INTEGRATED PEST MANAGEMENT FOR CRANBERRIES IN WESTERN CANADA

A GUIDE TO IDENTIFICATION, MONITORING AND DECISION-MAKING FOR PESTS AND DISEASES

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FOREWORD

This manual is a reference tool designed to help cranberry growers and pest management consultants with identification, monitoring and control of key pests and diseases in cultivated cranberry fields in Western Canada.

The manual begins with several short sections explaining integrated pest management (IPM), monitoring, use of pheromone traps, insect classification and life cycles, and identification of moth larvae (caterpillars).

Following these introductory explanations are two sections describing key insect pests. The first section presents pests found during the dormant to pre-bloom stages of cranberry vines in early spring. Pests found during the summer stages of bloom and fruit sizing are described in the second section. In each section, the most common pests are presented by usual order of prevalence in cranberry beds. Less common pests are also described, because you may see them when monitoring fields. For all pests, a description of the life cycle and feeding habits is provided so that you may better understand pest biology. Details on methods and timing of monitoring for major pests will help you detect these pests in cranberry beds.

Not all insects and animals in cranberry beds are pests. Sections on pollinators and on natural enemies of insects and weeds will help you identify, encourage and protect the “good guys”.

Symptoms of the most common fungal diseases seen in this region, along with the causal organisms, are presented in the section on diseases. A table demonstrating the infection periods and the timing of disease in the beds will help growers detect and manage blights, diebacks and rots.

Because the concepts of integrated pest management are based on economical and environmental aspects, special emphasis has been placed on presenting biological, behavioural, physical and cultural practices for controlling pests and protecting against diseases.

General recommendations for chemical control of insects are suggested. The 2000 Canada Cranberry Pesticide Chart and a table of products registered by the Canadian Pest Management Regulatory Agency (PMRA) are included to help growers choose appropriate insecticides. We emphasize that insecticide, fungicide and herbicide registrations change from year to year. Always read the label carefully to ensure that the chemicals you choose are registered on cranberry for the target pest, be it an insect, a disease or a weed.

The information contained in this manual was compiled from many sources, including research reports, field observations, scientific articles, books, and extension guides and manuals. A list of references, good websites and IPM resources is provided if you desire more information.

We hope that this manual will assist all concerned users and will facilitate your pest management techniques and practices.

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INTEGRATED PEST MANAGEMENT (IPM)

IPM is a knowledge-based decision-making process that strives to manage crop pests in an economical, efficient, environmentally friendly manner. IPM decision-making requires understanding the pest problem, applying the economic or action thresholds for triggering pest management, knowing the risks and benefits of the various management options, and choosing the lowest risk, most efficient pest management strategy available.

Inherent to the IPM Stratedy are:

1. The concept of monitoring the pest population and/or factors influencing the pest population so that control is used only if the pest is present at numbers to be concerned about and/or if conditions are conducive to pest reproduction and growth.

2. All appropriate methods should be used. A combination of approaches is desirable, rather than reliance on a single technique. Combinations must be economical.

3. Broad-spectrum pesticides should be avoided, with the use of selective chemicals desired.

4. The least disruptive approach is to be used. Thus, adequate controls that do not upset desirable aspects of the system will be adopted.

Recognizing these principles and concepts, this IPM manual promotes the use of sound IPM strategies and techniques by cranberry growers to ensure the development of sustained cranberry production in Canada.

(Exerpted from text by Jere Downing, Ph.D., Executive Director of the Cranberry Institute)

MONITORING

Monitoring for insects is like doing detective work. "Monitoring" simply means sampling on a regular basis, usually weekly. Monitoring is recommended to find pests on cranberry and to be aware of the damage they may cause. Monitoring may be done by a paid cranberry pest management consultant, or by a farm employee trained in monitoring techniques and record-keeping. Several monitoring methods are used to find different species of pests and to gather information that will help growers decide on the type and timing of treatment. Visual sweeps, sweep-netting in the daytime or at night, walking counts, pheromone traps and light traps may be used to detect the presence and the developmental stage of insect pests in cranberry fields. Monitoring for dead pests at a safe interval after a pesticide application is recommended to check that the treatment was effective and to see if newly hatched larvae are present.

In British Columbia, monitoring begins early in the spring by looking for larvae of the blackheaded fireworm. Monitoring for this pest requires a lot of observation. The method used to find these larvae is visual sweeping: crouching down to examine cranberry uprights. This technique is explained in detail in the section "KEY PESTS: DORMANT TO PRE-BLOOM; Blackheaded Fireworm; Monitoring". When damaged uprights are found it is important to record the size and number of larvae per sample before making a decision on treatment. Maps of each bed showing location of sample sites, records of larvae found, damaged areas and "hot spots" where larvae are numerous should be done at each visit. Mapping these areas allows growers to go back to precise spots and check for dead larvae after a treatment, and gives information on the area to watch for infestations year after year. Visual sweeps provide a good opportunity to collect unknown pests feeding on cranberry foliage for further identification.

Sweep-netting

In the Pacific Northwest, sweep-netting is used mostly at night to find cutworm larvae and adult weevils feeding on the cranberry foliage. A long-handled sweep net 37.5 cm (15 inches) in diameter is drawn across the tips of the vines as the person sweeping walks through the bed. One "sweep" is a 180-degree arc around the person sweeping. One "sweep set" refers to a number of sweeps (10, 20 or 25) taken as the person walks through the bed. It is recommended to take as many sweep sets as practical, some from the edges and some from the middle of the beds. Sometimes other pests can be found in the net at the same time. Sweep-netting during the daytime for fireworm larvae is not usually done in Western Canada.

Pheromone trap

Light trap for night-flying moths

Walking counts can be used to estimate the number of girdler moths flying over areas of the beds. Where many girdler moths are seen, many eggs will probably be laid by female moths. Walking counts help predict where damage may be done by larvae in the following months. Walking counts are explained in detail in the section “KEY PESTS: BLOOM AND FRUIT-SIZING TO HARVEST; Cranberry Girdler; Monitoring”.

Pheromone traps are baited with a synthetic pheromone (sex attractant) to draw male insects (usually moths) into a trap where they are confined or trapped on a sticky surface. Pheromones are usually species-specific, although non-target pests are sometimes caught in pheromone traps baited with the pheromone of a target pest. Pheromone traps provide information on the presence or absence of the target species, the time at which the first moths fly and the peak of moth flight, which is useful in predicting the timing of the next generation of larvae. Target moths in pheromone traps should be counted at least once a week (on the same day each week) and dead moths should be removed from the bottom of the traps.

Light trapping can be used to trap moths for which synthetic pheromone lures are not commercially available. The usual light trap consists of a blacklight tube and two to four baffles hung vertically over a bucket. At night, flying moths are attracted to the light and fall into the bucket through a funnel located at the base of the black light tube. Traps should be checked every morning to collect good specimens for identification. These traps will attract flying insects from adjacent fields or forests, bringing great quantities of many species of insects.

Information collected during all types of monitoring should be recorded and kept at the farm for reference.

USING PHEROMONE TRAPS

In British Columbia, pheromone traps are used mainly for monitoring blackheaded fireworm and cranberry girdler.

1. Hang top of trap from wire hanger

The type of pheromone trap usually used is the wing trap, which has a roof-like top, a bottom and a sticky "floor" insert that traps moths. The pheromone lure that attracts moths is suspended from the trap roof. Wing traps are supported by a wire hanger, which also attaches the trap to a stake for placement in the field.

To obtain accurate and reliable information from pheromone traps, it is important to follow the guidelines below.

1. ASSEMBLING THE WING TRAP

Begin by hanging the top of the trap from the wire hanger. Insert the lure, following the instructions below. Attach the trap bottom to the wire hanger, then place the sticky insert inside the trap to form the floor. Secure the sticky insert to the trap bottom with a paperclip. This will keep the insert in the trap on windy days.

2. Insert the lure

2. HANDLING THE PHEROMONE LURE

Use disposable gloves or small plastic bags to handle pheromone lures. Hold a lure with one hand and position it so that it is suspended from the top (ceiling) of the trap.

The pheromone on the lure is odorless (to us), and colourless. However, pheromone will adhere to the outside surface of the glove or bag used to handle the lure. Therefore, do not touch any other part of the trap with a glove or bag that has handled a pheromone lure. Do not use the same glove to handle fireworm lures AND girdler lures.

3. Attach trap bottom

Once you have placed all the lures of one type (fireworm or girdler) in traps, remove the gloves or bags by turning them inside out. Tie them up and discard them.

3. PLACING TRAPS IN THE CRANBERRY BEDS.

Attach the wire hangers to wooden stakes, and place traps in the beds so that the trap bottom hangs about 15 cm (6 inches) above the vine tips. Raise the traps as the vines grow. The recommended number of traps per area is discussed in sections on blackheaded fireworm and cranberry girdler.

4. Place sticky insert inside trap to form the floor

Place traps in the beds at least one week before moth flight begins. For blackheaded fireworm, place traps in the beds in mid-May. For cranberry girdler, place traps in the beds in the first week of June.

4. CHECKING TRAPS WHEN MONITORING

Visit the traps once or twice per week, on the same days each week (for example, Wednesdays only, or Mondays and Thursdays). Pull out the insert, then count and remove the target insects. Scrape their bodies and wings completely off the sticky insert. If the glue becomes darkened with moth scales, replace the insert with a fresh one. Replace the insert in the trap, and secure it with a paperclip.

Keep records of your counts on a sheet of paper or in electronic format, as you prefer.

5. REPLACING LURES

Replace blackheaded fireworm lures every 6 weeks. Remove the old lure and replace it with an unused lure, using disposable gloves as described above. Place the old lure(s) in a bag and throw them into the garbage.

Replace cranberry girdler lures every 4 weeks. Remove the old lure and replace it with an unused lure, using disposable gloves as described above. Place the old lure(s) in a bag and throw them into the garbage.

DO NOT LEAVE THE OLD LURE IN THE PHEROMONE TRAP OR IN THE BED NEARBY.

Store unused lures in a sealed plastic bag in the freezer until use.

6. PHEROMONE RELEASE FROM LURES

When a fresh lure is placed in a trap, the pheromone on its surface is rapidly released into the air. You might visualize this as a “blast” of odour coming off the lure for the first few days.

After a few days, the release rate of pheromone from the lure is reduced and becomes relatively constant. The amount of pheromone released from fireworm and girdler lures during this period is sufficient for monitoring these pests.

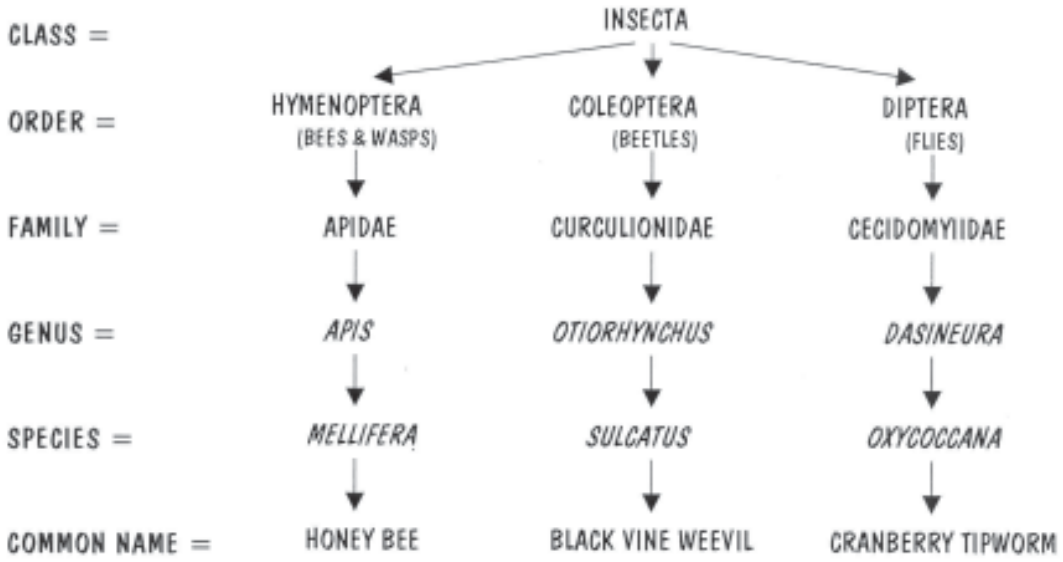
Four to six weeks after placing a fresh lure in the field, most of its pheromone has been released. The lure is not empty or ineffective at this point. However, its attractive power has been reduced and it should be replaced, as described above.

INSECT CLASSIFICATION

Each insect has a common name and a scientific name. The common names are easiest for us to understand and pronounce because they usually describe characteristics of the insect (e.g., "blackheaded fireworm") and are in English. The scientific names are universal. For example, the scientific name "*Rhopobota naevana*" is understood by entomologists throughout the world.

The scientific name is composed of a genus name (*Rhopobota*), a species name (*naevana*), and the authority, or person responsible for naming the insect (Hübner). Each insect species is known by a unique combination of genus name and species name, which are written in italics.

Insects are classified, or grouped, according to their similarities. For example, *Rhopobota naevana* is grouped with similar small moths in the family Tortricidae. Tortricids and other families of moths are grouped together in the order Lepidoptera – the butterflies and moths.

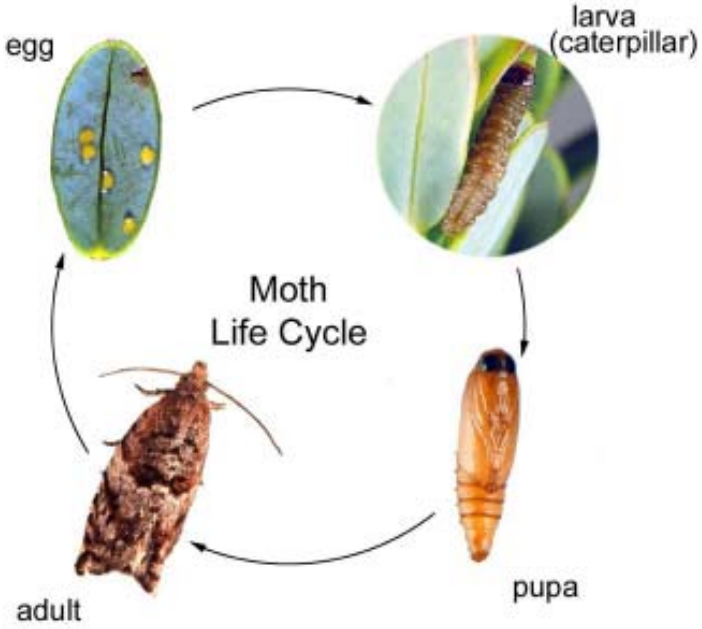


Here are some examples of insect classification.

Plants, animals and fungi also have scientific names and are classified according to the similarity of characteristics.

The class Insecta numbers about one million classified species and is divided into approximately thirty orders. In crop protection, the most important families are: Coleoptera, Lepidoptera, Diptera, Hymenoptera, Heteroptera, Homoptera, Thysanoptera and Orthoptera. The majority of these orders includes potentially harmful species (pests of crops and trees, predators of food products, biting insects) and beneficial species (pollinators, decomposers, natural enemies of pests, and insects otherwise valuable to people, e.g. the honey bee and the silkworm).

LEPIDOPTERA (BUTTERFLIES AND MOTHS)



All Lepidoptera undergo complete metamorphosis in which there are four life stages per generation: egg, larva (caterpillar), pupa, and adult. There may be one generation or multiple generations per year, depending on species, although some arctic species take up to 17 years to complete a single generation. The overwintering stage can be either egg, larva, pupa, or adult, again depending on the species.

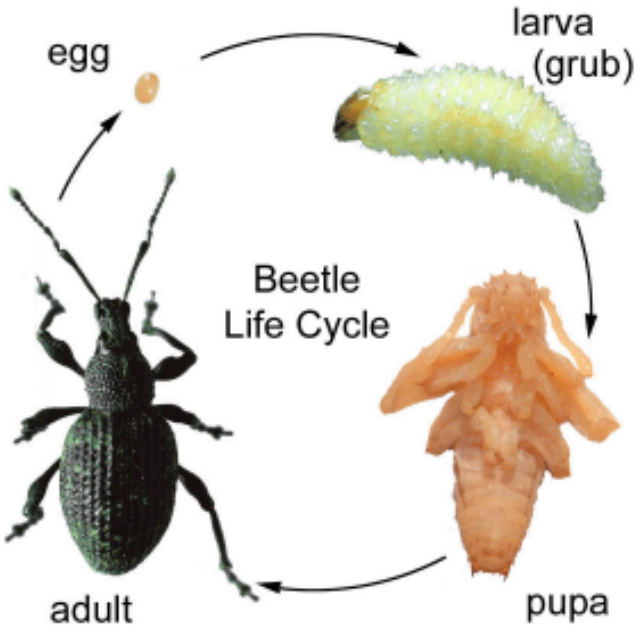
Egg: Females lay eggs either by dropping them on the ground (e.g., girdler moths), or by laying them on or in specific host plants (e.g., blackheaded fireworm moths). The number of eggs varies from several to several hundred, depending on the species.

Larva: Larvae (plural of larva) are the destructive stage. Development is usually rapid as they are ravenous feeders. The larval skin does not stretch and is shed several times during the larva's life to allow for growth. The stage between each molt is called an instar. The newly hatched larva (or neonate) is called a first instar. After the first molt it's called a second instar and so on. There are commonly five to nine instars, depending on the species. Larvae have three pairs of thoracic legs near the front and two to five pairs of abdominal prolegs towards the back.

