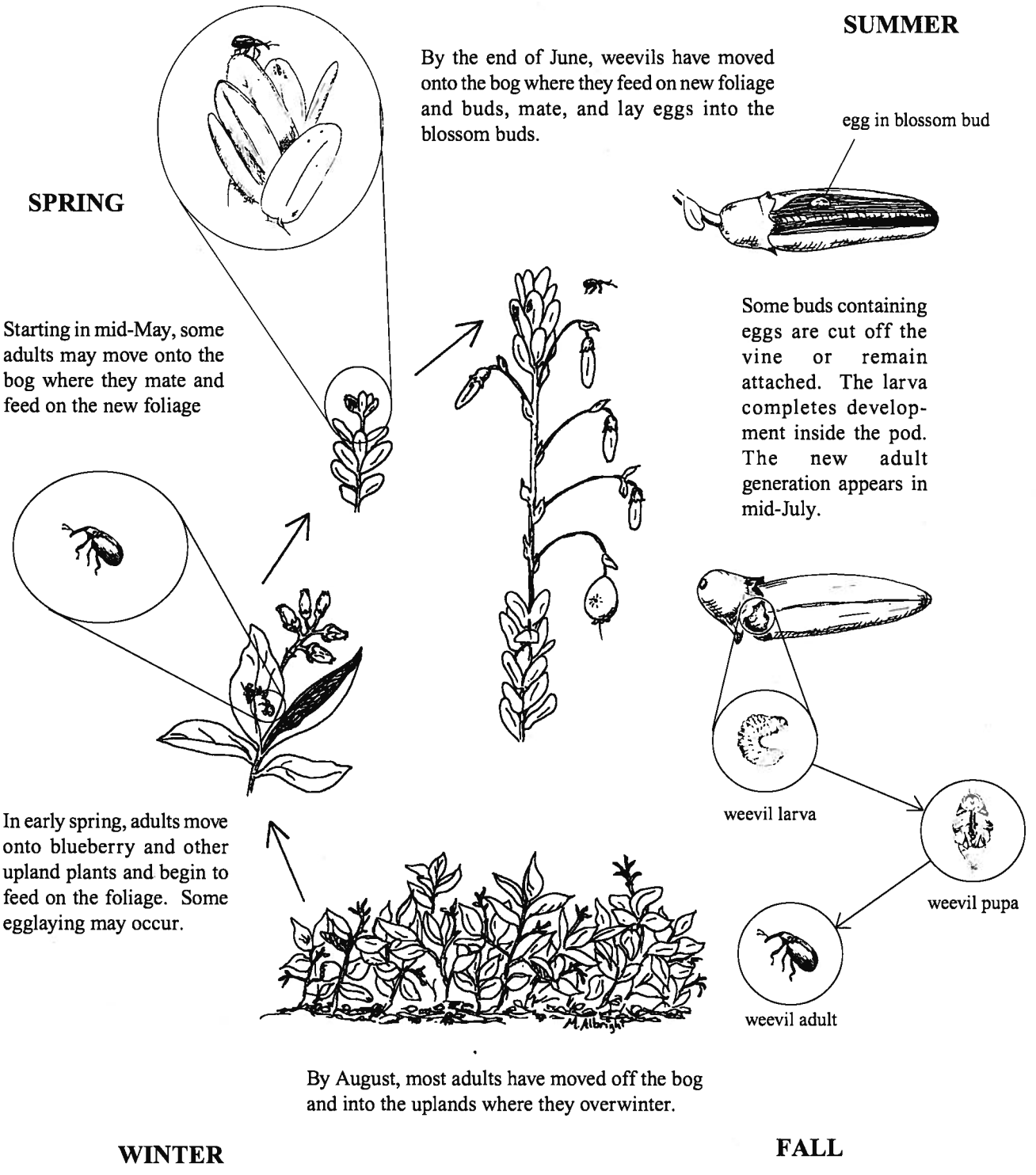
Early season host plants of weevil in Massachusetts are early low-bush blueberry, low sweet blueberry, and high-bush blueberry. Transitional species are black huckleberry, swamp sweetbells, and staggerbush. Mid-season species are cranberry, dangleberry, sheep laurel, and swamp honeysuckle. Late season species are wintergreen, maleberry, and sweet pepperbush (Mechaber 1992).

Some bogs in Massachusetts tend to have more significant problems with this species, perhaps owing to the conditions in the surrounding areas, such as the availability of alternate host plants and the extent, suitability, and proximity of overwintering sites.

Character of Injury

In the spring, the beetles occasionally drill holes into the under side of the old leaves and in the dormant terminal buds. They move to the new growth as it develops. According to LaCroix (1926), the most severe early season damage is the beetle's ravenous feeding on the new terminal growth and cranberry buds. Using their chewing mouthparts that are located at the end the snout, they may drill multiple feeding holes into the same bud. While feeding by adult weevils creates petal damage with characteristic round holes, some injured flower buds may still open for pollination. Often, however, the bud never opens but dries up on the pedicel and eventually drops off. Franklin (1948a) and Lacroix (1926) also noted that in many cases the beetles bore into the very basal portion of the new shoot so that the shoot dies back to the old wood, turning black in a few days and appearing the same as having been killed by frost. According to Franklin (1948a), they may also break over where the stem has been punctured, although we have not seen this.

Eggs develop inside blossom buds. Many of the infested buds fall to the ground, some before the egg hatches. In the lab, we observed egg laying in large, fully developed buds. Subsequently, females completely severed the pedicel with their chewing mouthparts. On smaller buds, females only partly cut the pedicel following egglaying, creating a point of weakness. It is known that on blueberry, the female also does this and the flower later breaks from the plant (Pritts and Hancock 1992). A few of the buds fall as the developing larva eats the end of the bud from within. If buds break off the vines when they are shaken freely,



Cranberry weevil life cycle, according to our current understanding. (Illustration: Albright)

The adult beetle: cranberry weevil.

Early season cranberry weevil adult feeding on the succulent new growth. Characteristic holes chewed on the leaf underside, are shown.

Adult feeding damage on blossom bud. The weevil has made multiple feeding holes.

Adult feeding on a pinhead. Holes are drilled using chewing mouthparts located at their snout's end.

this is a clear indication of weevil's presence on a bog.

The larva eats the pistil and the stamens of the flower bud, leaving the excavated ovary together with the unopened corolla a mere shell. If this is opened, it usually is found to contain a larva or pupa and some fine brown castings. Because the larval-infested bud does not open during bloom, the lobes of the corolla remain closed tightly and become dry and rigid in that position. As a nice convenience for the larva, this becomes a protective cell in which to complete its development (LaCroix 1926). Buds containing a larva turn from pink to a brownish-orange.

The beetles of the new generation appear while the berries are small. They feed on them and on the more tender foliage, riddling both with holes. Feeding by the beetles on the backs of the leaves at this time is very characteristic.

Where very abundant, this insect may destroy much of the entire prospective crop by damaging the blossom buds, and the newly emerging beetles may damage small berries. Adult feeding may also kill the tips of the uprights.

Description and Seasonal History

A single generation was reported by both Franklin (1948a) and LaCroix (1926). However, Mechaber (1992) asserted that "from field collections and lab rearing of insect eggs from both states [MA and NJ], as well as field and laboratory observations, there is evidence that there are at least two complete generations in these two states." She found that early in the season, overwintering females lay eggs in early season host plants, particularly blueberry, and suggested that these resulting progeny mate and lay eggs in cranberry as uprights begin to produce flower buds. These larvae develop, producing a second generation. Overall, her study opens many questions for additional research.

The insect passes the late summer, fall, winter, and spring as a beetle.

The majority of beetles reportedly overwinter near to the bog under debris and fallen leaves in surrounding wooded areas. We have found that these overwintering adults become active on warm days in late April and may move to blueberry plants, often before buds swell (Long, unpublished data). Mechaber's (1992) studies using a technique to mark the adults showed that the weevils feed and lay eggs on many different host plants, moving from one flowering plant to another. She found that females were more likely to disperse than males. Based on our observations, we found that weevils appear on cranberry in late May through early June; depending on the bog site, this appearance may be delayed into later June. They hide in trash under the vines or burrow a little in the sand on cold windy days, coming out only in warm, sunny weather. When active, they are easily swept from the vines with an insect net. When disturbed they either drop to the ground and play possum or fly off a few feet.

The early season weevils are observed mating on cranberry around the first of June. The female beetle begins to lay eggs when the first blossom buds show pink, but before they have become advanced enough to droop over; this timing will vary with season. In the lab, females laid as many as 39 eggs with an average of 20 (LaCroix 1926) and some have been observed to lay fifty or more (Franklin 1948a). According to LaCroix (1926), females preferred to lay on the very hottest days, laying 3 or more eggs in a day. Only one egg is laid in a bud, and is placed inside the bud at the base of the anthers among the stamens. The female first drills a hole with her mouthparts, then turns and locates the hole with her extended ovipositor. Following egglaying, we observed that the female exudes a bit of viscous fluid at the opening of the hole, which dries and seals the opening. Egglaying may continue for three weeks, depending on the development of the cranberry bud and weather conditions (LaCroix 1926).

The egg hatches in three to nine days, based on temperature. The normal hatching period is the last half of June. The larvae develop and pupate in the blossom buds. They mature in ten to fourteen days.

Franklin reported that the pupal stage lasts about six days. Mechaber (1992) found that at 22-25°C, pupal development occurred in 10-15 days. When the beetle emerges, it eats its way out of the bud near the calyx lobes. In LaCroix's (1926) studies, a new generation of beetles appeared from about 26 June to 10 July. These observations are consistent with our studies that showed that peak numbers of weevils were swept during the month of July. In August, the numbers fell sharply and weevils were rarely captured in sweeps. LaCroix (1926) found few or no weevils by mid-September; a few weevils were found on the bog floor, but only after careful and lengthy search. In our work, sticky traps were set out in 10 meter intervals into the uplands away from an infested bog. We found that the majority of weevils were caught close to the bog (10-30 meters) with fewer caught more distant (40-50 meters) and none even farther out (60 meters). Together, the observations suggest that, similar to some other species of *Anthonomus*, the adults overwinter in nearby protected areas, away from the crop.

The Egg

It is smooth, glistening, oblong-ovoid, pale yellowish, and nearly 0.5 mm (1/50") long.

The Larva

The mature larvae is whitish and has a yellowish head but no legs. It is about 3 mm (1/9") long.

The Pupa

This is about 2 mm (1/11") long and pale yellow at first, but it finally turns brown. The legs, wing pads, and snout lie tightly against the body.

The Adult

The beetle is about 1.6 - 2.0 mm (1/16+") long. It has a distinct, and slightly curved snout about a third as long as the rest of the body. This bears a geniculate antenna on each side beyond the middle and mouthparts are positioned at the end. The wing covers are ornamented lengthwise with rows of little pits. Narrow white scales, noticeable only under a microscope, are scattered over the body and legs and often form transverse patches on the wing covers. When the beetle emerges from the pupa it is light brown, with the head and snout deep reddish brown. It changes to its normal color of dark red within two or three weeks, then being blackish with the wing covers, the legs and the under side of the abdomen mostly deep reddish. It has a few whitish markings on the elytra.

Management

Adult weevils may be collected from cranberry with a sweep net. All plants, other than cranberry, may be sampled on warm days by placing a light cloth or sweep net under the bush, and shaking the bush vigorously. Adult weevils will drop down onto the cloth.

During cold, wet or windy weather, beetles are not found in sweep counts. According to LaCroix (1926), during such weather, they can be found on the bog floor, inactive.

To determine presence of eggs or larvae, flower buds need to be cut open and examined with a hand lens, field microscope, or laboratory dissecting microscope.

Cranberry weevil populations are not affected by the winter flood or late water, probably because the weevil overwinters in the uplands and does not move onto the bog until May. A complete reflood about 1 June was reported to be effective, but control must have been incomplete, based on some of Franklin's comments.

Typical habitat, woodlands surrounding cranberry bog, where weevil adults overwinter.

Sampling for cranberry weevil on a blueberry bush by shaking branches over a white drop board.

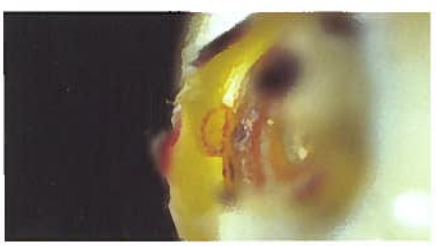
This grey weevil (species unknown) may be picked up in small numbers while sweeping. It is not known to do cranberry damage. It should be omitted from weevil counts.

Cranberry uprights with typical empty pedicels. The blossom buds were clipped by females following egglaying. Often, this damage is noted during out-of-bloom counts when uprights are carefully inspected. (Illustration: Garnett)

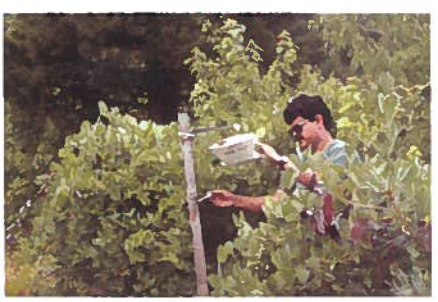
The cranberry fruitworm moth is a mix of dark and light grey that mimics a bird dropping.

A male cranberry fruitworm moth (left) has a feathery base of the abdomen. The female moth (right) has an orange base.

Cranberry fruitworm moths lay their eggs in the calyx, at the bottom of the fruit.



An orange-lined egg.



Sex pheromone traps for cranberry fruitworm moths are undergoing evaluation in blueberry; our work shows they have limited value in predicting egglaying in cranberry.

CRANBERRY FRUITWORM
***Acrobasis vaccinii* (Riley)**
Lepidoptera: Pyralidae

This insect, in its larval stage, has been more destructive than any other cranberry pest in Massachusetts. Many moths come onto the bog from external sources most years in Massachusetts, as demonstrated by the fact that new bogs made in isolated locations typically become infested in a few years. However, in extensive, season-long collections of wild blueberries and huckleberries throughout bog uplands, we found cranberry fruitworm eggs very rarely, so the source of this continuous invasion is a mystery. In the absence of a large wild reservoir of moths, it seems more likely that moths are moving extensively among cultivated cranberry sites (see discussion below).

Distribution and Food Plants

This species has been found in Quebec, Prince Edward Island, Nova Scotia, Maine, Massachusetts, Rhode Island, Connecticut, New York, New Jersey, North Carolina, Michigan, Wisconsin, Texas and Washington.

The host range of cranberry fruitworm is narrow, limited to two plant genera, *Vaccinium* and *Gaylussacia* (Neunzig 1986). The larvae feed in the fruits of the mountain cranberry, deerberry, and highbush blueberry and are sometimes a considerable pest in cultivated fields of the latter. We have found them to a limited extent in Massachusetts blueberry. They are found to a greater extent on New Jersey blueberry. They commonly web together several blueberries to feed.

Character of Injury

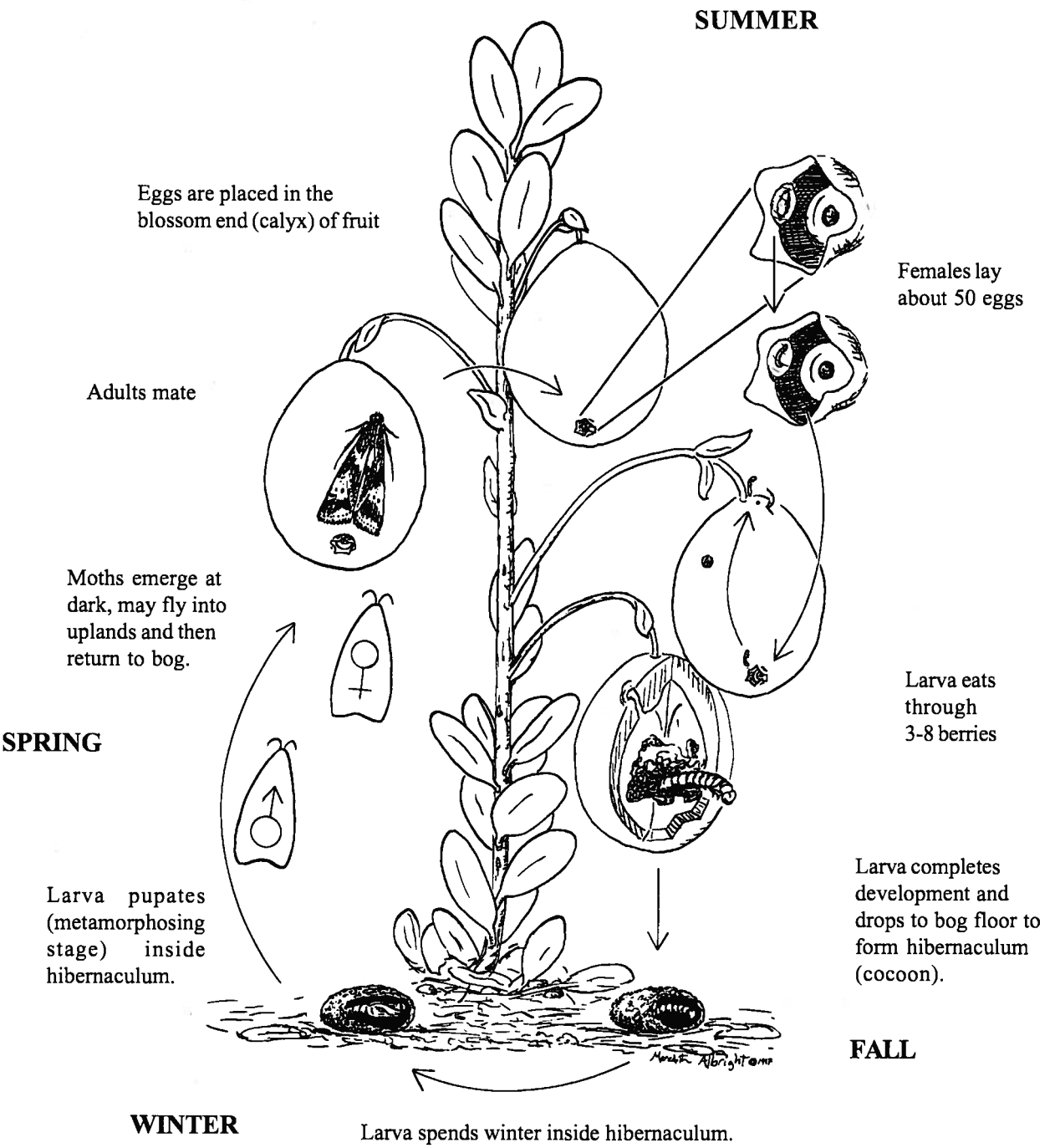
The larva fills the berry with its frass (excrement), revealing a very messy feeding site when the fruit is opened. Berries turn red prematurely as they are filled with frass. Appearance of red berries is the first sign of feeding activity. The damaged berries then gradually dry and shrivel and may cling to the vines as husks until the next year. All first and second instar cranberry fruitworm construct a silken closure at the surface of the berry where they entered the fruit. We found that 80% of third and fourth instars, and 30-50% of fifth instars silked over the entry site, while none of the sixth instars did so.

Refer to page 51 for a comparison of *Sparganothis* and cranberry fruitworm.

Description and Seasonal History

There is a single generation a year. The larva overwinters inside a silken hibernaculum made of trash and sand. Pupation occurs within the hibernaculum in June where the winter flood is removed in March. Although the hibernaculum fills with water after being submerged for about five days, the larvae in them are generally unaffected by cold water or the winter flood.

Moths tend to emerge from hibernacula in late afternoon. The moths hide among the vines during the day and are hard to flush, so even when abundant, they are seldom seen. Egglaying begins at dusk, and initial work suggests that peak activity occurs 1-2 hours after sunset. We believe that the moths move actively and extensively throughout the habitat. In our lab, Sharma (unpublished data) has carried out light trapping in both bogs and surrounding uplands. Based on hourly samples, he found that females were active on the bog in early evening, consistent with observations of Franklin (1948a) and others that moths are very active on calm evenings and may be seen at dusk hovering over the vines. Surprisingly, however he found that after midnight, there was considerable female activity in traps placed high in upland trees. Peak male activity occurred after midnight on the bog and between 1 and 3 AM in the uplands. By dawn, activity was again high in the bog. Movement by moths between the bog and the uplands has been supported by numerous mark-recapture studies (Sharma, unpublished data). We speculate that moths move to trees to accumulate at mating sites and then return to the beds. The moths have been known to fly 82 m (270') in a single flight (when Franklin released them from a boat), and in our studies, a marked male was captured at a bog 0.5 km (0.3 mile) from the bog where it was released.



Cranberry fruitworm life cycle. (Illustration: Albright)

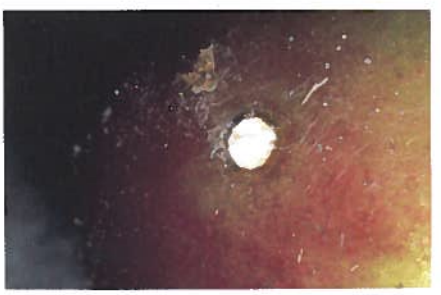
The moths occur from very late May until September. In Massachusetts, in a typical year, we observe peak moth flight from a point in end-June to the first week of July, with a second smaller peak of emergence that occurs in some years at the end of July. We find, as did Tomlinson (1962), that moths are caught into September. In New Brunswick, Canada, Maxwell and Morgan (1951) found emergence of moths extended from 15 June to 26 July, with mean emergence on 9 July. In the second year, the emergence period was shorter, occurring later in the spring and ending earlier, but the mean emergence date was similar, occurring on 8 July.

The majority of the larval population is active from about 12 July to mid-August, but often a late small peak of emergence or continuous presense of moths through the summer may lead to some larvae feeding in berries into September.

Berries that have sized up just beyond pinhead stage (arrow) are preferred by females at the onset of egglaying (Illus: Shear 1916).

A cranberry fruitworm larva aligned with the stem of the berry as it drills into a first fruit.

A first instar cranberry fruitworm larva feeding inside fruit on seeds.



A silk door is placed over the entrance hole by the fruitworm larva in the first four instars.

A cranberry fruitworm larva inside a berry filled with frass.

In Massachusetts, egg laying begins when the small berries start to grow and sometimes continues to late August. In New Brunswick, Canada, Maxwell and Morgan (1951) found eggs from 2 July to 19 July in 1950 and from 3 July to 22 July in 1951. In our Massachusetts studies, we found that even when many females were present and reproductively mature, they strongly discriminated against pinheads for egglaying, and only began to deposit eggs when the fruits had begun to expand. In cases of mixed plantings, Ben Lears and to a lesser extent Stevens beds may have very high numbers of eggs when compared to adjacent Early Black or Howes beds, where fruit enlarge later or more slowly. It is clear that females seek larger berries and freely move among beds.

In contrast to pinheads, which have a great probability of shrivelling up, berries that have begun to develop are likely to remain a sound resource for the first instar larva when it hatches. Our observations in field conditions showed that first instar mortality was very high when larvae were forced to move among berries.

We have observed that females invariably place the egg under one of the lobes at the blossom end (calyx) of the berry, with an exceedingly rare egg being placed elsewhere on the surface. This is in contrast to Maxwell and Morgan's (1951) report of eggs also being present on the leaves, stipules, and bracts at the base of the berry stem. We observe such egg placement by laboratory-held moths, but we have not seen this under field conditions.

Extensive sampling of entire bogs showed that the eggs are laid patchily at several levels. We found significantly more eggs along bog margins and along internal ditches. Further, more eggs were laid in weedy areas and eggs were generally patchy among sampled plots. Further, berries located on uprights that were protruding above the vine canopy were most likely to contain an egg. Multiple eggs, two and sometimes more, were frequently found on single berries. Again, these findings are in contrast to Maxwell and Morgan (1951) who found only single eggs per berry.

The eggs hatch in about five days when held at 25°C (77°F) and within 9 days at 20°C (68°F). Eggs parasitized by the braconid parasitoid, *Phanerotoma franklini,* take a few days longer to hatch.

The newly hatched larva often crawls over the berry surface from its place of emergence at the calyx and enters close to the stem. Many larvae align their body along the pedicel and feed into the berry while so attached, taking about 1.5 hours to eat into the fruit. Its entrance is so small that it is barely visible to the unaided eye. Some larvae enter the berry within the calyx.

The first instar eats the seeds and more or less of the pulp and then enters a second berry. On average, one larva feeds on three to six berries, but the number will vary with berry size. Most of the pulp is eaten. Instars 1-4 close the entrance with a white silk cover. A large number of medium to large larvae will silk together two fruits at the point of contact. Then, the larva slips to a new berry, unexposed.

When through feeding, the sixth instar larva drops to the bog floor and spins a silken, oval hibernaculum, drawing into it sand and debris. If sand is available, a hibernaculum looks like a lump of sand. The mature larva spends the winter within the hibernaculum.

The Egg

The egg is generally oval and so plastic when laid that it adapts itself readily to an irregular surface. See page 50 for further information.

The Larva

The newly hatched larva is light to darkish green with a light brown head capsule. The mature larva is about 13 mm (1/2") long and is green, often tinged with reddish on the back. The head is yellowish. The parasitized larvae seldom become much over 8 mm (1/3") long.

The hibernacula made of sand and leaves silked together are generally a little over 9.5 mm (3/8") long.

Mean head capsule size and duration of six larval instars of cranberry fruitworm. (Maxwell and Morgan 1951)

Instar	Head capsule (mm)	Duration of instar stage (days)
1st	0.18	1
2nd	0.43	5
3rd	0.63	9
4th	0.86	9
5th	1.08	16
6th	1.37	overwinters

The Pupa

The pupa is 7-9 mm long and is pale greenish at first but soon turns yellowish brown. It becomes dark brown.

The Moth

The moth expands about 17 mm (2/3"); wing length is 8-9.5 mm (1/3"). The forewings are mostly dark grayish-brown above with a slight pinkish tinge, each having two whitish areas, one towards the base and one running back from beyond the middle of the front margin, there are two dark dots in the latter. The under side of the forewings and both sides of the hindwings are tan.

Variation in the forewing of cranberry fruitworm occurs. Most of the moths have the upper side of the forewing as described earlier, but dark moths, observed by Tomlinson (1967), make up about 8% of the total population. Neunzig (1986) notes that paler than usual specimens occur also. He also notes that males have a distinct golden-yellow costal streak on the underside of the forewing.

Management

The sex pheromone has been identified in cranberry fruitworm (McDonough et al. 1994), but we have not established guidelines for its use in pest management programs. In Massachusetts, we have captured large numbers of males in wing traps baited with a blend of (E,Z)-8, 10-pentadecadien-1-ol and (E)-9-pentadecen-1-ol acetate. However, we are unable to identify a relationship between timing of captures with oviposition of females. Peak numbers of males were frequently captured early in the season, substantially earlier than the appearance of eggs on fruit. In these cases, the females apparently held their eggs until berries had begun to enlarge.

The phenology of the cranberry plant gives a better estimate of the onset of egglaying. For many years, growers have observed fruit set (percent of flowers that are out of bloom) to pinpoint the peak egg-laying interval, combined with inspections of randomly-collected berry samples for eggs (see Sylvia 1998).

Late water (see p. 89) greatly impacts cranberry fruitworm (Averill et al. 1997). This practice has been utilized for over a century in Massachusetts. Franklin's work showed that the larvae within the hibernacula cannot survive when submerged in water above 15.5°C (60°F) for over 2 weeks. However, monitoring of berries to check for eggs remains essential. We believe moths are highly mobile and apparently move back and forth between bogs and uplands, perhaps to mate or to find more suitable resting conditions. Thus, even if late water is held, if nearby beds remain unflooded, moths likely will move easily among all sites. Regardless of these precautions, late water remains an excellent tool for cranberry fruitworm management.