Pupa: The pupa is the resting stage during which the larva changes into a butterfly or a moth. When a larva is fully grown, it finds a concealed place to pupate. Butterflies typically hang upside down on a leaf or branch and shed their skin to form a chrysalis. Moths typically pupate within a cocoon constructed in a variety of ways. It may be made entirely of silk or, more frequently, a mixture of silk and foreign materials. It is usually hidden in the soil or under bark.

Adult: The adult's sole purpose is to mate and lay eggs. Female moths secrete pheromones that attract males for mating. Specialized cells on the male antennae are stimulated by the specific pheromone blend and the male flies upwind in a zig-zag pattern as it follows the pheromone plume to the female. Adults of some species feed on nectar or juices from rotting fruit but those of many species do not feed at all.

COLEOPTERA (BEETLES)



Like the Lepidoptera, beetles undergo a complete metamorphosis. There may be one to several generations per year, or larval development may take several years.

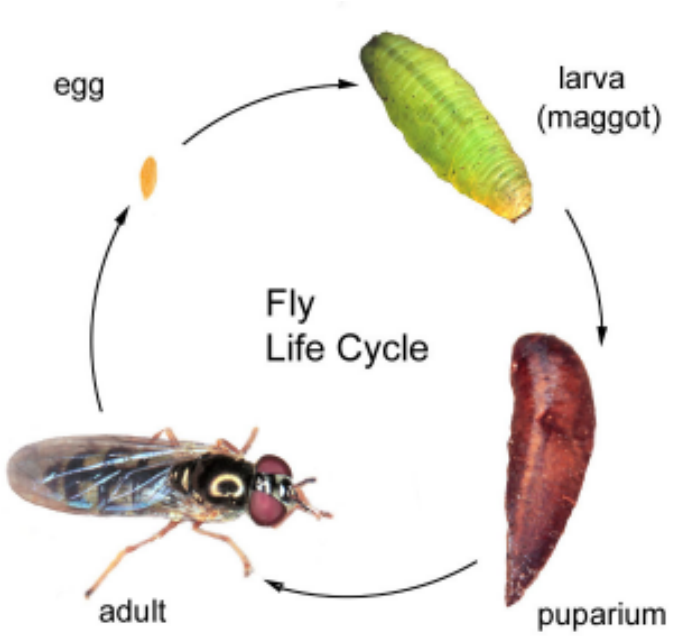
Egg: The number of eggs laid by the adult beetle varies among species. Eggs are usually laid in the habitat of the larvae and seldom diapause (enter a dormant stage for winter).

Larva: Beetle larvae are often called grubs. There are normally three to eight instars. Beetle larvae are varied in form but the head is well developed and sclerotized (hardened) in all species. Thoracic legs (near the front of the larva) are usually present but there are no abdominal prolegs (near the posterior end of the larva). The majority of the species are terrestrial but some species larvae and/or adults are aquatic.

Pupa: Like the Lepidoptera, the last instar larva sheds its skin to form a pupa. Pupation usually takes place in the soil or in the food plant. In some groups, a cocoon is spun.

Adult: Adults of some species live only a few days, while other species may live a year or more. Species of carabids (ground beetles) are carnivorous as larvae and adults and prey on pest species like weevil larvae. Other beetle groups, such as cucurlionids (weevils), are herbivorous and are often pests as adults and larvae.

DIPTERA (FLIES)



Like the Lepidoptera and Coleoptera, flies undergo complete metamorphosis; however, there is a major difference between these orders and the Diptera. The dipteran larva does not shed its skin during pupation — in most groups the larval skin hardens to form a shell. Because of this difference, the resting stage of Diptera is called a puparium. There may be one to several generations per year, depending on the species.

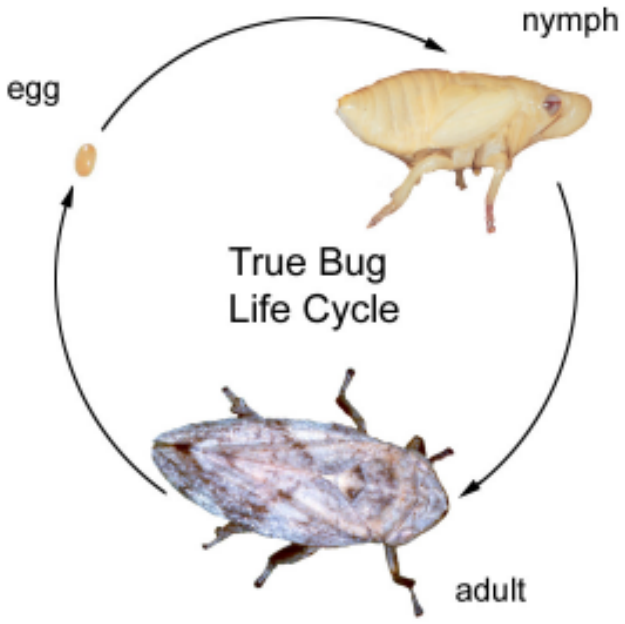
Egg: Mated female flies lay eggs directly on the food source. Egg development is normally rapid and larvae appear in a few days.

Larva: Fly larvae, more often called maggots, are soft-bodied. The larvae of most species of flies have a reduced head capsule. They do not have true legs and move by waves of muscular contraction through the body. They have an enormous variety of feeding habits, and individual species often have very precise requirements. Many consume decaying organic matter or are predacious. A large proportion are parasitic on other insects and other organisms. Larvae of most usually go through four instars but some species have as many as eight.

Pupa: Puparia (plural of puparium) may be naked or in a cocoon.

Adult: Adult flies have only one pair of functional wings, are mostly free-living and fly during the day. Some groups consume liquid food such as nectar (e.g., hover flies), others lap up juices from decomposing matter (e.g., blow flies), while many others are predacious (e.g., robber flies), or parasitic (e.g., black flies).

HOMOPTERA / HETEROPTERA (THE TRUE BUGS: SPITTLE BUGS, APHIDS, ETC.)



The true bugs have incomplete metamorphosis in which there are only three life stages per generation: egg, nymph and adult. There may be one generation or multiple generations per year, depending on the species. Species like cicadas may take many years to mature. Species such as aphids give birth to living young during spring and summer, but lay eggs in the autumn, which overwinter. Like in all insect orders, diversity is the rule.

Egg: Eggs are ovoid and simple. They are laid on or more often inserted into the foodplant.

Nymph: Depending on the species, there are usually three to seven instars. The nymphs resemble wingless, miniature versions of the adults. Froghopper nymphs, known as spittlebugs, produce a spittle-like mass that surrounds them for protection.

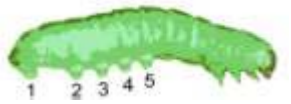
Adult: Most adults have two pairs of wings. The wings usually have a membranous texture and are held rooflike over the body. All species are terrestrial insects that feed on plant fluids. The damaging effect on plants may be direct or indirect. When the population of bugs is large the loss of sap results in poor yield and quality of plant. Indirectly, the weakened plant is more susceptible to attack by other pathogens, especially fungi and viruses. Many species of true bugs spread viruses from one plant to another. On the beneficial side, many homopterans play an important part in weed control. Some species prefer to feed on stems, others prefer the leaves, and some prefer the roots of plants. Several groups make galls on plants and feed within these growths.

KEY TO CATERPILLARS FOUND IN BRITISH COLUMBIA CRANBERRY BEDS

1. Three pairs of front (thoracic) legs behind head plus two pairs of hind legs. White stripes down sides and back . . . . . .Winter Moth and Bruce Spanworm (larvae similar)

- Three pairs of front legs plus three or more pairs of hind legs. . . . 2

2. Three pairs of hind legs. White stripes down sides and back. . . . . Alfalfa Looper



- Five pairs of hind legs 3

3. Five pairs of hind legs and body smooth 5

- Five pairs of hind legs and body fuzzy. 4

4. Blackish spines arise from blue bumps on first five segments and from red bumps elsewhere . . . . . Gypsy moth

- Four distinct yellowish brushes arise from caterpillar's back, two black brushes point forward like feelers . . . . . Rusty tussock moth

5. Head black. 6
- Head not black 7

6. Body greenish yellow . . . . . Blackheaded fireworm

- Body dark brown with yellow dots and pale stripe down each side . . . . . Straw-coloured tortrix

7. White or cream-coloured stripe down each side. 8
- Stripes down side bright yellow or absent 9

8. Brown with white stripe in young larvae, cream stripe in mature larvae. Head brown . . . . . *Ochropleura implecta*

- Green below with white, dark green, and yellowish stripes down sides. Head red . . . . . False armyworm

9. Two bright yellow stripes down each side . . . . . Zebra caterpillar
- Stripes absent. 10

10. Greasy looking, yellowish green caterpillar with sparse spines usually found in trash layer. . . . . Cranberry girdler

- Green caterpillar with darker green plate behind head; usually found inside berries. . . . . Cranberry fruitworm

KEY PESTS: DORMANT TO PRE-BLOOM

MOST COMMON

Blackheaded Fireworm
Black Vine Weevil
Strawberry Root Weevil
Clay Coloured Weevil
Townsend's Vole

MAY BE SEEN

Winter Moth / Bruce Spanworm
Straw-coloured Tortrix
CUTWORMS
- Zebra Caterpillar
- False Armyworm

Gypsy moth
(not found on cranberries in B.C.)
Cranberry Tipworm
CRANE FLIES
- Marsh Crane Fly
- European Crane Fly

Meadow Spittlebug
Mites

MOST COMMON PESTS

BLACKHEADED FIREWORM *Rhopobota naevana* (Hübner)

Pest Status: This insect is one of the major pests of cranberry in British Columbia.

Blackheaded fireworm eggs

Life cycle and feeding habits : This insect overwinters in the egg stage**.** Overwintering eggs are yellow, about 0.5 mm (less than 1/16 inch) in diameter, and are found on the underside of cranberry leaves. Hatching of this first generation usually begins in late April, reaches a peak in early May and is completed by early June.

Blackheaded fireworm larva

Newly hatched larvae burrow into the leaf near the egg, then move up to the growing tip of uprights or runners. Larvae may tunnel into unopened buds or web together the terminal leaves of uprights with silk and feed inside this shelter or "tent". Each larva may make five or six tents before it pupates. After a feeding period of 3-5 weeks, fully grown larvae, which are about 8 mm (1/3 inch) long with a shiny black head, go into the pupal stage in the trash layer or within their tents. Larvae have three pairs of front legs and five pairs of hind legs.

The first adults usually appear in late May or early June. This first flight of moths lasts until July. During this time, the male and female moths (6 mm (1/4 inch) long) can be seen flying among the vines. Most mating occurs in late afternoon and evening. Eggs are laid on the underside of cranberry leaves. These second-generation eggs begin

hatching in late June or early July. In addition to making tents, larvae feed on uprights and runners directly and may burrow into the developing fruit.

Damage associated with mature fireworm larvae

When the larval population is high and injury is severe, damaged plant tissue dries out and appears scorched as if by fire. Following pupation, moths of the second generation are present from late July through September. Although most eggs laid by second-generation moths will not hatch until the next spring, a third generation of larvae may be seen in August and September if temperatures remain warm. These third-generation larvae are injurious to fruit. In warm years, moths of the third generation may be seen flying as late as December on dry-pick farms .

Monitoring: Monitoring for this pest begins by looking for larvae (worms) in late April. Look closely at runner tips and buds along warm edges of beds for small tents and frass made by newly hatched larvae (about 1.5 mm (1/16 inch) long). One to two weeks after larvae are seen, more extensive monitoring can be done by "visual sweeps": crouching down to examine areas of about 0.18 square metres (2 square feet). When searching visually, examine the edges of the bed and known "hot spots" (areas of previous infestation) first, doing at least 10 visual sweeps per acre (25 per hectare).

"Tent" made by fireworm larva

Regardless of actions taken in spring for larvae, pheromone traps for monitoring moth flight should be placed in fields in mid-May. A minimum of three traps should be placed on farms of 4 hectares (10 acres) or less. On larger farms, one trap per 2 hectares (5 acres) is recommended. When placing lures in traps, use disposable gloves and keep gloves from touching any other part of the trap. Check traps weekly by counting the number of fireworm moths, then scraping them off the sticky floor of the trap or replacing the sticky bottom or insert of the trap if necessary. Change lures after 6 weeks and before the second flight of moths. Ten days to 2 weeks after the greatest number (peak) of moths is caught or 3 weeks after first catch, begin checking field edges and known "hot spots" for larvae. It is helpful to map the location of fireworm larvae.

Control: An insecticide treatment is recommended if an average of one larva per visual sweep is found. Most larvae should be 3 - 6 mm (1/8 to 1/4 inch) long when insecticide is applied. During bloom, do not apply insecticides that are toxic to bees.

The need for insecticide application may be reduced or eliminated by using 3M Sprayable Pheromone for Mating Disruption of Blackheaded Fireworm. This product interferes with moth communication and

prevents most male fireworm moths from finding and mating with females. Sprayable pheromone should be applied at the label rate at or just before first moth catch in pheromone traps. Two or three applications at intervals of 2.5 - 3 weeks should reduce mating of the first flight of moths. As or just before the second flight begins, applications of sprayable pheromone should begin again, and continue at intervals of 2.5 - 3 weeks until flight ends. During the first year of sprayable pheromone use, insecticide applications against fireworm larvae should continue as usual. During the second and subsequent years, it should be possible to reduce or eliminate summer applications of insecticide against fireworms. Sprayable pheromone is not toxic to mammals or beneficial insects like bees**.**

"Decoy-female" pheromone traps are used to track the efficacy of sprayable pheromone. The lures placed in these traps estimate the number of male fireworm moths that can locate one female fireworm moth. These lures should be stored in a freezer and replaced in traps every three weeks. Decoy female traps should be placed in the beds the day after the first application of sprayable pheromone. The recommended number of traps is: a minimum of three traps on farms of 8 hectares (20 acres) or less; five traps on farms of 8 - 40 hectares (20 - 100 acres); and 10 traps for farms greater than 40 hectares (100 acres). If application is done by chemigation, place one trap close to the area where the pheromone is first delivered and one in the area receiving the spray last. It is also important to avoid putting traps in areas known as fireworm "hot spots".

Blackheaded fireworm moth

Regular pheromone traps (= monitoring or (IPM) traps) are also required in fields to track the flight pattern and peak catch. Decoy-female traps and IPM traps should be placed at least 37 metres (120 feet) apart. Monitoring for fireworm moths in both kind of traps should be done once a week during the flight periods.

A tiny parasitic wasp, *Trichogramma sibericum* (Sorokina), is sometimes found in beds not treated with insecticides. These tiny wasps are well-adapted to parasitize fireworm eggs.

The tachinid *Hemisturmia tortricis* (Coq.), a beneficial parasitic insect, has been reared from blackheaded fireworm larvae collected from unmanaged farms and farms seldom treated with insecticide.

A granulosis virus is also known to infect blackheaded fireworm larvae on unmanaged cranberry farms. Infected larvae become sluggish, flaccid, and liquid as they succumb to the virus.

BLACK VINE WEEVIL *Otiorhynchus sulcatus* (F.)

Black vine weevil adult

Black vine weevil larva

Pest Status: This is the most common weevil pest in cranberry beds. In British Columbia, weevil damage is usually restricted to beds that are not flooded at harvest.

Life cycle and feeding habits: The adult black vine weevil is a black snout beetle about 8 - 9 mm (1/3 inch) long. Adults emerge from pupal cells in the soil from mid-June to the end of June; some adults may live through the winter. Adults feed on foliage for 4 - 6 weeks before egg-laying begins. Black vine weevils are all flightless females so there is no mating before egg-laying. Eggs are laid at the soil surface during the summer beginning in July and hatch within 2- 3 weeks. The newly emerged larvae descend to feed on rootlets and, later, on the larger roots and root bark. The larvae are white, legless, have a brown heads, and often curl their bodies into the shape of the letter C. They feed from the time they emerge from the egg until pupation the next spring. They may be inactive during very cold spells in winter. There is only one generation per year.

Monitoring: In spring and in fall, the larval population of black vine weevils can be monitored by rolling back damaged vines and looking through the top 5 cm (2 inches) of soil for girdled vines and weevil larvae curled in a “C”. Mature black vine weevil larvae are about 8 - 9 mm (1/3 inch) long in spring. In fall, they are younger, smaller and harder to see.

Weevil larvae can completely girdle roots up to the crown of the plants. Damaged vines look similar to girdler-damaged vines, but lack the frass left by girdler larvae at feeding sites. Symptoms of damage (wilting, weakening, browning, death) begin to appear in May or June and intensify through the season.

Monitoring for weevil adults is done using a sweep net. On warm, still nights after dusk in early July, sweep beds once or twice a week until eggs begin to mature within the adult weevil and egg-laying begins. To determine the presence and maturity of eggs within an adult weevil, pinch the abdomen of about 10 weevils and look for spherical white eggs. When ready to lay eggs, the weevil’s entire abdomen contains eggs and little else. If weevils are found, treatment is recommended. Weevil detection can also be done by observing vegetation in the vicinity of the cranberry bed. If present, characteristic leaf-notching caused by feeding adults will be readily seen on plants such as salal near the cranberry bed. Notching on cranberry can be difficult to see.

Control: When flood water is used during harvest, most weevil larvae will be drowned. On dry-pick farms or young, unharvested beds, weevil larvae and pupae can be drowned by flooding beds in winter.

Hold water on the bed for 2 - 4 weeks, if the plants can safely sustain water for that long. Re-infestation can occur by recycling flood water from one bed to another. There are no insecticides registered for control of adult black vine weevils.

Nematodes can be applied in spring (May) and in fall (September) to target black vine weevil larvae in the soil. Soil temperatures should be at least 13º C (55º F) and lots of irrigation applied to the bed before and after nematode application.

STRAWBERRY ROOT WEEVIL *Otiorynchus ovatus* (L.)

Strawberry root weevil adult

Pest Status: This smaller weevil is often found with black vine weevil and causes damage if numerous. It has only been found in beds not flooded at harvest or during dormancy.

Life cycle and feeding habits: Adults are about 4 - 5 mm (1/5 inch) long (half the size of the black vine weevil). Adults are shiny black with thinly scattered yellowish short hairs, reddish-brown antennae and legs, and coarse, deep, punctures on the wing covers. Like the black vine weevil, the wings are fused making the weevils flightless. No males have been found. Strawberry root weevils have a life cycle similar to black vine weevils. Larvae feed on small roots and on bark of larger roots in a manner similar to the larvae of black vine veevil. Like the black vine weevil, other hosts include some small fruits, fruit trees, shrubs, and many conifers in nurseries and plantations.

Monitoring and control: Techniques used for black vine weevil will also help to manage strawberry root weevil. The insecticide registered for control of strawberry root weevil is most effective when applied on a calm, warm evening when adults are feeding on the foliage.

CLAY-COLOURED WEEVIL *Otiorynchus singularis* (L.)

Clay-coloured weevil adult

Pest Status: This weevil is not as common as black vine or strawberry root weevils. It has only been found on beds not flooded at harvest or during dormancy. If numerous, clay-coloured weevils could cause damage.

Life cycle and feeding habits: Clay-coloured weevils are intermediate in size between strawberry and black vine weevils, and have a mottled, clay-coloured exterior that may look black when wet. Adults emerge very early in spring, when the other two species are still larvae or pupae; egg-laying by clay coloured weevils also precedes

the other two species. Larvae feed on cranberry roots. Adults feed on the foliage of cranberries and other plants. There is one generation per year.

Monitoring and control: Clay-coloured weevil adults can be detected very early in the spring because they overwinter as non-feeding, soft-bodied adults while the other two species are still larvae and pupae. Sweep from the middle of April through June to detect clay-coloured weevil adults. To control clay-coloured weevil larvae, nematodes would need to be applied approximately 4 - 6 weeks after mature eggs are found in adults.

TOWNSEND'S VOLE *Microtus townsendii* (Bachman)

Pest Status: These vertebrate mammalian pests are often found in cranberry beds. Since Townsend's vole is common in agricultural lands in the Lower Mainland, this species is most likely to be the one found in cranberry fields.

Townsend's vole

Life cycle and feeding habits: Voles, also called meadow mice, field mice, short-tailed mice, or orchard mice, are small short-eared, short-tailed rodents. Townsend's voles produce their litters continuously every few weeks from April through October, or later. They may have up to nine young per litter per female. All voles are plant feeders. Townsend's voles eat crowns and roots of grasses, sedges and other succulent herbaceous plants. They also feed above ground on seeds, bark and leaves. These small rodents tunnel through cranberry beds. They cause damage by feeding on the roots and by cutting the vines. Voles are active day and night in all seasons. They spend most of their time underground or in dense grass. They are the main food source for many birds of prey. Crows also feed on them. Townsend's voles are considered good swimmers and dive readily.

Observation of damage and detection: The first signs of vole activity are 2.5 - 3.7 cm (1 - 1.5 inch) open holes in the ground with connecting compacted paths. Voles cut vines along the corridor of the main run. Because voles confine most of their above-ground feeding to these paths, clipped vegetation can generally be found around the open holes and along runways. If you were to begin digging at one of the holes you would find a second runway, just below the soil surface, where these animals spend the rest of their time feeding on plant roots. Digging a little deeper, you would find another set of burrows 15 - 25 cm (6 - 8 inches) below the soil surface where they store food, build nests, and rear their young.

Control:

Non-chemical approaches:

- frequently mow ditch banks to reduce food and protective habitat for the voles;
- encourage raptors such as owls, hawks, and kestrels by mowing ditch banks to allow easier visual contact with their prey; and
- flood if possible.

No rodenticide baits are registered for vole control within the beds. Therefore, only bait stations placed off the beds can be considered. Several bait stations should be used around a bed. It is not necessary to treat the entire area, but only those edges adjacent to vole habitat. Best control with all baits will occur with applications in fall or winter when food is scarce. There are several types of bait stations. PVC pipe 2.5 - 4.4 cm (1 to 1.75 inches) in diameter, constructed in an L-shape or upside-down T-shape, makes an excellent bait station. The horizontal pipe should be at least 30 cm (12 inches) long so that bait does not spill out the end and so that it will stay dry. Zinc-phosphide baits should not be reapplied within 90 days of a previous application because voles become bait-shy due to the fast action of these baits. The anticoagulant baits kill after 3 - 5 days of continuous feeding. More than a single feeding is usually necessary with anticoagulants.

Fill the tube no more than one-quarter full with bait if the tube is closed at one end. If the tube is open at both ends, coat the bait with syrup to stick it to the inside of the tube. Remove uneaten bait from stations. All baits are attractive to domestic pets and also kill non-target birds and other wildlife. It is very important to avoid injury to non-target animals. Do not pile the bait. Pick up all spills. Dispose of bait properly.

To estimate the degree of control obtained by using baits, put apple pieces in vole runs before you put out bait and monitor the number of munches after 12 hours. Then follow up with more apple sections a week or two after you put out the bait.

PESTS THAT MAY BE SEEN

WINTER MOTH *Operophtera brumata* (L.) **(Introduced)**

BRUCE SPANWORM *O. bruceata* (Hulst) **(Native)**

Bruce Spanworm moth

Bruce spanworm larva

Bruce spanworm showing diagnostic dot on hindwing

Winter moth larva

Winter moth showing absence of hindwing dot

Pest Status: Both species are polyphagous (feed on many host plants). Periodic outbreaks of winter moth have occurred on shade trees, apples and blueberries in Victoria, Vancouver, Richmond and Delta. Bruce spanworm tends to be present in these areas and occasionally reaches damaging levels. Both species are found throughout the Fraser Valley and may be seen in cranberries.

Life cycle and feeding habits: Winter moth and spanworm eggs hatch in March or early April. Larvae begin feeding on leaves, flowers and buds of deciduous ornamental and fruit trees. Larvae may be seen in early April through mid-May as they hang down on silken threads from the trees. The wind will blow them to neighbouring trees and larvae will also fall on cranberry beds located close to trees.

Larvae are pale green with a light whitish stripe along the side. They vary in length from less than 2 mm (1/16 inch) upon hatching to over 13 mm (1/2 inch) at maturity. Larvae have a pale green head, three pairs of front legs, and two pairs of hind legs. The number of hind legs distinguishes these larvae from leafrollers. Fully grown larvae are 2 cm (7/8 inch) long and have three white stripes on each side. When larvae have finished feeding they drop to the ground and pupate in the soil. Male moths fly during winter in November, December and sometimes January. Although the female moths are flightless, larvae may be carried by the wind and eggs and larvae can be inadvertently transported in or on vehicles or containers. Spanworm adults generally emerge one to two weeks later in the fall than winter moths. Spanworm males can be separated from winter moth males by the presence of a small dot on the hind wing of the spanworm that is not seen on the winter moth. There is one generation per year of both species.

Monitoring: Since the same pheromone attracts males of both species, it is possible to trap them from November to January. However, the pheromone is difficult to synthesize and rarely available. Winter moth or spanworm larvae will be detected during monitoring for blackheaded fireworm. Winter moth/spanworm larvae make tents similar to those made by fireworm larvae. Winter moth/spanworm larvae are most often found near infested deciduous trees or blueberries.

Control: Chemical control is usually not necessary but, if high populations are found, insecticides recommended for fireworm will also provide control of winter moth/spanworm larvae. Larvae and pupae of both species are subject to attack by parasitic and predatory

insects. Pupae may or may not be killed by flooding at harvest.

STRAW-COLOURED TORTRIX *Clepsis spectrana* Treitschke

Straw-coloured tortrix larva

Pest Status: This leafroller, which attacks other fruit crops such as raspberry, strawberry and currant as well as white spruce and white cedar in the Pacific Northwest, is found occasionally in cranberries in British Columbia.

Life cycle and feeding habits: Larvae are dark chocolate-brown with tiny yellowish dots on segments along the side. Mature larvae are 12 - 15 mm (1/2 - 2/3 inch) long. Larvae have three pairs of front legs and five pairs of hind legs. Adults are nocturnal and readily attracted to lights. They fly from late March until early August. Larvae have been seen feeding on tips of hardhack (spirea) on dikes. They roll and tie terminal leaves together and feed within this protected site. Larvae found in March have apparently overwintered from the fall generation of the previous year. Those found from May to August represent the current year generations. There are two to three generations a year in British Columbia.

Straw-coloured tortrix moth

Monitoring: Larvae will be detected during fireworm monitoring.

Control: There are no insecticides registered for this insect on cranberry. Insecticides against blackheaded fireworm will provide some control.

CUTWORMS Zebra caterpillar *Melanchra picta* (Harris)

False armyworm *Xylena nupera* (Lintner)

Pest status: Various species of caterpillars are called cutworms. Damage from cutworms involves the chewing or cutting off of foliage and buds.

ZEBRA CATERPILLAR *Melanchra picta* (Harris)

Zebra caterpillar larva

Pest Status: Larvae are occasionally found on cranberries but prefer to feed on weeds, especially blackberry.

Life cycle: This cutworm spends the winter as a partially grown larva. There is only one generation per year. Larvae have very conspicious yellow stripes running along each side of the body separated by alternating black and white stripes running around the body. Larvae have three pairs of front legs and five pairs of hind legs. Larvae can reach more than 3 cm (1.25 inches) in length.

Zebra caterpillar moth

Monitoring: Larvae may be found during monitoring for blackheaded fireworm larvae.

Control: Chemical control is usually not necessary but, if many larvae are detected feeding on cranberry plants, a registered insecticide for climbing cutworms is recommended. Consider spot-spraying if the infested area can be defined. Damage will be minimized if larvae are detected soon after hatching and if insecticide is applied in the evening. Insecticides are most effective when larvae are small.

The tachinid *Winthemia quadripustulata* (Fab.), a beneficial parasitic insect, is known to parasitize zebra caterpillar larvae.

FALSE ARMYWORM *Xylena nupera* (Lintner)

Pest Status : This pest is not common on cranberries in British Columbia.

Life cycle and feeding habits: False armyworm moths emerge in September, overwinter and fly again in spring. Females lay their eggs in late April or early May, and eggs hatch during the second and third week of May.

False armyworm larva

Newly hatched larvae are whitish with many black spots. Young larvae feed freely during the daytime. Larvae have three pairs of front legs and five pairs of hind legs. Larvae feed nocturnally as they mature in late June. They vary in colour from green with whitish lines along the back and sides when young to grass green to dark brown or black when mature. At maturity, they are 5.1 cm (2 inches) long. Mature larvae remain dormant in the ground for 2 - 6 weeks before pupating. There is only one generation of false armyworms per year. They are voracious feeders, consuming all new growth. Other host plants include apple, wild cherry and many weeds.

False armyworm moth

Monitoring: Young larvae are rarely seen but would be detected during monitoring for fireworms. They feed on terminal buds. As larvae mature, sweeping at night is the most effective monitoring technique. Mature larvae consume new vine growth and flowers.

Control: Chemical control is usually not necessary, but if many larvae are detected feeding on cranberry plants, a registered insecticide for climbing cutworms is recommended. Consider spot-spraying if the infested area can be defined. Damage will be minimized if larvae are detected soon after hatching and if insecticide is applied in the evening. Insecticides are most effective when larvae are small.

GYPSY MOTH *Lymantria dispar* (L.)

Pest Status: The gypsy moth has not been found on cranberries in British Columbia. It is presented here because it occurs sporadically on deciduous trees in southwestern British Columbia. Local monitoring, using pheromone traps, is done by the Canadian Food Inspection Agency every year in southwestern British Columbia.

Gypsy moth larva

Life cycle and feeding habits: In Eastern Canada, this pest is known as a voracious feeder. On cranberry, the young hairy larvae attack the terminal buds first and, as the new growth develops, devour the leaves, flower buds, and blossoms. When very abundant, they also attack the old foliage. Young larvae feed mainly at night but mature larvae feed day and night.

The insect overwinters in the egg stage. Hatching occurs in late April and may last to late May, depending on the weather. Newly hatched larvae are typically hairy and about 2 - 3 mm (1/8 inch) long. Mature larvae are up to 6 cm (2.5 inches) long. Mature larvae are very distinctive, with two rows of large spots along the back usually arranged in five pairs of blue and six pairs of red from head to rear; many long hairs cover the body. Larvae have three pairs of front legs and five pairs of hind legs. They are usually found feeding on tree foliage or, in early instars, hiding in shady spots. Small larvae may be blown by the wind to new locations, assisted by their light, hairy bodies and long silk threads.

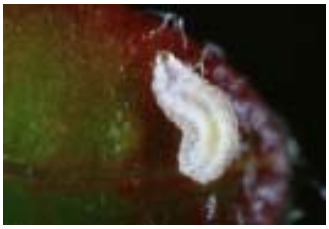
Gypsy moth male

Gypsy moth female

Once feeding is complete, most larvae move to protected locations, such as bark crevices, to pupate. The pupal stage lasts on average 2 weeks and occurs in July. Moths start emerging in late July and early August, peaking in the second to third week of August.

The male moth is tan to brown with irregular black wing markings and plumose (feather-like) antennae. Males have a wingspan of 3.7 - 5 cm (1.5 - 2 inches) and are strong fliers. Females are often larger than males with a wingspan ranging from 3.7 - 6.2 cm (1.5 - 2.5 inches). Females are whitish with faint darker and wavy bands across the forewings. Despite having full-size wings, the female European gypsy moth cannot fly. She emits a pheromone to attract the highly mobile and responsive males. Adults do not feed, and live for several weeks. After mating, indiscriminate laying of a single egg mass per female occurs from late July to September. There is only one generation per year.

CRANBERRY TIPWORM *Dasineura oxycoccana* (Johnson)



Cranberry tipworm larva
(photo courtesy of J.-F. Landry)

Cranberry tipworm puparia in cocoons
(photo courtesy of J.-F. Landry)

Cranberry tipworm male
(photo courtesy of J.-F. Landry)

Cranberry tipworm female

Pest Status: This pest was found in cranberry in British Columbia for the first time in 1998. It is an increasing problem.

Life cycle and feeding habits: Tiny larvae develop through three instars: first clear, then light green, then orange. Larvae have no visible head and are no more than 2 mm (1/16 inch) long in size when mature. Orange third-instar larvae metamorphose into puparia, which are pink to tan or brown. Puparia enclosed in silk remain in the damaged tip on the vine or fall to the trash layer. Adults emerge soon after, then mate and lay eggs (35 - 45 per female) at the base of small leaves on the plant tip. The adult is a very small fly similar to a midge less than 2 mm (1/16 inch) long.

Tipworms have at least two generations in the Pacific Northwest. Puparia of the last generation spend the winter on the floor of the bed. Larvae use rasping mouthparts for extracting the juices from plant tips resulting in browning (or whitening) of the two uppermost leaves.

Monitoring: Injury caused by tipworm is often mistaken for fireworm or frost injury. The first sign of cranberry tipworm is a cupped leaf at the tip of a cranberry upright. Using a magnifier or dissecting microscope, inspect upright tips for maggots. Up to four larvae can be found feeding in the same tip.

Damage from the first generation of tipworms becomes visible in late May or June. The second generation attacks the tips in July. Early-season injury can cause lateral branching. Injury is more common on lush vegetative growth. However, uprights showing damage as late as mid-August may make a complete recovery in terms of flowering potential for the next season.

Control: In Massachusetts and Wisconsin, where tipworms are relatively common, entomologists have evidence that cranberry vines usually recover from tipworm attack and, therefore, rarely recommend insecticides for control of this pest. However, if there are other factors causing vine stress, tipworms may cause damage and a registered insecticide for control of tipworm may be recommended. The most effective time to treat infested fields is during peak egg hatch of the first generation. Peak egg hatch is determined by inspecting 50 - 100 uprights for recently hatched larvae. Vine tips must be dissected under a microscope to find tiny, clear or greenish white larvae. A new sample of uprights should be inspected at a safe interval after an insecticide application to look for dead larvae. This will determine if a second treatment is required. For best control, target first or second

generation larvae during their early stages of development. Insecticides targetting orange larvae or pupae will be too late and ineffective.

CRANE FLIES (leatherjackets)

MARSH CRANE FLY *Tipula oleracea* (L.)

EUROPEAN CRANE FLY *Tipula paludosa* Meigen

European crane fly larva

European crane fly

Pest Status: Adults (craneflies) are seen flying in cranberry beds; larvae (leatherjackets) are found in roots of grasses and sedges in cranberry beds. At this time, these insects are considered potential pests of cranberry.

Life cycle and feeding habits: European crane fly adults emerge, mate and lay eggs in late August through September. Eggs hatch during the fall into larvae that begin feeding at the roots and crowns of turf. Larvae overwinter and continue to feed in spring. In about mid-May, depending on weather, they stop feeding and pupate, staying underground in a non-feeding stage until they wiggle to the surface and emerge as adults in August and September.

Marsh crane flies emerge in April as well as in the fall. Following the emergence of marsh crane flies, egg-laying and larval development occur. Little is known about the life history of the marsh crane fly. Larvae of both species have a tough, grey/brown skin and a cylindrical body tapered at both ends, with no apparent head or legs.