Franklin (1928) noted that bogs vary greatly in their tendency to become greatly infested and suggested that this is probably due to differences in the bogs surroundings.

Berries that have been fastened together with silk; the larva passes between the fruits without exposure.

Berries fed on by cranberry fruitworm larva dry up and look like raisins.

Cranberry fruitworm spend the winter on the bog floor as a larva inside a sand hibernaculum.

The sand hibernacula of cranberry fruitworm. Unparasitized hibernacula (left) are significantly larger than those parasitized by *Phanerotoma franklini* (right).

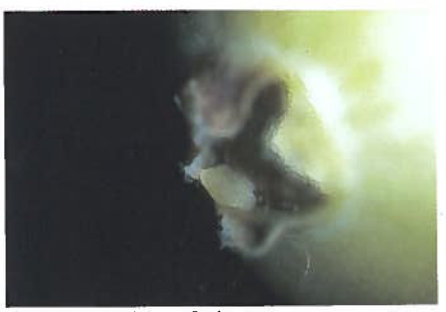
Wings of most moths appear as in specimen on left, but some are darker (right). (Photo: Tomlinson 1967)

Phanerotoma franklini is a common parasitoid of cranberry fruitworm.

To find more eggs to practice inspection and identification, use these techniques:

1) Collect berries near a bog ditch containing water.
2) Collect berries sticking above the vine canopy.
3) Early in fruit set, collect enlarged berries while most are still pinheads.

A green or newly laid cranberry fruitworm egg is most difficult to see.



A green cranberry fruitworm egg.

An orange-lined cranberry fruitworm egg. The orange line appears a day or more after the egg has been laid.

Two overlapping eggs. Orange-lined egg below and green egg above.

Cranberry fruitworm egg status: Alive, dead, parasitized, or a grain of sand/pollen?

Determining if a cranberry fruitworm egg is viable (capable of hatching) is a difficult task. Careful attention must be paid to determine viability, and thus, risk of larval infestation.

Green eggs are recently laid and will hatch after 5 to 10 days depending on ambient temperature. They are difficult to see against the green calyx.

Orange-lined eggs are well-developed eggs that may hatch in only a day or two. These are also known as "blood stage".

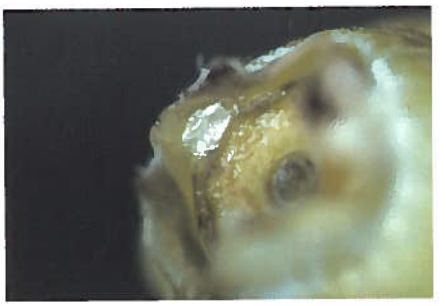
Development time of cranberry fruitworm eggs at three different temperatures.

Mean Temp	Days to appearance of orange line	Total Days to hatch
15°C (59°F)	3	17
20°C (68°F)	2	9
25°C (77°F)	1	5

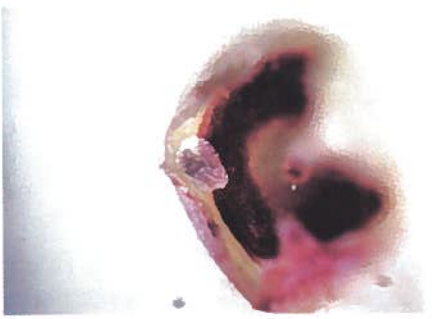
Hatched eggs are white egg shells from which the larva has exited. Very often, you can find the larva's entrance as a pinhole close to the stem or some may enter within the calyx.

A **dead or dried out egg** often has been exposed to pesticide or has naturally dried out. A microscope check of questionable eggs is advisable, when possible, or holding the egg for a second check.

Parasitized eggs are black. Cranberry fruitworm eggs containing *Trichogramma* spp. wasps turn black. The wasp kills the fruitworm egg and emerges through a conspicuous circular hole it cut in the host egg shell. Even when the wasp emerges, the cranberry fruitworm egg shell remains black.

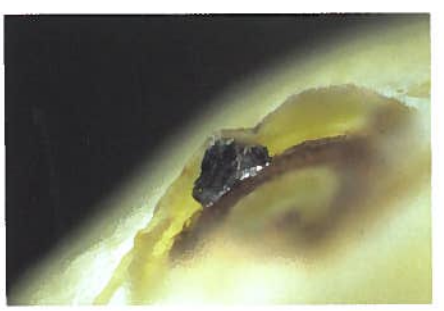


A hatched egg appears like a white shell.

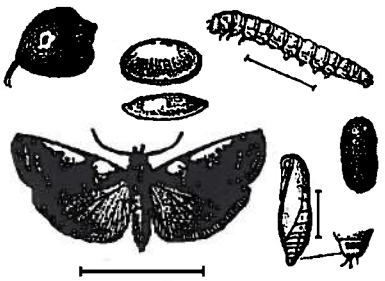


A dead cranberry fruitworm egg. The shrivelled body of the cranberry fruitworm larva can be seen within.

A dried-out egg. As the season progresses, eggs are often dead or desiccated and must be examined carefully to distinguish them from viable eggs.



These eggs are black: they have been parasitized by a *Trichogramma* wasp.



Cranberry fruitworm stages (Illus: Smith 1903)

Early instar cranberry fruitworm silk a door over its entrance into the berry. *Sparganothis* fruitworm never silks its entry.

Clean berries (left) compared to cranberry fruitworm infested berries (right).

Cranberry fruitworm feed only inside the berry.

Cranberry fruitworm (above) tends to be green while *Sparganothis* fruitworm (below) tends to be yellow (shown here) or dingy green (see right side of this page, bottom). (Photo: W. Z. Fort)

Infested berries: Is it cranberry fruitworm or *Sparganothis* fruitworm?

Sampling and management of these two species are totally different. Accurate identification is absolutely critical.

Using fruit damage alone, cranberry fruitworm damage is virtually indistinguishable from small *Sparganothis* fruitworm larvae that have entered the fruit. However, small cranberry fruitworm always construct a silken closure over its entry site and *Sparganothis* larvae do not. As the larvae become larger, the cranberry fruitworm entry is round, typically the diameter of the body. *Sparganothis* entries are typically larger and more ragged.

The tunnels of *Sparganothis* larvae are sometimes lined with a few tresses of white silk. The color of *Sparganothis* is more dingy, a whitish to yellowish-butterscotch or a darkish, dingy green. In contrast, cranberry fruitworm are typically a clean apple-lime green, often with a reddish tinge in older larvae.

For berries that have been damaged by medium to large larvae, the damage does allow a fairly reliable way to distinguish between cranberry fruitworm and *Sparganothis* fruitworm. Older *Sparganothis* always eject frass away from sites in the berry, leaving the hole and the internal feeding area clean. Cranberry fruitworm fills the berry with brown frass, which often becomes mushy.

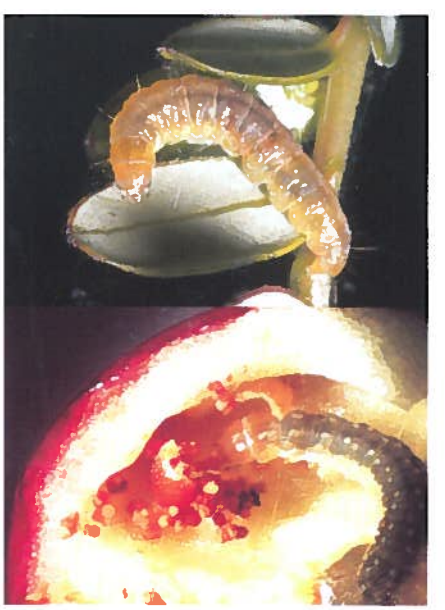
Become familiar with the appearance and behavior of *Sparganothis* fruitworm larvae in the spring. Caterpillars are present in loosestrife leaves that are folded and webbed.

For a side-by-side comparison of *Sparganothis* and cranberry fruitworms, *Sparganothis* is typically more "streamlined" in appearance and active. *Sparganothis* is more compressed-looking while cranberry fruitworm has a quite cylindrical body shape. *Sparganothis* typically wriggles spasmodically upon initial prodding, cranberry fruitworm does not.

Berries that have been fed on by *Sparganothis* fruitworm. (Photo: W. Z. Fort)

Young *Sparganothis* feeding inside of a cranberry fruit.

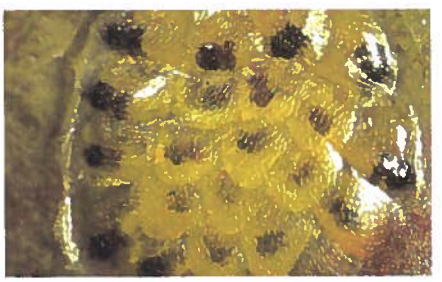
A clean berry, a fruitworm infested berry, and a *Sparganothis* infested berry (left to right).



A *Sparganothis* fruitworm can be found feeding on foliage in the spring (above) and inside the berry in the summer (below).

Recently laid sparganothis fruitworm egg mass. (Photo: W. Z. Fort)

Sparganothis eggs are deposited on the upper side of the leaf. The egg mass on the right is older.



The black heads of the first instars can be seen in developed eggs. The black head is lost when the larva molts to the second instar.

Sparganothis larvae can be pale whitish-yellow or butterscotch-yellow.

Late instar Sparganothis larvae may also be dark, dingy green on the upper side, with distinct white spots.

"SPARGANOTHIS FRUITWORM"
Sparganothis sulfureana (Clemens)
Lepidoptera: Tortricidae

Sparganothis fruitworm is a serious problem in Massachusetts, New Jersey and Wisconsin. It is hard to find or absent on wild and abandoned bogs. It is an induced pest and large populations, particularly of the summer generation, have appeared in localized outbreaks on commercial bogs. These are very difficult to manage.

Although in the same family as black-headed and yellow-headed fireworms, this larva does less vine webbing. Because its most important injury is from berry feeding, it has been called Sparganothis "fruitworm". It has also been called false yellow-headed fireworm because of the larva's close resemblance to that other species.

In New Jersey, Sparganothis has been one of the most destructive pests in cranberry with flights of thousands of moths observed swarming on the bogs (Marucci and Moulter 1992a) prior to the introduction of DDT. Earlier, Marucci (1953) had reported periodic outbreaks in localized areas in 1935, 1936, 1941, 1943, and 1946.

According to Tomlinson (1947), when the insect was first reported in outbreak numbers in 1935-36, he speculated that Sparganothis was probably present for years previous to this without being differentiated from yellow-headed fireworm (*Acleris minuta*). When full grown, the Sparganothis larvae are slightly larger than yellow-head larvae; diagnostic features of the larvae as a means to distinguish the two species of larvae have not been elucidated. Regarding their feeding sites, yellow-headed fireworm forms a more extensive tent of uprights and more completely defoliates the upright, resulting in a "burned" appearance that is not seen with Sparganothis.

Early in Massachusetts production history, Sparganothis fruitworm was of no importance. They were noted by Franklin (1907) occurring only in small numbers. Outbreaks began soon after the introduction of DDT in the late 1950's. It has become an increasingly serious pest of cranberry. We suspect that in the late 1990's, a key factor favoring its increase was the gradual loss of effectiveness of organophosphate cover sprays. In New York apple, Sparganothis resistance to organophosphates is also suspected (Weires and Reidl 1991).

A second key factor, of equal or greater importance, is the impact of broad-spectrum insecticide applications on natural enemies. In a survey of infested New Jersey bogs, Beckwith (1942) concluded that serious infestations were limited to those bogs that were heavily sprayed with insecticide, in this case arsenate of lead. He felt that the late season generation was unleashed as a result of the spray's destruction of natural enemies. He wrote:

> "It can be assumed that all bogs have a few false yellow-head fireworm most of which are parasitized. If enough arsenate of lead were applied regularly every year to kill 75-90% of the worms, the parasitized ones, being weaker would be killed together with their internal parasites. The healthy worms could quickly build up a serious infestation and maintain it year after year if the parasites were kept at a low figure. This would account for the constant presence of this worm on these bogs though they do not appear on other bogs."

This was substantiated in New Jersey where Marucci and Moulter (1992a) established a half-acre bog that was not sprayed with insecticides. Following three years of heavy loss to Sparganothis, in the fourth year, fruit loss to larvae dropped to about 5% and the authors described parasites (tachinids and ichneumons) "flying around on this bog in an abundance never seen on commercial bogs." In collections of larvae and pupae in low to moderate-spray commercial bogs in Massachusetts, we have observed high levels of parasitism, but the rates have varied enormously.

Distribution and Host plants

This is a native species that has been reported in Nova Scotia, Ontario, and Alberta and is generally common in New

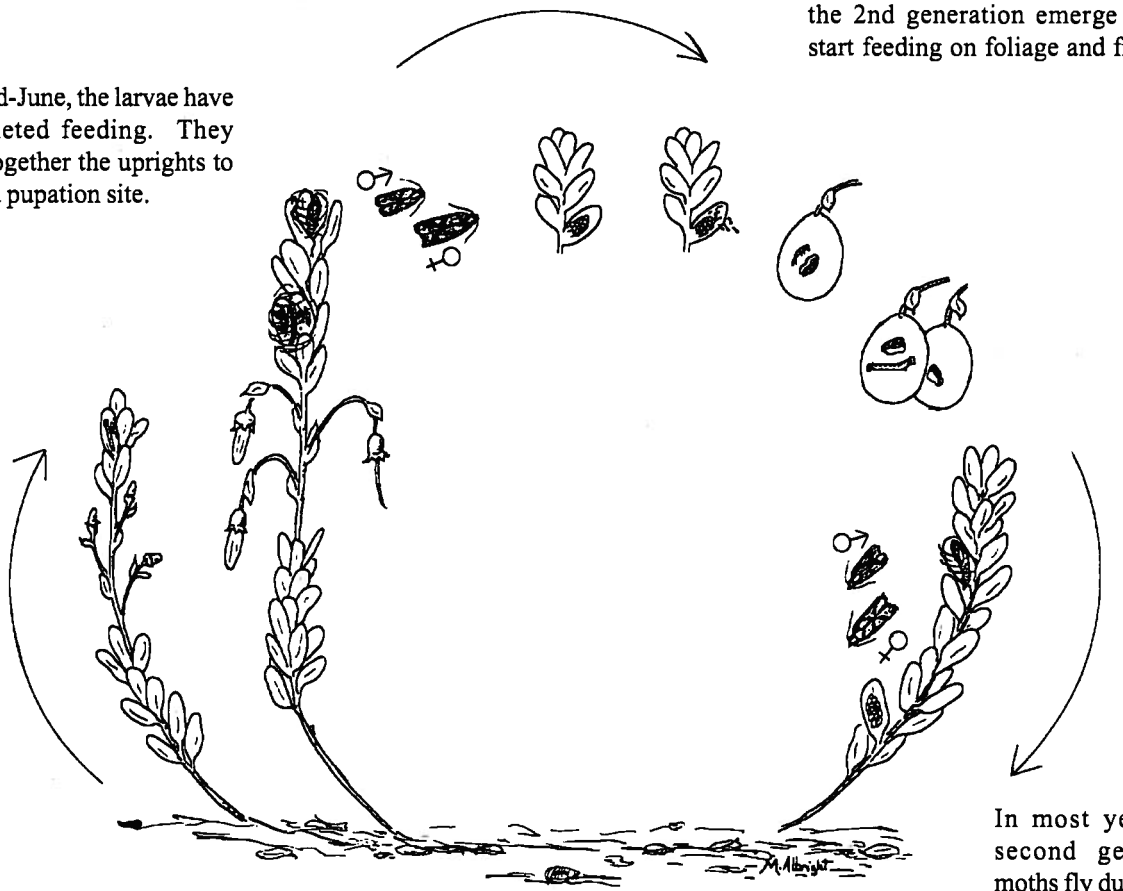
SPRING

The moths emerge and mate in late June and early July. Females deposit egg masses on the foliage and perhaps, on developing fruit.

SUMMER

After 10-14 days, the tiny larvae of the 2nd generation emerge and start feeding on foliage and fruit.

By mid-June, the larvae have completed feeding. They web together the uprights to form a pupation site.



In most years, the second generation moths fly during early harvest in September and lay eggs.

In early spring, as it warms up, the larvae become active and move onto the foliage to feed.

The eggs hatch in the fall and the tiny first instar larvae spend the winter either in the trash layer or webbed into the uprights.

WINTER

FALL

Sparganothis fruitworm life cycle. (Illustration: Albright) Moths fly twice each season. It remains unknown how the first instar larvae overwinter.

An early season larva in a webbed tip of loosestrife.

Sparganothis fruitworm larvae have webbed together vines on the right; normal vines on left.

Larvae of sparganothis fruitworm feed on berries and cause this "shotgun" appearance by gouging feeding holes into the berries.

Sparganothis fruitworm larvae may also feed internally in berries causing them to turn red, similar to cranberry fruitworm. Note how berries are clustered with silk.

York (Chapman and Lienk 1971). It is known as a general feeder on a wide range of wild and cultivated plants including apple, alfalfa, hawthorn, blueberry, celery, strawberry, clover, corn, cotton, and red, white and pitch pines, honey locust, willow, great burdock, tall buttercup.

Although Sparganothis feeds on all of these hosts, Chapman and Lienk (1971) suggest that based on work of Marucci (1953), cranberry, blueberry, and certain others, such as loosestrife and sweetfern, may be the principal primary hosts, with apple utilized only as a secondary host. However, in both New Jersey and Massachusetts, it clearly prefers cranberries and loosestrife (*Lysimachia terrestris*), and in Massachusetts, it has not been found as a pest in blueberries.

Marucci's (1953) early studies addressed the issue of moth movement between the bog and uplands. His observations clearly showed that the moth flight and oviposition were confined to the bog and ten yards from the bog edge. In our work, we have set out sex pheromone traps throughout the uplands surrounding a bog and have seldom captured more than a few males. It is very likely that invasion of Sparganothis moths from wild sources is not important in the development of an infestation.

Character of Injury

Larvae feed on new plant growth and at first, web single leaves together in a sandwich; as they become larger they web vine tips together. If numerous, the spring feeding larvae may cause some crop reduction by their feeding on developing blossoms. Generally, most injury is from the summer larvae that hatch during fruit set and mature in late summer. They feed by surface gouging berries, as well as feed inside berries, and on foliage. Their habit of feeding on several berries as they grow makes them more damaging than their numbers would seem to indicate. They prefer berries, and according to Beckwith (1937) attack fruit exclusively when the berries are half grown.

In early August, an infestation frequently is detected by the observation of a shrivelled red berry or berries that are silked together with adjacent green berries and vegetation. The green berries in the cluster may have large holes on the bottom, be hollowed out, or will have shot-hole feeding. This berry feeding is often low in the vines. The half-grown larva is found feeding within one of the green berries or resting within a shrivelled or rotten berry in the cluster. The areas of infested clusters of fruit are patchy on the bog, and infestations often appear on the bog margins. Infestations also may be greater on heavily fruiting bogs and bogs clean of weeds.

We have seen heavy infestations on Ben Lears compared to other cultivars. Establishment of larval populations may be superior on these large, early fruit or perhaps, larvae enter the fruit earlier, avoiding sprays. Larvae also may evade parasitoids because they cannot be reached by the parasitoid's ovipositor in the much larger Ben Lear fruit.

The winter survival rate of Sparganothis larvae may be low. Heavily infested bogs in summer may have low infestations in the following spring. High survival of the summer generation and the high reproductive potential of the species is suggested by the very high populations that can appear in the summer from an apparently small spring population of larvae (Marucci 1953).

Seasonal History and Description

See life cycle, page 53. There are two generations per year, an overwintering generation and a summer generation. The species overwinters as a first instar larva, perhaps off the cranberry plant inside a hibernaculum constructed of silk in the debris on the bog floor (Marucci 1953), but this has been questioned. The small larva becomes active in the spring when new tip growth appears.

In New Jersey, Beckwith (1937) found the overwintering larvae beginning to feed as the terminal buds began to develop at the end of April. When leaves become larger, small larvae web two leaves together and feed on the leaf surface within. As the larvae grow, they web together more leaves, eventually

drawing together adjacent uprights. The larvae mature irregularly from mid-June to mid-July and pupate within their silken enclosure.

Adults fly in late June and early July and females lay new egg masses within one to two days after emergence. Eggs hatch within 9-12 days. The earliest appearing larvae in the summer feed on the foliage and move to the fruit as they enlarge, doing their key damage of fruit destruction. The larval period lasts from 30-40 days and the pupal period from seven to twelve days.

If the berries have enlarged when a larva first hatches, it often will enter a berry and feed entirely within it, in a fashion identical to cranberry fruitworm, but it does not web the surface of the entry hole. For the first instars, the larva may remain in the berry, filling it with frass; this causes the berry to turn red. For later instars, the pattern of feeding is often to web together several berries and feed in a concealed manner on the underside of each of the berries. They tend to make fairly large irregular feeding holes, 1-3 mm (1/16 - 1/8 inch) wide. The hole is not silk covered, but tresses of white silk may appear where the larvae have been feeding. The larger larvae feeding within the berry leave no frass; a damaged berry is cleanly hollowed out. This is a clear way to distinguish feeding of large, late-season Sparganothis larvae from that cranberry fruitworm. In the cranberry fruitworm, the fruit is filled with a mess of frass, turning the interior mushy and brown. See p. 51 for comparison discussion.

Full grown larvae of the summer generation are found in late July and early August. They typically pupate within damaged fruit. Adults fly again starting in mid-August into September and females lay eggs. These eggs hatch and overwinter as tiny first instar larvae.

In Massachusetts, we assume that the first instar larvae seek sites on the plant or within the bog floor debris and enter diapause; they do not develop beyond the first instar. However, in New Jersey, Beckwith (1938a,b) found that the earliest hatching larvae of the summer generation did not enter diapause in the first instar but continued to develop; none reached the pupal stage though. However, Beckwith (1937) makes the significant observation that these larger, overwintering larvae may not survive as they are not found the following spring. In a later study, Marucci (1953) concluded that a partial third generation was favored when there was early completion of the summer generation (i.e. by 14 August) as well as when there was a mild autumn. Current observations in New Jersey provide support for development past the first instar in the fall in New Jersey (S. Polavarapu, personal communication). In the accelerated 1998 season in Massachusetts, we saw absolutely no evidence of a third generation completing development, even on sites where moths began flying 2-3 weeks earlier than usual.

The Egg

The moths lay eggs in masses of 20-50 eggs, usually on the upper side of the cranberry leaf or on berries and weeds. The egg-mass is overall oval in outline and is initially pale yellow-green. The black head of the larva may be seen through the egg shell just prior to hatching. In 10-12 days, the eggs hatch into small black-headed larvae that resemble black-headed fireworms.

The Larva

The first instar larva is 1-2 mm (1/16") long and has a shining black head and prothoracic shield. The head capsule of the second instar is dark brown and the prothoracic shield is narrowly edged with dark brown. Later instars have a yellowish brown head capsule.

The larval body color varies. In many instances, as described by Chapman and Lienk (1971), the dorsal half of the body is darkish green and stands in contrast to the pale ventral half of the body. Not all full-grown larvae exhibit this degree of color contrast and in some the dorsal half may be relatively pale. The two-tone condition is shown most consistently in penultimate instar larvae. The abdominal pinacula are pale and are prominent in individuals having the typical dark green dorsum. The color

Sparganothis fruitworm pupae can be found webbed up in loosestrife, cranberry foliage or in berries.

Male and female Sparganothis fruitworm moths are sulfur yellow with a distinctive X marking.

Pheromone traps are an effective technique to monitor Sparganothis fruitworm moth activity.

Sparganothis fruitworm larva and moth. (Photo: W. Z. Fort)

on the ventral half is a dingy yellow. Many larvae are purely whitish-yellow and butterscotch-yellow.

The mean lengths of full-grown larvae are 14.5 mm (7/12") (males) and 16.5 mm (2/3") (females). The head width is 1.13 mm (males) and 1.3 mm (females) (Chapman and Lienk 1971). They wriggle, when disturbed, similar to their fireworm relatives.

The Pupa

The pupa is dark brown to black and measures 7.5-10 mm (5/16-6/16") in length.

The Moth

Males and females are similar in appearance. Three colors of scales are found in the wings: vivid yellow, reddish orange and grayish magenta. Excluding the outer costal spot, the magenta colored scales form a wide V-shaped marking. With the wings folded, these markings combine to make an X-shaped mark on the back. The average length of the forewing is 7.7 mm (ca. 5/8") (females) and 7.0 mm (2/3") (males) and the average expanse of wings is 17.2 mm (11/16") (females) and 15.5 mm (5/8") (males).

Management

Control of outbreak populations is problematic. See p. 52 for possible explanations of outbreaks, including likely development of insecticide resistance. Larger larvae of the summer generation that are webbed up and protected inside a berry are difficult to kill, and sprays aimed at them may aggravate the situation by killing off parasites that are important in keeping them under control naturally. It is likely that the parasitoids that seek out the larvae within fruits or their webbed retreats provide more control than chemical cocktails applied in later summer.

Sex pheromone has been used in pest management programs as a monitor of male moth populations using traps (Brodel 1985). Pheromone disruption techniques are under evaluation and are highly promising (S. Polavarapu, personal communication).

Late water is not an effective control, except to enhance synchronization of the larval population in the spring. The results of flooding are somewhat vague in the old New Jersey literature. In 1942, Beckwith suggested that a summer flood saved the crop when an intense infestation was not controlled with lead arsenate. A reflow from 3 June to 5 June, when larvae were probably middle instars, gave excellent control, but as noted by Marucci (1953), most "summer reflows" gave variable results, probably as a result of timing and water temperature. A recent late summer flood in Massachusetts showed promise for management of a very serious outbreak population (M. Weldon, personal communication). Overall, further evaluation is mandated.

STEM, FOLIAGE AND BUD FEEDERS

"CRANBERRY TIPWORM"
***Dasineura oxycoccana* (Johnson)**
Diptera: Cecidomyiidae

This tiny insect is a fly and lies within the family of gall midges, the Cecidomyiidae. It also lies within one of the most vigorous debates in cranberry cultivation over the past 100 years. Although disputed by many growers, we believe that vigorous vines very often recover from the attack of this insect and yield well the next year.

Distribution and Food Plants
The tipworm is abundant in Massachusetts, New Jersey, Maine, and Wisconsin cranberry, and it has been reported in Michigan and the Pacific coast.

Character of Injury
The larva is the damaging stage and will be found at "the very heart" of the young shoot (Smith 1903). Ultimately, the feeding kills the apical tip of the cranberry upright. The larva is a legless maggot, with black sickle-like mouthooks that are utilized to scrape at the inner surface of the succulent leaves of the bud and new leaves while salivary secretions are exuded. Over time, the tip of the upright becomes cupped, tough, lighter colored, and bunched together. Later, the damaged area turns brown and breaks off, often leaving a black stub. Howes vines are damaged to the greatest degree, with Early Blacks and Stevens following.

Early season damage results in the development of secondary lateral shoots. Extensive work has shown that in Massachusetts, under normal growing conditions, these new shoots bear the same number of berries when compared to tips that were never damaged. Under specific and uncommon stressful growing conditions, such as drought, we did see substantial impact of June to July tipworm damage in one sequence of years. On the other hand, we always see a yield impact of late-season tipworm damage (after mid-August). However, the populations are consistently very low on a normal bog (< 5%) in July through August — this is an intuitively obvious trend because the larvae are only able to survive in newly growing buds. At this writing, we have concluded that concern over late-season damage has little merit in Massachusetts. Time will tell.

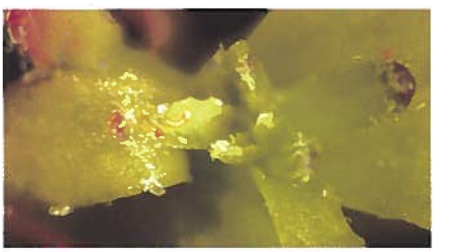
Description and Seasonal History
This species is multivoltine. The pupa is reported to overwinter on the bog floor. Adults begin to appear in early May or at first bud break. They are first seen near the bog margins. The first generation of larvae feeds mostly during the first half of May. According to Voss (1996), eggs hatch within a few hours following oviposition. There are 3 larval instars of a duration of 2, 3 and 4 days, respectively. The largest growth increment occurs in the third instar (Gagne 1989). From one to five larvae appear in each infested tip.

Pupation occurs in the injured tips. The pupal stage lasts 5 days. The total generation time is 14 days and the adults survived 4-5 days in the lab, although longevity is likely shorter in the field.

In the lab, females laid 35-40 eggs, with a daily output of 5-12 eggs/day. Females utilize a pliable and telescoping ovipositor to insert eggs among leaves within the base of the growing leaf. Depending on seasonal conditions, there may be 4 or 5 generations per year, perhaps more. A generation may take 2 to 4 weeks to complete.

Population trends are consistent, with a large peak of active larvae found in tips through late May and June. In delayed years, the peak may spread into July. Following this, the numbers crash and remain low throughout the remainder of the season, except at rare sites where there is another increase (10-20% of tips infested) in early August. Using visual inspections of a bog, it may seem that infestations occur later than they do. Over a number of years, we consistently showed that the peak of visible damage is 2 - 3 weeks later than actual infestation (determined by tip dissection).

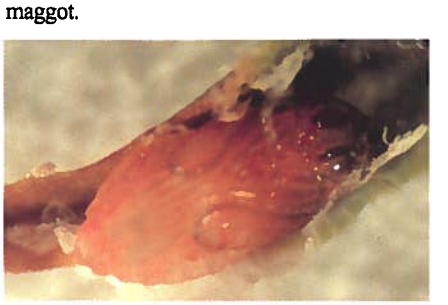

Eggs of tipworm.


Just hatched tipworm larvae.


First instar tipworm larva is a clear maggot.


Second instar tipworm larva is a white maggot.


Third instar tipworm larva is an orange maggot.


Newly formed tipworm pupa.

Tipworm pupa.

Tipworm cocoon in a webbed cupped tip.

Tipworm pupa in a webbed cupped tip.

Tips damaged by tipworm larvae with this characteristic cupping will remain on the bog for many weeks after the insects are gone.

Tipworm adult female.

The Egg
The eggs are elongate-ovoid and are translucent with scattered reddish pigment. They are about 0.36 mm (1/70") long.

The Larva
The larva is legless, tapered at both ends and is flat-cylindrical. Full grown, it becomes about 1.6 mm (1/16") long. The first instar is clear, the second is white, and the third instar is peach colored.

The Pupa
The cocoon is constructed, usually within the cupped leaf, of closely spun white silk and is a slightly flattened case and is about 1.6 mm (1/16") long. Those of the final overwintering generation are reported to be attached to fallen leaves or other trash. The pupa is tan or brown.

The Adult
The adults are delicate flies less than 1.6 mm (1/16") long and with wings expanded are less than 3 mm (<1/8") across. The male is rather dark and inconspicuous, but the female has a large bright reddish abdomen.

Management
Our work and that of Dittl (personal communication) shows sanding reduces population levels, particularly early spring levels. However, suppression typically lasted only for a few weeks.

If entire bog areas are sanded, suppression is reported to be more long-lived than when only localized areas are sanded. Franklin (1914, 1915) compared 5 sanded and 10 unsanded beds. In the year prior to sanding, average tipworm infestation was the same; in the year following, the sanded beds had a mean of 7.1% (range 3-14%) of tips damaged while the unsanded beds had a mean of 37.3% (range 15-69%) of tips damaged. In those days, a thicker layer of sand was dumped on vines. This could account for the excellent suppression of this delicate fly, as suggested by Franklin's data when compared to our modern data that show only partial, short-lived suppression.

SOUTHERN RED MITE
***Oligonychus ilicis* (McGregor)**
Acari: Tetranychidae

This species is not an insect. The mites are more closely related to spiders and ticks. In Franklin's day, mite infestations were most often noted on rather small bogs that were dry or only scantily flooded in the winter, and especially in years without much heavy rainfall in the first half of the growing season. He noted that the mite seldom attacks the same bog seriously two years in succession. Based on our observations, excepting the impact of rainfall, these generalizations no longer hold.

Southern red mite is only a problem in MA; it has been speculated that the more humid conditions in NJ beds do not favor populations there. We have seen high numbers on abandoned bogs.

Distribution and Food Plants
This mite is a pest in southern and eastern United States where it is an important pest of ericaceous and aquifoliaceous ornamentals (Mague and Streu 1980) such as holly and azalea. In MA, it often attacks sweet pepperbush severely, causing the leaves to curl and turn brown, and it sometimes appears in large numbers on sheep laurel, chokeberry, black alder or winterberry, and leatherleaf where these occur on thickly infested cranberry bogs. It has also been found on rose and camellia.

Character of Injury
The mites pierce the upper surfaces of the cranberry leaves and extract plant cells (containing the green pigment chlorophyll), leaving them roughened and as time passes, stippled with minute brownish scars. They do not affect the backs of the leaves much. A severe infestation gives the foliage a characteristic dingy-green appearance in summer and sometimes causes considerable dropping of the leaves late in the fall. Injury is almost always patchy in areas of the bed. Growers often note "bronzed" areas at harvest, after the damage is completed. It is unknown what level of impact the injury has on the growth of the berries.

Description and Seasonal History
The mites pass the winter in the egg stage on the cranberry foliage and begin hatch in mid-April to early May. The first adults of the season are found early in May (Brodel 1987), and based on Brodel's study, the mites completed the first generation on old foliage. They did not move from old foliage to new foliage until the end of June when on Early Blacks and Franklin and in July when on Howes, long after the new growth had become available (Brodel 1987).

Females lay eggs in late June and early July, from which a second generation hatches and there can be a dramatic increase in the population level. Similar to most other mites in the Tetranychidae (McGregor 1950), populations are high during late spring and summer, with severest infestations in late June, July and August. The summer eggs are laid mostly on the new growth, on both surfaces of the leaf. A precipitous decline in numbers is observed in the fall; in Brodel's study, numbers crashed in mid to late September (Brodel 1987).

Under conditions of a relatively dry and hot summer, numbers soar. As the season advances, the mites in all stages of their development and their eggs, hatched and unhatched, are found together on the cranberry leaves. An estimated 6 to 8 overlapping generations occur each season (Brodel 1987). The mites are active well into the fall until killed by cold temperatures. The overwintering eggs are laid, usually singly, on the cranberry bark and leaves.

Mague and Streu (1980) made the following observations, all on holly and all at 24°C (75°F). Egg incubation lasted a mean of 6.5 days, with a range of 2-8 days. Following eclosion, the mite passed through one active larval and 2 active nymphal stages, each followed by a period of quiescence and subsequent molt. Each of the stages lasted ca. one day. Mean time from egg deposition to adult emergence was 12.5 days, and mean life expectancy of an adult was 16.5 days. The preoviposition period in summer females was 1.2 days vs. 3.6 days in females producing diapausing eggs. Summer females oviposited for almost 15 days, laying eggs at a rate of 2.4 per day and average 36 per female lifetime. Details of the mite's life history on cranberry have not been studied, but parallels with the above work will likely be found.

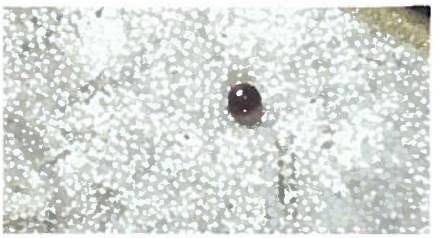
Similar to related species, males "guard" females that are in the pre-adult stage, a behavior that enhances the male's mating success. The eggs are cemented to the leaf with a gummy material produced by a female during oviposition.

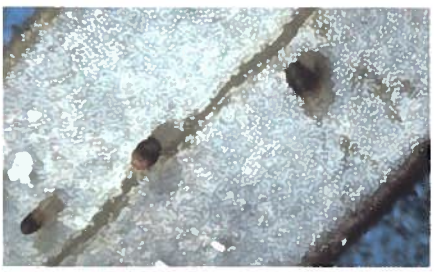
The Egg
The eggs are spherical, usually deep red, shiny, and little more than 0.7 mm (3/100") in diameter.

The Mite
The mites grow considerably after they hatch, having three pairs of legs at first (called 'larvae') but four pairs later (called 'nymphs'). They pass through a pre-adult stage that is quiescent. They are still so small when mature that a 10x lens should be used to observe them. The youngest mites appear reddish-orange and take on a reddish brown color as they near maturity. They are elliptical, and look like minute spiders. They leave their white cast exoskeletons on the backs of the cranberry leaves, and these are seen much more readily than the mites themselves.

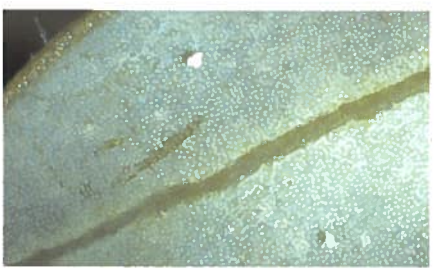
Management
Late water is an excellent management approach for southern red mite (Averill et al. 1994) and as Franklin (1950) states, "it never fails". See Appendix: Late Water p. 89. We found that populations of mites remained low in the year following the late water flood, but began to climb to high numbers by the second year following the flood.

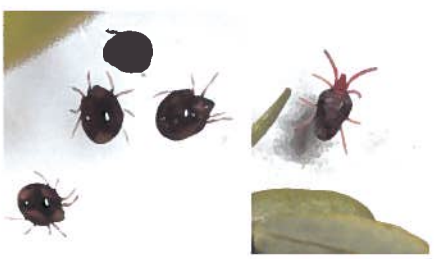
Care must be taken not to mistake other species' eggs or other species of mites when scouting for southern red mite. These are not known to be a pest on cranberry.


Southern red mite eggs are deep red.


Many stages of the southern red mite can be on any one leaf. (Photo: CES archives)

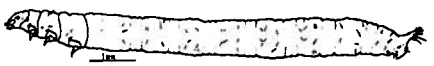

Southern red mite.


White cast exoskeletons.


Abundant "coffee bean mites" (left) and large mites (right) should not be mistaken for southern red mite.


Bronzing may result from southern red mite feeding.

Red-headed flea beetles appear in July and August.



Larva of the red-headed flea beetle. (Illus: Peters and Barton 1969)

Flea beetles have hind legs that allow them to leap when disturbed.

Red-headed flea beetle eats the tissue of the leaf underside.

The leaf areas fed on by flea beetle turn brown after a few days and damage becomes more apparent.

"RED-HEADED FLEA BEETLE"
***Systena frontalis* (F.)**
Coleoptera: Chrysomelidae

This beetle was picked up on unmanaged bogs but seldom was seen in significant numbers on cultivated Massachusetts bogs until recently. Highly patchy infestations have been found on many bogs. In New Jersey, it is also present on some bogs, particularly new bogs.

Character of Injury

Adults feed on the cranberry leaves, more on the under side than on the upper surface, eating off the tissue but leaving the veins and often the upper skin also. They also gouge the growing berries. They attack the Howes cultivar much more then the Early Blacks. In Massachusetts, we have seen dense patches of adults feeding in areas of lush cranberry growth. By marking damaged uprights in the field, we found that feeding by the adult beetles can significantly impact bud development for the following year.

The larvae reside in the soil and feed on roots. We have no information on the larval habits in Massachusetts, although to date, root damage has not been documented. The species has such an array of hosts that females may lay eggs and larvae may feed preferentially on weed species over cranberry. In Iowa corn, the larvae actually burrow into the corn roots to feed (Jacques and Peters 1971). However, Dittl (personal communication) has documented larval feeding on cranberry roots in Wisconsin.

Distribution and Food Plants

This species is found in all arable regions east of the Rockies, including the Southern States and Southern Canada. Its favorite food plants are wild bean, beggar-ticks, buttonbush, hardhack, water horehound, loosestrife, knotweed, evening primrose, redroot, sheep sorrel, lady's thumb, lamb's quarters, spotted touch-me-not, and willow herb. It also feeds on alder, swamp honeysuckle, brambles, garden beets, sugar beets, flowering fern, fireweed, sweet gale, goldenrod, gooseberry, grape, horseweed, greenbrier, iris (larger blue flag), swamp loosestrife, high bush blueberry, pear, pigweed, poison ivy, ragweed, rose, rose mallow, marsh St. John's-wort, smartweed, arrow-leaved tearthumb, trumpet-weed or joe-pye weed, willow, and winterberry or black alder.

Description and Seasonal History

There is a single generation a year. The eggs overwinter and hatch the following May. Little is known of the habits of the larvae on cranberry. They do remain in the soil. Under lab conditions and on artificial diet, three larval instars were observed and the time between eclosion from the egg and the mature larval stage was 30 days (Jacques and Peters 1971).

The beetles appear on the bogs in July and remain until after mid-September, feeding throughout this period. The beetles jump like fleas when disturbed and fly readily. Eggs are laid in August and September and are deposited just beneath the soil surface.

The Egg

The eggs are elongate-oval, about 0.8 mm (3/100") long by about 0.25 mm (1/100") wide, brownish-yellow to pale yellow, and with a finely punctate shell.

The Larva

According to Peters and Barton (1969), the mature larvae are creamy-white and cylindrical, ca. 8 mm (5/16") long, with a brownish head and small true legs. An anal proleg is present and there is a single fleshy tubercle that projects dorso-posteriorly from the anal segment. The abdomen is 9 segmented with numerous setae and inconspicuous plicae.

The Adult

They are from 3.5 to 5 mm (1/8 to 1/5") long and shiny black. The face and top of the head are usually more or less reddish. Their antennae are slender and nearly half as long as the body, the two basal segments being mostly deep brown, the next three or four mostly pale yellow, and the rest mostly brown. The thighs of the hind legs are greatly thickened as compared with those of the front legs.

"FIRE BEETLE"
***Cryptocephalus incertus* (Oliv.)**
Coleoptera: Chrysomelidae

This little beetle does not appear in cultivated bogs in either New Jersey or Massachusetts, but we commonly find it at wild and abandoned sites in Massachusetts. In Franklin's day, fire beetle was a very occasional cranberry pest in Massachusetts, becoming troublesome on small areas now and then, but disappearing from them even without treatment within a few years. For example, he noted that in a number of years it could hardly be found on any of the bogs, but in 1936 through 1939, it was widely prevalent and harmful. It infested mostly bogs that were flooded during the winter, not dry bogs.

Distribution and Food Plants
It ranges from northern Massachusetts, New Jersey, to Florida, where it is abundant. It is also distributed through New York and the Middle and Western States. Besides cranberry, high bush blueberry, black huckleberry, fetterbush, beach plum, and wax myrtle are favored food plants.

Character of Injury
Nothing is known about the feeding habits of the larvae. The beetles feed voraciously on both the upper and the under surfaces of the cranberry leaves and fray their margins. In Franklin's day, severe infestations, yielding eight to nine hundred beetles to fifty sweeps of an insect net, browned a bog much like fireworm feeding. The beetles also excavate or eat around some of the new terminal buds of the vines and so directly reduce the crop of the following year somewhat. They were found attacking severely the foliage of the Howes, Holliston, Bugle, and Aviator cultivars of cranberries, but they did not harm Early Black vines much even where these grow close to other vines that were badly infested.

Description and Seasonal History
There is a single generation each year. The egg stage overwinters. They can survive the winter cranberry flood. The eggs hatch late in May. Larvae develop through the summer. The beetles are found on the bogs from early or mid-August to very late October and are up on the vines on warm, sunny days. They feed much more in August and early September than later, when they are less active because of the lower temperatures. The beetles generally crawl slowly. They often fly freely and never jump. They mate in August and September. Some of the females lay as many as ninety-eight eggs. They are laid throughout September. The female beetles cover each egg with a rough case made of pellets of their feces that are deposited on the egg gradually as it is laid. To do this, they hold the egg and case to the tip of their abdomen and rotate them slowly with their hind legs, supporting themselves meanwhile with their two other pairs of legs. Most of the encased eggs are dropped on the bog floor, but many lodge among the vines and thus, may be swept with an insect net.

The Egg
The eggs themselves are oval, smooth, yellowish white, translucent, and about 0.6 mm (1/40") long. The cases are rough, oval, and about 1 mm (1/25") long; they are green at first but gradually turn brown as they dry.

The Larva
The larvae crawl about after hatching, bearing on their backs the dung sacs that covered the eggs. They soon disappear and may go into the soil to feed on the cranberry roots. No evidence has appeared that they do much harm in this way.

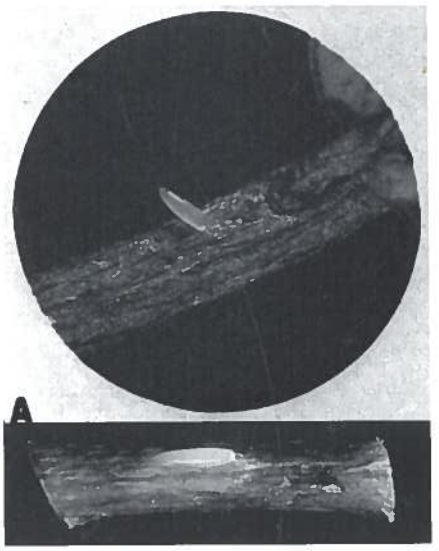
The Beetle
They are from about 2-3 mm long (1/16" to 1/8"), the smallest specimens being males and the larger ones females. They are usually seal brown, but some of the females are almost black. Both sexes usually have rather conspicuous, but irregular and poorly defined, whitish or cream-colored longitudinal stripes on the wing covers and extending forward onto the hind part of the pronotum. The legs are colored like the body. The wing covers are marked lengthwise with rows of pits. The head does not come out in front of the pronotum much, the face being very flat. The antennae are simple and slender and fully half as long as the body. The female has a noticeably shiny concavity near the tip of the venter.


Fire beetle adult.


Leaf feeding by fire beetle is similar to flea beetle, but fire beetle feeds on both sides of the leaf.

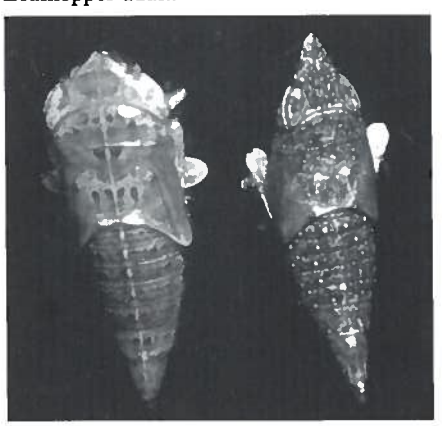
BLUNT-NOSED CRANBERRY LEAFHOPPER
Limotettix* (=*Scleroracus*) *vaccinii
(Van Duzee)
Homoptera: Cicadellidae

Very seldom seen on commercial bogs in Massachusetts, blunt-nosed cranberry leafhopper currently is a dominant species on wild and abandoned cranberry stands. In Franklin's day, on a badly infested bog from four to five hundred of these hoppers were sometimes obtained with fifty sweeps of an insect net. Historically, the insect has tremendous importance. It is a principal vector of a phytoplasma (very similar to a virus), cranberry false blossom. According to Chen (1995), there is no known cure. The disease threatened the entire cranberry industry in the early 1900's. Infected vines from Wisconsin were shipped to all of the cranberry-growing areas in North America. False blossom was most problematic in New Jersey where the cranberry industry was



Egg of blunt-nosed leafhopper on stem of cranberry. (Franklin 1950)

Leafhopper adult.



Cranberry leafhopper nymphs, *Limotettix* on left, *Scaphytopius* on right. (Franklin manuscript).

Examples of false blossom. (right photo: W. Z. Fort)

almost eliminated (Marucci and Moulter 1992).

Rare pockets of false blossom are still present in Massachusetts as we have seen it regularly (F. Caruso, personal communication) in the wild bogs on Cape Cod. Early reports of false blossom in wild vines were made in Wisconsin, where the disease is thought to have originated (Beckwith and Hutton 1929). In New Jersey, Marucci and Moulter (1992) state that the disease is "nearly extinct" now. However, when they ran a long-term experiment (1966-1978) wherein insecticides were eliminated from a commercial bog, blunt-nosed leafhoppers became established. After 12 years under a no-spray program, false blossom disease began to appear on this unsprayed bog (Marucci and Moulter 1992). More recently in New Jersey, Polavarapu (personal communication) observed occasional blunt-nosed leafhoppers in low-spray beds.

Franklin (1950) wrote that overall, this species does not move around much, and colonization of bogs occurs slowly.

Distribution and Food Plants

This hopper in nature is common in all states east of the Rocky Mountains (Beckwith and Hutton 1929). It has several acceptable food plants, all ericaceous shrubs common in swamps and around cranberry bogs (Blisard 1931). It is abundant on leatherleaf, dwarf huckleberry, and fetterbush, which seem to be favorite food plants, and less plentiful on sheep laurel. It ranges from the provinces of Nova Scotia and Quebec south to New Jersey and Maryland and west into Minnesota and Iowa. It is not found on the cranberry bogs of the Pacific Coast, and this probably accounts for the failure of false blossom to spread when introduced there.

Character of Injury

The nymphs and adults are sucking insects that utilize the plant juices of the cranberry, which is extracted with sharp piercing-sucking mouthparts. According to Beckwith and Hutton (1929), the "beak" may be inserted into tender stems or leaves, or even buds. Franklin felt that these leafhoppers drain the vines considerably when they are very abundant.

Description and Seasonal History

There is one generation a year. They undergo gradual/incomplete metamorphosis and thus, have three stages in the life cycle: egg, nymph, and adult. The egg overwinters. The eggs begin to hatch in the first half of June on Cape Cod, the exact time depending upon the progress of the season, and most of them are hatched by the 25th of the month. Scattered hatching, however, may continue into July even when the winter flood has been removed in early spring. Holding late water until May delays the entire hatch for seven to ten days. The young hoppers, called nymphs, have no wings, attaining them only when they become fully grown. The nymphs molt five times before they become mature, winged adults, a process that takes about a month.

The adult hoppers generally begin to appear early in July, the males being a week or more ahead of the females. They are most abundant in late July and early August and disappear before or at the time of the first hard frosts. When disturbed, these insects hop or fly a short distance, a meter or so, and settle down on a cranberry stem, usually with head upward. The adults do not feed on the leaves much.

The eggs are laid mostly in the last half of July and in August. They are generally thrust lengthwise under the thin bark of the more tender parts of the cranberry stems and are hard to find, but a few fail to be deposited well and remain partly exposed. They pass the winter, enduring the bog flood. Franklin noted that many of them hatched even when the winter flood was held into June.

The Egg

They are cylindrical with rounded ends, watery-whitish in color, and about 1 mm (1/25") long and 0.25 mm (1/100") wide.

The Nymph
First instar nymphs are almost transparent immediately following hatch and then become pale greenish yellow. Second instars are various shades of green from yellowish-green to a dull light green. The third instar is darker green. In the remaining two instars, they become progressively darker and vary greatly in color, some being yellow, some blackish, and some greenish-gray.

Body length of nymphs (mm)

First instar	1.0 - 1.3
Second instar	1.5 - 1.8
Third instar	2.0 - 2.4
Fourth instar	3.0 - 3.4
Fifth instar	3.4 - 4.0

The Adult
The adult has the very characteristic blunt head. They vary in color from light yellowish-gray to dark brown. The females are a bit larger than the males, reaching about 4 mm (>1/8") long.

Management
Flooding is effective. A summer flood (held until July) eliminates the crop but also kills the overwintering eggs. Such late flooding also causes higher mortality of vines infected with false blossom disease. Flooding a bog in June for 24 hours, just prior to bloom and just after egg hatch, kills the nymphs. This approach must be carried out under proper conditions and even then, there is a high risk to the vines and crop (Chen 1995).

Franklin (1950) claimed that this "checked" the insect, but that late hatching eggs would survive. These late nymphs would appear too late to flood safely.

"SHARP-NOSED LEAFHOPPER"
Scaphytopius sp.
Homoptera: Cicadellidae

Based on an unpublished manuscript and notes made by Franklin, as well as on observations made by Beckwith (1929), this species historically occurred on both Massachusetts and New Jersey bogs. We currently do not see it on commercial bogs, but we have seen large numbers of sharp-nosed leafhoppers on several wild and abandoned bogs in Massachusetts. Likely, when specimens are returned from the taxonomists, they will be one or more species of *Scaphytopius*, perhaps *S. magdalensis* (Prov.) and *S. verecundus* (Van Duzee).

Distribution and Food Plants
According to Ramsdel (1995), several species of *Scaphytopius* are found in blueberry and other plants surrounding blueberry fields, including pin cherry, black cherry, chokecherry, dewberry, wild raspberry, and blackberry. The sharp-nosed leafhopper is responsible for vectoring a mycoplasma disease that causes blueberry stunt disease. This is not a known problem in cranberry.

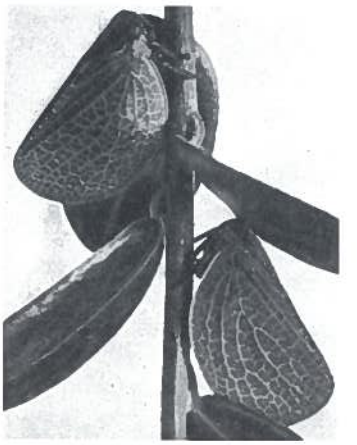
Description and Seasonal History
There are two generations a year. The eggs overwinter in the cranberry leaf. Hatch begins in mid to late May. There are five nymphal instars. Adults appear the last week in June into July. Eggs are laid and the second generation of nymphs begins to hatch the last week of July. Adults are found on vines again in late summer well into September. Females deposit overwintering eggs inside the tissues of the leaves.

The Egg
The egg is watery-whitish, fragile and elongate and cylindrical.

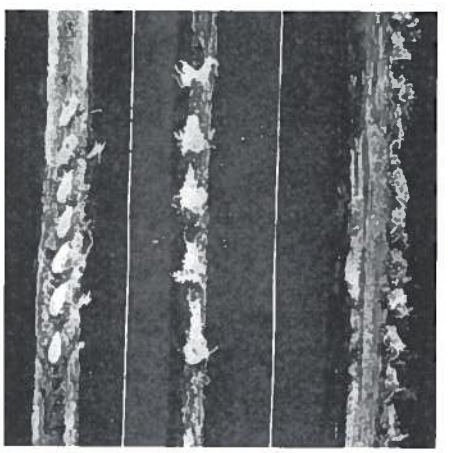
The Nymph
Nymphs are mottled brownish or brownish-black, often with a cream or white hourglass shaped marking on the back. The nymph has a sloped and pointed anterior projection of the head.

The Adult
The adults are uniformly dark brownish black and 5 mm (1/5") long.