In spring (June), larvae of the European crane fly measure about 13 - 20 mm (9/16 - 7/8 inch), while marsh crane fly larvae are smaller, about 5 - 10 mm (1/4 - 1/2 inch). Larvae chew and feed on the roots and crowns of grasses. In addition to grasses, European crane fly larvae are known to feed on strawberries, flowers and vegetable crops; marsh crane fly larvae may feed on conifer seedlings.

Monitoring: Marsh craneflies may be seen flying over the vines in spring, early summer, and fall whereas European crane flies are only seen in late summer or fall. If present in cranberry beds, larvae are usually found in the roots of grasses and sedges. Look for larvae by checking soil around and under roots and crowns of cranberry plants. Watch for damage in new fields shortly after planting, especially if a previous weedy piece of land or grassland was used to plant the cranberry vines. Young vines in grassy fields may be at risk of damage, especially if grasses are killed or removed.

Control: It may be advisable to kill larvae by flooding before

controlling grasses.

MEADOW SPITTLEBUG *Philaenus spumarius (L.)*

Pest Status: This insect is sometimes observed but is not known to cause serious damage to cranberries in British Columbia.

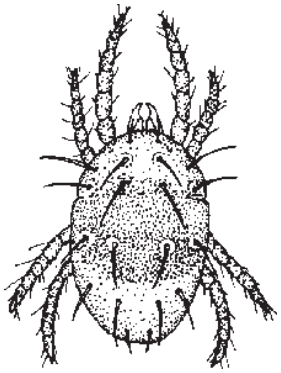
Meadow spittlebug nymph

Life cycle and feeding habits: The nymphs live in white masses of spittle which they form around themselves on the plant stem. When fully grown, spittlebug nymphs are about 6 mm (1/4 inch) long and are yellow to orange. They suck sap from cranberry shoots. The adults, which do not form froth shelters, feed on the vines in a similar manner. There is only one generation per year. These insects overwinter as eggs in the bark of cranberry vines. Eggs hatch in early spring and the first spittle masses, containing the nymphs, occur in late April to May. Adults appear in late May and are present until late fall. Eggs are laid from July until the first frost. The adults are wedged-shaped, greyish brown insects with short, blunt heads with large eyes. Adults measure about 6 - 10 mm (1/4 - 3/8 inch) long. They jump and fly readily.

Control: Spittlebugs do not do enough damage to warrant control. Occasionally they may do local damage. Their feeding causes upright tips to bend over and heavy feeding can deform the tips even more. Insecticide chemigation is not effective against the nymphs which are protected in the spittle, so backpack sprays may be more effective should infestations occur.

MITES

Pest Status: The mites found on cranberries in British Columbia do not feed on the plants and are not pests.



Mite

Description and feeding habits: Mites are not insects. They are closely related to spiders and ticks. They are extremely small and cannot be seen without magnification. Mites have four pairs of legs whereas all adult insects have three pairs. Mites are abundant in soil and organic debris. Many are parasitic, while others are free-living and predaceous (killing other animals), or phytophagous (plant-feeding), or scavengers (feeding on decaying organic matter).

Detection: Examination of cranberry uprights and buds in spring may reveal two species of mites. One species, *Latilamellobates balogi* (Mahunka), is also known to inhabit moss in forests of central Europe (Behan-Pelletier, 2000). The other species, *Humerobates arborea* (Banks), is an arboreal mite that probably feeds on fungi and algae.

References cited in this chapter:

KEY PESTS: BLOOM AND FRUIT SIZING TO HARVEST

MOST COMMON	MAY BE SEEN
Cranberry Girdler	Cranberry Fruitworm
Blackheaded Fireworm	Rusty Tussock Moth
Black Vine Weevil	Straw-Coloured Tortrix
Strawberry Root Weevil	CUTWORMS
Clay-coloured Weevil	• Zebra Caterpillar
	• Alfalfa Looper
	• *Ochropleura implecta*
	Cranberry Tipworm

MOST COMMON PESTS

CRANBERRY GIRDLER *Chrysoteuchia topiaria* (Zeller)

Pest Status: Cranberry girdler is a serious pest in cranberry beds, as well as in turf, lawns and young conifer plantings.

Cranberry girdler larva

Cranberry girdler pupa

Cranberry girdler moth

Life cycle and feeding habits: Young larvae feed on soft tissues such as crowns, leaves and roots of grasses. Mature larvae feed on the bark of cranberry roots and crowns, girdling or severing the roots in the process. This pest is reported to overwinter as a mature larva wrapped in a silk cocoon covered with soil. Recent evidence suggests that in British Columbia, pupation may occur in fall and pupae may overwinter. There is usually only one generation of cranberry girdler per year but, in warm years, a second flight of girdler moths may occur in late summer.

Most moths emerge from the soil and take flight from early June until mid July. They are about 1.3 cm (1/2 inch) long with straw-coloured forewings fringed with silver, and three dots along the outer edge. The moth folds its wings close to the body when at rest, giving it a long, slender appearance, and has a “snout”. Eggs are scattered on the trash of the cranberry beds during the flight period. The larvae emerge after 4 days to 2 weeks, depending on temperature. Newly hatched larvae are about 1.5 mm (1/16 inch) long. Larvae mature to 1.3 cm (1/2 inch) after several weeks, and chew on the bark of roots and underground stems, girdling and severing vines. Larvae have three pairs of front legs and five pairs of hind legs. Mature larvae do most of their damage from late August through early September.

Monitoring: Patches of many dead or dying uprights in late summer and early fall may indicate girdler damage. It may be mistaken for mouse damage, but mice nip vines cleanly on an angle without gnawing. Damaged roots and larvae can be found by peeling back

dying vines and digging carefully in the upper 5 cm (2 inches) of soil and trash. Girdler larvae leave characteristic brown to orange sawdust-like frass (excrement).

Roots damaged by cranberry girdler

Pheromone traps and walking counts are used to detect and monitor moths. Pheromone traps are placed in the beds in early June. Place traps so that the bottoms are roughly 20 cm (4 inches) above the vine tips. A minimum of three traps should be placed on farms of four hectares (10 acres) or less. On larger farms, one trap per 2 hectares (five acres) is recommended. When placing lures in traps, use disposable gloves and keep gloves from touching any other part of the trap. Girdler traps may be placed side-by-side (but not end-to-end) with fireworm traps. Check traps weekly by counting the number of girdler moths, then scraping them off the sticky floor of the trap or replacing the trap if necessary. Change lures every few weeks, according to the manufacturer' s instructions.

Cranberry vines killed by cranberry girdler

It is helpful to walk through the beds on a warm day and count the number of girdler moths that fly up. This will help to identify spots where most egg-laying will likely occur. These walking counts can be done when the probability of observing flying girdler moths is greatest. Moth flight is most likely when windspeeds are low (0 - 9km/hr on the dike and 0 - 6 km/hr in the bed), air temperatures are at least 16 ºC, weather is sunny or overcast, and when insecticide has not been applied for at least 7 days. Walking counts can be done for the first time 1 - 2 weeks after the first girdler moth is caught in pheromone traps. Walk through the bed in a pattern that will allow visual inspection of the perimeter and inner areas. The walking pattern may be a long zig-zag or two circles, one around the edges and one around the middle of the bed. Count the number of girdler moths that fly up as you walk through the vines. Record the location and number of these moths on a map of the bed.

In late August through September, damaged areas of the bed should be inspected for the presence of larvae. On a warm afternoon, roll back the damaged vines and follow roots through the top 5 cm (2 inches) of soil, looking for girdled vines, sawdust-like frass, and the beige-white larvae.

Control: Nematodes can be applied 2 - 4 weeks after peak flight to control young larvae. The recommended rate varies from 1 - 3 billion per acre (2.5 - 7.5 per hectare). Larvae can be drowned by flooding beds in August. Flood water should be deep enough to cover the highest weeds, because larvae crawl up them to escape, and should be left on the beds for 24 - 48 hr. Flooding in August will greatly increase the risk of fruit rot on producing beds. Flood-harvesting in

early September may kill larvae that have not yet spun their cocoons and become impervious to flooding.

Older beds with a thick trash layer and little sand tend to have the most serious infestations. Regularly sanded beds (6 mm or 1/4 inch) tend to have fewer girdler problems, probably because the sand covers fungi, moss and small plants on which young larvae feed. Sand may also be abrasive and damaging to larvae. The cranberry girdler is also a pest in lawns and turf. Observe dikes and grass areas surrounding the beds as a possible source of infestation.

BLACKHEADED FIREWORM *Rhopobota naevana* (Hübner)

Blackheaded fireworm larva

Late July usually marks the end of the first flight of fireworm moths. Eggs laid by first-generation female moths hatch from late June through July, and second-generation larvae resume feeding on cranberry foliage. New tents and damage begin to appear along the edges of the beds in late June or early July. Depending on the timing of the larvae and fruit development, this second generation of larvae may burrow into the berries. Following pupation, moths of the second generation are present from late July through September. Most of the eggs laid by second-generation females enter diapause (a dormant, hibernation-like state for winter). However, a small percentage of eggs hatch to produce third-generation larvae that feed on fruit.

Control: During bloom, the application of insecticides that are toxic to bees is not recommended. The need for insecticide application may be reduced or eliminated by using 3M Sprayable Pheromone for Mating Disruption of Blackheaded Fireworm.
Refer to the section "KEY PESTS: DORMANT TO PRE-BLOOM" for more information.

Blackheaded fireworm moth

A tiny parasitic wasp, *Trichogramma sibericum,* is sometimes found in beds not treated with insecticides. These tiny wasps are well-adapted to parasitize fireworm eggs. *Trichogramma* are now available commercially and can be applied to cranberry fields during and after the second flight of fireworms to target eggs laid by females of the second generation. *Trichogramma* wasps reduce the number of fireworm larvae by consuming the contents of fireworm egg and emerging as *Trichogramma* adults the next spring. The current recommendation is to apply 800,000 *Trichogramma* per acre divided into two applications 7 - 10 days apart. This biological control agent is well suited as a companion technique with mating disruption since the wasps parasitize high levels of fireworm eggs in "hot spots", while mating disruption is most effective at low fireworm densities. Both

techniques are best used with the advice of a pest management specialist.

BLACK VINE WEEVIL *Otiorhynchus sulcatus* (F.)

Note: All weevils are usually found on dry-pick farms or those not regularly flooded at harvest.

Adult weevils feed on foliage from mid-June until mid-July before egg-laying begins. Eggs are laid in mid-July at the soil surface beneath the vines and hatch 2 - 3 weeks later in August. The newly emerged larvae descend to feed on rootlets and later on the larger roots and root bark. Larvae feed and grow in the soil from the time they emerge from the egg until pupation the next spring.

Black vine weevil

Monitoring: On warm, still nights after dusk, in early July, sweep beds once or twice a week until eggs begin to mature within the adult weevil and egg-laying begins. To determine the presence and maturity of eggs within an adult weevil, pinch the abdomen of about 10 weevils and look for spherical white eggs. When ready to lay eggs, the weevil's entire abdomen contains eggs and little else. If weevils are found, treatment is recommended.

Refer to the section "KEY PESTS: DORMANT TO PRE-BLOOM" for more information on control.

STRAWBERRY ROOT WEEVIL *Otiorynchus ovatus* (L.)

Adults are about 4 - 5 mm (1/5 inch) long (half the size of the black vine weevil). They have a life cycle similar to black vine weevils. The timing of their presence in the field is also similar to black vine weevil.

Strawberry root weevil

Refer to the section "KEY PESTS: DORMANT TO PRE-BLOOM" for more information on monitoring and control.

CLAY-COLOURED WEEVIL *Otiorynchus singularis* (L.)

Clay-coloured weevils are intermediate in size between strawberry and black vine weevils, and have a mottled, clay-coloured exterior that may look black when wet. Because the life cycle of clay-coloured weevil precedes the other two species, larvae would likely be detected in early to mid-summer in cranberry beds.

Clay-coloured weevil

Refer to the section "KEY PESTS: DORMANT TO PRE-BLOOM" for more information.

PESTS THAT MAY BE SEEN

CRANBERRY FRUITWORM *Acrobasis vaccinii* (Riley)

Pest Status: Cranberry fruitworm is present in Washington and may be present in British Columbia.

Cranberry fruitworm larva in cranberry
(photo courtesy of J.-F. Landry)

Life cycle and feeding habits: The fruitworm spends the winter in the larval stage, wrapped in a hibernaculum made of old leaves, sand, soil and other material under vines on the bed floor. Pupation occurs in spring and the moths begin to appear in the middle of June. Generally, peak flight occurs about the same time cranberries are in full bloom and may continue through much of July.

Cranberry fruitworm moth
(photo courtesy of J.-F. Landry)

The moths are dark brown with very noticeable white bands on the forewings and have a wingspan of about 1.5 cm (2/3 inch). They rest under the vines during the day, particularly during bright sunshine. When disturbed, they fly 15 - 17 metres (40 - 50 feet) before coming to rest on the vines. Moths are strong fliers, moving readily between cranberry beds and alternate hosts such as highbush blueberries.

The eggs are generally laid on the calyx end of the cranberry. When the larva hatches, it usually crawls to the stem end, chews into the berry, and seals its entrance hole with a white silken web. Only very close inspection will reveal that the berry has been attacked. The larva is pale green with a yellowish head. Larvae have three pairs of front legs and five pairs of hind legs. When fully grown, a larva is 1.3 cm (1/2 inch) long. It rarely leaves a berry until it has eaten all the pulp and seeds, and filled the berry with frass (excrement). Usually it leaves the berry by boring through the side and into an adjoining berry. One larva may eat three to six berries before going into diapause (a dormant, hibernation-like state) in the trash for the winter. Infested green fruits redden, then shrivel up like raisins.

Monitoring: Male moths are attracted to traps baited with cranberry fruitworm pheromone. In Massachusetts, egg-laying begins when berries have just begun to grow, and may continue to late August. Females prefer to lay eggs on berries larger than pinhead stage. Studies in Massachusetts demonstrated that female moths wait for the fruit to expand before they began laying eggs. The phenology of the cranberry plant gives a good estimate of the time of egg-laying. Work in Massachusetts showed that most eggs are found at the calyx end of berries from edges of beds and ditches, in weedy areas, and on berries that stick up above the vine canopy. If possible, 25 - 50 berrries from these areas should be examined under a magnifier or microscope to look for eggs.

Control: If eggs are found during monitoring, a registered insecticide

should be applied. Insecticides should not be applied during bloom or against fruitworm larvae, which are protected in the berries.
In the eastern U.S.A., the holding of late water (equivalent to a spring reflood) has been used for over a century to control cranberry fruitworm. Research on biological control of cranberry fruitworm is underway in Quebec.

RUSTY TUSSOCK MOTH *Orgyia antigua* (L.)


Rusty tussock moth larva


Rusty tussock moth male


Rusty tussock moth female

Pest Status: This pest has caused economic damage to localized areas of flood-pick farms in Delta.

Life cycle and feeding habits: Young larvae hatching in the spring are 4 - 7 mm (1/4 - 3/8 inch) long, while mature larvae are around 3 cm (1.25 inches) long. The larvae are very colourful and distinctive with two long dark tufts behind their head. Larvae have three pairs of front legs and five pairs of hind legs. They feed on woody plants. The female moth does not fly. Moths emerge in mid-summer, then mate and lay eggs that overwinter. There is only one generation per year. Cranberry beds become infested by windborne young larvae which disperse on long silk threads from adjacent forests. The long fine body hairs allow larvae to be carried by air currents for as much as 500 metres (1600 feet). Infestations in cranberry beds are patchy and may occur in the same area year after year.

Monitoring: Larvae are usually detected during monitoring for second-generation fireworm. To sample for older larvae, sweeps should be done at night. Headlands and ditch vegetation may be a source of crawling larvae. It is recommended to watch for outbreaks in surrounding forests or tree stands. Early detection is important, because most damage is done by mature larvae.

Control: There are no insecticides registered for control of this pest in cranberry. Insecticides applied with a boom or a backpack sprayer to target second-generation blackheaded fireworm larvae may also reduce the numbers of rusty tussock moth larvae.

STRAW-COLOURED TORTRIX *Clepsis spectrana* Treitschke

Pest Status: This leafroller, which attacks other fruit crops such as raspberry, strawberry and currant as well as white spruce and white cedar in the Pacific Northwest, is found occasionally in cranberries in British Columbia.

Straw-coloured tortrix larva

Straw-coloured tortrix moth

Life cycle and feeding habits: Larvae are dark chocolate-brown with tiny yellowish dots on segments along the side. Mature larvae are 12 - 15 mm (1/2 - 2/3 inch) long. Larvae have three pairs of front legs and five pairs of hind legs. Adults are nocturnal and readily attracted to lights. They fly from late March until early August. Larvae have been seen feeding on tips of hardhack (spirea) on dikes. They roll and tie terminal leaves together and feed within this protected site. Larvae found in March have apparently overwintered from the fall generation of the previous year. Those found from May to August represent the current year's generations. There are two to three generations a year in British Columbia.

Monitoring: Larvae will be detected during fireworm monitoring.

Control: There are no insecticides registered for this insect on cranberry. Insecticides against blackheaded fireworm will provide some control.

CUTWORMS Zebra caterpillar *Melanchra picta* (Harris)

Alfalfa looper *Autographa californica* (Speyer)

Ochropleura implecta Lafontaine

Pest status: Various species of caterpillars are called cutworms. Damage from cutworms involves the chewing, or cutting off, of foliage and buds.

ZEBRA CATERPILLAR *Melanchra picta* (Harris)

Zebra caterpillar larva

Zebra caterpillar moth

Pest Status: Larvae are occasionally found on cranberries but prefer to feed on weeds, especially blackberry.