Adults of sharp-nosed leafhopper (top) and blunt-nosed leafhopper (bottom). (Photo: W. Z. Fort)



Cranberry vinehopper adult. (Photo: Scammell 1917)



Cranberry vinehopper eggs and damage to stems from egglaying. (Photo: Scammell 1917)

"CRANBERRY VINEHOPPER"
Amphiscepa bivittata Say
Homoptera: Fulgoridae

This insect did not appear in Franklin's original work, but was included in Scammel's Farmers' Bulletin of 1917. He noted that the 'vinehopper' tended to be the "most frequently encountered of the lesser pests of the woody parts of the cranberry." The nymphs and adults suck juices from the cranberry upright.

In sweep net sampling in Massachusetts, we have found abundant vinehoppers on abandoned bogs, but not on either the wild dune bogs or commercial bogs.

Seasonal History and Description
There is a single generation each year. The egg overwinters and hatch in late June. The nymphs complete development by the end of July. Adults are present through August into September. At our

White froths of bubbles, or spit, hide the nymphs of the spittlebug from any and all.

When the spittle is removed, the nymph remains.

Spittlebugs on cranberry, showing both colors of adults.

Spittlebug adults. (Illus: Franklin 1948a)

abandoned bog study sites, the adults were most abundant in September. The eggs are deposited in slits made with a sawlike ovipositor into the woody part of the stem or in dead pieces of cranberry wood on the ground.

The adult vinehopper is green with large, sandwich-like wings. They are about 6-7 mm (1/4") long.

"CRANBERRY SPITTLE INSECT" HEATH SPITTLEBUG *Clastoptera saint-cyri* Provancher Homoptera: Cercopidae

This insect is within the group commonly called froghoppers; they are small hopping insects with a bit of resemblance to minute frogs. In Massachusetts, they are frequently observed on wild and abandoned bogs. Very occasionally, they are seen on cultivated bogs in Massachusetts and New Jersey. Franklin (1950) observed "harmful" numbers on Cape Cod bogs and reported that nymphs were so plentiful that "they thoroughly wet the shoes of one walking among infested vines." He felt that holding a winter flood limited populations (Franklin 1919) as did a late spring reflow held until June (Franklin 1950).

Distribution and Food Plants

This species ranges throughout southwestern Canada and the northeastern United States, south into Maryland and west into Minnesota.

In addition to cranberry, this insect has been reported on a number of other host plants, all in the family Ericaciae. Franklin reported populations occurring on black huckleberry, dangleberry, male berry, fetterbush, leatherleaf, late low blueberry, low sweet blueberry, and highbush blueberry. He noted that these host species grow abundantly near most cranberry bogs and provide a persistent reservoir of adults that may move into cultivated bogs.

Character of Injury

The nymphs live on the cranberry stem in a white froth of bubbles caught within a moist and sticky substance secreted from abdominal glands; thus, the nymphs have commonly been referred to as 'spittle' insects. Within the mass of froth, they suck sap with piercing-sucking mouthparts that are beaklike. The adults, which do not form froth shelters, feed and injure the vines in a similar manner.

In the past, Franklin's (1919) experiments showed that infestation could often reduce the crop materially owing to reduced bud formation and leaf drop. Vine death could also occur over time.

Description and Seasonal History

There is a single generation each year. The egg overwinters and in early seasons, nymphs begin to appear before the end of May and in later seasons, nymphs may not be observed until mid-June. Nymphs complete development in early July. Franklin noted that the species is remarkably free of parasitoids and predators, and suggested that the spittle may serve as an effective protection.

According to Franklin (1950), color polymorphism existed within the adult population, based on sex. He noted that males were smaller than females and were blackish. Females varied greatly in markings, but the majority of them were black with light yellow stripes. Only a few females were all dark-colored like the males. Both sexes had legs that were mostly yellow. He found that adults began to appear on the bogs in early July and remained into August.

More recently, in sweep surveys that we conducted on several of the dune bogs on Cape Cod and two abandoned bogs in Mattapoisett, we observed large numbers of adults. Initially, in early July, we picked up the all-black type with the posterior portion of the wing brownish-transparent. About a week later, sweeps picked up large numbers of adults that were black with strong yellow marking. Peak numbers of the black type were observed in mid-July and of the yellow-marked type about a week later. The latter type tended to be more abundant

later in the season. We need to return to these samples to verify whether sex was linked with color type.

A reading of Doering's (1928) treatment of the genus *Clastoptera* indicates that there is considerable confusion regarding the taxonomy of this group. She separates *C. saint-cyri* into two "varieties," one that is yellow and black-striped (*C. saint-cyri* var. *saint-cyri*), and a second one that is all black above with a brownish-hyaline apex (*C. saint-cyri* var. *anceps*). She noted that males and females of both varieties were simultaneously collected while sweeping low vegetation.

The adults are good jumpers and fly readily when disturbed. The female inserts eggs under the bark of the host plant, usually singly at each site along the upright.

The Egg
The eggs are whitish and about 0.8 mm (1/32") long. The egg is rounded at one end and pointed at the other.

The Nymph
Early instar nymphs are whitish and can be easily removed from the mass of spittle that surrounds them. Later instars have legs, head, and most of the thorax various shades of brown and the abdomen mostly yellowish-white.

The Adult
The adults are glossy and have yellow legs. The body may be black with yellow stripes or entirely black. While it is likely that the former color type is largely females and the latter is largely males, as suggested by Franklin (1950), additional work is required to eliminate the possibility that these are actually taxonomically distinct groups (see discussion above).

The body size ranges from 3-4 mm (1/8 - 1/6") long.

Management
Flooding for 24 hours as soon as the first blossoms open will kill the nymphs, and effectively clears a bog completely for 2 to 3 years.

"CRANBERRY SCALE"
Aspidaspis oxycoccus (Woglum)
Homoptera: Diaspididae

Franklin reported the appearance of three species of scale insects: oystershell scales (*Lepidosaphes ulmi* L.), dearness scale (*Rhizaspidiotus dearnessi* (Ckll.) and cranberry scale. While dearness scale has been reported on Wisconsin cranberry (Jackson and Koval 1977), we have only heard of cranberry scale occurring in the Northeast recently. Historically, cranberry scale was the "only scale insect of really great importance on Massachusetts cranberry" (Franklin 1952).

Scale insects are highly modified from the ordinary insect form, having degenerate eyes, antennae, and appendages. The scale insects listed above produce a secretion over the body.

Character of Injury
Scales suck plant juices from the vine. Franklin (1950) described high populations of adult scales forming a crust on the cranberry stem and resulting in patches of dead vines. When males occurred in high numbers, they were observed to settle on cranberry leaves, causing vine stunting and reddened foliage. Females tend to prefer cranberry stems. Scales were also observed to settle on green cranberries, resulting in deformed berries or fruit with deep red spots.

According to Marucci (1995), in the 1950's, after a series of mild winters, severe infestations of cranberry scale were observed in both MA and NJ. Vine death occurred in large areas within a short interval. The infestations of cranberry scale were not readily observed owing to the insect's tendency to prefer the large woody stems close to the ground. Only a small portion of the total population was found feeding on the foliage. Franklin (1952) reported that highest populations are often along bog ditches.

Seasonal History and Description
There is one generation a year. The nearly mature insects overwinter under the scale covering. The female scale is

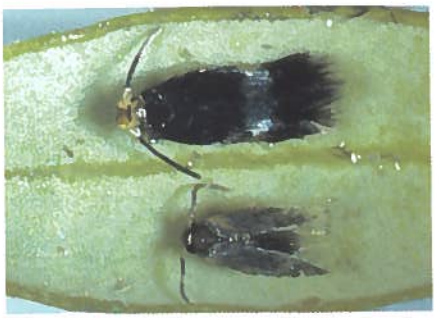

Scale insect on leaves. The scales prefer to settle on the stem. (Photo: W. Z. Fort)


Scale insect close-up. (Photo: W. Z. Fort)


Scale insects encrusting a stem. (Photo: Franklin 1952)

roundish oval and dark yellow. The scale covering is about the size of a pinhead and is roundish-oval and dark brown. Many are loosely attached and brush off easily, leaving characteristic white scars on the cranberry stems and reveal the soft and legless insect underneath. The male scales are much smaller than the females and are mostly oblong and dark brown. Eggs are produced largely during the last three weeks of June. From 25-90 eggs are formed and are yellow, oblong oval and microscopic. Predominantly in the last half of June and into July, the young hatch. They are mobile and leave the protective covering of the female's scale and relocate by crawling. Each settles and inserts its beaklike mouthparts into the upright and begins feeding on sap. Once settled, it stays in place.

Management
In the past, the summer flood (holding a flood until mid-July) was very effective (Franklin 1950).



Adult leafminer moths; Serpentine leafminer above and *Coptodisca* leafminer below.

Leaves with *Coptodisca* leafminer damage.

The *Coptodisca* leafminer larva constructs a case by silking together the upper and lower leaf surfaces. It then pupates inside and the case falls from the leaf.

Close-up of the leaf case; they may be picked up in sweep sets.

"COPTODISCA LEAFMINER"
***Coptodisca negligens* Braun**
Lepidoptera: Heliozelidae

This species does not appear in Franklin's bulletins. *Coptodisca* leafminers were reported from Wisconsin in the 1930's with small outbreaks in the Wisconsin Rapids area in the 1960's (Boush and Anderson 1967). It is now found in increasing numbers in Massachusetts and Connecticut cranberry (Maier 1988). Such outbreaks of other species of leafminers have been reported in other crops, such as apples. There is little doubt (in our minds) that leafminers are a secondary, or induced, pest. Outbreaks occur because the leafminers have become resistant to insecticides (applied for other insects) and/or their natural enemy populations have been eliminated by broad-spectrum sprays.

Much of the information utilized in the description below is derived from Maier (1988).

Seasonal History and Description

There is one generation per year. Nine months are spent as an egg, which is the overwintering stage. By fall, egg laying sites can be noted as elevated red tissue and oviposition scars on the bottom of leaves. In the following spring, the larvae feed inside the cranberry leaf. Only one larva survives in most infested leaves, even when up to five eggs are laid in a single leaf. When mining larvae met, one larva killed the other. The larval stage required about 3 months.

It undergoes five instars, but feeds only in the first four. In June, the fourth instar completes feeding. The fifth instar is actually a pre-pupa, owing to its lack of feeding. It constructs an elliptical case from the upper and lower part of the leaf, sewing the edges together with silk (except for an emergence slit). These cases are about 3.5 mm (1/8") long. Oval holes (constituting about 1/5 of the total leaf area) are left in the cranberry leaf.

Pupation occurs in mid-June to early July. Moths begin to emerge in late June with peak emergence occurring during full bloom in the first 2 to 3 weeks of July.

Injured leaves tend to turn brown in the area around the hole and drop off the vine. Numerous leaves with single oblong holes in them may be picked up during early spring sweeping. Work has not been carried out to determine if leafminers reduce yield in cranberry. Maier's (1989) study showed that second-year leaves abscise more often and earlier when damaged by *Coptodisca* larvae. *Coptodisca* damage in some shrubs around the bog, such as leatherleaf and sheep laurel, may be noted.

The Egg

Yellowish eggs are laid singly within young leaves by piercing the underside of the leaf.

The Larva

The larvae are legless and light-brown. They measure 3.0 x 0.5 mm (1/8 x 1/50") when full grown.

The Pupa

The pupa is dark mahogany brown and is 2.5 mm x 0.75 mm (1/10 x 1/32").

The Moth

The adult is a minute moth 3.5 mm (1/7 - 1/8" long) with light gray scales and a fringing at the base of the wings.

"SERPENTINE LEAFMINER"
***Stigmella* (?) sp.**
Lepidoptera: Nepticulidae

This insect had not been previously recorded in commercial cranberry and does not appear in Franklin (1948a). It has not been identified to species. It is a minute member of the moth family and is often overlooked because of its small size. It is a very rapid flyer and can be seen darting over the leaves. In high populations, the moths can be seen scurrying over the surface of the leaves in large numbers. As noted for *Coptodisca* leafminer, there is little doubt that the pest status of this insect has been induced by broad-spectrum insecticide sprays. The seasonal history has not been determined.

The Egg
The females lay single eggs on the underside of the leaf that are clear at the outset and become increasingly dark brown.

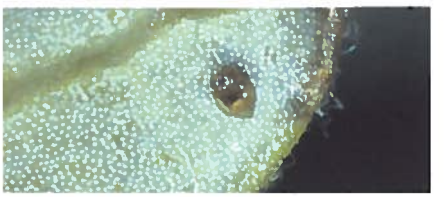
The Larva
As the larva hatches, it tunnels within the leaf, creating a distinct mine. The serpentine mine can be seen, beginning at the point of egglaying and around the extreme periphery of the leaf. The mine is brown and may turn reddish, and can be difficult to discern.

In cases of high populations in cranberry, multiple eggs are laid on a single leaf and larval mines coalesce and the surface of the leaf becomes completely brown.

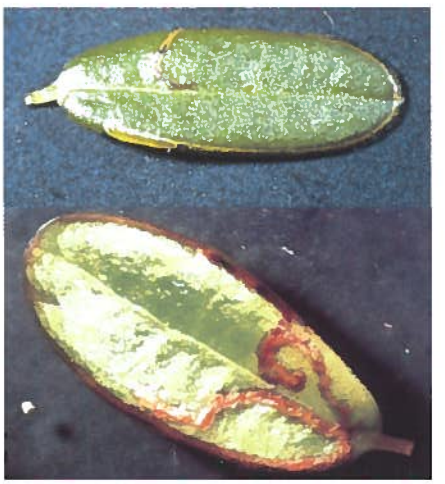
The Moth
This species is black with a distinct silver stripe near the base of its wings.

SPRINGTAIL
Species within the order Collembola

These minute insects much resemble the common snow flea to which they are related. Most of them are green or brown, and they spring briskly by means of a forked tail-like organ. An insect net often sweeps great numbers of them from the vines, especially in late spring and early summer and on bogs not flooded during the growing season. They are not known to be harmful.



Serpentine leafminer egg.

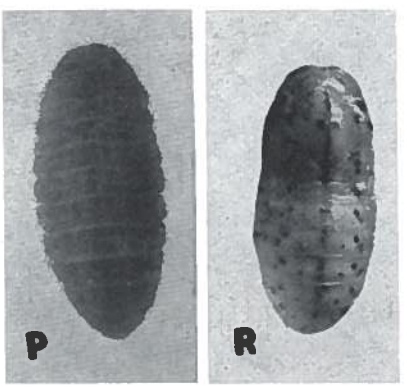


Mines of serpentine leafminer.

Completed serpentine leafminer mine with pupa in the upper center.

Springtails can be remarkably abundant in sweep nets in the spring. They are <u>not</u> believed to be a pest on cranberry.

The bog copper. (Illus: Franklin 1948a)



The bog copper, mature larva on left and pupa on right. (Photo: Franklin 1948a)

"BOG COPPER"
***Lycaena epixanthe* (B. & L.)**
Lepidoptera: Lycaenidae

This is very small butterfly and is the only species of butterfly known to utilize cranberry as a host plant. It is found in cranberry bogs throughout northeastern North America. We see it on the dune bogs of Massachusetts and it has been reported on the bogs of the pine barrens in New Jersey. Regarding the latter area, Ehrlich (1984) wrote that he saw densities of tens of thousands of butterflies per hectare (=2.4 acres) when he visited sites. This species is an example of a true specialist: many aspects of the bog copper's life history are finely-tuned for survival in a bog habitat on cranberry.

Most of the information contained below is derived from a lengthy publication by Wright (1983).

Distribution and Food Plants

This is a Nearctic species, restricted to acid bogs from Nova Scotia to Newfoundland, Manitoba and southwards to New Jersey, Pennsylvania, and West Virginia and westward to Ohio, Minnesota and Wisconsin. *Vaccinium macrocarpon* and the small cranberry, *V. oxycoccus*, are the only known host plants.

Description and Seasonal History

There is a single generation each year. The egg overwinters. In NJ, Wright observed egg hatch from 16 April to 27 April. There were four larval instars and on average, larval development is completed in ca. 40 days. First and second instar larvae eat holes into the underside of old leaves. The larvae are entirely concealed, but can be found by cueing in on the brown blotches that appear on the upper surface of the leaf when the larva chews out the lower surface. Third and fourth instar larvae feed in an exposed manner on the tender new growth as the shoots develop, but are still difficult to detect owing to their cryptic coloration. During the pre-pupal stage, the full-grown larva, which reaches a length of 15 mm (5/8"), contracts to 9 mm (<3/8"). Pupation occurs on the underside of leaves low in the vine canopy. In Wright's (1983) study of a NJ population, the pupal stage lasted 13 days. The total period of development, from egg hatch to adult emergence, ranged from 52-60 days, with an average of 54 days.

Emergence of adults coincides with the beginning of cranberry bloom and lasts for about four weeks in June and July. In the pine barrens in 1981, Wright (1983) recorded onset of flight on 12 June and observed the last individual on 10 July. In a study of bogs on Cape Cod, MA Franklin (1907) observed the butterfly in great numbers during late June and July.

The butterflies are weak fliers and are seldom seen far from cranberry. Cranberry blossoms are their major nectar source. Courtship and mating take place on the bog. Males perch and then fly out to investigate passing butterflies, resulting in spiral encounters of upward flight. Most mating occurs from noon to 2 PM. Females prefer oviposition sites near the margin of the bog where the cranberry plants are hidden by sedges or in hummock areas in the bog's center. They walk to the lower portions of the bog canopy and tend to be well hidden when they lay single eggs on the cranberry leaf undersurface near the tip of new growth. Females have been observed to lay 20-40 eggs in a lifetime (Wright 1983, Cook and Watson 1908).

Desiccation of the egg may be a critical source of egg mortality. However, characteristics of the cranberry leaf, the sites within the bog where eggs are placed, and the design of the egg itself may all serve to diminish this problem. Wright (1983) observed that the cranberry leaf tends to trap water on its lower surface and that desiccation would be low within the cool and moist environment near the bog floor, which typically is covered with a sphagnum moss carpet. The egg possesses a thick chorion and appears impermeable, suggesting that water loss could be minimized a good deal.

Many bogs are flooded for lengthy periods during the egg stage of the bog copper and many observers have noted that the eggs can withstand submergence.

Wright (1983, p. 75) asserted that the "highly convoluted chorion [of the egg] encloses a labyrinth of continuous airspace which covers almost the entire egg.... providing a constant gas film" that likely serves as a physical gill allowing gas exchange when the egg is underwater.

The Egg

The eggs are dome-shaped, resembling sea-urchins, and are somewhat sunken in the middle of the upper surface. The surface is covered with a network of depressed pits, which under magnification is configured in a honeycomb. At first, eggs are pure white but become duller over a few days. Average width is 0.75 mm (1/34") and height is 0.48 mm (1/50").

The Larva

The larva appears slug-like and possesses three pairs of thoracic legs, four pairs of abdominal prolegs and a pair of anal prolegs. The head is capable of retracting into the prothorax. First and second instars are green with a red stripe running along the back. Wright asserted that this coloration was cryptic; the young larvae blended with the green leaves and red stems of the cranberry plant. The third instar has a less conspicuous dorsal red stripe, while the fourth instar is solid green. The body surface (integument) of the first instar is largely flat and possesses conspicuous long hairs scattered evenly and in relatively small numbers over the body. The integument of later instars is very different and the surface "is now highly sculptured...into a pattern of uniformly spaced oval depressions" (Wright, 1983, p. 67). The later instars also appear hairy in comparison to the first instar.

The Pupa

The typical pupa is green with black speckles, a few are a solid dark purple without markings. There is no pupal covering. From a side view, they continue to maintain somewhat of the "slug-like" body shape but appear to have a double hump. They average 8.5 mm (1/3") in length.

The Butterfly

The upper wings of the male are dark brown with a blue-purple iridescent gloss. Often, they have bright orange margins on the wings. The female is duller colored with gray to grayish-white upper wings. The underside of the wings is either white, creamy yellow or yellowish, depending upon population; many reports indicate that there is much variation from site to site, but that there often is considerable uniformity within any single site. Wright (1983) found that over six years, his study population was consistently polymorphic. There was a low frequency (5%) of individuals having gray on the wing underside with the huge majority possessing a yellow underside. The wingspan is 17-22 mm (7/8").

Average body length, width of head capsule, and duration of the immature stages of the bog copper.

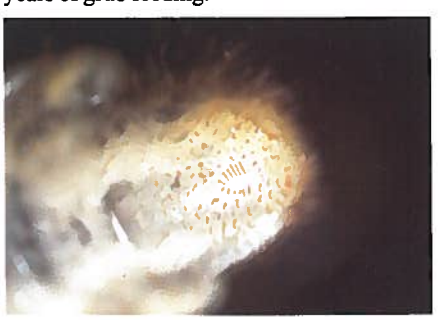
Instar	Body length (mm)	Head capsule width (mm)	Duration (days)
1st	2.5	0.27	11
2nd	5.0	0.39	9
3rd	8.0	0.63	7
4th	15.0	1.05	14
pre-pupa	9.0	1.05	—

SOIL INSECTS

C-shaped scarab grub larvae, *Hoplia modesta* (left) and cranberry white grub (right).

Dead areas of vine may appear in spring, summer, or fall depending on the species of grub that is actively feeding at the time.

Bare spots appear following several years of grub feeding.



Japanese beetle grub rastral pattern. At this point, there is no evidence that this is a cranberry pest. Adults are found along dikes and an occasional grub is found in the bogs weedy areas.

A number of immature insects (all in the beetle or moth orders) that feed on the underground stem portions and roots of cranberry are a major problem in cultivated cranberry. After a hiatus of about three decades, owing to now-banned insecticide applications, there is a resurgence in the abundance and variety of soil insect problems. Four species of scarab beetle grubs feed on the fine roots and will often feed so extensively that the vine may be easily lifted with the surface soil like a roll of commercial turf. In an infestation of scarab grubs, the larvae will be readily apparent, lying on the soil surface in the area where the vine was peeled back. The larval feeding causes the vine growth to be short and spindly and areas of vine finally die in severe cases, leaving patches of bog bare or weedy. It is more difficult to spot some of the other soil species such as small larvae of striped colaspis or the root weevils. It is very difficult to detect cranberry girdler larvae.

Sampling for soil insects destroys the vines. However, these larvae are often exceedingly patchy. Sampling may need to be extensive to confirm degree and type of infestation. In the area of suspected infestation, five to ten plots, that are at least 30 cm x 30 cm (1' x 1') squares, should be inspected in the dieback area and into the healthy vine near the affected vines. At the points in the season when scarab grubs are actively feeding, the larvae will be seen in the soil within 5 - 10 cm (2 - 4") below the surface, in the area just below the main body of the roots. This depth may vary with soil moisture, time of year, and temperature. Inspection for pruning of the fibrous roots should be carried out while sampling for the larvae.

There is value in accurate identification of the actual species in an infestation. The management programs vary greatly.

SCARAB GRUBS
Coleoptera: Scarabaeidae

The adults of these species are rather large beetles (between 7 and 23 mm; between 1/4 and 9/10"), and excepting cranberry root grub adults, they have tough (elytra) wing covers. We have not found this group of scarab grubs in wild or unmanaged cranberry beds to date.

These species feed on the roots of the cranberry plant in the larval stages, which may severely damage the health of the vines. The larvae are white or dingy-colored C-shaped grubs with brown head capsules; they are often lumped together and called "white grubs." Infested plantings may be weakened and not show overt evidence of damage until a period of drought stress or application of some herbicides. As the vines die, an area first shows a dark orange coloring followed by appearance of dead patches that are overrun by weeds. As the infestation progress, it tends to radiate outward from the area of dead vines.

Earlier in the century, the grubs were controlled using either summer flooding or effective chemical treatments that were cancelled and are now illegal to use. Then in 1955, cheap, very long-lasting, and effective compounds were introduced (dieldrin, aldrin) for control and infestations became minor (Tomlinson 1982). Registration of these compounds was revoked in the 1970's. However, even by 1982, scarab grubs and soil insects in general had not reappeared, perhaps owing to the residues in the bog soil and the time required for the species to recolonize the bogs. We have seen a resurgence of scarab grubs in cranberry since the latter half of the 1980's.

In New Jersey, oriental beetle and cranberry white grub are the two scarab species that have been observed. In Massachusetts, in addition to these two species, cranberry root grub and *Hoplia modesta* are also common.

In a two-year survey in Massachusetts (Dunn and Averill 1996), we examined 33 cranberry beds with grub infestations. Half of the beds had more than one species of scarab grub. Of the scarab group, we found that cranberry root grub and cranberry white grub were the most common. Two previously unreported species were found to be common: *Hoplia modesta* was found at a third of the sites and oriental beetle at 12% of sites. Only three Japanese beetle grubs were found, and always in weedy areas. A single large infestation of Japanese beetle on a cranberry bog was confirmed in late 1996, but no larvae could be found in the following spring. The grower held a fall flood (a technique detailed under cranberry girdler) but this may not have been the agent responsible for observed grub mortality. At this point, although Japanese beetle adults are frequently seen flying on and around bogs, the grubs are not considered a cranberry pest.

Oriental beetle and *Hoplia modesta* were found in higher average densities (occasionally over 50 grubs/plot) than cranberry white grub and cranberry root grub. The average number of grubs per 30 x 30 cm (1 x 1 ft) samples of infested bog soil was 17 *Hoplia modesta*, 12 oriental beetle, 6.5 cranberry root grub, and 2 cranberry white grub.

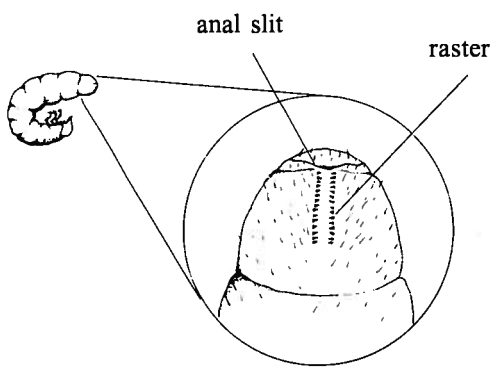
All of the species were found in soil samples in the grassy areas taken near the infested bog. This suggests that bogs that are renovated to eliminate grub infestations may have a constant threat of reinvasion from off-bog sites. This is particularly true of oriental beetle.

Cranberry root grub can be easily distinguished from the three other species. Cranberry root grubs are usually about 25 mm (1") long when full grown and are covered with reddish-brown hairs. The grub body appears slightly compressed from top to bottom and each tarsus (foot) has a claw on the end. In comparison to cranberry root grub, the other species appear white, are not covered with hair, and have fairly rounded, cylindrical bodies. Further, the end of the cranberry white grub tarsus looks like a "paw," and does not have the distinctive sharp sickle claw of the cranberry root grub.

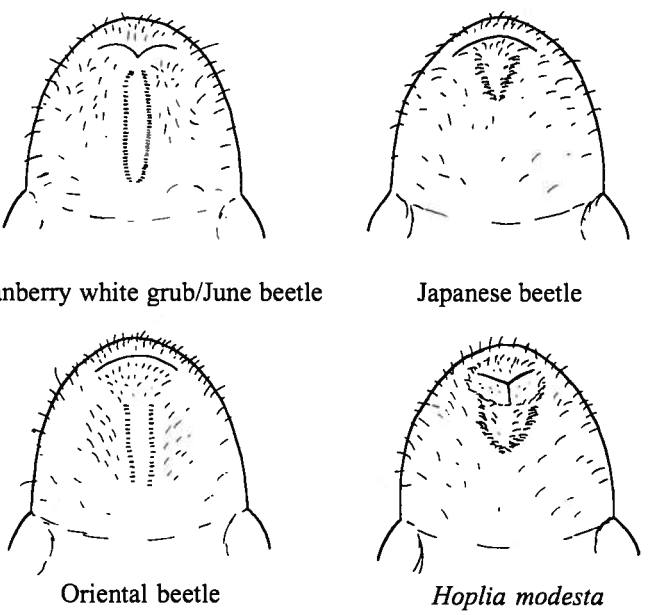
Larvae of cranberry white grub, oriental beetle, and *Hoplia modesta* are identified specifically by the pattern of stiff hairs and spines (rastral pattern) found on the undersurface of the last abdominal segment and the appearance of the anal slit.

Grub species	Rastral pattern Anal slit
White grub	2 parallel rows V- or Y- shaped
oriental beetle	2 parallel rows Transverse
Hoplia modesta	V-shaped Long-armed Y-shaped
Japanese beetle	V-shaped Transverse

When the third instar of these scarab species has completed development, the larva moves downward in the soil and forms a cell in the soil by moving its body back and forth, compressing and smoothing the earth of the cell wall. Within the cell, the larva becomes a pre-pupa, which is a pale, soggy stage that does not move. Pupal formation follows.



The raster is located on the bottom side of the scarab grub's last segment. Because the larvae of the different grub species appear so similar, the raster is used in identification.



Cranberry white grub/June beetle

Japanese beetle

Oriental beetle

Hoplia modesta

Descriptions of rastral pattern and anal slit. As an example, the stiff hairs on the end of a *Hoplia modesta* grub are in a "V" arrangement and the anal slit is Y-shaped. For observation, a 10x magnifier will be necessary as well as good illumination. The rastral pattern of the Japanese beetle is included because grubs are sometimes found in small numbers in bogs, invariably in weedy areas. [Illustration: Garnett (left) and Albright (right)]

Second and third instar cranberry root grub larvae.

Cranberry root grub larvae are flatter and hairier than all other grub species.

The cranberry root grub adult beetle flies on the bog during bloom in June and July and is often mistaken for a bumble bee. The males fly rapidly, close to the vine canopy, and also along areas adjacent to bogs.

Female cranberry root grub adult beetle on left, male on right.

"CRANBERRY ROOT GRUB"
Lichnanthe vulpina Hentz
Coleoptera: Scarabaeidae

Currently, cranberry root grub is found on a number of bogs and is one of the most difficult pests in Massachusetts cranberry. It is not reported in New Jersey. The root grub was first found to have damaged cranberry bogs as early as 1911, and it had become a considerable pest by 1917. In Franklin's day, this grub was the "Number 1 insect pest" (Beattie 1948) or just behind cranberry fruitworm as the worst cranberry pest in southeastern New England (Franklin 1948b). A 1945 survey showed that 42% of the acreage in MA was infested. A cranberry root grub control "campaign" was initiated in 1946 to acquaint 85 enrolled growers with proper control measures (Beattie 1948).

Distribution and Food Plants

This insect has been collected in sandy areas near rivers. It is widely distributed in the northeastern part of the United States, Maine to North Carolina. We have found larvae feeding on grasses adjacent to a cranberry bog, and on abandoned cranberry bogs where no cranberry remained. Thus, reports that the larvae are cranberry specialists (Franklin 1950) are not confirmed.

Seasonal History and Description

The larvae overwinter. There are three larval instars. According to Franklin (1950), some of the grubs live in the soil four years, some five, depending on food availability.

The mature grubs form prepupae before the middle of May. Within a few inches of the surface, the larva becomes soft, white, and apparently lifeless, their internal organs breaking down into a creamy consistency. Pupation takes place mostly early in June. Root grub pupae do not move any part of their body, even when severely disturbed.

Adults normally emerge in middle or late June and activity can be seen until the second or third week of July. They spend most of their time in the soil and emerge synchronously for short intervals, and only on certain mornings, to mate. The adults, particularly males, tend to hover over the ground surface when they fly and because of their yellowish hair, may resemble bees. They never eat the cranberry foliage or fruit. The females come to the surface and rest on vines or weeds; they are very seldom observed to fly. As a result, infestations appear to spread slowly.

Within a day, the beetles become active just after sunrise at 5:30 AM until 7:30 AM and peak beetle activity occurs between 6:00 AM and 10:00 AM (O'Donnell 1996). The males fly freely over the bog and adjacent grassy areas and bog roads. Our data suggest that the adults tend to fly under conditions of low saturation deficit, meaning that the air has low drying power. Consistent with this observation, Franklin (1950) noted that large flights occur only in clear weather after a cool night with heavy dew, and all of the beetles generally return into the soil before noon.

When the females come out of the ground, they tend to be found rapidly by males. Females produce a sex pheromone, which is in the final stages of identification (P.S. Robbins, unpublished data). Males are highly active fliers, probably searching for sedentary, pheromone-releasing females. O'Donnell (1996) reported that males exhibited meandering flights that evolved into a tighter and tighter zig-zag pattern as they approached a calling female within the cranberry vines. Males drop to the vegetation close to the female and crawl to her. Franklin (1950) observed that one male will mate with several females and often several times with the same female. Grubs or beetles taken from the soil rebury themselves at once.

O'Donnell (1996) also observed adults feeding on the pollen of meadow sweet (*Spirea latifolia*), a weed species found in and around cranberry bogs in Massachusetts. This is inconsistent with other reports that adults never feed (Franklin 1950). Mating pairs were frequently observed on the flowers. We have not observed the beetles feeding on other flowers or on cranberry pollen.

The eggs are scattered singly through the soil to a depth of about 7.5 cm (3"). They hatch in July and early August.

The grubs of all sizes, from about 6 mm (1/4") long up to 25 cm (1") or a little over, are usually found together in the cranberry soil. The various sizes are the larval populations that were established in different years. They feed on roots mostly within 8-10 cm (3-4") of the surface in the spring and early summer, but as the bog becomes drier with the advance of the season, they go deeper and many may be found 10-25 cm (4-10") down in late July and August. They are then below the main body of the cranberry roots on most bogs, a few even being in the peat under the sand. They do not approach the surface again until the bog is wet. Probably, therefore, they feed on the cranberry roots more during the early part of the growing season than at other times.

Franklin (1950) found over twenty of these larvae to a square foot in the soil in bad infestations. We also found that populations of larvae can be high in infested areas. O'Donnell (1996) surveyed larval density at eight infested cranberry beds. The larvae were aggregated, with numbers ranging from 20 larvae in a 30 x 30 cm plot (1 square ft) to 4 larvae in a similar size plot that was only 5 meters (16.4') distant.

The Egg

The eggs are nearly spherical, whitish, rather soft, and are about 2.3 mm (1/11") in diameter.

The Larva

The full-grown grub is a little more than 25 mm (1") in length. The head is deep reddish-brown, with considerable reddish hair. The tips of the jaws are black. Body dirty whitish and much flattened dorso-ventrally, with hind part of abdomen often appearing dark because of its contents. Body is without spines and clothed moderately all over with fine and mostly short reddish or brown hair, that along the sides longer than that on the back and venter and tending to be in tufts. Front of head flattened and much pitted. Clypeus nearly flat and roughly punctate except along its front margin. Labrum shorter than the clypeus, its front margin arcuate. Antennae not nearly reaching the tips of the jaws; the third segment rather bushy with hairs; the last segment vestigial, less than a third as long as the one next to it. Jaws stubby, with prominent grinding teeth toward the base and with a reduced cutting blade. The legs always held pointing strongly forward, never sprawled, the first segment extending beyond the attachment of the second and about as long as the third; each tarsus with a well-developed, moderately curved, sharp-pointed, dark-tipped claw. The last dorsal abdominal segment relatively long and with a broadly arcuate hind margin.

The Pupa

Pupae are about 14-17 mm (2/3") long, dirty whitish, rough, and without hair or spines; have ocular areas with eye pigment; hind corners of pronotum drawn out into very noticeable pointed extensions or epaulets; hind margins of dorsal abdominal segments two to five, inclusive, strongly elevated. The pupa does not move any part of the body.

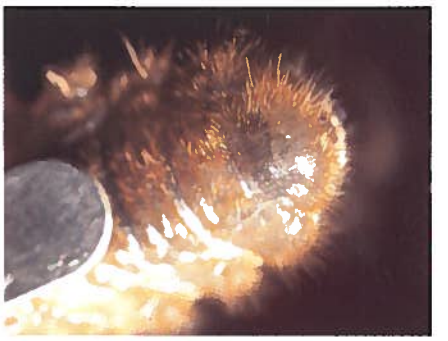
The Beetle

The beetles of both sexes are 13 - 16 mm (1/2 - 5/8") long, mostly blackish with wings and wing covers brown and tip of abdomen reddish; males with a coat of fox-red hair; females with a shorter and thinner hairy covering of lemon yellow; wing covers not nearly reaching the end of the abdomen, narrowed gradually caudad with tips well separated when at rest, finely punctate, and clothed thinly with many short hairs; antennae nearly as long as the head, the last three segments of each being flat plates and together forming an oblong knob.

Management

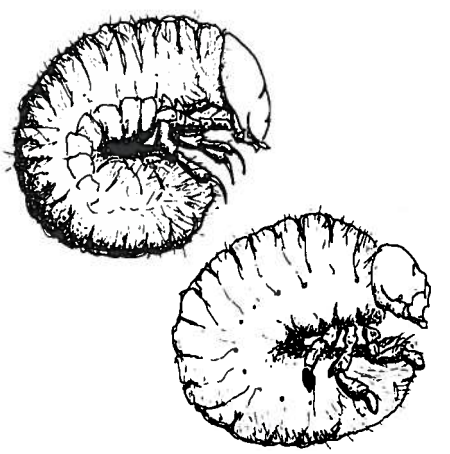
The cranberry root grubs tolerate much flooding, probably because they are a wetland species. The hairs on the grub's body may trap air bubbles or serve in other ways that allow survival when submerged.

A summer flood is effective for cranberry white grub and cranberry root grub. Franklin (1950) recommended this procedure: The winter flood is removed early (early to mid-March) and the bog allowed to dry out, with ditches empty until ca. mid-May. Completely reflood mid-May and keep well flooded until mid-July. This treatment usually kills 90% of cranberry root grubs and always destroys the crop for that year. Retreatment must be done in 5-10 years. Franklin maintained that yield in the year following a summer flood was good, but recent reports have not been so encouraging. See Appendix: Flooding Management, p. 87 for more on summer flood.



Underside of cranberry root grub showing that it has no specific pattern of hairs.

Greatly magnified cranberry root grub eggs.



Compare the sickle-shape claws on the legs of cranberry root grub (above) with the "paw" shape of the legs of cranberry white grub (below). (Illustration: Garnett)

Cranberry white grub adult beetle. These beetles are commonly called "June beetles" or "June bugs".

Cranberry white grubs form a cell inside the soil when preparing to pupate.

Large cranberry white grub.

Large cranberry white grub.

"CRANBERRY WHITE GRUB" "COMMON JUNE BEETLE"

***Phyllophaga anxia* LeConte**

Coleoptera: Scarabaeidae

Larvae of the cranberry white grub are often found in high areas, especially those near bog margins, but can be found throughout a bed. They are often found scattered among other scarab grub infestations (Dunn and Averill 1996). These C-shaped white grubs are the largest of all the soil insects and are over 35 mm (1 3/8") long when full grown. The adults of the white grub are called May beetles or more commonly, June bugs. The large adult beetle is reddish brown without marking, and is nocturnal. The beetles you see near your lights at night may or may not originate from cranberry. Several different species of beetles look so similar that they must be identified by examination of features of their genitalia.

Distribution and Food Plants

In the genus *Phyllophaga*, which contains many pest species, cranberry white grub is generally the most widespread, found throughout North America. It is highly injurious to other crops, such as turf (Tashiro 1987), potatoes, corn, and can be troublesome in blueberry (Franklin 1950). According to Hammond (1948), the grubs are polyphagous. He reported that the limiting factor to the total destruction of any plant was size and toughness of the roots. Franklin (1950) recorded alder, elm, peach, and willow as favored host plants of the larvae and said that the grubs generally abound in the soil of the uplands around Massachusetts.

The adult beetles feed on various food plants, but they have never been reported feeding on cranberry. A lengthy host plant list is contained in Hammond (1948) of the adult beetle. Favored host plants include American elm, all species of oak, large-toothed poplar, common lilac (petals), rose, white ash, aspen, butternut, apple (petals), and raspberry.

Character of Injury

These grubs are monstrous feeders, doing individually more harm than any other kind of grub that attacks cranberry roots in Massachusetts. They also seem to travel around in the soil more than the other grubs, except possibly the cranberry root grub, and so damage greater areas of vines than their numbers seem to justify. Hammond (1948) observed the larvae feeding gregariously on fibrous-rooted plants. In a survey in eastern Canada, he found that a key characteristic of infested areas was a relatively light soil (sandy loam) that was well drained.

Only the grub stage has a pest status. The adult beetles have not been reported to feed on cranberry foliage.

Description and Seasonal History

These grubs have a three-year life cycle. They will be found overwintering as a larva or an adult depending on the point in their life cycle.

They lay their eggs mostly in June. Hammond (1948) reported that they hatch in about 30 days. He also reported that the first instar molts to a second instar within 6-8 weeks. The second instar burrows into the soil to overwinter. The larvae do the worst damage to the roots in the second year of development, as second and third instars. As the soil warms in the spring, the second instar larvae migrate upward and feed until late July, at which time they molt to third instars. After feeding for some time, they will burrow into the soil again for overwintering. In the spring, the third instars do little feeding and begin to pupate in July. When mature, the larvae create cells in the soil and pupate in late July and August. Thus, larvae that began development in different years are found together in infested sites. All sizes of larvae will be present in the soil.

Newly formed beetles appear in the soil in August and early September. These beetles remain in the soil, and in a field in Quebec (Guppy 1982) overwintered at a depth of about 8-28 cm (3-11"). They are reported to be unaffected by the winter flood in cranberry. The adults finally emerge from the ground in May and early June in the following year.

Females produce a sex pheromone

(Zhang et al. 1998), a 3:1 ratio of the two amino acids, valine and isoleucine. We have utilized this in trapping tests in Massachusetts cranberry. Based on pheromone trap catches in MA, we found that male beetles were first captured in the first two weeks of May. Peak captures were made in the third week of May through the first two weeks of June. In high populations, captures continued into early July. The last adults were captured by mid-July.

Both Hammond (1948) and Guppy (1982) found that beetles take flight when evening temperatures exceeded 10°C (50°F), and occurred 10-46 minutes after sunset. Adults were observed to fly to tree tops where they feed on a variety of host leaves, preferring American elm, oak, white ash, rose, lilac, butternut, apple and raspberry. In heavy populations, defoliation of trees was observed. Here they mate, and as the season progresses, females disperse to oviposition sites. Adults always return to the soil at dawn. We have seen adults flying away from cranberry bogs at dusk, but they have not been tracked.

The Egg
The eggs are nearly round, pearly white, and are scattered in the soil within 2-20 cm (1-8") of the surface.

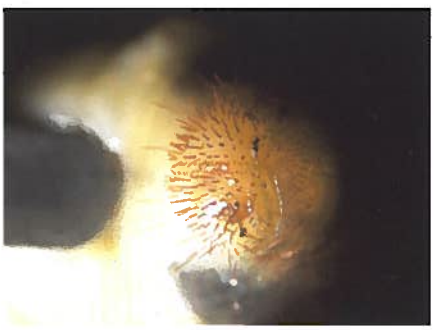
The Grub
Length full-grown, almost 35 mm (1 3/8"); head brownish-yellow, with tips of mandibles black; body white, increasing in size toward the hind end, with hind part of abdomen appearing dark because of its contents. Head with scattered hairs, these most numerous on the sides behind the antennae; front broadly rounded and very sparsely punctate; clypeus much rounded from front to rear and nearly impunctate; labrum somewhat longer than the clypeus, its front margin rather angular in the middle; jaws, their third segment with very few hairs and their last segment half as long as the one next to it. Front half of dorsum of abdomen clothed with many short brown spines and some scattered hairs, apical part with considerable reddish hair; spiracles light reddish-brown and often sprawled with the hind ones reaching backward somewhat; first segment considerably longer than any of the others; each tarsus with a single small, nearly straight, spinelike claw, those of the hind pair vestigial.

The Pupa
The pupae sometimes move the abdomen noticeably when disturbed. They are 19-22 mm (3/4 to 7/8") long; rough in appearance and without hair; mostly yellowish-white at first, later rather tawny, the leg and wing cases light brown and the ocular areas with brown pigment; the abdomen with two pairs of slitlike structures near the middle of its dorsum and a bifid tip with each branch ending in a brown spine.

The Beetle
The adults are the common brown May or June beetles. They are 18-23 mm (7/10 - 9/10") long; shiny brown, with much yellow hair on the underside of the head, thorax, and front of the venter; wing covers not nearly reaching the tip of the abdomen.

Management
A summer flood is effective (see p. 87). Pheromone traps are available for this species to monitor activity and infestation. Mass trapping (p. 14) could be considered.

Cranberry white grub adult beetle.



The raster on cranberry white grub has a series of hairs in a railroad track pattern and a c-shaped anal slit.

ORIENTAL BEETLE
Anomala orientalis Waterhouse
Coleoptera: Scarabaeidae

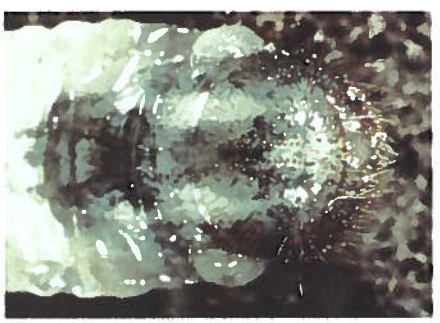
This species was recorded for the first time in Massachusetts cranberry in the mid-1990's with extensive infestations located at several sites in the Cape region. It is currently a problem in New Jersey cranberry, also. Unreferenced information contained in this section was freely extracted from Tashiro (1987).

Oriental beetle was probably a native of the Phillipine Islands and was carried to Japan. From here it was introduced to the United States. The beetle was first reported in the United States in 1920 in a New Haven, Connecticut nursery. The beetle has spread, and currently the larvae damage lawns and nursery plants through the north and central portions of eastern United States.

Oriental beetle adult.

Oriental beetle adult.

Oriental beetle grub.



Oriental beetle grub rastral pattern; note two parallel rows of hairs, with 10-16 in each row.

The bottom part of a pheromone trap filled with hundreds of oriental beetles collected during a week in July.

Distribution and Food Plants

It has been reported through the Northeast, North Carolina and Hawaii. Because the grubs are similar to several other species, it is likely that it remains undetected in other areas. It is the most problematic turfgrass pest in areas of Long Island, New Jersey and Connecticut.

Seasonal History and Description

The life cycle of this insect has not been verified in cranberry. In other host plants, most larvae completed their life cycle in one year, but Tashiro (1987) reported that ca. 15% of a given population will undergo a two-year life cycle. We found that populations of grubs sampled on Massachusetts cranberry beds contain multiple life stages, suggesting that a two-year life cycle may be the rule here.

In turf, the third-instar larva moves downward as the soil cools to less than ca. 10°C (50°F) and overwinters. In April, as the soil warms, the third instar migrates to the surface and feeds for about 2 months before creating an earthen cell and pupating in June. The pupal stage lasts about 8 days. Following adult emergence, the beetle remains in the earthen cell for about a day until the exoskeleton hardens. Adults eat little, mostly feeding on flowers and searching for moisture. In turf populations, mating normally occurs within 5 days of adult emergence and oviposition within 4-20 days with a mean of 7 days.

Females lay an average of 25 eggs and deposit each singly in the soil at a depth of 2.5 to 28 cm (1-11"). In cranberry, we found that eggs were laid from late June to August. Survivorship and development of the embryo is dependent upon adequate moisture. The egg stage lasts 17-25 days in the field. Larvae feed close to the surface on roots and organic matter. Duration of the first and second instar is about 30 days at 24°C (75°F).

The sex pheromone utilized in traps is a 89:11 blend of (Z)- and (E)-tetradecen-2-one according to Facundo et al. (1994). Within highly infested areas of turf, they found that during the day, adults were difficult to locate whereas the pheromone trap catches averaged 1,000 per day.

In cranberry, pheromone traps have been deployed and monitored over an entire growing season (Dunn and Averill 1996). We found that beetles were first captured in small numbers in mid-June. Peak captures were made in July and dropped to low numbers by the end of July. At high infestation sites, beetles continued to be captured in low numbers through August.

Daily flight activity patterns are unknown for cranberry, but probably will be similar to Facundo et. al's (1994) findings. In Long Island turf, they found that the adult beetles flew when it was warm and that they were crepuscular; the majority of flights occurred at sunset. This was inconsistent from other reports that oriental beetles are most active during the warm sunny portions of the day, from mid-late afternoon (Tashiro 1987). In turf, there may be as many as 40-60 larvae per 30 x 30 cm (1 square foot), with much higher numbers reported occasionally. In similar size plots, we found an average of 12 larvae in cranberry soil.

The Egg

When first laid, the egg is white, smooth, ovoid and is about 1.2 mm x 1.5 mm (1/21 x 1/17"). Older eggs become more spherical and enlarge to 1.6 x 1.9 mm (1/16 x 1/13").

The Larva

First instar larvae range in size from 4 to 8 mm (5/32 - 5/16"), based on maturity. Second instar larvae reach a length of 15 mm (slightly less than 5/8") and fully grown third instars are 20-25 mm (3/4 - 1") in length. Head capsule sizes are 1.2 mm (1/21"), 1.9 mm (1/13") and 2.9 mm (<1/8") for first, second, and third-instar larvae, respectively. The larvae can be distinguished from other scarab larvae found in cranberry by examination of the rastral patterns on the underside of the abdomen. There are two somewhat parallel rows of setae (hairs), with 10-16 setae in each row. The anal slit is transverse.

The Pupa

The third instar stage develops to a

quiescent prepupal stage. The newly formed pupa develops within the old exuvia and then the exuvia splits to release the formed pupa. The mature pupa is ca. 10 mm (>3/8") long and 5 mm (1/5") wide at its largest point. Two lobes that appear on the lower bottom of the abdomen of the male pupa are absent on the female.

The Beetle
The adult is usually straw colored with black markings; the pattern and extent of the black marking may be quite variable. The legs are spiny and the back is convex. The mean length of males is 9.0 mm (5/16 - 3/8") and of females 10.3 mm (2/5"). The sexes can be easily distinguished by examination of the lamella (terminal segment) of the antennae. The female's lamellae are shorter than the rest of the antenna while the male lamellae are as long as the remaining segments of the antenna.

Management
A pheromone trap is available. Mass trapping could be considered. 1000's of males can be removed from the population. See section on mass trapping (p.14). Whether or not summer flood works on this species remains to be seen; see section on summer flood (p. 87); it would be surprising if it failed.

"HOPLIA MODESTA"
Hoplia modesta (Haldeman)
Coleoptera: Scarabaeidae

Hoplia modesta has only been reported in Massachusetts cranberry. It had not been reported in cranberry previously, and no reports of a pest status have been reported from other crops.

Character of Damage
All of the damage appears to be done by the larvae and is similar to the damage described above in the general section on scarabs. *Hoplia modesta* infestations tend to be more extensive and become more rapidly established than cranberry root grub or cranberry white grub infestations. We have seen both localized and extensive infestations within a bed. In a survey of infested sites, the average number of grubs in a 30 x 30 cm (1 square foot) sample was 17 grubs; in some of these samples up to 50 grubs were found.

Adults were not observed feeding on any part of the cranberry plant.

Seasonal History
The species overwinters as a larva. Our observations suggest that they undergo a two-year life cycle in cranberry, overwintering as a larva in both the first and third larval instars (Dunn and Averill 1997). The grubs can be found in infested areas in May and also late in the fall.

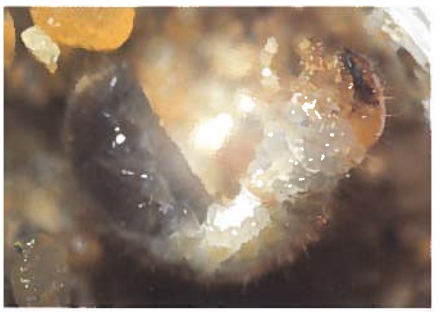
The adults emerge from the soil during cranberry bloom, from mid-June to mid-July. We observed beetles emerging in the late afternoon, ca. 4-5 PM, in a "mass flight" that lasted for 0.5 h to 1.5 hours. The activity occurred only on certain days. Because flights occurred within 1-2 days after a bog received water, we speculated that flight may be correlated with rainfall and irrigation events. This has been observed for other scarab species where survivorship of eggs and first instar larvae is highly and positively correlated with soil moisture (Dunn and Averill 1997). Females produce a sex pheromone as yet unidentified (Robbins, unpubl. data).

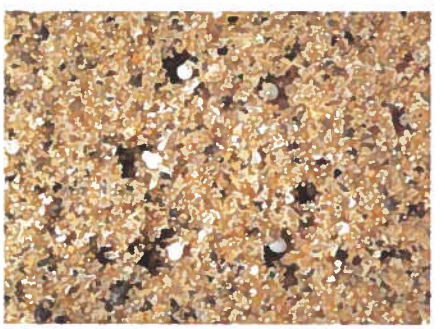
The Larva
The grub is C-shaped and with a white upper body with reddish brown hairs along the dorsal side. The lower portion of the body is slightly flattened with a gray, bulbous end. There are three instars; the head capsules for each of these is 1.2 mm (1/21"), 1.8 mm (1/14"), and 2.4 mm (1/11") across. The newly emerged first instar is ca. 5 mm (1/5") long and a third instar may be as long as 15 mm (5/8"). The larva has a Y-shaped anal slit with the stem of the "Y" half the length as either arm and the rastral pattern is V-shaped.

The Pupa
Pupae are light tan and the average length is 7-8 mm (5/16").

The Beetle
In general, beetles in this group are oval, yellowish-brown to dark brown with dense erect, short gold hairs. The


Hoplia modesta adult beetle.


Hoplia modesta larva.


Hoplia modesta eggs laid into sand.

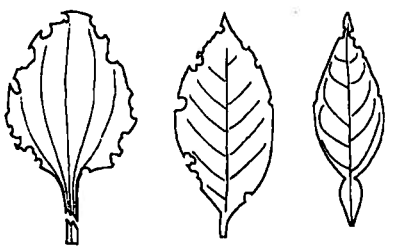

Hoplia modesta pupa, found in the soil in late May.


Hoplia modesta adult beetle.

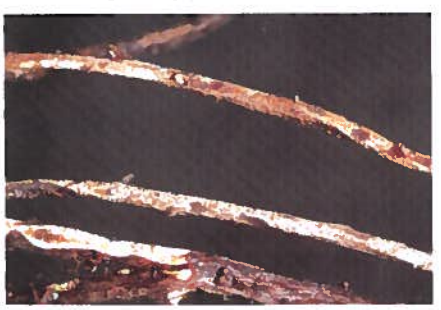
Hoplia modesta beetles. Male on left with more developed antennae, female on right with larger abdomen.

Black vine weevil adult. Note that weevil is nearly the size of two cranberry leaves.

Characteristic notching of black vine weevil adult to cranberry foliage.



Adult weevil feeding results in leaf notching on several plant species.