Life cycle: This cutworm spends the winter as a partially grown larva. There is only one generation per year. Larvae have very conspicious yellow stripes running along each side of the body separated by alternating black and white stripes running around the body. It can reach more than 3 cm (1.25 inches) in length. Larvae have three pairs of front legs and five pairs of hind legs.

Monitoring: Larvae may be found during monitoring for blackheaded fireworm larvae.

Control: Chemical control is usually not necessary, but if many larvae are detected feeding on cranberry plants, a registered insecticide for climbing cutworms is recommended. Consider spot-spraying if the

infested area can be defined. Damage will be minimized if larvae are detected soon after hatching and if insecticide is applied in the evening. Insecticides are most effective when larvae are small.

The tachinid *Winthemia quadripustulata* (Fab.), a beneficial parasitic insect, is known to parasitize zebra caterpillar larvae.

ALFALFA LOOPER *Autographa californica* Speyer

Pest status: The alfalfa looper has many host plants and larvae are often found on dry-pick farms.

Life cycle and feeding habits: This insect is primarily an alfalfa pest but can be found in garden crops, horticultural crops, ornamental trees and tree fruits. The damage is caused by the larvae, which move like spanworms by arching their backs. Alfalfa looper larvae have three pairs of front legs and three pairs of hind legs. Larvae may be seen in cranberry in June and July. Larvae are light green with a narrow light stripe on each side of the body, two light stripes along the back and a pale head. Mature larvae are about 2.5 cm (1 inch) long.

Alfalfa looper larva
(photo coutesy of J. Miller)

The moth's forewings are grey with a distinct silver, sickle-shaped spot near the middle of each wing. The body and the hind wings are dull grey or brown. These moths appear all summer long due to overlapping generations.

Alfalfa looper moth

Control: Chemical control is usually not necessary, but if many larvae are detected, a registered insecticide for climbing cutworms is recommended. Consider spot-spraying if the infested area can be defined. Damage will be minimized if larvae are detected soon after hatching and, if insecticide is applied in the evening. Insecticides are most effective when larvae are small.

OCHROPLEURA IMPLECTA Lafontaine

Pest Status: This pest caused economic damage on dry-pick farms in Richmond in 1997 and 1998.

Life cycle and feeding habits: Moths fly, mate, and lay eggs from mid-May until late June, and again from late July until late August. Eggs hatch in about 10 days. Young larvae are dark chocolate-brown with a white lateral stripe and mature larvae are paler brown with a beige lateral stripe. Mature larva are 2.5 cm (1 inch) long. Larvae have three pairs of front legs and five pairs of hind legs. Larvae feed at night and are particularly fond of berries. They partially consume unripe and ripe berries in July and August.

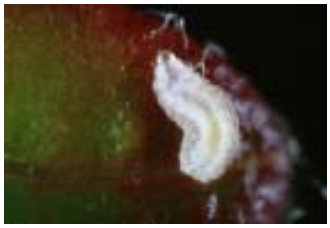
Ochropleura implecta
larva

Ochropleura implecta moth

Monitoring: Sweep at night for larvae in early June. Moths are attracted to pheromone traps for blackheaded fireworm and to light traps.

Control: If many larvae are detected, a registered insecticide for climbing cutworms is recommended. Consider spot-spraying if the infested area can be defined. Damage will be minimized if larvae are detected soon after hatching and if insecticide is applied in the evening. Insecticides are most effective when larvae are small.

CRANBERRY TIPWORM *Dasineura oxycoccana* (Johnson)



Cranberry tipworm larva
(photo courtesy of J.-F. Landry)

Pest Status: This pest was found in cranberry in British Columbia. for the first time in 1998. It is an increasing problem in Washington but is not common in British Columbia.

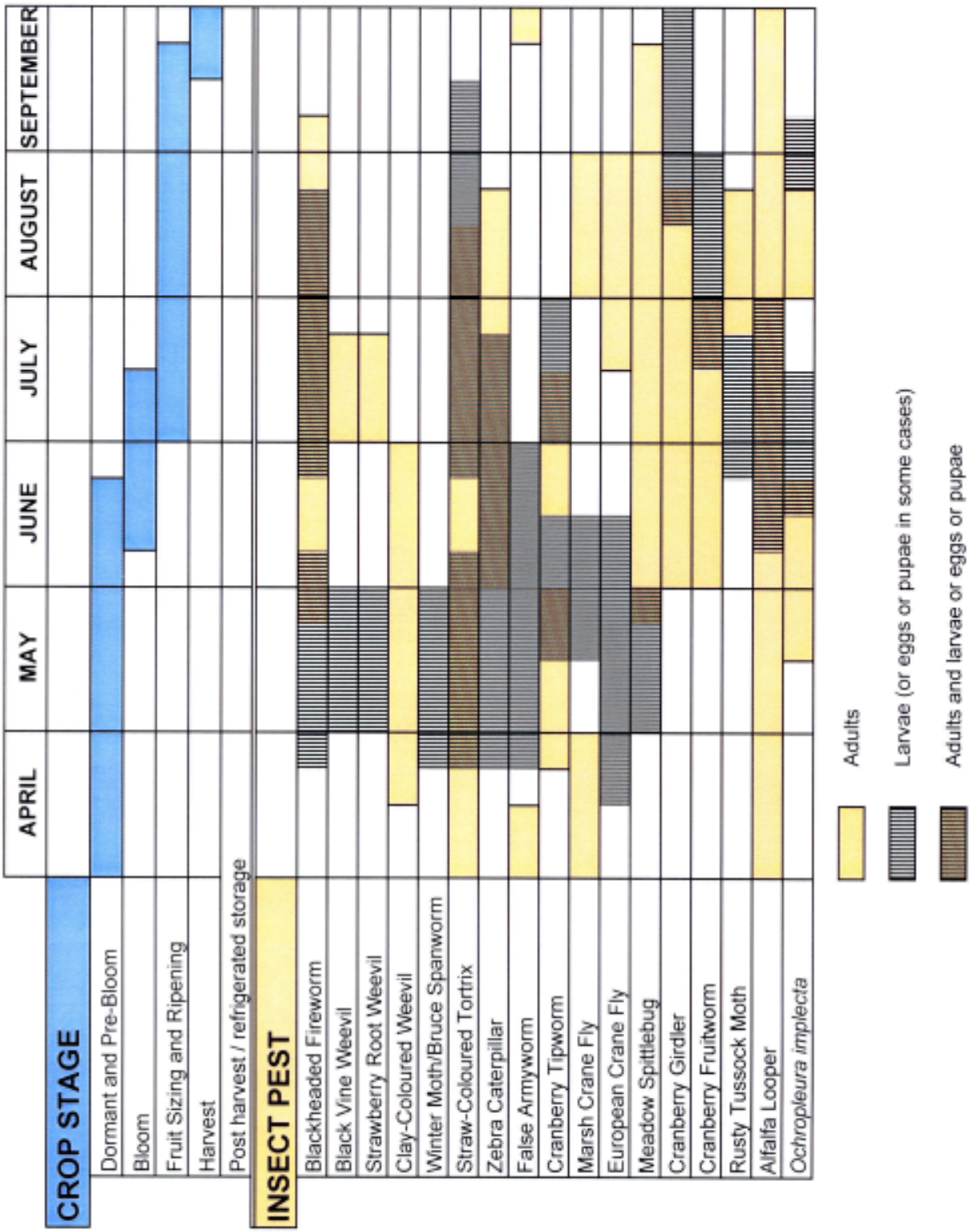
Life cycle and feeding habits: Tiny larvae develop through three instars: first clear, then light green, then orange. Larvae have no visible head and are no more than 2 mm (1/16 inch) long when mature. Orange third-instar larvae metamorphose into puparia, which are pink to tan or brown. Puparia enclosed in silk remain in the damaged tip on the vine or fall to the trash layer. Adults emerge soon after, then mate and lay eggs (35 - 45 per female) at the base of small leaves on the plant tip. The adult is a very small fly similar to a midge less than 2 mm (1/16 inch) long.

Cranberry tipworm puparia in cocoons
(photo courtesy of J.-F. Landry)

Tipworms have at least two generations in the Pacific Northwest. Puparia of the last generation spend the winter on the floor of the bed. Larvae use rasping mouthparts for extracting the juices from plant tips resulting in browning (or whitening) of the two uppermost leaves.

Monitoring and Control: Refer to the section "KEY PESTS: DORMANT TO PRE-BLOOM" for more information.

MONITORING PERIODS FOR PESTS OF CRANBERRIES, ACCORDING TO CROP STAGE AND DATE



The cranberry flower is specialized for insect pollination. The petals reflex backward to expose the reproductive parts: a single pistil and a ring of eight stamens each with a basal anther sac and a long appendage ending in a terminal pore. Because of this floral morphology and the fact that cranberry pollen is heavy and sticky, bees are the primary cranberry pollinators and wind is not involved. For fruit set to occur, cranberry flowers require only a small amount of pollen to be deposited on the stigma. When more pollen is deposited on the stigma, more seeds will result. The more seeds a berry has, the larger it will be. Poor pollen transfer has a direct negative effect on fruit size and crop yield. Bumble bees and honey bees are the main pollinators of cranberry.

BUMBLE BEE (*HYMENOPTERA: APIDAE*)

Bumble bee

Bumble bees are the most important native pollinators of cranberries in British Columbia. Two studies done in the early 1980's in the Fraser Valley found that the most common bumble bee species on cranberry were *Bombus mixtus* Cress., *B. terricola* Kirby, *and B. occidentalis* Greene (Winston and Graf, 1982; MacKenzie and Winston, 1984) (Note: *terricola* and *occidentalis* are considered the same species by some and separate species by others). Bumble bees are robust, hairy bees with black, white and yellow and/or orange markings. These colours serve as warning signals indicating distastefulness and possession of a defense mechanism for animals that might otherwise prey on the bees. Unlike honey bees, bumble bees can sting repeatedly without losing the stinger as it has no barbs and does not become embedded in the enemy.

Bumble bees forage for both nectar and pollen on cranberry, usually simultaneously. To collect pollen, they hold onto the flower with their legs and vibrate their wing muscles, causing the release of a cloud of pollen that sticks to the hair on the bee's ventral surface. When the stigma of a flower touches pollen that has accumulated on the bee's body, pollen transfer occurs. Pollen transfer also takes place while the bee is collecting only nectar. Bumble bees remove pollen from the body hair by brushing the hindlegs over the body, collecting it in special indentations on the hindlegs called pollen baskets. The pollen is transported back to the nest in pollen baskets.

Bumble bees are social insects and build their nests in the ground,

often in abandoned mouse burrows, empty bird nests, and even in other insulating materials such as discarded mattresses, manure piles and the walls of old buildings. The mated queen overwinters in the soil while the rest of the colony dies at the onset of cold weather. In the early spring, she establishes a new nest and rears the first worker brood. These workers are small sterile females that enlarge the nest, forage and tend to the next generation of workers which, due to conditions within the nest such as increased temperature, cell size, and food availability, are also larger. In late summer, males (called drones) and fertile females, next year's queens, are produced. The sole function of the drones is to fertilize the queens before dying in the fall.

HONEY BEE (*HYMENOPTERA: APIDAE*)

Honey bee

Apis mellifera, the only honey bee species in North America, is valued for the honey it produces. Honey bees forage on cranberry mostly for nectar. They harvest pollen by drumming the anthers of cranberry blossoms with their forelegs which causes pollen to be released.

Like bumble bees, honey bees are social insects. Honey bees build nests in which both workers and the queen overwinter. In contrast to the bumble bee, the honey bee queen requires the help of the sterile female workers. When a colony gets too large, a swarm consisting of the old queen and many workers will leave the hive to find a new home, leaving a new queen and the remaining worker population in the old colony.

Females develop out of fertilized eggs, while drones are produced from unfertilized eggs. Larvae are fed a mixture of glandular secretions and pollen. A queen is produced when young female larvae are fed only these gladular secretions, often called royal jelly, in greater amounts than that fed to worker larvae. This will happen when the colony is getting ready to swarm or when the old queen is aging. A queen lives up to 5 years during which time she continues laying eggs, her only activity in the hive. Workers carry out all the duties required by the colony. Honey bees have a caste system in which the youngest bees perform the most menial tasks while the responsibilities and the importance of the work, for instance the rearing of the brood, increases with the bee's age and experience. Due to their complicated communication system, bees are able to inform their fellow workers of the exact locations of food sources.

A colony can sometimes consist of more than 80,000 individuals, although colonies consisting of 30,000 to 40,000 are more common.

New queens emerge in late spring or early summer. The drones mate with these new queens and then die. Unmated drones are either starved to death or killed by the workers in late summer or early fall.

Honey bees prefer other forage to cranberries. Blackberries, false dandelion and clover are very attractive to honey bees and thus compete with cranberries for honey bee pollination.

RENTING HONEY BEES

Because bumble bees and other native bees are not present in sufficient numbers to pollinate commercial cranberry plantings, managed honey bees are important for berry production.

For pollination of commercial cranberries, place bee hives near the beds at 10 to 20% bloom. One to two colonies (hives) per acre (two to three per ha) is recommended. Because blooming weeds, especially brambles, will attract honey bees away from the cranberries, it is a good practice during bloom to mow or remove weeds if possible. Hives should be removed after cranberry bloom has finished.

COMPARING HONEY BEES TO BUMBLE BEES

Bumble bees are more consistent foragers for cranberry pollen than honey bees, which tend to forage more for nectar due to the great demand in the hive. “In field observations, on average 74% of the bumble bees collected pollen compared with only 3% of the honeybees” (MacKenzie,1994). Honey bees are able to collect cranberry nectar without contacting the stigma and, therefore, without transferring pollen. Bumble bees are faster foragers than honey bees. Bumble bees also visit more blossoms per minute than honey bees. Bumble bees work longer hours than honey bees, and continue foraging in cool weather or light rain. Bumble bees deposit more cranberry pollen and carry purer pollen to a stigma than do honey bees.

It has been estimated that two pollen collecting honey bees equal one bumble bee based on working rate and a 30% longer working day for bumble bees (MacFarlane and Patten, 1994). On a favorable 10-hour day in this study, one bumble bee visited 6,000 flowers. Eighty percent of honey bee foraging occurred between 11 am and 4 pm, while 85% of bumble bees foraged between 10 am and 7 pm. Honey bees have a more extensive foraging range than bumble bees and honey bees communicate within the hive about the quality of food sources while bumble bees learn from actually sampling the flowers.

OTHER BEE POLLINATORS

Alfalfa leafcutting bee
(photo courtesy of K. MacKenzie)

The alfalfa leafcutting bee, *Megachile rotundata* F., is a species of solitary bee in which each female is a reproductive that looks after her own young. It nests in tunnels above ground so it is possible to construct artificial nests and develop management strategies for this bee. Alfalfa leafcutting bees are managed extensively in Western Canada and the U.S.A. This bee has a number of potential advantages over honey bees. It has a limited flight range and foraging range so tends to stay where it is put. It is not aggressive, all females forage for both pollen and nectar, and management techniques are well developed and relatively easy.

More research is being done in New Jersey, Nova Scotia and Wisconsin to determine the economic usefulness of these bees in commercial beds. However, alfalfa leafcutting bees require brighter days with warmer temperatures than bumble bees and honey bees, so it may not be well suited for cranberry production in British Columbia.

Alfalfa leafcutting bee
(photo courtesy of S. Marshall)

There are many other species of solitary bees in the Fraser Valley, but very few individuals of these species are found in managed cranberry beds (MacKenzie and Winston, 1984). Many solitary bees specialize on plant species not found on cranberry farms. Solitary bees in other growing areas nest in bare patches and among vines right on the cranberry bed. Pesticide use on cranberry farms, competition with honey bees and habitat loss probably reduce the survival and reproduction of solitary bees.

ENCOURAGING BUMBLE BEES

Encouraging bumble bees to establish on cranberry farms will contribute to better pollination of cranberry flowers. Bumble bees store only enough food reserves to keep the colony going for a few days. Therefore, improving the sequence of flower sources around cranberry bogs is considered the leading way to maximize residential populations of bumble bees. Bumble bees nest only where there is an ample food source early in the spring, and there is a heavy requirement for resources during reproductive production in the summer. Providing a sequence of flower sources around cranberry beds during these times will sustain and encourage residential populations of bumble bees. A succession of perennial plants like winter blooming heather (*Erica carnea* and *E. darleyensis*) covering the early spring period, followed by varieties of *Rhododendron* that flower in March and April plus later-flowering trees (plum, cherry, crabapple) can be planted in small area close to beds. After cranberry bloom, forage plants are also needed because bumble bee colonies

continue to grow and produce queens and drones in early to mid-summer. After mating, the new queens feed to build up their fat for overwintering. When lots of nectar and pollen sources are available, there is a good chance that a large population of queens will overwinter. Providing off-bog pollen and nectar sources that flower in July and August, such as cultivars of white clover or blooming heather (*E. cinera*), is also very important.

Note: Plants that enhance bumble bee foraging and survival may also attract honey bees away from cranberries. We suggest that you consider carefully the role of each type of pollinator on your farm before planting perennials for bumble bees. In this regard it may be helpful to consult with your beekeeper.