Feeding on stem of cranberry upright below trash layer by black vine weevil larvae.

pronotum generally has fewer hairs than the elytra. They are 7-8 mm (5/16") in length and ca. 4 mm (5/32") in width. The hind tarsal claws are cleft near the tip. Females are more robust and have a more pointed abdomen than males. The characteristic lamellate antenna is clearly shorter in the female, being 1.2 mm (1/21") as compared to the male's, which is 1.8 mm (1/14").

Management

Whether or not summer flood works on this species remains to be evaluated. It would be surprising if it failed. There is some evidence that some nematodes are effective against this species (see p. 8).

CURCULIONID SOIL WEEVILS

There are two new species of root-feeding weevils that are damaging to cranberries: black vine weevil and strawberry root weevil. These species do not appear in any of the earlier discussions of cranberry insects. Compared to the scarab grub larvae, these larvae are quite small. They can be clearly distinguished from the other soil insects because the larvae are legless.

Females produce eggs parthenogenetically and males have never been reported. The females are flightless with fused elytra. When sampling the soil, the life history of the weevil should be consulted to avoid intervals when the population is in the adult stage.

BLACK VINE WEEVIL
Otiorhynchus sulcatus (F.)
Coleoptera: Curculionidae

This is a cosmopolitan pest. According to Smith (1932), the first record of an infestation of black vine weevil was made in Germany on cultivated plants in 1934 and subsequently in many other parts of the world, including North America. A severe infestation of cyclamens in a greenhouse in Massachusetts was the first report of a pest status for black vine weevil for that state (Hagen 1890). Although a severe pest for some time on west coast cranberry, this weevil first appeared in MA cranberry only in the 1980's. It is called a "snout beetle" because the adults have a long, curved beak. Most soil insecticides are not effective against the weevil larvae. Nematodes have been used successfully in management programs, along with insecticidal baits and insecticides against adults.

Distribution and Food Plants

The black vine weevil is an important pest throughout the world, especially in potted plants, greenhouses, strawberry and raspberry fields, and tree nurseries. Black vine weevils feed on a range of herbaceous and woody plants such as rhododendrons, azaleas, and yews; these are its favorite host plants.

Host-range tests carried out by Masaki et. al (1984) showed that the species is highly polyphagous, with adults accepting dozens of species for feeding. When offered roots of 68 candidate species, the larvae fed on 55 species in 24 families. Both adults and larvae preferred hosts in the rose family, Rosaceae.

Character of Injury

Injury from the adult weevils feeding on the leaves is unimportant, but can serve as a key indicator that a vine weevil infestation is present. The adult feeding is highly characteristic. Rounded notches are eaten from the margins of leaves. Such feeding is highly noticeable on favored weeds such as running bramble (*Rubus* sp.).

The damage of the larvae feeding on the roots and the bark of the stem results in serious damage, usually eventually killing the vines. The infestations are generally patchy.

Often, vine weevil damage appears similar to cranberry girdler because the grubs feed on the bark of the vine below the trash level; the feeding is seldom as deep as that of cranberry girdler.

Seasonal History and Description

There is a single generation each year. The larvae overwinter and form prepupae in the spring. The pre-pupal stage lasts

several weeks; duration is based on soil temperature. The pupal period lasts 2-3 weeks.

The adults emerge from pupal chambers in the soil during June through July. During the day, the adults hide in the leaf litter; at night, the weevils move up on the bog's foliage to feed. Night sweeping under dry conditions in June through July, particularly when it is warm, will pick up the weevils in areas of infestation.

Weeks pass before the females begin to lay their eggs; in the meantime, they feed on cranberry and other plants in the area, such as bramble. The adult feeding is very characteristic because of notches created on the leaf edge. Most weevils stay close to where they developed as larvae. In mark-release studies, Garth (1977) and Maier (1978) found that adults rarely dispersed more than 6-10 meters if a food source was available. Maier recaptured some females up to 70 meters distant from a release site, but this was rare.

Once begun, egglaying may continue for six to eight weeks. A single female may lay up to 500 eggs. In Maier's (1981) feeding study, adults fed on two species of yew produced a mean of 295 to 488 viable eggs, with ca. 10% of all eggs being inviable. Many fewer eggs were laid if females were fed flowering dogwood or mountain laurel foliage. Cram and Pearson (1965) compared pre-oviposition periods and total eggs laid when females were provided various host plants from British Columbia cranberry and blueberry plantings. The pre-oviposition period was significantly shorter when females were fed on Himalaya blackberry (*Rubus thyranthus* Focke) when compared to salal (*Gaultheria shallon* Pursh), labrador tea (*Ledum groenlandicum* Oder), cranberry, highbush blueberry, fireweed (*Epilobium angustifolium* L.), or sheep sorrel (*Rumex acetosella* L.).

Larvae go through six instars. Larvae grown on roots of rhododendrons that were maintained at 18-22°C in a greenhouse required 84 days to complete larval development and between 130-211 days when outdoors at ambient conditions (LaLone and Clarke 1981).

The larvae overwinter, begin feeding again in the spring, and thus, larvae will be found both in the fall and in the spring. Because there is one generation per year, no larvae will be found in late spring and early summer.

The Egg

The eggs are almost spherical and range in size from 0.65-0.80 mm (1/35") long. At first, the egg is pearly white. After a few days, the egg darkens to a dark brown.

The Larva

The larvae are legless. When the larva first hatches, the head is chestnut brown and the body pinkish white and covered with fine hairs. The body is not curved. As the larvae reaches later instars, they become almost c-shaped and are yellowish white. The larva is 10-12 mm (7/16").

Head capsule widths by instar of black vine weevil larvae

Instar	width (mm)
1st	0.32
2nd	0.40
3rd	0.62
4th	0.78
5th	1.10
6th	1.50

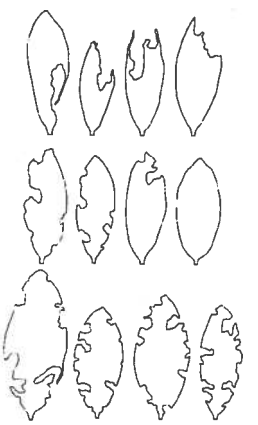
The Pupa

The last instar larva forms a pupal cell in the spring. According to Smith (1932), the last instar larva completely voids material in the gut, rendering its body color completely milky white. He suspected that the gut materials were used to smooth and harden the walls of the pupal cell. Over time, the body becomes a dirty yellow color.

When the pupa first appears, it is milky white. The body parts of the adult form and can be seen. The head, mouthparts, antennae, wings, and legs are apparent and gradually turn brown, and then black over time.

Black vine weevil eggs. (Photo: CES archives)

Black vine weevil larva. Note that it is legless, a diagnostic feature distinguishing it from other groups of soil insects in cranberry.



Varied feeding patterns, or notching, of black vine weevil adults on rhododendron species.

Black vine weevil larva (top) and pupa (below).

Black vine weevil adult.

Comparison of size between black vine weevil and strawberry root weevil.

Vine damage looks similar for both black vine weevil or strawberry root weevil. Reddish vines appear shortly after the winter flood is withdrawn.

Adult strawberry root weevil. Notice weevil is about same size as a cranberry leaf.

Strawberry root weevil larva (right) and pupa (left).

The Adult

Populations are made up of parthenogenic females. They are black with yellow flecks and are 9-11 mm (3/8 - 7/16") long, with many parallel rows of pits along its back. The mouthparts are extended into a snout with antennae extending from the distal end. They have a hard-shelled body with white patches of scales on the forewings. They cannot fly.

Management

Night sweeping in June-July picks up these weevils. Maier (1983) suggested the use of trap boards that are placed on the ground near areas of suspected infestation. He found that adults used the boards to rest under during the day; they can be sampled then.

In general, black vine weevil is found in bogs that are seldom flooded; strawberry root weevil populations tend to appear in bogs that are winter flooded, but that have high sections. In the Northwest, much of the cranberry acreage that is not flooded in the winter is under threat of infestation (Shanks 1979). They are vulnerable to treatments of beneficial nematodes (see p. 8).

STRAWBERRY ROOT WEEVIL
Otiorhynchus ovatus (L.)
Coleoptera: Curculionidae

This is a fairly small beetle. Similar to black vine weevil, strawberry root weevil has only been reported in MA in the last 10 years or so. It is not a problem in New Jersey, but has been known as a cranberry pest for years on the west coast.

Distribution and Host Plants

Strawberry root weevil is found throughout North America and is reported to be a native insect (Downes 1922). In addition to feeding on strawberry, larvae feed on a variety of crop and ornamental plants including cane fruits, nursery plants, hemlock, and peppermint (Emenegger and Berry 1978).

The adults also feed, and Downes (1922) reported that adults are capable of feeding on almost any vegetation. Preferred hosts were strawberry leaves, clover, wild grasses and various weeds. Blackberry and raspberry were also included. They notch the leaves on the margin in a very characteristic manner similar to black vine weevil.

Description and Seasonal History

The larva overwinters. In the following May, the larva creates an earthen cell and pupates. Pupae reared at 15°C (59°F) completed development in an average of 23 days. Adults emerge in May and June.

On peppermint in Oregon (Emenegger and Berry 1978), adults hid during the day and were completely inactive. They were most active 1-7 hours after sunset. Eggs are laid in the soil. Eggs hatch in less than 2 weeks when incubated at 20°C (68°F) (Emenegger and Berry 1978). There are five larval instars.

In studies on the west coast, adults lived from two to four months in the field.

The Egg

The egg is oblong-oval, initially white and turning amber-brown within a day or two. The egg is 0.47 mm (1/50") long and 0.37 mm in diameter (Emenegger and Berry 1978).

The Larva

First hatched larvae are white, 0.5 mm long and have an orange-brown head capsule. The body is covered with minute hairs. The larvae are legless. At maturity, larvae are 6 - 7 mm (1/4") long. The body is white and the head light brown. They assume a curved position in the soil.

There are 6 prominent epicranial setae on the head and 4 setae in the anterior row on the pronotum, arising from small tubercles. According to Emenegger and Berry (1978) these setae patterns allow differentiation from other species.

The Pupa

The pupa is white and ca. 6 mm (1/4") long when full grown. The various appendages (wing pads, legs, antennae) of the insect can be seen. It is able to partially move its caudal segments.

Pupae may also be separated from other *Otiorhynchus* spp. by the presence of 4 setae in the anterior row on the pronotum, arising from small tubercles.

The Adult

This weevil resembles black vine weevil except that it is significantly smaller, 5-6 mm (2/10") long and 3 mm (1/8") wide. Also, the legs and antennae are reddish brown and the body is reddish to brownish to almost black. The elytra (wing covers) are fused and are for protection only. The adult cannot fly. The elytra are striated with deep punctures. The thorax is deeply pitted.

Management

See section under black vine weevil.

CHRYSOMELID SOIL INSECTS

The following two species, cranberry rootworm and striped colaspis, can be distinguished as larvae by examination of the ventral tip of the abdomen. The cranberry rootworm is divided into two equal lobes while that of striped colaspis is not (see illustration in key p. 96).

CRANBERRY ROOTWORM
***Rhabdopterus picipes* (Olivier)**
Coleoptera: Chrysomelidae

This is a major root feeder in New Jersey. Early in the 1900's, Quaintance (1912) reported cranberry rootworm feeding on the roots of cranberry in New Jersey. We have not seen it in Massachusetts in the 1990's. Franklin (1950) noted that it very rarely did substantial harm in Massachusetts. However, he often did find a few beetles while sweeping with an insect net; thus, we may see this species again in Massachusetts. He felt that it did not seem to attack bogs much before they were fifteen years old or bogs of large acreage.

Distribution and Food Plants

This species seems to be confined to the coastal lowlands from Mississippi to New England. It attacks the roots, foliage, and fruit of cranberry and the roots and foliage of highbush blueberry, being quite troublesome in cultivated blueberry fields in New Jersey. More recently, it was reported as a serious problem of ornamentals in Louisiana (Oliver and Chapin 1980). In this paper, they provide a very lengthy list of host plants where adult feeding was observed including species of cherry, hickory, oak, dogwood, pear, plum, rhododendron, rose, raspberry, blackberry and holly. Harmon (1931) recorded cranberry rootworm as an apple pest in New York where it was observed feeding on fruit and foliage surfaces.

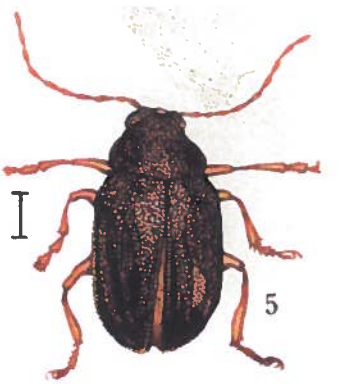
Character of Injury

The feeding of the beetles on the cranberry foliage, though usually moderate, is sometimes severe on limited areas, causing the bog to turn brown as if badly infested with fireworms. Oliver and Chapin (1980) found that on ornamentals, such as camellia and azalea, the beetles preferred young foliage. On cranberry, Scammell (1915) noted some adults feeding on small berries, where they gouged furrows around the fruit. In nurseries, Oliver and Chapin (1980) found that the lowest concentrations of adult feeding damage occurred on foliage in non-shaded areas of nurseries and in open fields that were weed-free.

While the adult feeding was not characterized for cranberry, feeding scars on leaves of camellia were elongate, curved cuts on the upper leaf surface (Oliver and Chapin 1980).

More important, however, is the feeding damage of the larvae. These live in the soil under the vines where they feed on the fine cranberry roots and eat the bark of both the large roots and runners that are in contact with the ground. According to Scammel (1915), the feeding damage of rootworm can be distinguished from girldler damage based on location: while girdler larvae tend to feed on runners and crowns in the trash layer, often feeding deep into the wood, rootworm larvae feed in the soil and prefer to feed on the bark of large and secondary roots. Rootworm severely attacks the fibrous roots. Its most severe injury occurs on vines in sandy areas. In

Strawberry root weevil pupa



Cranberry rootworm beetle. (Illus: Franklin 1948a above, Photo: Scammell 1917 below)

The larva of cranbery rootworm. (Photo: Scammell 1917)

Cranberry rootworm egg mass (A) and grub (B). (Photo: Franklin 1950)

Rootworm pupa. (Photo: Scammell 1917)

areas with severe infestations, vines are easily pulled and rolled back like a mat.

Description and Seasonal History
Franklin's (1950) description of the life history in Massachusetts follows. Nearly mature larvae overwinter in earthen cells 5-15 cm (2-10") deep in the bog soil. Late-holding of the water does not harm them but delays the onset of pupation. Pupation occurs normally in June, mostly in the surface inch of soil, and the adult beetles emerge during the first half of July, remaining into August. They are readily picked up in a sweep net, mostly late in July. The eggs were laid singly or in masses, sometimes in among deep trash on the bog floor but usually on the surface soil, mostly in July. They hatch in about a week, and the young larvae begin their root feeding, which continues until October. He observed that some of the larvae are found at any season and concluded that each year, a few fail to complete their growth and spend two winters in the ground. Generally, the insect has a one-year life cycle.

The New Jersey phenology has changed with changes in water holding practices over the past 10 years. The above phenology is off by about 3-4 weeks. In New Jersey, pupation begins in the third or fourth week of May, beetles emerge in the first week of June. Adult activity is over by mid to late July.

In Scammel's (1915) description of the life history in New Jersey, the average duration of the pupal stage was 14.5 days. New adults remained in the pupal cell in the soil for 2-3 days prior to emerging. The beetles were active in mid-June, with peak numbers occurring toward the end of June. Adults were captured as late as early October. Eggs were found just beneath the ground surface of the bog. The egg stage lasted from 6 to 11 days, with a mean of 8 days. First instar larvae fed within a few cm (1-2") of the bog surface on the fibrous roots. In fall and winter, the larvae moved down in the soil to overwinter.

According to Oliver and Chapin's (1980) observations, the beetles are nocturnal and hide in leaf litter near host plants during the day. Following emergence from container plantings in a nursery, the females fed on foliage for about two weeks before beginning to oviposit. Females laid an average of 150 eggs.

The Egg
The eggs are about 0.67 mm (1/40") long, oblong-elliptical, dirty white at first and later becoming uniformly yellow. The shell is smooth and shiny and transparent enough to reveal the outline of the larva before it hatches.

The Larva
The larva is about 8 mm (ca. 5/16") long and is yellowish-white with a light brown head. The larva usually assumes a curved position. The front of the head is broadly rounded and sparsely punctate, with scattered hairs. The clypeus is smooth, shiny, and longer than the labrum; antennae not nearly reaching the tips of the jaws. The dorsum and sides of body have simple scattered brown hairs, but no spines; abdomen not noticeably darkened by its contents; each segment of venter with a cross row of brownish spines pointing obliquely caudad, with others clustered toward the sides of the body. The anus is guarded by three light brown plates, one dorsal and one on each side; legs often sprawled, with the hind one reaching backward somewhat; each tarsus with a single, simple, slender, well-developed, somewhat-curved, sharp pointed claw.

The Pupa
The pupa is about 4.7 mm (3/16") long, white, with the habit of waggling the abdomen vigorously when disturbed. There is a considerable scattering of strong hairs over the head and back; a large solitary spine on some of the leg cases, and a prominent spine, curved outward, on each side of the hind end of the abdomen.

The Beetle
The beetle is about 5 - 6 mm (1/5") long, dark brown, bronzed, shiny; oblong-oval, convex; antennae and legs reddish-yellow, the former often dusky toward the tip; wing covers coarsely punctate and covering the tip of the abdomen.

Management
Late water (holding water until 20 May) had no effect in reducing an infestation in either New Jersey or Massachusetts.

The adults' nocturnal behavior would require night sweeping for accurate monitoring. The two-week feeding on foliage may allow for development of adult management approaches.

"STRIPED COLASPIS"
***Colaspis costipennis* Crotch**
Coleoptera: Chrysomelidae

Isolated but severe infestations of this species have been seen in commercial Massachusetts cranberry only. The grubs feed on both the roots and the bark of the vine.

Distribution and Food Plants
The insect ranges from New England to Mississippi. The beetles have been found on azalea, wild aster, blueberry, cranberry, grape, pecan, and sweet fern.

Description and Seasonal History
The larvae, largely grown, overwinter and complete their development in the spring, pupating toward mid-June in cells in the soil. The beetles emerge in June and remain into July. They feed on the cranberry foliage, blossom buds, and flowers. They mate and eggs are laid in the soil. There is one generation each year.

The Larva
The larva is curved; fat-bodied; 6-7 mm (1/4") long when full-grown; nearly white, without markings; simple pale hairs, noticeable under a lens, scattered over the back and sides. Head pale yellow; antennae not nearly reaching tips of jaws. Abdomen not noticeably darkened by its contents, the tip with a considerable ridged prominence extending caudad on each side, the underside covered with a brush of brown hairs, with those at the sides clustered and larger than those in transverse lines across the middle. All the legs with slender, single, simple, sharply pointed claws. This grub is much like that of the cranberry root worm (*Rhabdopterus*), but its head is somewhat narrower relative to the width of the body.

The Pupa
These pupae waggle the abdomen very freely when disturbed. They are much like those of the cranberry rootworm in appearance, size, and structure. They are waxy white; about 5 mm (3/16") long; with rather long, light-brown hairs scattered freely over the back of the head, thorax, and abdomen, many of them borne on conical tubercles.

The Beetle
The adults seem to spend much time in the soil, but they come out in the day to feed and fly about freely. They are ca. 4 - 5 mm (1/5 - 1/6") long; oblong-oval, moderately convex. Head and prothorax generally metallic greenish-black and, especially the latter, thickly punctate. Eyes black. Antennae slender and mostly yellow, the final segments dusky. Wing covers blackish, striped with smooth yellow costae and thickly punctate between them, covering the tip of the abdomen. Legs all yellow.

Management
The adult beetles feed freely on cranberry foliage and can be picked up in infested areas in fairly large numbers during daytime sweeping in June. Adult feeding occurs near larval-infested areas. The beetles chew the outer margins of cranberry leaves, near the tip of the upright. The result is a ragged notching along the leaf edge.

The larvae in the soil can be difficult to spot. Grubs can be seen in infested areas in May to early-June and also late in the fall; this should be carefully observed so that sampling is done when larvae are present.

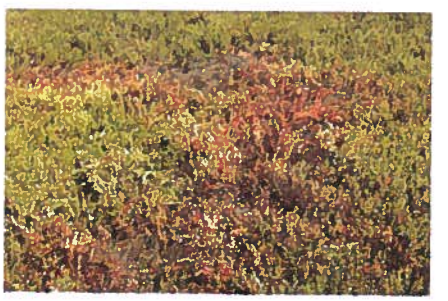
WIREWORMS or Click beetles
Species not determined
Coleoptera: Elateridae

Wireworms or larvae of the beetle family Elateridae are frequently found in the soil of cranberry bogs in association with weedy areas. We have never observed them feeding on cranberry roots and do not consider them to be a cranberry pest.

The larvae typically are hard, yellowish brown, and wire-like. The larvae reach about 25 mm (1") long. The adults are usually drab brown or black beetles and are about 20 mm (<3/4") long. They have the ability to snap, or "click" the thorax and abdomen when upside down on a surface. This clicking behavior propels the beetle into the air and allows it to right the body.

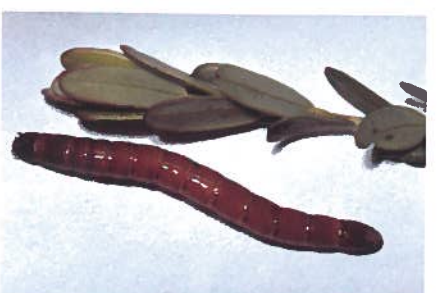
Striped colaspis adult beetle.

Striped colaspis adult beetle feeding on cranberry foliage found in June.



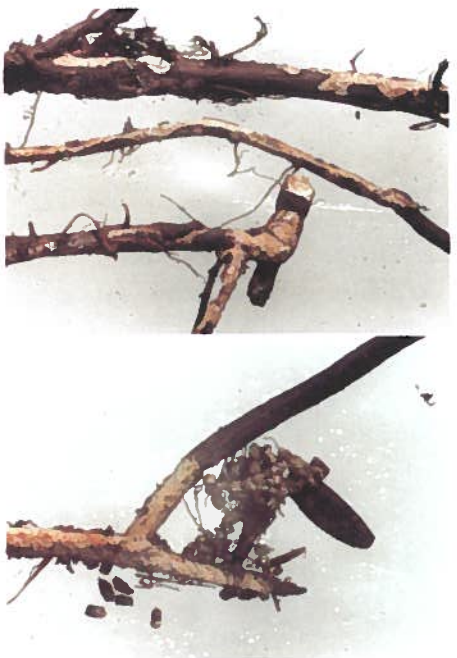
Striped colaspis grub damage.

Striped colaspis grub. (Franklin 1950)

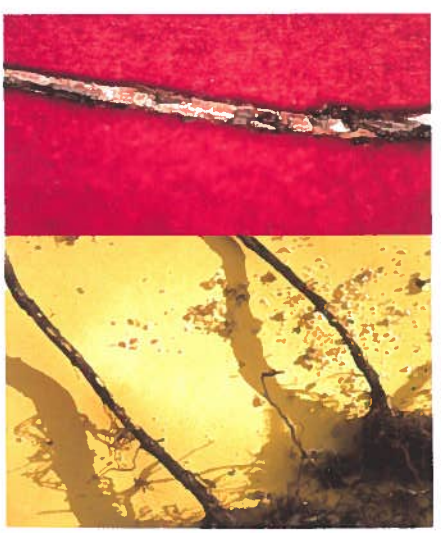


Wireworms, or click beetle larvae, are commonly found in bog soil but do not harm the roots, i.e. this is not a cranberry pest. They are found in association with weeds.

Cranberry girdler larva. (Photo: CES archive)



Examples of girdler larva damage, including insect frass in the lower picture. (Photo: W. Z. Fort)



Damage from larval girdler feeding is at the base of the upright, most often with the trash layer.

CRANBERRY GIRDLER
***Chrysoteuchia topiaria* (Zeller)**
Lepidoptera: Pyralidae

This insect appears consistently in Massachusetts and New Jersey cranberry. In past times, it was more destructive in New Jersey than in Massachusetts, largely because most of the bogs in that state were not sanded. Further, Franklin (1950) noted that it tends to infest bogs where the winter flood is held as opposed to where it is not held. Today, cranberry girdler is generally of less importance owing in part to cultural practices, sanding and trash flows, that disallow trash accumulations that are necessary for high survival of the larvae. Further, the introduction of parasitic nematodes for management has allowed alternative management of some populations.

Cranberry girdler is within a large subfamily of grass-infesting larvae. The adults are sometimes referred to as "lawn moths" or "snout moths" owing to the prominent labial palpi that extend, snoutlike, in front of the head.

Distribution and Food Plants

This species is found throughout North America and Europe. Grasses, sheep sorrel, cranberry, and "three square" are known food plants. It is known as a pest in commercial grass seed production, turfgrass, and coniferous seedling plants (Tashiro 1987).

Character of Injury

The larvae feed in a concealed manner near the surface of the ground, chewing on the stems and runners and somewhat on the roots. They not only eat the bark but gnaw into the inner conductive layers that provide water and nutrients to the upright. They often completely sever runners or eat them down to mere splinters. Quantities of frass, often held together more or less by silk threads, are commonly found near where they have eaten. They often cause the vines to die over considerable areas in a single season. These areas usually grow larger and more numerous yearly until most of the bog becomes infested. After severe girdler feeding, the vines may be so loosened and severed that they can be rolled back easily from the trash beneath.

According to Franklin (1950), the larvae evade their abundant natural enemies most when they feed under a thick accumulation of fallen leaves and other trash. Evidently for this reason, areas that are heavily vined and on which resanding has been neglected are attacked most often. Such areas are also more likely to be hurt by frost and in previous times, by the false blossom disease. According to Kamm (1973a, b) numbers of cranberry girdler larvae, both in and out of cocoons, in grass fields in Oregon were substantially reduced by birds throughout the fall and winter.

Girdled vines usually do not show any effect of the injury until the fall when their foliage turns brown, thus sharply defining the injured areas. This often does not reveal the full extent of the damage, which is realized only when the winter water is let off the following spring and the dead vines from which the leaves have fallen during the winter are seen. If the girdler feeding ceases, runners may grow out and tend to recover the dead areas, but this takes several years and such areas are likely to become patches of weeds in the meantime.

When an infestation is checked, a much greater number of vines than those that are dead or injured beyond recovery are only partly girdled and will recover if they are not mistreated further. The wounds gradually heal by growth along their margins, but the scars remain for several years. Where girdler injury has not been great enough to kill the vines, it often impairs their vitality and reduces materially the quantity and quality of the berries.

Description and Seasonal History

There is one generation a year. The fully grown larva overwinters within a cocoon. When through feeding in the fall, the larvae make cocoons or hibernacula about themselves using either sand or fallen leaves, dried frass, or other trash from the bog floor or a combination of these materials. It is held together and lined with silk. In the spring, the larvae

normally pupate in May and very early June, but pupation may be delayed until late June or even July if late water is held until mid to late May.

The moths generally begin to emerge in the second week of June until late June. Based on pheromone trap captures in MA cranberry, peak flight is often around the first week of July. The moths remain in numbers until after mid-July and often some are seen until mid-August. In June, the sexes are about equal in number, but in late July and August the males are greatly in excess. The females are on average larger than the males and have a rounder abdomen, especially when they are full of eggs. In field observations, Kamm's (1974) studies suggest that females call (actively release pheromone) between 1000 and 1500 h (EST). He observed peak emergence and moth activity occurring approximately 1 hour after sunrise.

The moths generally remain concealed among the vines but are easily flushed. When disturbed, they often fly several meters with a quick, jerky flight before darting into the vines again. They often slide down into the trash on the bog floor. When at rest, they have the wings folded closely around the body and look like little cornucopias. Once they have come to rest, they may be quite difficult to see.

When reared on cranberry, Franklin observed a female that produced seven hundred eggs, but they average about two hundred. The eggs are scattered at random on the sand or trash under the vines. When fed red fescue grass (*Festuca rubra* L.) in the lab, females did not lay eggs until the second day following emergence and laid an average of 471 eggs (Kamm 1973a, b).

The egg stage lasts from six to eighteen days, averaging about ten. Because of the small size, dingy color, and concealed feeding habit of the larvae, they are rarely found. If they are exposed to strong sunlight when one turns over the trash, they will start to crawl for cover after a little and may be found easily. The vertical tubes or cases mentioned by some of the older writers as being made by these larvae are not found on cranberry bogs.

The damage of early feeding larvae seems to do little harm, but late in August and especially in September, they feed ravenously. Some of the larvae complete their cocoons during the last days in September, while the rest do so early in October. The overwintering larvae can endure a winter flood even when this is held into June. A few survive even if a summer flood is held well into July.

The Egg

The eggs are very hard to find on a bog, being only about 0.45 mm (1/50 - 1/60") long. They are whitish at first, but become pink and finally reddish as they near hatching. They are oval, broadly rounded at the ends, and ribbed slightly from end to end. They are not viscid when laid.

The Larva

They are 13 - 16 mm (1/2 - 5/8") long when mature, the body being dirty whitish and the head brown. The body bears a scattering of noticeable hairs. First instar larvae are 2 mm (1/12") when first hatched.

The Pupa

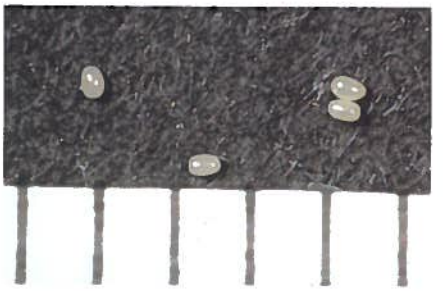
The pre-pupal stage resembles a shortened larva that is not active. The pupa always forms with its head toward the neck of the cocoon, through which the moth finally emerges. It is about 9.5 mm (3/8") long and its general color is pale yellow, with the eyes black at the end of the stage. The pupal stage lasts from about twelve days to a month, averaging about three weeks.

The Cocoon

They vary in shape, but are usually broadly rounded at one end and drawn out into a narrow neck at the other. They are 10 - 20 mm (2/5 - 4/5") long, the smaller ones being made by parasitized larvae in the trash under the vines.

The Moth

The moth has a whitish appearance when in flight. The forewings are rather narrow, with a ground color of silvery yellow on the upper side, marked



Cranberry girdler eggs. (Photo: CES archive)

Cranberry girdler forms a cocoon or hibernaculum, on the floor of the bog out of peat, roots, sand and leaves. The larva overwinters inside.

Cranberry girdler moth (top), pre-pupa (middle), and pupa (lower). (Photo: CES archive)

Cranberry girdler moth.

1

Cranberry girdler moth (Franklin 1948a).

2

Silver-striped webworm is similar to cranberry girdler. Both moths are caught in the pheromone trap but this is a grass feeder (Franklin 1948a).

Small pheromone wing traps can be used to monitor girdler moth flights on bogs where there has been a history of activity.

Girdler damage leads to dead areas over time.

lengthwise with smoky lines, and with a narrow silvery crossband and a few touches of black near the outer margin. The under side of the forewings and the hindwings are silvery brownish gray. The body and legs are clothed mostly with silvery scales. The body is 11 - 12 mm (7/16") long. The forewings expand to about 15 mm (3/5").

Management

Regular sanding strongly suppresses or retards the development of girdler infestations. Dead areas badly hurt by the girdler should be cleared of the dead vines and trash, resanded with about two inches of sand, and replanted. Damaged areas without considerable dead vines should be resanded enough to bury the trash on the bog floor to an inch deep. This makes conditions less suitable for the larvae and also encourages the injured vines to develop new growth. No other treatment so helps girdled vines to recover. Franklin notes that fertilizer should never be used in connection with girdler infestations.

Fall flooding of the bog for girdler management: timing is absolutely critical. Although the harvest flood or the fall reflow may not always give complete control, if done regularly it should greatly diminish girdler problems by drowning some larvae and also through slowing of the trash build-up that protects the larvae and favors their increase.

Timing of the fall flood is critical because after a cocoon is formed, the bog may be flooded for several days without killing the larva. The cocoons fill with water within three or four days after the bog is flooded, but this does not harm the larvae. Thus, for a flood to be successful, it is important to note that some of the larvae make their cocoons during the last days in September, while the rest do so early in October. For years, Franklin said "The water should be put on by 25 September if possible, before 1 October anyhow, and be held for a week." Further, the vines should be covered completely, because the larvae often come to the surface in numbers, and vines above the water surface provide a refuge. In past times, this flood was done regularly with fruit of late varieties still on the vines — this was done with reasonable safety, according to Franklin.

Sex pheromone traps containing (Z)-11-hexadecenal and (Z)-9-hexadecenal (Kamm and McDonough 1982) have been utilized successfully to monitor adult flight. The traps are not completely specific and the appearance of the moths must be used to identify the pest. Girdler moth's "snout" and general size and shape may be used in identification when scale patterns on wings have been lost. Another moth that is closely related to girdler may also appear in bogs and may be mistaken for girdler. It is the silver-striped webworm (*Crambus praefectellus* Zinck). Although the same shape, it has a conspicuous white stripe along the middle of each forewing and the wingspread is larger, 20 mm (3/4"). It is common on bogs in June and July, but does not feed on cranberry; it feeds on grasses.

Research conducted by Roland (1990) showed that larvae of cranberry girdler preferred grasses (7 species were tested) to cranberry plants. Larvae that were feeding on cranberry moved to the favored grasses when plantings were adjacent. Larvae were easily detected in the grass plots, which was not true for cranberry. He suggested that foxtail (*Alopecurus pratensis* L.) plots could be used as monitoring sites on cranberry beds to 1) detect low levels of girdler infestation and 2) to evaluate efficacy of control measures.

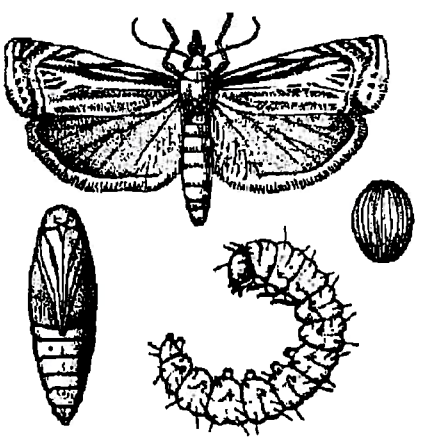


Illustration of cranberry girdler life stages (Illus: Smith 1903).

APPENDIX: FLOODING MANAGEMENT

Regarding summer flood for grub management:
A summer flood is effective for cranberry white grub and cranberry root grub. Franklin (1950) recommended this procedure: The winter flood is removed early (early to mid-March) and the bog allowed to dry out, with ditches empty until ca. mid-May. Completely reflood mid-May and keep well flooded until mid-July. This treatment usually kills 90% of cranberry root grubs and always destroys the crop for that year. Retreatment must be done in 5-10 years. Cutworm infestations, e.g. black cutworm and armyworm (pp. 17-21) should be anticipated when the summer flood is drawn. Franklin also cautions that budding of the new growth late in the season may need protection from severe fall frosts. He maintained that yield in the year following a summer flood was good, but recent reports have not been so encouraging.

Oxygen deficiency can injure cranberry vines. Since it is warmer in the summer, the plant's rate of respiration is higher which mean more oxygen is needed. As the water temperature increases, the ability to hold oxygen decreases. Warm water holds less oxygen. Plants get their oxygen from the water for respiration, but also give off oxygen during photosynthesis. Since more photosynthesis occurs on sunny days, there is less danger in flooding cranberry bogs on these days. Photosynthesis is the reason why it is so important to keep the water clear so the sunlight can penetrate to the plants. It is best to flood with clear water (from clear streams and pond with gravel bottoms) as opposed to the murky water of swamps and reservoirs. Circulating the water will also increase the amount of oxygen. It may be possible to open the lower levels of the flume while pumping fresh water in from the top.

It is important to watch for algal scum growth during a summer flood. See "Prevention and treatment of scum" under late water section, p. 89.

Regarding blossomworm:
Historically, other floods were utilized also, occurring in the fall or the spring. Franklin (1928) recommended that after the crop was picked, the bog should be flooded for 18 days, beginning in late September if possible. In later recommendations made by the Cranberry Experiment Station, the duration of this fall flood was reduced to 6 days. This reportedly kills the blossomworm moths and probably, any remaing pupae. Franklin believed that this fall flood reduced cranberry fruitworm and cranberry girdler as well. Franklin (1928) also advised that the gypsy moth treatment, that of flooding late in May (around 29 May) (in normally proceding years) for 14 hours destroys young instar blossomworm larvae. This was also reported by Tomlinson for New Jersey cranberry. In later recommendations made by the MA Cranberry Experiment Station, similar to the treatment for false armyworm, the flood is recommended earlier, ca. 18 May and for 10 hours. Likewise, Tomlinson (1948) noted that if the winter water was removed early (i.e March), the flood could be moved up to 15-20 May, thus reducing the flood danger to developing flower buds. Finally, the June floods recommended for blackheaded fireworm were also effective against blossomworm.

Regarding gypsy moth:
Franklin (1928) also recommended reflooding on about 29 May for about 36 hours. If it was among the earliest of springs, the flood could go on ca. 24 May; if it was among the latest of springs, the flood could be delayed until 3 June. At the time of the reflood, most of the airborne first instars should have arrived on the bog. Unless they are very numerous, up to the time of the flood, they cannot do much vine damage. If the larvae a 1/3 grown, a 14 hour flood kills them. If the larvae are abundant, delay of the reflood was not advised, probably owing to the great damage potential of the larvae. The small larvae often cling to the vines as the flood water rises and never come to the surface, and this actually enhances survivorship; larger larvae do go to the surface where they thrash themselves to death. The other insects impacted by a late May flood are false armyworm, cranberry blossomworm, black-headed fireworm and green spanworm.

Regarding brown spanworm:
Franklin (1948a) noted that the early June refloods interfere with the egglaying enough to prevent the development of infestations, if flooding is carried out regularly. Complete reflooding of the bog for 36 hours when the moths reach peak flight activity may sometimes eliminate an infestation. Because the larvae are active so late in the season during bloom, floods against larvae are not practical.

Regarding yellowheaded fireworm:
Complete winter flood, especially if the water is held until May, is known as an effective control (Franklin 1948a); Tomlinson 1948). We speculate that standard late water, where water is removed in March and the bog reflooded for a month in April to May may be less effective than "late holding" where the flood is held continuously through the winter until spring. Suspicion arises from the fact that the moths are overwintering throughout the bog habitat and then laying eggs in April.

Smith (1903) found that a 48-hour reflood when the larvae were half-grown in the spring was highly effective. He detailed the practice in his report and notes that it was widely adopted in New Jersey at the turn of the century.

Regarding blackheaded fireworm:
Franklin (1928) stated that complete flooding early in June was long the standard control for the first generation. He noted that this reflood was also effective against several other pests as well. The reflood must be done before

The factors affecting the results of flooding vary to such a degree that it is hard to set rules for the flooding operation. Franklin included the following table for clear water from a clean pond or stream.

Highest temperature reached by water at tops of vines during flood (°F)	Time complete flood should be held (hours)
65	50
70	44
75	38
80	31
85	24

blossoms begin to open much. When the winter flood has been removed before 8 May, then 7 June is usually about the right date. Crop injury was a key concern, however.

Spring reflooding has been studied in the lab and field in Wisconsin by Cockfield and Mahr (1992). In the lab, they found that larval mortality was very high after 2 days under low dissolved oxygen levels. Under conditions of high dissolved oxygen, the larvae could survive for days; their silken shelters likely trapped air when the vines were submerged. In Wisconsin field trials, a 1-2 day flood in mid-May showed variable results, but there was a reduction of the population. This suggested that under conditions of known egg hatch, plant development, water temperature and water dissolved oxygen, such a flood could be of utility (Cockfield and Mahr 1992).

The following is a discussion of the blackheaded fireworm flood that was contained in Franklin's 1928 volume on cranberry insects, but was omitted from his 1948a treatment.

In general, vine injury was less likely if the weather and the water were clear while the flood water was on. Strong sunlight leads to sufficient photosynthesis and a normal supply of oxygen in the water. A too lengthy interval of insufficient oxygen is the main cause of flood injury to the vines. Cloudiness and a high water temperature are especially dangerous in that the warmth increases respiration by the plants, and thus, their oxygen requirements. A rise in temperature of -7.7°C (18°F) doubles the rate of respiration. The floral parts and growing tips respire much faster than other parts of the vines and so are damaged most easily by flooding.

Water from swamp reservoirs is more likely to do harm than that from ponds or streams, for it usually has a lower initial oxygen concentration. However, the conditions of weather and water that injure the vines most quickly are also the conditions that result in the highest larval mortality.
If the weather became cloudly or the water was dark and from a swamp reservoir, the time should be set at 8 to 24 hours according to conditions. If the weather is very warm, this reflood should be put on at night if possible and also taken off at night owing to the sensitivity of the tender growing vines that may scald if allowed to stand in water under a hot sun.

Franklin further noted that this early summer reflood fungal infection of the vines, and as a result, if alternative were available for blackheaded fireworm, they may be favored. On the other hand, he suggested that false blossom disease was greatly checked by the reflood, probably by impacting the key vector, blunt nosed leafhopper. Finally, back in his day, he also noted that if a flood was held earlier before most of the eggs hatch (say 25 May), and then not followed up by additional treatments, the infestation may actually become worse , as a result of the initial flood treatment's interference with natural enemies.

Today, the standard recommendation contained in the Cranberry Chart Book (Sylvia 1998) for blackheaded fireworm is two floods, on 1 June and 10 June for 10 hours. Fruit rot and crop reduction are serious threats to this approach. Blackheaded fireworm infestations have not been treated with a flood in our experience. Infestations are very uncommon in Massachusetts.

APPENDIX: LATE WATER AND CRANBERRY MANAGEMENT

This section was prepared by C.J. DeMoranville, A.L. Averill, F.L. Caruso, and H.A. Sandler. These recommendations are specific to Massachusetts.

Late Water (LW) is a 30 day spring reflood applied several weeks after the winter flood has been removed and before the plants have lost dormancy (not yet fully green). LW suppresses some insects and Southern Red Mite (SRM). Fruit rot disease is reduced on LW bogs and keeping quality is improved. LW has also been shown to suppress growth of dewberries (brambles).

Significant reductions in pesticide inputs may be achieved with the use of late water.

FLOOD MANAGEMENT

When to use LW: Late water should be used no more than one year in three. LW can provide positive benefits in insect, mite, disease, and weed control (see below). If the previous summer was very sunny and none of the adverse weather conditions listed below are present, the use of LW should be considered.

When* not *to use LW: To minimize crop reduction, late water should not be used more often than once every three years. Bogs with poor quality water supplies may not be good candidates for late water. Do not use LW if the winter has been unusually cold or abnormally warm (particularly if the fall was also warm). Inspect the bog after withdrawing the winter flood - if stress, winterkill or leaf-drop are apparent, do not use LW. Do not use LW if the bog was sanded the previous fall or winter. However, barge sanding in the LW flood has been successful. Experience has shown that in some years (on average, 1 in 10 years) late water bogs may produce lowered yields. Overall, however, this low yield may be offset by higher yields in subsequent years. Costs in the LW year should also be less particularly if inputs are reduced due to reduced pest pressure, helping to offset any losses. It is not known exactly what factors contribute to these occasional lowered yields, but avoiding LW in the conditions listed above should provide some insurance against a large crop loss.

Timing: The late water flood should be applied on or about April 15th and held for 30 days. If temperatures in late March / early April are warm (50°F per day above normal), the flood may be applied earlier (up to one week). We recommend putting sprinkler heads in place prior to the flood. This allows easy application of algaecide (see below) and ensures that you will be ready if a frost night occurs immediately after flood removal.

Depth and temperature: The flood depth should be maintained so that all vines are well covered by water. Shallow floods and/or flood temperatures consistently greater than 65°F should be avoided to prevent injury and crop reduction. Flood water temperatures will generally be cooler if the flood is deep (> 12 inches above the vines).

Prevention and treatment of scum: Algae (scum) often forms in LW floods. Water temperature is a major factor in the development of scum: shallow floods and inland, warmer locations may be more prone to this problem. If your flood is shallow or if you have had scum problems in LW or winter floods, plan to treat using a liquid copper algaecide applied two weeks into the flood period (see the Weed section in the current Chart Book for options). The material is injected into the sprinkler system running at 20 psi (30 minute injection, you may continue running for 1-2 hours after to disperse the material). Rates are calculated using label information and the number of acre-feet to be treated. To calculate acre-feet, multiply the number of acres by the depth of the flood in feet (take into account variation due to non-uniform flood depth). If you do not use this treatment, you must scout shore ditch edges for the presence of algae and treat with copper compounds as soon as scum is observed. Remember that copper only prevents further algal growth (it doesn't eliminate existing scum), so prompt treatment is necessary. If scum is severe, early withdrawal of the flood may be necessary. If heavy scum is present after the flood, it should be broken up mechanically so that light can reach the vines. Even so, crop reduction may occur when scum is severe.

Draining: The date of flood removal will vary with location. If air temperatures become unseasonably warm, and flood water temperature becomes too high, the LW flood may need to be removed before 30 days have passed. If herbicide was applied prior to flood or if algaecide used, release the flood slowly over the top board to protect water resources.

Inland locations: hold no later than May 15th

Coastal Plymouth County: hold until about May 20th

Cape Cod: hold until late May

MANAGEMENT AFTER LATE WATER:

Irrigation: There should be no need to irrigate (unless protecting for frost) for at least 2 weeks after the LW flood is withdrawn.

Frost protection: After removal of the LW flood, cranberry buds are sensitive to frost injury. During LW, the appearance of the terminal bud is arrested at the spring dormant stage but internal changes in the bud lead to a loss of frost tolerance despite appearances. A one week flood early in the spring has no impact on frost tolerance - protect based on appearance. After more than one week of flooding appearance of the buds will not be an accurate predictor of tolerance. After short duration LW, protect the bogs for 27°F (after 2 weeks) or 30°F (after 3 weeks or the standard 4 weeks).

Fertilizer use: LW bogs respond readily to fertilizer, N dose should be reduced to avoid overgrowth. A 30-40% reduction of N is possible by eliminating the spring application and/or reducing the fruit set dose. Further reductions may have impact on bud development for the following year. The best tactic for a LW bog is to add no fertilizer for at least 2 weeks after flood withdrawal and then add small amounts with close monitoring of response. Generally, no fertilizer should be needed until bloom. Time your applications by the plant's development. This is especially important when development has been shifted in time by the use of LW.

Insect and mite management: Many insects are affected by LW. Emergence is delayed, and when a type of insect does appear, emergence is often synchronous. LW can be used to manage several pest insects:

Early season insects - False armyworm and gypsy moth may be suppressed. In general, cutworms have not been a problem in recent years on LW bogs. Pre-bloom sprays are seldom needed, but sweep netting should still be carried out.

Cranberry fruitworm - Fruitworms, which overwinter in the bog in cocoons, may be greatly reduced. Mortality is higher when the flood is warm (ca. 60°F). Monitoring for infestation is important: Fruitworm sprays may be eliminated. Second and third sprays are seldom needed. See insect section for more information.

Southern Red Mite - Mites can be severely impacted by holding late water. Intense infestations can be essentially eliminated in the year of late water. The mites begin to increase in the second year following the flood, but even then, may stay much below the original infestation level prior to the flood.

Disease management: Late water is an excellent cultural control strategy against fruit rot.

Processed fruit and fresh fruit Howes - You can use reduced rates and applications of fungicides. If two applications of fungicide are made, apply the first at 10% bloom with the second two weeks later. If one application is to be made, apply at 50% bloom. *Reduced fungicide rates should be employed*, especially for Howes which has greater resistance to rot. Experience with Stevens in LW is limited, but generally it has even better rot resistance than Howes.

First year after late water has been held - Fungicide applications and rates can still be reduced without sacrifice in fruit quality.

Second year after late water has been held - Fungicide applications and rates should be increased to a normal schedule or fungal inoculum will increase and cause significant field and storage rot losses.

New Plantings - Late water held in a newly planted (one or two year-old) bog will help prevent inoculum buildup, as well as help the vines spread over the floor of the bog. Both of these factors will help reduce the amount of rot during the initial two crop seasons. Late water also may slow down weeds on new bogs (see following).

Weed management: While LW may delay weed development and suppress the growth of some perennial weeds, this technique alone does not result in *control* of most established weeds. LW does not control dodder.

Dewberries (running bramble) - Some success in retarding the growth of dewberries (*Rubus* spp.) by holding late water has been reported. Sawbrier (*Smilax glauca*) was less affected. Casoron/Norosac applied before the reflood may contribute to control. LW suppression of dewberries should be followed up with other controls such as hand-wiping with glyphosate.

Herbicide use —

1. Casoron/Norosac may be applied before the flood, but it must be sprinkled or rained on before the flood. **This herbicide must be applied at least 7 days prior to the flood.** Application 2 weeks prior to the flood (85-100 lb/A) has been reported to control narrowleaf goldenrod (*Solidago tenuifolia*).
2. Herbicides other than Casoron/Norosac will not give long lasting control if applied prior to the flood.
3. None of the early season herbicides should be applied after the late water is withdrawn.

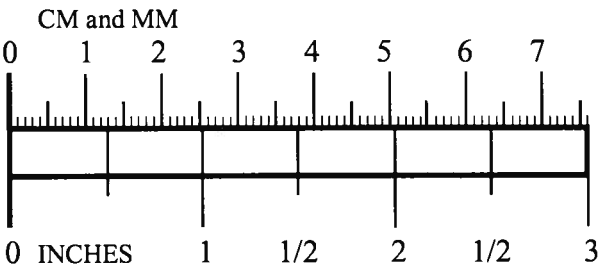
Bees: Bees for pollination may be more important on LW bogs due to the fact that the period of flowering is of shorter duration than for early water. Protect bees from pesticide exposure.

KEY TO NORTHEAST CRANBERRY INSECTS

A series of options is provided that, through comparison with your unknown specimen, will lead to identification. Begin with the first couplet, #1 and choose among the options presented. If a description fits your specimen proceed to the couplet number indicated on the right until a name is reached.

Keys are provided for:

A. Moths
B. Beetles
C. Caterpillars (worm-like)
D. Insects (immatures) found in soil or trash below vines



ADULT INSECTS

A. MOTHS

—for identification of many specimens, the moth will need to be in pretty good condition. Upon capture of live moths, if they are allowed to beat the wings against a container, wing markings (scale patterns) will be lost that are important for use of this key. Freeze them as soon as possible or place them in a cooler. Typically, wing venation is widely utilized in traditional taxonomy; thus, very beat-up specimens can often still be identified. However, this approach is beyond the intended scope of this guide.