Most bumble bees nest in the ground, often in deserted mouse nests, or other dry and sheltered sites. On cranberry farms, bumble bee nests have been found at flood level on dykes bordering beds. High spring rain is detrimental to residential bumble bee populations because nests can be flooded and limited foraging time can lead to starvation. Nest boxes may be used to encourage bumble bees to nest near cranberry beds in the spring. These are wooden boxes the size of a large shoe box with an overlapping lid to keep bees dry, a small entrance hole, and a filling of upholster's cotton, pink wall insulation or bulk wool. While *B. occidentalis* prefers surface or underground hives, *B. mixtus* uses aerial waterproofed hives. Deer mice are enemies of surface colonies. Ants and wasps can establish colonies within the boxes. Nest boxes should be placed above the upper limit of the water table where they will stay dry. Another good idea is to locate nest boxes near a prominent feature such as a fence post or on a high point of land as this aids the bumble bees in orienting to their home. Place hives near attractive flower sources in early spring before queens start flying and before nest initiation. Each new queen digs a small cell in the soil for winter hibernation, and is likely to return to the natal nest site the following year to begin searching for a nest. After bee activity finishes (workers and old queen die) in the late fall, boxes should be collected, cleaned with a diluted bleach solution and stored until next spring.

PROTECTING BEES

Most organophosphate (e.g., diazinon, parathion, malathion, acephate, phosmet) and carbamate (e.g., carbaryl) insecticides used to control second-generation blackheaded fireworm larvae are highly toxic to bees. It is recommended not to apply any of them during blossom or within 7 days of the introduction of honey bees.

"Do not move hives back into parathion-treated fields until at least 36 hours after the application. Our tests have shown that about 90 percent of the killing of bees by parathion occurs during the first 24 hours after application" (Mayer and Johansen 1999).

If for some reason insecticides are needed during bloom, select an insecticide of lowest toxicity to bees, and apply it in the evening after bee activity has ceased for the day. Studies in Long Beach, Washington, demonstrated that 80% of honey bee cranberry foraging occurred between 11 am and 4 pm while 85% of bumble bees forage between 10 am and 7 pm (MacFarlane and Patten 1994). Do not treat during warm evenings when honey bees are clustered on the outside of the hive and bumble bees are likely to continue foraging, especially if it is at all light. If an insecticide must be applied, spray at night then irrigate in the morning until bees start flying to flush insecticide from the foliage. This practice will minimize but not eliminate bee kill. Honey bees in hives have to be protected from insecticide application, as do bumble bees and other indigenous bees nesting and foraging naturally in cranberry fields. Bumble bees forage only 277 - 460 metres (300 - 500 yards) from their nesting sites, and solitary bees may be found nesting right in the beds. Growers should also continue to use caution if applying insecticides in late summer, because any bumble bees still foraging on late blooming cranberries or flowering weeds in the bog will be killed. Remember to respect the pre-harvest interval when applying any pesticide.

PESTICIDE IMPACT AND BEE POISONING

The following information was summarized from Mayer and Johansen (1999).

Insecticide applications to cranberry fields have an impact on native bees by reducing their abundance and the diversity of the species. Insecticide sprays during pollination also have damaging affects on managed honey bee colonies.

Bees are poisoned when they touch contaminated foliage, flowers, or water, and/or when they collect contaminated pollen or nectar. One honey bee forager returning to the hive with a load of contaminated pollen or nectar can cause extreme agitation and death of a number of bees including larvae. Several such foragers can seriously disrupt and damage the colony. Bees have been observed performing abnormal communication dances on the horizontal landing board at the hive entrance while under the influence of insecticide poisoning.

The most common symptom of bee poisoning is the appearance of excessive numbers of dead bees in front of the hives. Aggressiveness in bees may be caused by organophosphate insecticides. Stupefaction, paralysis, and abnormal activities of bees are commonly caused by organophosphate insecticides.

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Beneficial insect and spider predators

Ground beetles - Carabids
Ladybird beetles
Lacewings
Wasps
Syrphid flies
Spiders

Beneficial parasitic insects

Tachinid flies
Ichneumonid wasps
Trichogrammatid wasps
Brachonid wasps
Eulophid wasps

Beneficial Nematodes

Steinernema spp.
Heterorhabditis spp.

Bats and Birds

Entomophagous insects are those that feed on other insects. Entomophagous insects play a major role in keeping down the population of pest species. For this reason, they are commonly called beneficial insects. Beneficial entomophagous insects are either **predators** or **parasites.**

Predators are usually active and strong insects that attack smaller and weaker insects. Parasitic insects, also called “parasitoids”, are usually tiny insects that live in or on their hosts, consuming all or most of them and eventually killing them. More than one parasitoid may live in or on the same host. The majority of parasitoids are parasitic only during the larval stage. As adults they locate hosts and lay their eggs in, on or near hosts.

Nematodes are microscopic round worms: non-segmented invertebrates that can parasitize plants or animals, including insects. Nematodes applied to cranberry beds for control of insects parasitize only insects.

Here is a description of the most important groups of predators, parasitoids, nematodes, bats, and birds seen or used in cranberry beds in British Columbia.

BENEFICIAL INSECT AND SPIDER PREDATORS

GROUND BEETLES - CARABIDS (COLEOPTERA: CARABIDAE)

Pterostichus sp. ground beetle

The most commonly occurring ground beetle species in British Columbia cranberry beds are the common black ground beetle (*Pterostichus* spp.) and the European ground beetle (*Carabus nemoralis* Müller). The beetles range in size from 3 - 36 mm (1/8 - 1.5 inches) and are often dark and shiny or brightly coloured and iridescent with striated or grooved wing covers. Their bodies are somewhat flattened and the head has well-developed mouthparts. Ground beetles are mostly nocturnal hunters. They are predaceous as both adults and larvae. Ground beetles feed mostly on soft-bodied insects like caterpillars and weevil larvae. Some also feed on weevil adults and snails. Depending on the species, the female lays her eggs singly or in batches into soil or other dark and moist places. After hatching, the larvae move about in search of prey. It takes 1 - 2 years before the larvae develop into adults that can live up to 2 years. Larvae are cannibalistic and eat each other as well as pests. Ground beetles are very susceptible to insecticides.

LADYBIRD BEETLES (COLEOPTERA: COCCINELLIDAE)

Ladybird beetle

Ladybird beetles are among the most familiar beetles occurring in British Columbia. Their often bright colourings — red or orange with black spots — advertise their “bitter” taste to possible predators. The female beetle deposits her yellow-orange eggs in clusters of 10 - 50 on foliage near a food supply. The emerging larvae are elongated and spindle-shaped. They often are brightly banded in patterns that identify the species.

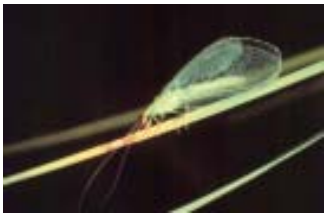
Ladybird beetle larva eating fireworm larva

Larvae do not resemble adults and are easily seen on cranberry foliage or on weeds in the beds. A full-grown larva can consume about 50 aphids in one day. An adult female needs up to 100 aphids before reproducing and will feed on approximately 2000 aphids in her lifetime, which can last 1-2 months during the warmer seasons. Adult ladybird beetles are very mobile and actively search for food. They are attracted by large numbers of aphids and increase their reproductive rates accordingly — up to 100 eggs per female. It takes 20 - 35 days for an egg to develop into an adult. British Columbia experiences 2 - 3 generations per year depending on the weather.

Ladybird beetles are predaceous both as adults and larvae. They prey mostly on aphids and on young scale insects. The larvae have also been observed to feed on small caterpillars like blackheaded

fireworm as well as on each other. In cranberry beds, ladybird beetle larvae have been seen attempting to pry open fireworm tents using their legs and mandibles. Ladybird beetles (*Coccinella californica* Mann.) have been observed feeding on fireworm larvae in Washington (Plank 1922). Ladybird beetles are often found overwintering in large swarms of adults under leaves and debris or in buildings, emerging again in spring.

GREEN LACEWINGS (NEUROPTERA: CHRYSOPIDAE)



Green lacewing
(photo courtesy of D. Gillespie)

Green lacewings are often seen on cranberries and on trees, shrubs and other low growing plants in the vicinity of cranberry beds. They have large membranous green wings, golden- or copper-coloured eyes and are active predators at night. The large green lacewing, which is 14 mm (5/8 inch) long, gives off a disagreeable odour when threatened. Both adults and larvae prey on soft-bodied insects like aphids and mites.

Green lacewing larva

The larvae hatch from white, stalked eggs laid on leaves. The brownish larvae have enormous curved pincers with which they seize their prey and suck it dry. Larvae are called “aphid lions” because of their ferocious appetite for aphids. They can consume a few hundred aphids in one day. After having reached about 6 mm (1/4 inch) in length, the larvae pupate in a white silk cocoon attached to the underside of a leaf. It takes 30 - 40 days for the eggs to develop into adults that live 4 - 6 weeks. One adult female can lay 100 - 200 eggs.

The adult green lacewings appear at the beginning of the season and are important as early aphid control agents. Later the larvae take over most of that function. They will also attack mites, leafhoppers, small caterpillars, and thrips. Commercially raised green lacewings are available.

BROWN LACEWINGS (NEUROPTERA: HEMEROBIIDAE)

Brown lacewing
(photo courtesy of S. Marshall)

Brown lacewing larva
(photo courtesy of S. Marshall)

These gray-brownish lacewings are nocturnal like the green lacewings and are commonly found in and near wooded areas. Brown lacewing adults are smaller than green lacewings. The females deposit their eggs on foliage near a food source. The eggs are white, but turn orange or pink and finally brown just before the larvae are ready to hatch. Larvae are similar in shape and colour to the green lacewings. The head ends in shorter and stouter pincers which are used to hold on to the prey, pierce it and suck out the liquid body contents. The development from egg to adult takes 24 - 30 days and there are

several generations per year. Brown lacewings are predaceous in their adult and larval stages and feed on spider mites, aphids and other soft-bodied insects.

WASPS (HYMENOPTERA: VESPIDAE)

Yellow jacket wasp eating caterpillar

Two commonly occurring species of wasps in B.C. cranberry beds are the bald-faced hornet (*Vespula maculata*) and the yellow jacket (*Vespula* spp.). They are both social wasps and build their nests out of "wasp paper", a material made from chewed wood and saliva. Yellow jackets, which are 12 - 16 mm (1/2 - 5/8 inch) long, usually with black, yellow and white markings, nest in the ground. The black and white bald-faced hornets, which are 16 - 20 mm (5/8 - 7/8 inch) long, construct nests that are free-hanging and often can be found attached to branches or houses. Both species rear their young by "progressive provisioning" which means the larvae are cared for until maturity by the adults. The larvae are fed pre-chewed insects while the adults live on nectar, honeydew, pollen, ripe fruit and insects. In both species, the colony consists of queens, workers and males. The fertilized queens overwinter and start a new colony in spring. The first brood consists of female workers that rear the second generation and take over all duties concerning the nest while the queen does little else but lay eggs. The males develop in late summer from unfertilized eggs and mate with the queens. Only the mated queens overwinter in soil or leaf litter.

SYRPHID FLIES (DIPTERA: SYRPHIDAE)

Syrphid fly

Adult syrphids, also called hover flies, mimic the movements and colourings of bees and wasps. These colours warn potential predators away from bees and wasps, and accomplish the same effect for the harmless syrphid flies that possess no stinger. Adult syrphids feed on pollen, nectar and the sugary secretion called "honey dew" produced by aphids. Larvae are very efficient predators**.**

The adult female moves up and down a plant, searching for aphids while hovering in one spot. After the female has located a colony, she deposits the eggs in small batches among the aphids. Depending on the species, the female lays between 400 - 1000 oblong, white eggs that hatch after a few days.

The tiny, blind larvae hunt for aphids by raising the front part of their bodies and swinging back and forth until they bump into their victim. On contact with an aphid, the syrphid larva uses its sharp mouthparts

to pierce the aphid, lift it up and suck it dry. One syrphid larva can destroy up to 400 aphids in its 7 - 10 days of life. The full-grown larvae pupate in the soil or rolled-up leaves. Metamorphosis takes about 7 - 8 days, after which the adult flies emerge. Depending on the climate, 3 - 7 generations a year are possible. Syrphids also play an important role as pollinators and can often be observed in and around cranberry beds.

SPIDERS

Spiders (class Arachnida) are not insects (class Insecta) but are more closely related to mites. The most obvious difference between spiders and insects is the number of pairs of legs. Spiders, like mites, have four pairs of legs whereas insects have three. Spiders do not metamorphose from larva to pupa to adult like insects do. When they hatch, juvenile spiders just look like miniature adults. Adult female and male spiders often differ considerably in size. Female spiders are larger than males of the same species. All spiders are predacious and feed mainly on insects. They play an important role in restraining insect populations.

Spiders are mostly generalist predators. They prey on any kind of insect they are able to catch. In crops like cranberries, both web-spinners and hunting spiders contribute to the reduction of aphids, flies, gnats, caterpillars and other harmful insects.

Wolf spider

Most web-spinners are unable to catch moths easily because of the moths' ability to shed the scales on their wings. While the webs of most web-spinners are designed to catch air-borne and jumping insects, the webs of some species adhere to the ground and trap crawling insects.

Compared with web-dwelling spiders, individual hunters (wolf and crab spiders) are not very efficient predators and do not catch nearly as much prey as they consume when fed in captivity. Their significance as predators stems from the fact that hunting spiders occur in vast numbers in small areas and, as a group, destroy great quantities of insects. Wolf spiders are effective pest control agents and, like beneficial insects, are adversely affected by insecticides.

Crab spider

Crab spiders walk mostly sideways like fiddler crabs. Most crab spiders are less than 1 cm (0.4 inch) long. They are predators, lying in wait to ambush their prey, then injecting a venom that quickly immobilizes them.
In cranberry fields, wolf spiders of the genus *Pardosa* and crab

spiders of the genera *Xysticus* and *Tibellus* have been found preying upon live fireworm moths in experimental field cages. Wolf spiders are active day and night.

Harvestmen, also called daddy long-legs, are arachnids like spiders. Spiders have two body parts, two fangs, and produce silk. Harvestmen have one oval body part, no fangs, do not produce silk and have eight extremely slender legs. Harvestmen are rarely found indoors, preferring moist areas outside. They feed on plant juices or dead insects, but some species could feed on living insects.

List of species found by Ursula Dole in cranberry beds in the Fraser Valley, in 1990.

Web-spinners

Araneus diadematus
Araneus marmoreus
Ceratinella paruala (Fox)
Lynphia spp.
Microlynphia spp.
Nuctenea patagiata (Clerck)
Nuctenea spp.
Theridion simile C.L. Koch
Theridion spp.

Hunters

Lycosa carolinensis
Metaphidippus spp.
Pardosa spp.
Phidippus spp.
Xysticus spp.

Harvestmen

Mitopus morio
Opilio spp.
Phalangium opilio
Rilaena spp.

BENEFICIAL PARASITIC INSECTS (PARASITOIDS)

TACHINID FLIES (DIPTERA: TACHINIDAE)


Tachinid fly

Tachinid flies are a very large family of active flies whose stocky bodies are covered with bristles. They vary in size from 3 - 14 mm (1/8 - 9/16 inch) and resemble bees or house flies. Adults fly from late spring until early fall and are among the most important parasitic insects. Tachinid flies feed on nectar and secretions of aphids, scale insects and leafhoppers, while larvae are internal parasites of a variety of insects. Live young or up to two eggs are deposited on or near a suitable host. Hosts maybe the larvae of moths, butterflies, sawflies, or beetles, or the adults of true bugs and grasshoppers. Tachinid larvae penetrate the host and feed on its internal organs until ready to pupate in the soil. The host almost always dies from the parasitism. Some tachinid species specialize in a certain host such as leaf-rolling caterpillars, while others prefer cutworms or winter moths. The tachinid W*inthemia quadripustulata* (Fab.) is known to parasitize zebra caterpillars. The tachinid *Hemisturmia tortricis* (Coq.) has been

reared from larvae of the blackheaded fireworm.

ICHNEUMONID WASPS (HYMENOPTERA: ICHNEUMONIDAE)

Ichneumonid wasp

Adult ichneumonid wasps are slender insects with long abdomens. They almost always have permanently a protruding ovipositor that can be several times longer than the body. Ichneumonids use the ovipositor to deposit one or more eggs on or inside the host. Ichneumonids range from 5 - 36 mm (1/4 - 1.5 inches) long and vary in coloration. Ichneumonids are mostly parasitic on the eggs and immature stages of a variety of insects and spiders. Most are external or internal parasites of lepidopteran, hymenopteran or coleopteran larvae. The growing larvae devour the host from within and emerge either when ready to pupate or as adults. Ichneumonids are very effective pest control agents and some members of the subfamily Gelinae are commonly found in cranberries.

TRICHOGRAMMATID WASPS (HYMENOPTERA: TRICHOGRAMMATIDAE)

Trichogrammatid wasp
(photo courtesy of M. Gardiner)

Trichogramma wasps are very tiny insects, 0.3 - 1.0 mm (1/16 inch) long. They are known to attack many lepidopteran eggs. They use their ovipositor to insert one or more eggs inside an host egg. Adult wasps will emerge from the host egg. Two species of *Trichogramma* native to British Columbia have been reared from blackheaded fireworm eggs. One was identified as *Trichogramma minutum* Riley and the other as *Trichogramma sibericum* (Sorokina) (Li *et al*, 1993). Field and laboratory experiments have been conducted by E.S. Cropconsult (Vancouver, British Columbia), on *Trichogramma sibericum* to analyse the potential of this species as a biological control agent against the fireworm. The tiny wasps are now commercially raised and available for release in cranberry beds to target eggs laid by second-generation blackheaded fireworm females.