1. Dull-colored or white forewings, robust thorax and abdomen, ca. 22-30 mm long, wingspan 35-50 mm wide ..... (what is robust?: check moth top of p. 16, 19) **8**
----Not as above (what is not robust or what is moderately robust?: check moth top of p. 30) **2**

2. Body slender or moderately robust, broad wings, ca. 15-20 mm long, wingspan 25-35 mm **11**
----Not as above **3**

3. Body slender or moderately robust abdomen and broad wings, body length ca. 26 mm and wingspan close to 50 mm, light gray to brown, tip of forewing pointed, light-colored line runs from tip of wing diagonally across wing ..... (p. 30) ..... **big cranberry spanworm**
----Not as above **4**

4. Small bodied, 5-12 mm long, wings may be square-tipped and held rooflike over body **5**
----Body very small, less than or equal to 4 mm long **10**

5. Wings white to silver or with large patches of silvery-white, marked with lines or drab blotches, body 10-12 mm long **6**
----Wing mostly all brownish, blackish, yellow(ish), may have marks **7**

6. Conspicuous "snout" extends from front of head, wings narrow and silvery-white toward front and yellow toward back, smokey lines, dots across forewings near back margin ..... (p. 84) ..... **cranberry girdler**
----No conspicuous snout extending from front of head, wings mostly dark grayish, with whitish areas and black markings, resembles bird dropping ..... (p. 46) ..... **cranberry fruitworm**

7. Wings vivid yellow, X-shaped brown mark on wings when folded ..... (p. 52) ..... **sparganothis fruitworm**
----Grey forewings marked with gray-brown and silver-grey bands, wings expand 9-10 mm .....
..... (p. 34) ..... **blackheaded fireworm**
----Gray forewings marked with black bands, wings expand to 19-24 mm .... (p. 40) ..... **hill fireworm**
----Uniform gold wings, wings expand 14-19 mm, body 8.5 mm long ..... (p. 36) ..... **yellowheaded fireworm**
..... summer adult
----As above in size, but with uniform grey wings ..... (p. 36) ..... **yellowheaded fireworm**
..... overwintering adult
----Brown forewings with two chocolate-colored stripes crossing each forewing diagonally, wings expand to 19 mm ..
..... (p. 39) ..... **spotted fireworm**
----Wings dark brown with single white spot on each forewing ..... (p. 38) ..... **red-striped fireworm**

8. Hindwings drab colored, dirty whitish, yellowish, brownish **9**
----Hind wings orange-coppery colored ..... (p.22) ..... **humped green fruitworm/**
..... **copper underwing**
----Hindwings snow white and marked with irregular lines, dotted along margin, body ca. 28-30 mm long .....
..... (p. 23) ..... **gypsy moth** female

9. Forewing mostly dull brown with triangular patch in middle of upper wing margin .....
..... (p. 18) ..... **spotted cutworm**
----Forewing brownish to reddish and crossed a a few discrete fine lines, at rest, body comes to fine point beyond head
..... (p. 16) ..... **blossomworm**
----Forewing coffee brown, variegated irregularly with dark markings, wings spread to over 50 mm .....
..... (p. 15) ..... **false armyworm**
----see also (p. 17) rare cutworm sections for fall armyworm, armyworm, black cutworm

10. Wings black with conspicuous silvery white stripe toward posterior of wing .....
..... (p. 66) ..... **Nepticulid**
---- Moth very small (<2 mm long), silvery wings with ragged fringe along margin .....
..... (p. 66) ..... ***Coptodisca***

11. Forewing brown with wavy blackish lines **12**
----Not as above **13**

12. Hindwings uniform brown ..... (p. 23) ..... **gypsy moth** male
----Hindwings with wavy markings, drab but somewhat yellowish to orangish (female) or with deep yellow to orangish (male) ..... (p. 28) ..... **brown spanworm**

13. Wings pale yellow (male) or sulfur yellow (female) with some brown spots .....
..... (p. 27) ..... **green spanworm**
----Wings pale gray with wavy lines ..... (p. 31) ..... **spiny looper /**
..... half wing geometer (male)
----Wings snow white, or pale gray with black markings on wings, noticeable spots along wing margin .....
..... (p. 32) ..... **chain spotted geometer**

B. BEETLES

1. With curved snout **2**
----Without curved snout **3**

2. Small (ca. 2 mm) dark reddish to blackish ..... (p. 42) ..... **cranberry weevil**
----5-6 mm long, reddish to blackish ..... (p. 80) ..... **strawberry root weevil**
----9-11 mm long, black ..... (p. 78) ..... **black vine weevil**

3. Small body, ranging from ca. 3-6 mm, antennae long and slender **4**
----Body ranging from 8-23 mm, antennae with "club"(terminal segments expand into rounded lobes that can form compact club) **5**

4. Mostly black with well-developed segment on rear leg near body ..... (p. 60) ..... **red-headed flea beetle**
----Striped with legs much lighter colored (yellow) than the underside of the body ..... (p. 82) ..... **striped colaspis**
----Striped with legs same color as the underside part of the body ..... (p. 61) ..... **fire beetle**
----Dark brown, bronzed and shiny ..... (p. 81) ..... **cranberry rootworm**

5. Hard, stiff elytra (forewings) curve around body **6**
----Not as above, wings brown and lying on abdomen, yellow hair clothes body ..... (p. 72) ..... **cranberry root grub**

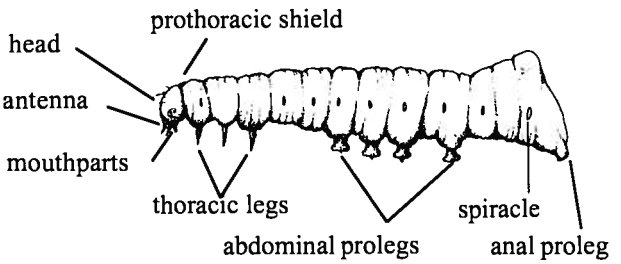
6. Body 7-8 mm, yellowish to dark brown ..... (p. 77) ..... ***Hoplia modesta***
----Body 9-10 mm, variable markings; often straw colored with black patterning ..... (p. 75) ..... **oriental beetle**
----Body 19-23 mm, dark brown ..... (p. 74) ..... **cranberry white grub**

IMMATURE INSECTS

C. *CATERPILLARS*

1. Caterpillar slug-like ..... (p. 68) ..... **bog copper**
----Not as above **2**

2. Caterpillar very hairy, black with series of colored tubercles (bumps) along back of body ..... (p. 23) ..... **gypsy moth**
-----Not as above **3**



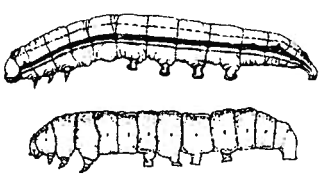
Body parts of a typical moth larva, a caterpillar. (Illustration: Garnett)

3. Caterpillar with 4 or fewer pairs of abdominal prolegs on the back of the body **4**
-----Caterpillar with more than 5 pairs of prolegs on the back of the body, body green and head capsule spherical, often with body distinctly curled ..... (p. 26) ..... **cranberry sawfly**

4. Caterpillar with 1 pair of abdominal prolegs ..... (spanworm group, p. 27) **5**
----Caterpillar with 4 pairs of abdominal prolegs **7**

5. Body mostly yellow with white spots, each spot bordered with black spots, such spots running along each side of body ..... (p. 32) ..... **chain-spotted geometer**
----Body mostly green with light-colored (often yellow) stripe along side ..... (p. 27) ..... **green spanworm**
----Body mostly brown or grayish **6**

6. Body mostly gray-brown with more or less conspicuous patches of color (often yellow to organge) along side, can see small black spines on low tubercles with good light and magnification ..... (p. 31) ..... **spiny looper**
----Body light to chocolate brown with a whitish stripe along side of body ..... (p. 28) ..... **brown spanworm**
----Body brown to very dark brown, no stripes, sets of tubercles (bumps) beyond middle of back ..... (p. 30) ..... **big cranberry spanworm**



noctuid (cutworm)

geometrid (spanworm)

tortricid (sparganothis and fireworm)

Compare body types on pages 15, 27, and 34/52 to distinguish among noctuid (cutworm), geometrid (spanworm), and tortricid (sparganothis and fireworm) groups.

7. Body more or less compressed, abdominal prolegs not very fleshy, head held out in line with body so mouthparts extend forward, often exhibits spasmodic wriggling when first disturbed ..... see figure above
..... (Tortricid group p. 34 and 52 [fireworm and sparganothis]) **8**
----Body cylindrical, not at all compressed, abdominal legs well developed and fleshy, head held downward so mouthparts largely face face downward ..... (Noctuid group p. 15 [cutworms]) **11**

8. Head black or very dark, body not spotted **9**
----Not as above **10**

9. Body greenish, prothoracic shield black ..... (p. 34) ..... **blackheaded fireworm**
----Body dark brown and marked lengthwise on back and sides with eight pale stripes .....
..... (p. 40) ..... **hill fireworm**

10. Body olive with conspicuous and somewhat elevated very white spots along whole body .....
..... (p. 39) ..... **spotted fireworm**
----Body with dull reddish lines along the back and sides ..... (p. 38) ..... **red-striped fireworm**
----Body pale yellowish ..... (p. 36) ..... **yellowheaded fireworm**
..... but see note following
----Body whitish, pale yellow, or darkish dingy green ..... (p. 52) ..... **sparganothis fruitworm**
..... but see note following

Note: Additional evidence is necessary to distinguish between sparganothis fruitworm and yellow-headed fireworm. Consider these points:

❖. Check area where sweep set was taken and if webbed uprights can be found, determine if:
a. uprights are extensively webbed and partially to extensively browned by feeding .....
..... (p. 36) ..... **yellowheaded fireworm**
b. uprights webbed together neatly and leaves eaten from within, usually feeding areas are not readily apparent
..... (p. 52) ..... **sparganothis fruitworm**

❖. Hold feeding larvae on fresh cranberry uprights until they form a pupa and/or moth
a. pupa has prominent and distinctive knob on its top and moth is either clear orangish-yellow or clear gray ..
..... (p. 36) ..... **yellowheaded fireworm**
b. pupa has no knob and moth is yellow with brown X on back ..... (p. 52) ..... **sparganothis fruitworm**

❖. Determine if vine cover of winter flood was not adequate, yellow-headed fireworm tends to appear in these non-flooded areas;

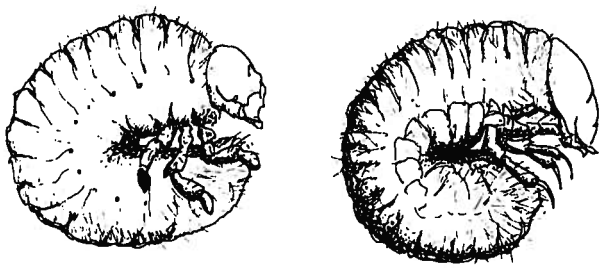
11. Body with pinky to reddish-brown back, or if back green, pinky -reddish tinge still apparent on sides of back ..
..... (p. 16) ..... **cranberry blossomworm**
----Body with a row of two to four angular dark spots on each side of the hind part of the back .....
..... (p. 18) ..... **spotted cutworm**
----Body mostly green and striped, conspicuous whitish line on large caterpillars (large = ca. 20 mm or more in length), also on large caterpillars, the back may be green to blackish .....
..... (p. 15) ..... **false armyworm**
----Body green; white and yellow line (line may be patchy) along spiracles, bears prominent hump on last abdominal segment ..... (p. 22) ..... **humped green fruitworm**
----If bog was wet or had standing water after end-May . (see descriptions p. 17) ..... other pest cutworms

D. INSECTS FOUND IN SOIL OR TRASH BELOW VINES

1. Caterpillar-like **5**
----Not as above **2**

2. Body brown or yellowish-brown and hard throughout, body long, slender and wireless ..... not a cranberry pest ..... (p. 83) ..... **wireworm**

3. Abdomen white, legless, body small (no longer than 12 mm), brownish head capsule .... (curculionid weevil group, p. 78) **6**
----Not as above **4**



Compare the sickle shape of the legs of cranberry root grub (right) with the "paw" shape of the legs of cranberry white grub (left). (Illustration: Garnett)

4. Three thoracic legs with sickle-like claws at tip of leg, no larger than 8 mm, abdomen whitish and not darkened by contents ..... (chrysomelid group, p. 81) **7**

---Three thoracic legs with sickle-like claws at tip, hind part of abdomen darkened by contents, body clothed all over with fine and mostly short reddish or brown hair, body flattened from top to bottom .... (p. 72) ..... **cranberry root grub**

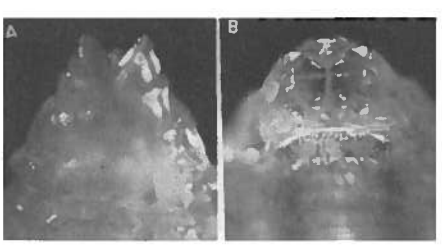
---Three thoracic legs with "paw-like" tips, hind part of abdomen appears dark because of contents, has typical "white grub" appearance ..... (compare photo, top p. 70) **8**

5. Body dirty whitish and head brown, bears scattering of hairs ..... (p. 84) ..... **cranberry girdler**
----Body not whitish, body may be striped, body cylindrical and plump, with 4 pairs of fleshy abdominal prolegs, body coiled ..... (p. 15) ..... **soil cutworms**

6. On pronotum, 4 setae arise from tubercles on anterior row ..... (p. 80) ..... **strawberry root weevil**
----no such setae on anterior row of pronotum ..... (p. 78) ..... **black vine weevil**

7. End (ventral tip) of abdomen divided into two equal lobes (see below).. (p. 81) ..... **cranberry rootworm**
----abdomen not as above ..... (p. 82) ..... **striped colaspis**

8. On raster, 2 parallel rows of stiff hairs and V-shaped anal slit ..... (p. 74) ..... **cranberry white grub**
----on raster, v-shaped series of stiff hairs; anal slit Y-shaped; on the Y, the arms are as long as the tail .... (p. 77) ..... ***Hoplia modesta***
---on raster, 2 somewhat parallel rows of hairs with 10-16 setae on each row; anal slit transverse .... (p. 75) ..... **oriental beetle**



End of abdomen of rootworm (left) and colaspis (right) (Franklin 1950)

Raster patterns on the scarab grubs are illustrated in the section on rastral patterns illustrated on p. 71

GLOSSARY

abdomen: of the three body regions of an insect, the segments of body that immediately follow the leg-bearing thorax

abdominal prolegs: prolegs (fleshy and unsegmented legs) arising from the abdomen

aedeagus: penis

anal comb: a pronged structure just above the anus and below the anal plate used to eject frass away from feeding site

anal plate: dorsal hardened area on the last abdominal segment

anal proleg: proleg arising from the last abdominal segment

annulated: ringed; body segments with shallow creases running around each segment as in spanworm caterpillars

antenna: elongate sensory structure on head, just forward from the eyes

apex: tip

apical: distal; distant from the point of attachment

apical margin: the outer edge of an insect wing

arcuate: curved; arched like a bow

baits, for cutworms: "poisoned baits" were recommended to reduce infestations of the Noctuid cutworms if the larvae were very large such that other management approaches were ineffective. Franklin (1928) recommended that per acre, a formula of 25 pounds wheat bran, 2 pounds sodium fluosilicate and enough water to moisten should be used. The dry materials should be mixed and water added such that the bait is damp throughout but not too wet to crumble and spread readily. The material should be broadcast by hand over the acre just after sunset (when the onset of larval activity should occur). He noted that the bait is not effective after it gets stale or has been soaked by rain, so a second application 3-4 days after the first is often advisable. It is not known if the bait containing sodium fluoaluminate (cryolite) for black vine weevil is effective for cutworms; evaluation is required.

basal: proximal; adjacent to or nearest the point of attachment

bifid: in two branches

carbamate insecticides: a group of synthetic organic insecticides that interfere with normal functioning of the insect nervous system; e.g. carbaryl (Sevin)

caterpillar: the larva of a butterfly or moth;may also include larva of a sawfly

caudad, caudal: pertaining to the tail or posterior portion of the body

cell: in insect description, an area of the wings enclosed by veins

cephalic: on or attached to the head

chorion: the shell of an insect egg

chrysalis: the pupa of a butterfly

clypeus: lobelike structure on the anterior portion of insect head ("face") between the frons and labium; may be hinged with the labrum

cocoon: protective covering in which pupation occurs; constructed of silk and/ or other materials by the larva

collar: in Lepidoptera, two flattened lobes attached to prothorax

complete metamorphosis: change in form during development; for insects that undergo complete metamorphosis, the immatures are 1) called larvae 2) do not resemble the adult form 3) transform to a pupa upon completion of larval development 4) usually are adapted to different environmental situations and feed on foods than the adult form.

convex: curved or rounded

costa (pl: costae): a thickened vein in wing

coxa (pl: coxae): the basal segment of the leg, articulating with the body

crepuscular: active during low periods of light, such as twilight

crochets: hooklike structures on the abdominal prolegs used to grasp substrate

cultural control: manipulation of a cropping system or specific crop production practices to reduce or avoid pest damage

cuticle: non-cellular outer layer of the insect (or other arthropod) body wall

diapause: a state of hibernation or suspended development in insects

distal: away from the base or point of attachment

diurnal: active during the day

dorsal: top or uppermost; pertaining to back or upper side of body

elytron (pl: elytra): a modified, hardened front wing of an insect, characteristic of beetles

exoskeleton: a skeleton on the outside of the body, as in insects and other arthropods

exuvia: cast exoskeleton, formed when an insect molts

family: a subdivision of an order that contains a group of related genera; family names end in *—idae*

femur: a leg segment, occurring before the tibia and beyond the trochanter

filament: a long, slender, threadlike (often segmented) process

filiform: threadlike, slender and of nearly equal diameter throughout

flagellum: the third and succeeding segments of most antennae

flagellomere: a division of the flagellum of the antenna

forewings: the anterior pair of wings (closest to the front of the body), arising from the mesothorax

frass: pelletlike excrement

frons: area between eyes bordered above the vertex and below by the clypeus

fuscus, fuscous: brownish gray, dusky

galea: outer, distal lobe of the maxilla (second pair of feeding appendages in mandibulate species)

generation: from any given stage in the life cycle to the same stage in the offspring

geniculate: elbowed or abruptly bent

genitalia: sexual organs and associated structures

genus (pl: genera): a group of closely related species; the first name in a scientific name, e.g. *Acrobasis* is the genus name of *Acrobasis vaccinii*. Names of genera are latinized, capitalized, and italicized.

geometrid: a family of small to medium size moths with slender bodies and small wings; larvae are commonly called inchworm and are often twig like; includes the spanworms and geometers

globose: spherical

gregarious: occurring in groups

hibernaculum (pl: hibernacula): a case or covering for protection during the winter

hindwing: the posterior wing, arising from metathorax

host: for our purposes, the organism that a parasitoid lives within or on; the plant on which the insect feeds

hyaline: transparent or nearly so; colorless

hypoproct: fleshy spur ventral to anus in loopers (Geometridae)

instar: the insect, from one molt to the next

integument: cuticle; body wall or covering

intersegmental: between adjacent segments

labial palps (pl: palpi): a segmented sensory appendage associate with the labium, usually projecting from the lower part of the head

labium: lower "lip" of the mouthparts

labrum: upper "lip" or the flaplike plate that rests over the jaws and just below the clypeus

lamella: a leaflike plate; on antennae leaflike plates at the end of the antenna

lamellate: formed of thin, overlapping plates; a type of insect antenna where the terminal segments are expanded laterally to form rounded or oval platelike lobes

laminate: formed of thin, flat layers or leaves

lanceolate: spear-shaped

larva (pl: larvae): immature feeding, growing stage of an insect that undergoes complete metamorphosis

lateral: along sides; typically at level of spiracles

late water: removal of winter flood in early spring and reflooding for ca. 1 month in April-May

luteous: yellowish with greenish tinge

mandible: jaw; the anterior pair of hardened mouthpart structures that lie between the labrum and maxillae

maxilla: the second pair of jaws

maxillary palpus (pl: palps): a segmented sensory structure located on the maxilla, extending from the lower part of the head

medial, median: running along or near the body midline

melanic: individual of species that has dark coloration

mesal: pertaining to or toward the midline

mesothorax: the second thoracic segment, bears forewings and middle set of legs

metamorphosis: a change in form during development

metathorax: the third thoracic segment; most posterior of thoracic segments that bears hindwings and hindlegs

middorsal: along dorsal midline of body

mine: excavation in plant tissue made by tunneling larva

molt: to cast off or shed exoskeleton and produce new one

midventral: along ventral midline of body

monophagous: feeding on a small number of species (e.g. plants), usually a single species or species within the same genus

multivoltine: producing more than two generations per year

noctuid: a large and diverse family of moths that contains the cutworms and humped green fruitworm

nocturnal: active at night

notum: the dorsal (top or uppermost) plate of each thoracic segment

nymph: immature stage of an insect that undergoes incomplete metamorphosis

ocular: of or pertaining to the eye

oligophagous: feeding somewhere in between monophagous (specialized feeder) and polyphagous (broad, general feeder); on several plants in different genera or the same family or a few closely related families

order: one of the major groups of insects, e.g. flies (Diptera), beetles (Coleoptera), moths/butterflies (Lepidoptera) are each on example of an insect order

organophosphate insecticides: a group of insecticides that interferes with normal functioning of the insect nervous system; usually short-lived and some are highly toxic to mammals (e.g. Guthion, diazionon, Lorsban)

ovipositor: egglaying apparatus

oviposition: egglaying

palpus (pl: palpi): segmented sensory appendage associated with mouthparts, usually on maxillae and labium

paraprot: small fleshy protuberances on either side of anus in loopers (Geometridae)

parasitoid: an animal that feeds on another living animal (the host) at least during a part of its life cycle and consumes host tissues; most insect parasitoids eventually kill the host

parthenogenesis: reproduction without mating; individuals arise from unfertilized eggs

pectinate: comblike

penultimate: next to the last

pheromone: chemical substance used for communication by members of the same species

photoperiod: environmental rhythm of darkness and daylight

pinaculum (pl: pinacula): a small, flat or very slightly elevated area with one to four hairs. In caterpillars, an enlarged, hair-bearing and soft projection that forms a flat plate

plica (pl: plicae): a fold

plumose: featherlike or bushy

polymorphism: the existence of two or more distinctive-appearing forms within a population

polyphagous: feeding on many species (e.g. plants), usually across several genera

prepupa: a quiescent (resting, motionless) stage between the larval period and the pupal period

prolegs: fleshy legs usually located on abdominal segments of caterpillars

pronotum: the upper surface of the prothorax

prothorax: first thoracic segment; most anterior of thoracic segments, bears front legs

prothoracic shield: in caterpillar, dorsal plate on top of the first thoracic segment

prothorax: first thoracic segment, to which head is attached

proximal: pertaining to the part of an appendage nearest the body

punctate: set with small impressions or pits

pupa: the transformation stage between larva and adult in insects that undergo complete metamorphosis; usually inactive and is non-feeding

pupate, pupation: to become a pupa

quiescent: resting, motionless

resistance: ability of an organism to resist control measures

raster, rastral: on scarab beetle larvae, pattern of stiff hairs and spines on underside of last abdominal segment

reniform spot: a spot, usually kidney shaped, in the outer part of the forewing of a moth, toward the top margin, and is typical of the noctuids

reticulate: netlike

scale: a modified, flattened seta (hairlike process); butterfly and moth wings may be covered with such scales

scape: basal segment of antenna

sclerites: hardened plates of insect exoskeleton

scolus (pl: scoli): elongate projection from body wall

serrate: sawlike

seta (pl: setae): hairlike process or outgrowth from head or body

setal base: hardened plate at base of seta

sexual dimorphism: obvious differences between males and females of the same species

spatulate: widened at the apex like a spatula

species: a group of individuals or populations that are similar and are capable of producing fertile offspring (and are sufficiently different in ways to preclude interbreeding with other such groups). Also, the basic unit in taxonomic classification

spinule: minute spine, often broadened at base

spinulose: bearing numerous minute spines or cuticular outgrowths

spiracles: lateral, oval to round openings of the respiratory system, in adults, usually found on the side of the thorax and abdomen

spiracular: adjacent to or passing through the spiracles

stria, striate: (with) grooves or depressed lines

subapical: back from or below the apex

subdorsal: to either side of the dorsal midline

subspiracular: below level of spiracles but above legs

tarsus (pl: tarsi): distal (away from base), segmented part of the leg attached to tibia

thorax: three segments immediately behind head that bear legs

tibia: segment of leg between femur and tarsus

tortricid: small to medium size moths that are often leaf tiers or rollers; family includes all fireworms and sparganothis fruitworm

transverse: running around a body segment, perpendicular to body axis

trochanter: segment of leg between coxa and femur

tubercles: a small knotlike or rounded protuberance

venter: underside or "belly"

ventral, ventrad: toward the underside of the body

vertex: dorsal or top portion of head

vestigial: a small, degenerate or imperfectly developed part or organ; non-functional

COMMON NAMES AND SCIENTIFIC NAMES OF SOME HOST PLANTS LISTED FOR INSECTS IN THE GUIDE

Common names are used in the text because they are generally recognizable. However, problems arise when more than one species has the same common name or if multiple common names are used to refer to the same species.

In parentheses, we have listed additional names that we found associated with a given species name.

alder (white alder), *Alnus incana* (L.) Moench
arrow-leaved tear thumb, *Polygonum sagittatum* L.
bayberry, (Northern bayberry), *Myrica pensylvanica* Loisel
beach plum, *Prunus maritima* Wang.
bearberry, *Arctostaphylos Uva-ursi* (L.)
beggar-ticks, *Bidens* spp.
black alder (winterberry), *Ilex verticillata* (L.) Gray
blackberry, *Rubus canadensis* L.
black highbush blueberry, *Vaccinium atrococcum* (Gray) Heller
black huckleberry, *Gaylussacia baccata* (Wang.) C. Koch
bog laurel *Kalmia polifoia* Wang
bristly dewberry (running bramble), *Rubus hispidus* L.
buttonbush, *Cephalanthus occidentalis* L.
chain fern, *Woodwardia virginica* (L.)
chokeberry (black chokeberry), *Pyrus melanocarpa* (Michx.) Willd
clematis, *Clematis* sp.
dangleberry, *Gaylussacia frondosa* (L.) T. & G.
deerberry, *Vaccinium stamineum* L.
dwarf huckleberry, *Gaylussacia dumosa* (Andr.) T. & G.
evening primrose, *Oenothera biennis* L.
evergreen blueberry (florist's greens, evergreen huckleberry), *Vaccinium ovatum* Pursh
fetterbush (swamp Leucothoë, swamp sweet bells), *Leucothoë racemosa* (L.) Gray
fireweed, *Epilobium angustifolium* L.
flowering fern (regal fern), *Osmunda regalis* L.
glaucous greenbrier (silverleaf sawbrier) , *Smilax glauca* Walt
gooseberry, *Ribes* sp.
great burdock, *Arctium lappa* L.
greenbrier (bullbrier, greenleaf sawbrier, horsebrier, catbrier), *Smilax rotundifolia* L.
halberd-leaved hearthumb, *Polygonum arifolium*
halberd-leaved rose mallow, *Hibiscus militaris* Cav.
hardhack (steeplebush), *Spiraea tomentosa* L.
hazlenut, *Corylus* sp.
highbush blueberry (swamp blueberry, rabbiteye blueberry), *Vaccinium corymbosum* L.
horse weed: see wild lettuce
Joe-pye-weed, *Eupatorium dubium* Willd.
knotweed, *Polygonum* spp.
Labrador tea, *Ledum groenlandicum* Oeder
lady's thumb (heart's thumb), *Polygonum persicaria* L.
lamb's quarters (pigweed), *Chenopodium album* L.
lance-leaved white violet, *Violoa lanceolata* L.
larger blue flag, *Iris versicolor* L.
leatherleaf, *Chamaedaphne calyculata* (L.) Moench
loosestrife (swamp or yellow loosestrife, swamp candles), *Lysimachia terrestris* L.
low bush blueberry (early low bush blueberry, late low blueberry, Southern low blueberry, hillside blueberry), *Vaccinium pallidum* Ait. (prev. *Vaccinium vacillans* Torr.)
low sweet blueberry (low bush blueberry, sweet lowbush blueberry), *Vaccinium angustifolium* (Ait.)

maleberry, *Lyonia ligustrina* (L.) D. C.
marsh fern (meadow fern), *Dryopteris Thelypteris* L.
marsh St. John's wort, *Hypericum virginicum* L.
meadow sweet, *Spiraea alba* DuRoi var. *latifolia* Aiton
mountain cranberry (lingonberry, foxberry, cowberry), *Vaccinium vitis-idaea* L.
pigweed, *Amaranthus retroflexus*
pilewort (fireweed), *Erechtites hieracifolia* L.
poison ivy, *Toxicodendron radicans* L. Kuntz
prickly dewberry (running bramble, Northern dewberry), *Rubus flagellaris* L.
ragweed (common ragweed), *Ambrosia artemisiifolia* L.
red maple, *Acer rubrum* L.
red root, *Lachnanthes tinctoria* (Walt.) Ell.
rhodora, *Rhododendron canadense* (L.) Torr.
rose, *Rosa nitida* Willd, *Rosa carolina* L.
running bramble (prickly and bristly dewberry), *Rubus* spp.
sensitive fern, *Onoclea sensibilis* L.
sheep laurel, *Kalmia augustifolia* L.
sheep sorrel, *Rumex acetosella* L.
small cranberry, *Vaccinium oxycoccus* L.
smartweed, *Polygonum hydropiperoides* L.
sparkleberry, *Vaccinium arboreum* L.
spotted touch-me-not, *Impatiens capensis* Meerb.
staggerbush, *Lyonia mariana* Nutt.
swamp honeysuckle (white swamp honeysuckle, swamp azalea, clammy azalea), *Rhododendron viscosum* (L.) Torr.
swamp loosestrife, *Decodon verticillatus* (L.) Ell.
swamp sweetbells (fetter bush), *Leucothoe racemosa* (L.) Gray
sweet fern, *Comptonia peregrina* L.
sweet gale, *Myrica Gale* L.
sweet melilot (white sweet clover), *Melilotus alba* Desr.
sweet pepperbush, *Clethra alnifolia* L.
tall buttercup (common buttercup), *Ranunculus acris* L.
tea berry (wintergreen, checkerberry), *Gaultheria procumbens* L.
"Three square" rush, *Scirpus americanus* Pers.
trailing arbutus, *Epigaea repens* L.
trumpetweed (Sweet Joe-pye-weed), *Eupatorium purpureum* L.
upright bramble (blackberry), *Rubus allegheniensis* Porter
water horehound, *Lycopus rubellus* Moench
wax myrtle, *Myrica cerifera* L.
white aster (heath aster), *Aster ericoides* L.
wild bean (ground nut), *Apios americana* Medic.
wild black raspberry (black caps), *Rubus occidentalis* L.
wild indigo, *Baptisia tinctoria* (L.) R. Br.
wild lettuce, *Lactuca canadensis* L.
wild rose, *Rosa virginiana* Mill.
willow herb, *Epilobium glandulosum* var. *adenocaulon* (Haussk.) Fern.
winterberry (black alder), *Ilex verticillata* (L.) Gray
wintergreen (checkerberry, teaberry, boxberry) *Gaultheria procumbens* L.
wool grass (common wool grass), *Scirpus cyperinus* (L.) Kunth.

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