BRACONID WASPS (HYMENOPTERA: BRACONIDAE)

Brachonid wasp

Members of the family Braconidae range from 2 - 15 mm (1/8 -5/8 inch) long. The adults are somewhat similar in appearance to ichneumonid wasps but their bodies are stouter, usually black and the ovipositor is seldom carried outside the body until it is needed to inject one or more eggs into a host. Braconids are important pest control agents and parasitize a number of different insects like aphids, caterpillars, weevil larvae, flies, true bugs, sawflies and other wasp-like

larvae. The developing larvae consume the host from the inside, killing it, and emerge to pupate or as fully grown adults. Aphids parasitized by braconids are recognizable by their golden, black, or silvery colour and by the parchment-like texture of the bodies. Only the outer shell of the aphid ("mummy") remains to protect the braconid until it emerges as an adult. Moth and butterfly caterpillars are often covered by silk cocoons, webs, and leaf rolls which seem to make them more attractive to some braconids as those coverings can be used as additional protection for the braconid larvae. The larvae that pupate on the outside do so in silken cocoons attached to the host or entirely apart, often in a group. One parasitoid of the genus *Microplitis* emerged from a blackheaded fireworm larva collected on a cranberry farm in Pitt Meadows, British Columbia.

EULOPHID WASPS (HYMENOPTERA: EULOPHIDAE)

Eulophid wasp

Eulophids belong to a large group of tiny insects 1 - 3 mm (1/16 - 1/8 inch) long. They are known to parasitize a number of crop pests. This is a biologically diverse group, with some species attacking mites (as predators), spider egg cases, scale insects, and thrips, but most attack beetle or moth larvae or pupae, flies or other wasps. *Sympiesis bimaculatipennis* (Girault) attacks leafrollers but is reported to prefer blotchmining or skeletonizing lepidopterans. On a cranberry farm in Pitt Meadows, British Columbia, females of this species were observed walking over the tents of blackheaded fireworms, tapping with their antennae and probing between leaf edges with their ovipositor, seeking a host.

BENEFICIAL NEMATODES

Infective juvenile nematodes enter the body of the insect via body openings such as the anus, mouth parts, or breathing holes, and release bacteria. The bacteria colonize the insect, which usually dies within 48 hours. The nematodes then feed on the bacterial cells and the degrading host tissue. Nematodes mature, mate, and may produce up to three generations in the same host. Most nematodes effective in pest control belong to two genera: *Steinernema* and *Heterorhabditis*. Commercially raised nematodes possess a number of attributes relevant to the control of weevils and cranberry girdlers. *Steinernema carpocapsae* is a passive sit-and-wait or "ambush" forager, remaining near the soil surface and attaching to passing hosts. Consequently, *S. carpocapsae* tends to be most effective when applied against highly mobile surface-adapted insects. *Heterorhabditis* species penetrate more deeply into the soil and use

an active “cruiser” strategy to locate and infect sedentary insects. *S. carpocapsae* is recommended for weevils and cranberry girdlers while *H. bacteriophora* is mostly recommended for cranberry girdlers. Both species can be applied by chemigation or boom sprayer. Nematodes are living organisms. To be effective as biological control agents they have to be kept alive, applied under the right conditions and handled properly. Nematodes are very sensitive to certain environmental factors and are quite intolerant of ultraviolet radiation, desiccation and temperatures below 14º C (54º F) and above 30º C (86º F).

Bats and Birds

BATS

Bats are flying mammals that are primarily nocturnal. Bats sleep during the day, and hunt and feed at night. They have teeth and a body covering of fur. They give birth once a year, in mid-June, to live young and nurse them with milk.

Because bats of Canada feed on insects, they are beneficial to agriculture and the environment. British Columbia has 17 species of bats, more than any other part of Canada. Some of our bats avoid winter by migrating elsewhere; others hibernate in caves or old mines. The little brown bat (*Myotis lucifugus*) is the most common Canadian bat and the hoary bat (*Lasiurus cinereus*) is the largest Canadian species.

Bat

Little is known about the local bat species of the Vancouver area. Approximately seven species, including the little brown bat (*Myotis lucifugus*), Townsend’s big-eared bat (*Plecotus townsendii*), and Yuma bat (*Myotis yumanensis*) make their homes under the bark of trees in Stanley Park.

Bats usually catch insects like moths, mosquitoes, beetles, mayflies, caddis flies, and midges in flight. Insectivorous species of bats typically consume 30 – 50% of their body weight in insects each night. Birds that pursue flying insects often catch prey in their mouth, but most insectivorous bats scoop up their victims in wing or tail membranes before transferring them to their mouth.

In the summer, female little brown bats aggregate in colonies that are often located in the attics of buildings. Several hundred of these bats may inhabit one colony, moving into it in April or May. The months of July and August are spent in heavy feeding, as the females and young build up their fat reserves for hibernation. Little brown bats live for up

to 10 years. In the fall, when weather conditions become harsher and the food supply of insects disappears, Canadian bats hibernate. Bats in Canada may be divided into two groups based on their seasonal movements. Some common species, including the building-roosting ones, travel from a few kilometres to several hundred kilometres between summer quarters and winter ones where they often hibernate in caves. Other species, such as the tree-roosting bats, migrate to more southern locations where they may hibernate in hollow trees or remain active.

"Echolocation is an active mode of orientation in which the bat emits pulses of sound and listens for the returning echoes using its large ears. The difference between the original sound and its echo contains the information used by the bat to locate and identify objects in its path. The ears of many insects, such as moths, lacewings, crickets, and some mantids, are sensitive to the echolocation calls of bats. These insects thus receive warning of a bat's approach and are able to evade capture. Again, the Spotted Bat is an interesting exception. Its lower-frequency echolocation calls are not detected by most insects, so the insects are less likely to flee" (Canadian Wildlife Service Hinterland Who's Who series website).

HOW TO ATTRACT BATS

Some bat species are gregarious. Whole colonies will roost and breed in caves, hollow trees, and attics. It is much easier to attract bats to temporary roosting boxes than it is to get them to breed. The bats most attracted to roosting boxes are the common species like the little brown and big brown bat and some less common species like Yuma bat and the Pallid bat (*Antrozous pallidus*). Spring and autumn are bats' favorite times for relocating and the most likely times that bats will find your box.

Boxes are usually placed 5 - 7 metres (15 - 21 feet) above the ground on poles, buildings or tree trunks that are relatively free of branches below the box to provide unobstructed access. It is recommended that the box face south or southeast and have at least 6 hours of direct sun per day. Boxes should be made of soft wood WITHOUT WOOD PRESERVATIVES which may be harmful to bats. The wood should be slightly rough on all surfaces so that bats can land and investigate by crawling over the box. Boxes should also be rainproof.

The best location for attracting a nursery colony of bats is within 400 metres of a pond, lake, or river, with diverse habitat, especially a mixture of farmland and natural vegetation.

Because the boxes cannot provide the stable, relatively warm winter temperature that bats require, bats will not use them to hibernate. Once bats have gone into hibernation, boxes should be taken down, cleaned with a garden hose, and stored.

Large, single-chamber bat houses can also be simply made by using a sheet of 1.25 cm (1/2 inch) thick plywood mounted on wood or masonry structures such as bridges, barns or other buildings with good sun exposure. Bats often roost naturally behind similar structures such as bilboard signs or shutters. Ventilation is critical in all houses. For more information on building bat boxes, see the REFERENCES section and visit the internet sites mentioned in the WEBSITES section of this manual.

BIRDS

While birds of prey feed on small mammals like voles, other bird species feed exclusively on insects.

Swallows have been observed flying over cranberry beds catching flying girdler and fireworm moths. Attracting swallows to cranberry farms is a natural way to help control these pests. At least two species, the barn swallow (*Hirundo rustica*) and the tree swallow (*Tachycineta bicolor*), are regularly seen nesting on farm sites.

HOW TO ATTRACT BIRDS

Waterproof bird houses, also called nest boxes, will provide shelter to nesting birds on your farm. Location of the nest box is very important. Nest boxes should not interfere with the normal maintenance of cranberry beds. Nest boxes should not be placed within range of sprinkler heads. Nest boxes should be out in the open, which makes it impossible to avoid direct sunlight. In order to prevent dehydration of the young birds inside, drill two 1.25 cm (1/2 inch) holes on either side of the box underneath the roof.

The entrance hole of the box should be the right size for the bird species you want to attract. Undesirable birds like house sparrows or starlings will compete for the same nesting cavity. The inside exit should have a rough surface so that the birds can get a good foothold to exit the box. When the birds have left their houses after nesting, boxes should be cleaned. Removing the nest and nesting material from the floor prevents bird parasites from infestating the next brood. For more information on building nest boxes, see the REFERENCES section and visit the internet sites mentioned in the WEBSITES section of this manual.

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Calligrapha californica larva

Calligrapha californica pupa

Calligrapha californica beetle

Altica sp. larva

Altica sp. beetle

Beneficial insects

Calligrapha californica (Lund)

Altica sp.

Two species of herbivorous (plant-feeding) beneficial insects of the family Chrysomelidae have been observed feeding on weeds in cranberry fields in Langley and Richmond, British Columbia.

CALLIGRAPHA CALIFORNICA (LUND) (COLEOPTERA: CHRYSOMELIDAE)

A large number of larvae of this beetle was seen feeding on beggarticks (*Bidens* sp.). The black headed larvae have a dark brown rotund body twice as wide as the head and three times as long. The adult is a dark beige beetle approximately 6 mm (1/4 inch) long with 3 black stripes on its back.

ALTICA sp. (COLEOPTERA: CHRYSOMELIDAE)

Adults and larvae of this genus were seen feeding on willowherb (*Epilobium watsonii)* in cranberry beds in Langley, British Columbia. The adult is a small shiny black beetle about half the size of *C. californica*. Larvae are olive-green with a black head.

DISEASES

Upright dieback
Rose bloom
Twig blight
Protoventuria Leaf Spot and Berry Speckle
Cotton Ball (Tip blight)
Red leaf spot
Phytophthora root and runner rot (not found on cranberries in B.C.)

Fruit rots
- End rot
- Viscid rot
  - Cotton ball (Hard rot)
- Black rot
- Bitter rot

CRANBERRY DISEASES THAT MAY OCCUR IN BRITISH COLUMBIA

DISEASE	CAUSAL ORGANISMS	AFFECTED PLANT PART			
		Roots	Uprights/ Runners	Leaves	Berries
Upright Dieback	• *Phomopsis vaccinii* (asexual stage)		X	X	
	• *Diaporthe vaccinii* (sexual stage)		X	X	
Rose Bloom	• *Exobasidium oxycocci*		X	X	
Twig blight	• *Lophodermium oxycocci*		X	X	
	• *Lophodermium hypophyllum*		X	X	
Protoventuria Leaf Spot and Berry Speckle	• *Protoventuria myrtylli*			X	X
	• (syn. *Gibbera myrtilli)*			X	X
Cotton Ball (Tip blight)	• *Monilinia oxycocci*		X	X	
Red Leaf Spot	• *Exobasidium rostrupii*		X	X	
Phytophthora Root and Runner Rot	• *Phytophthora cinnamomi*	X			
	• *Phytophthora* spp.	X			
End Rot	• *Fusicoccum putrefaciens* (asexual stage)				X
	• *Godronia cassandrae* (sexual stage)				X
Viscid Rot	• *Phomopsis vaccinii* (asexual stage)				X
	• *Diaporthe vaccinii* (sexual stage)				X
Cotton Ball (Hard Rot)	• *Monilinia oxycocci*				X
Black rot	• *Strasseria geniculata*				X
	• *Allantophomopsis lycopodina*				X
	• *Allantophomopsis cytisporea*				X
Bitter rot	• *Glomerella cingulata*				X

Most diseases on cranberry plants are caused by fungi. Fungi may cause a root rot, a fruit rot, a dieback of the uprights and runners, or a blight on the leaves. Some fungi may cause more than one of these symptoms. Disease development is favoured by environmental factors and vine stress. While some of the upright and leaf diseases have distinctive symptoms and are fairly easy to diagnose, individual fruit rots are difficult to differentiate. Damage on the plants or on the berries is often the first sign of disease in the beds. In many cases, a definitive diagnosis can only be obtained by culturing the causal organism from an infected part of the plant. Disease-like symptoms such as dieback of the vines may in fact be caused by insects such as root weevils or cranberry girdlers. Fungicide applications and good cultural practices will help to prevent damage or to stop an infection. At the moment, because of the lack of a monitoring system for disease organisms, the common practice in British Columbia is to apply fungicide twice during the season as a preventive measure. The first application is done at pre-bloom prior to "rough neck" stage of upright development. The second fungicide application, recommended particularly to dry-pick beds to prevent fruit rot, is done at 50 - 80% out of bloom.

GOOD CULTURAL PRACTICES TO REDUCE VINE DISEASE AND FRUIT ROT

- Avoid or minimize sources of vine stress such as picking injury
- Optimize vine vigor by sanding, improving drainage, optimizing fertility, avoiding mechanical damage, and managing pests
- Time fungicide applications to obtain continual protection during periods when vines and berries are vulnerable to infection
- Optimize uniformity of fungicide coverage
- Avoid irrigation in the late afternoon and evening
- Remove harvest trash to reduce inoculum for next year and keep trash pile at least 0.5 km from beds
- Sand vines to bury inoculum
- Protect vines during heat-stress periods
- Avoid excessive vine growth from heavy fertilizer (nitrogen)

Readers are referred to the Compendium of Blueberry and Cranberry Diseases for photographs and for more detailed information on diseases. The list of registered fungicides may be found in the 2000 Canada Cranberry Pesticide Chart (in this manual) and in the Berry Production Guide (BCMAF).

UPRIGHT DIEBACK

In the Pacific Northwest, the fungus *Phomopsis vaccinii* (the asexual stage of *Diaporthe vaccinii*) is associated with this disease. The same fungus also causes the fruit rot called viscid rot.

Symptoms: In spring, leaves of infected uprights turn yellow, then orange and bronze. Vines then turn brown and die before bloom. Affected uprights may be present with healthy uprights on the same runner. The disease does not affect roots. The disease usually appears on scattered uprights or in patches. Dieback may also occur during the growing season. Hot and dry conditions favour the development of the disease.

Control: Providing moisture and cooling vines by sprinkling water during hot and dry periods should create unfavourable conditions for spread of the disease. Fungicide applied soon after bud break is the most effective control. Good cultural practices will also reduce development and spread of the disease.

ROSE BLOOM

This is a very apparent and well-known disease caused by the fungus *Exobasidium oxycocci*. Diseased uprights have abnormal branches with fleshy pink leaves that look like miniature roses.

Symptoms: When vine growth resumes in spring, infected axillary buds grow into fleshy, abnormal lateral branches. Rose bloom may be seen scattered throughout the beds from late April until mid-June. The fleshy branches are first pale green, then turn pink as they enlarge and finally powdery white when spores are produced on the surface. The white, powdery branches become dry, dark brown, hard and withered by mid-bloom. Flowers and berries are occasionally affected. Most newly infected buds will not show the abnormal growth until the following spring.

Control: Control is only advised if many rose bloom growths are observed. Control is based on protecting new upright growth during the period of spore production (early May through mid-June). Application of fungicide should begin with the appearance of spores on the surface of the fleshy pink growths. During this period no more than three applications are recommended at 14-day intervals. Effective control will reduce the number of rose bloom growths the following spring.

TWIG BLIGHT

Two fungi, *Lophodermium oxycocci* and *L. hypophyllum*, found only on cranberry can cause twig blight. It is not a serious problem in cranberry bogs in B.C.

Symptoms: Infection occurring in the summer will show damage only in the following spring on the newest growth that will turn brown. The fungi kill only the one-year-old wood on uprights and runners. Infected cranberry leaves are dull instead of glossy. Later in the spring, the infected leaves turn a bleached tan and, eventually, a silver-gray colour. Black football-shaped spore-producing bodies form on the lower surface of blighted leaves. By mid-summer, leaves drop to the bog floor. The pathogens do not survive or produce spores on dead leaves in the trash layer.

Control: The infection period varies from year to year and lasts 4 - 6 weeks in the summer from late June to mid-August. Control is based on protecting new growth during the period of spore release in the beds. Fungicide applications are recommended. Cultural practices have little or no impact on this disease.

PROTOVENTURIA LEAF SPOT AND BERRY SPECKLE

Protoventuria leaf spot and berry speckle disease has been reported in British Columbia. It is common only in cranberry beds that have not been treated with fungicides. This disease causes little damage. The speckles on berries make them less attractive for fresh-market sales but does not affect their keeping quality.

Symptoms: At the end of the summer, small distinct red to purple lesions appear on the surface of the cranberry leaves. In the following spring, the lesions are enlarged but less well-defined. Minute black fruiting bodies clustered in the centre of the lesions may be seen in the summer. At that time many of the affected leaves may drop. Speckling appears on berries in the summer as tiny red lesions on green fruit. They increase in size and number during berry development. On ripe fruits, the lesions appear pale yellow, dark red, or black and color is lighter in the centre.

Control: Fungicides applied in the summer to control fruit rot also control this disease.

COTTON BALL (TIP BLIGHT)

The same fungus, *Monolinia oxycocci*, causes disease at two different stages of development. In the spring, spores of the fungus infect new upright growth causing tip blight. A second type of spore produced on the dead uprights infects flowers, leading to the fruit rot called cotton ball or hard rot. The disease is economically important on cranberry in British Columbia, reducing both yield and fruit quality. It is most common on Pilgrim and Bergman.

Symptoms: The disease originates from overwintering structures (called mummies) of the fungus in the remains of infected berries in the trash layer of the beds. Spores released from germinating mummies infect new growth on cranberry uprights. Infected upright tips bend over like a sheperd's crook, showing grayish-white masses of spores. The leaves turn a tan colour and fall off when dried, leaving little evidence of tip blight. Spores from infected uprights may infect open flowers and cause fruit rot. Young infected berries show no external symptoms of disease. The fungus develops inside the berry. The name "cotton ball" originates from the white cottony mass of fungus inside infected berries. Symptoms become visible externally on berries when they begin to ripen. Infected berries remain a greenish yellow with tan stripes or blotches and are usually firm.

Control: Recent work in Wisconsin showed that the number of protective fungicide applications required depends on the previous year's disease pressure. If disease pressure was low to moderate (fewer than 15 % of berries infected), two fungicide applications are

recommended: one at 10 - 20% bloom and again 7 - 10 days later. If disease pressure was high in the previous year (greater than 15% of berries infected), two additional fungicide applications are recommended: one when about half the shoots have started to elongate and the second 7 - 10 days later (McManus 1999).

RED LEAF SPOT

This disease most often appears in young bogs with excessive growth due to high nitrogen.

Symptoms: As the name describes, the main symptom is the appearance of glossy red spots on the upper surface of cranberry leaves. Below the spots on the underside of the leaf, the spores form a dusty tan spot. Red leaf spot alone does not do damage unless the fungus spreads from the leaves to the stems, causing the death of the new upright tips.

Control: This disease is not usually severe enough to cause economical damage. Since there is no registered fungicide for this disease, cultural practices may help in reducing infection. Fungicides applied for control of fruit rot seem to be effective for red leaf spot. Red leaf spot can be minimized by avoiding excessive vine growth in new beds. This disease is often seen on overfertilized, young plantings of Stevens.

PHYTOPHTHORA ROOT AND RUNNER ROT

This disease has not been found in British Columbia on cranberry. It is mentioned here because, in some cranberry growing areas, it is the most important disease of cranberry roots. Several species of *Phytophthora* can cause the root rot but *Phytophthora cinnamomi* is the most virulent one. *P. cinnamomi* is present in Oregon and Washington and is the primary causal agent in Massachusetts and New Jersey. Other species of *Phytophthora* seem widespread in cranberry growing regions. It is reported to be most severe in low or poorly drained areas within beds.

Symptoms: The most apparent symptom is the absence of vines in small patches in cranberry beds. In the early stages vines appear weak and unthrifty, there are few, small leaves, flower and fruit production are reduced, small fibrous roots are lacking, and vines are easily pulled from the ground. The cranberry girdler can cause symptoms similar to *Phytophthora* root rot. However, symptoms of *Phytophthora* appear mostly in the spring, while injury from girdler becomes apparent at the end of the summer. Girdler damage will show characteristic chewing on the roots.

Control: This root disease can be controlled by improving drainage of the soil. Excessive irrigation should be avoided. Low areas in the beds where water accumulates can be sanded. Fertilize plants to stimulate root growth. The fungus is usually introduced into new areas by planting infected vines.

FRUIT ROTS

Various fungi may cause cranberry fruit rots in the beds or after harvest in refrigerated storage. The causal organisms are usually present in the fields throughout most of the growing season. Infection occurs during bloom and/or early fruit set, depending on the fungus. Infected berries change colour or consistency and it is nearly impossible to identify the rot just by looking at the berry. Fungicides are used to control the various fruit rots. Where fruit rot was a problem the previous year, two or three fungicide applications are usually recommended to protect the berries at the early stage of development. Protection is needed before any symptoms appear. Applications during bloom and early berry development are usually most effective.

END ROT

End rot is an important disease occuring primarily in storage. Although also present in the beds as a leaf spot and a twig blight disease in British Columbia. It is not usually economically significant at these phases.

Symptoms: The early symptoms on the berries are a soft, watery rot starting usually at the blossom end of the berry. Later the whole berry becomes soft and elastic and filled with gas produced by the rotting process. Berries may burst from the increasing pressure of the gas. Reddish brown spots develop on the upper surface of the leaves when first infected. Spots then turn tan or gray in the center with a black border as they expand. The surrounding part of the leaf may turn red. Minor twig blight can appear if the fungus invades young twigs. The fungus overwinters in the old bark on the vines and in dead leaves and rotted fruit in the trash layer.

Control: Since end rot is mainly a storage rot, control is usually recommended only if berries are to be used for fresh market. Fungicides applied to control other fruit rots also control end rot. Berries may be predisposed to end rot if too much nitrogen fertilizer is applied, if bruised during harvest, or if subjected to high humidity and poor aeration during storage**.**

VISCID ROT

Viscid rot is mainly a storage disease but may cause also rot in the field.

Symptoms: Infected fruits are soft, off-coloured and may be slightly mottled. This disease cannot be identified without isolation of the causal organism. The same fungus causes upright dieback of cranberry. The fungus may be present in the beds of healthy looking uprights, flowers and berries early in the season.
Control: Fungicide applications during early bloom, late bloom and berry development are recommended if disease pressure was high the previous year.

COTTON BALL (HARD ROT) see COTTON BALL (TIP BLIGHT)

BLACK ROT

Black rot is a disease that develops on berries after harvest in storage. The causal organisms present in the trash layer of cranberry beds at harvest infect the berries when beds are flooded for harvest. Disease incidence is directly proportional to the time berries remain in floodwater. During storage, wounded berries may also be infected by the fungi that tolerate temperatures of 2-4ºC. Black rot also occurs in dry-harvested fruit.

Symptoms: Infected stored berries turn black or are mottled grey-brown. The berries progress from dry and firm to dry and shrivelled.

Control: Fungicide applications have not been effective in controlling this disease. Reducing the time that fruits remain in the water during harvest and accelerating the drying of fruit after harvest may reduce disease development. Storing fruit at low temperatures near 0º C reduces the extent of black rot.

BITTER ROT

This fruit rot occurs sporadically. The fungus overwinters on infected parts, dead leaves and rotten berries from the trash layer. Fruit are infected during the early stages of development. Most of the rot occurs before harvest and early in the storage of fresh fruit.

Symptoms: This rot does not have definitive symptoms. It is necessary to culture the fungus from rotted berries to identify the causal organism.

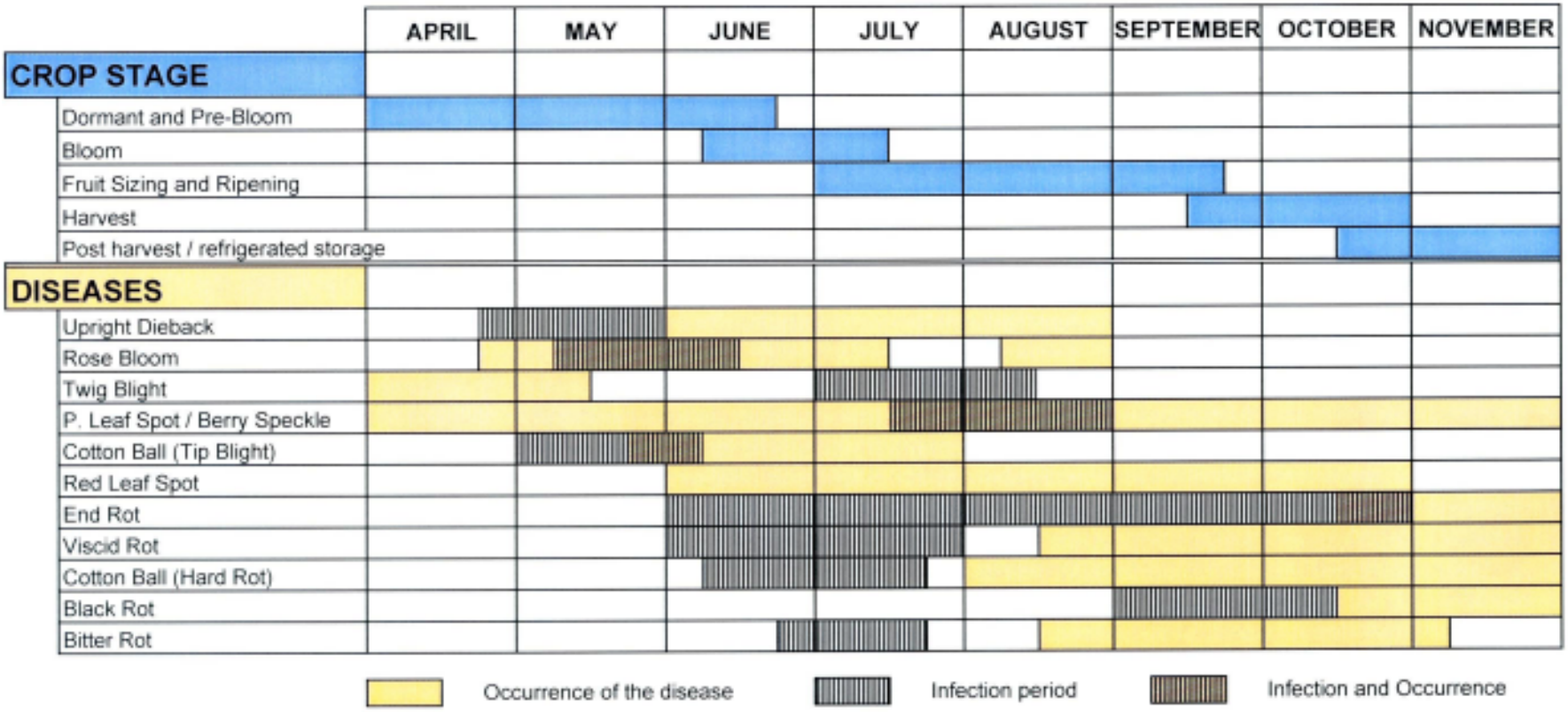
Control: Fungicides applied to control other fruit rots also control bitter rot. Cultural practices such as good water management and appropriate use of fertilizer may reduce the spread of bitter rot.

Other fruit rots, such as blotch rot, ripe rot and Pestalotia rot have also been isolated from rotten berries in British Columbia. Cultural practices used to reduce other fruit rots will also reduce these rots.

References cited in this chapter:

McManus, P. S. 1999. Cottonball disease of cranberry. University of Wisconsin-Extension. Publication A3194.

APPROXIMATE INFECTION PERIOD AND OCCURRENCE OF THE MOST PREVALENT DISEASES OF CRANBERRIES ACCORDING TO CROP STAGE AND DATE



IPM RESOURCES

Agricultural products distributors:

- **Fertilizers**
- **Pesticides**
- **3M Sprayable Pheromone**
- **Pheromone traps and lures (small quantities)**

Evergro Canada Inc.
Westgro Sales Inc.
Evergro Products Inc.
7333 Progress Way
Delta, BC V4G 1E7
Tel: (604) 940-0290
or (800) 663-2552
Fax: (604) 940-0258
Internet: westgro@westgro.com

Coast Agri
464 Riverside Road South
Abbotsford, BC V2S 7M1
Brian Johnson
Tel: (604) 864-9044
or (604) 857-1239
Fax: (604)864-8418
E-mail: brianj@terralink-horticulture.com
Internet: www.terralink-horticulture.com

Integrated Pest Management Consultants

E. S. Cropconsult Ltd.
Deborah Henderson, President
3041 West 33rd Avenue
Vancouver, BC V6N 2G6
Tel: (604) 266-6560
E-mail: debhend@axion.net

GREENBUG Biological Pest Control Inc.
Ursula Dole, President
Vancouver, BC
Tel: (604) 733-4638
E-mail: udole@direct.ca

Coast Agri
464 Riverside Road South
Abbotsford, BC V2S 7M1
Brian Johnson
Tel: (604) 864-9044
or (604) 857-1239
Fax: (604)864-8418
E-mail: brianj@terralink-horticulture.com
Internet: www.terralink-horticulture.com

Suppliers of Field Scouting Equipment

BioQuip Products
17803 LaSalle Avenue
Gardena, CA 90248-3602, USA
Tel: (310) 324-0620
Fax: (310) 324-7931
E-Mail: bioquip@aol.com
Internet: www.bioquip.com

Pheromone Traps and Lures (large quantities)

Phero Tech Inc.
7572 Progress Way
Delta, BC V4G 1E9
Tel: (604) 940-9944
or (800) 665-0076
Fax: (604) 940-9433
E-mail: Pherotech@mindlink.bc.ca
Internet: www.pherotech.com

Cooper Mill Ltd.
RR3,
Madoc, ON K0K 2K0
Tel: (613) 473-4847
Fax: (613) 473-5080
E-mail: ipm@coopermill.com
Internet: www.coopermill.com

Suppliers of Nematodes and Beneficial Organisms

Nature's Alternative International Inc.
1636 Island Hwy East
Nanoose Bay, BC V9P 9A5
Chris and Angela Hale
Tel: (250) 468 7911
or (877) 930-2847
Fax: (250) 468-7900
or (877) 940-2847
E-mail: nai@bcsupernet.com

E. S. Cropconsult, Ltd.
Deborah Henderson, President
3041 West 33rd Avenue
Vancouver, BC V6N 2G6
Tel: (604) 266-6560
E-mail: debhend@axion.net

Evergro Canada Inc.
Westgro Sales Inc.
Evergro Products Inc.
7333 Progress Way
Delta, BC V4G 1E7
Tel: (604) 940-0290
or (800) 663-2552
Fax: (604) 940-0258
Internet: westgro@westgro.com

Weather Monitoring Equipment

Onset Computer Corporation
536 MacArthur Blvd., Box 3450
Pocasset, MA 02559-3450, USA
Tel: (508) 759-9500
Fax: (508) 759-9100
E-mail: sales@onsetcomp.com
Internet: www.onsetcomp.com

Spectrum Technologies Inc.
23839 W. Andrew Rd.
Plainfield, Illinois 60544,USA
Tel: (800) 248-8873
Fax: (815) 436-4460
E-mail: specmeters@aol.com
Internet: www.specmeters.com

Davis Instruments
3465 Diablo Ave.
Hayward, CA 94545, USA
Tel: (510) 732-9229
or (800) 678-3669
Fax: (510) 670-0589
E-mail: sales@davisnet.com
Internet: www.davisnet.com

WEBSITES

Note: These websites are current as of October, 2000. Website addresses may change without notice at any time.

CRANBERRY INSECTS

http://www.library.wisc.edu/guides/agnic/cranberry/cranpests.html
Cranberry insects, weeds and diseases

http://www1.uwex.edu/ces/pubs/subcat.cfm?catid=11
University of Wisconsin, Cooperative Extension Publications 2000-2001, Diseases of cranberry and pest management publications (free to download)

http://www.ent.iastate.edu/imagegal/diptera/tipulidae/3936.94craneflylarv.html
Crane fly larva (pictures) entomology image gallery

http://www.oda.state.or.us/Plant/hot_topics/cranefly/
Identification of European crane fly adult (pictures)

http://www.oda.state.or.us/Plant/hot_topics/cranefly/
A Graphic Guide for Identification of Adult European Craneflies *Tipula paludosa* and *T. oleracea* (Diptera:Tipulidae) Eric LaGasa, Washington State Department of Agriculture

http://www2.ncsu.edu/unity/lockers/ftp/bwiegman/fly_html/diptera.html
http://www2.ncsu.edu/unity/lockers/ftp/bwiegman/fly_html/larvae.html
Diptera (flies)

http://192.211.16.12/user/serv_res/research/arthropod/TESCBiota/Carabidae/DENTON97/genera/CARABUS/C_nemoralis.HTM
Common black ground beetle (picture)

http://cedarcreek.umn.edu/insects/album/024107127ap.html
Chrysomelidae *Altica* (picture)

http://www.britannica.com/bcom/eb/article/5/0,5716,36145+1,00.html
http://www.britannica.com/bcom/eb/article/0/0,5716,108360+18+105961,00.html
Meadow spittlebug (Homopteran)

http://www.inra.fr/Internet/Produits/HYPPZ/ZGLOSS/6g—032.htm
http://www.inra.fr/Internet/Produits/HYPPZ/glossary.htm
Entomology glossary and description of different insect species (HYPP Zoology)

http://www.inra.fr/Internet/Produits/HYPPZ/pests.htm
Photographs of insects

http://www.umass.edu/umext/programs/agro/ipm/
Massachusetts Integrated Pest Management

GYPSY MOTH

http://www.for.gov.bc.ca/hfp/forsite/fhealth/biology.htm
Biology of gypsy moth

http://www.fsl.wvnet.edu/NA_online/gm_news36/agmintro/agmintro.html
Asian gypsy moth introduction into North America

http://www.bio.umass.edu/biology/kunkel/asiadisc.html
Asian gypsy moth

http://www.fsl.wvnet.edu/NA_online/gm_news46/can.html
Canadian Food Inspection Agency

BATS AND BIRDS

http://www.cws-scf.ec.gc.ca/hww-fap/nestbox/nestbx.html
Canadian Wildlife Service - Nest boxes for birds

http://www.wildbirdcenterlangley.com/nestbox.htm
Bird houses (dimensions) - Birds to attract

http://www.cws-scf.ec.gc.ca/hww-fap/bats/bats.html
Canadian Wildlife Service Hinterland Who's Who - Bat information

http://www.cancaver.ca/bats/bc/index.htm
B.C. bat resources

http://www.achilles.net/ofnc/htbats.htm
How to attract bats to your yard (box)

BENEFICIAL INSECTS AND NEMATODES

http://www.direct.ca/pestpage/ben3.html#intr
Beneficial Insects of British Columbia Cranberry Bogs, by Ursula Dole, 1991. British Columbia Cranberry Growers Association

http://www.entomology.wisc.edu/mbcn/fea607.html
Parasitoid major groups of natural enemies

http://www.oardc.ohio-state.edu/nematodes/biologyecology.htm
Nematodes

http://www2.oardc.ohio-state.edu/nematodes/cranberry_fact_sheet.htm
Nematode information related to cranberry

http://www.fuzzylu.com/greencenter/q39/nema90.htm
Nematodes

http://www.nysaes.cornell.edu/ent/biocontrol/pathogens/nematodes.html
Nematode genera *Steinernema* and *Heterorhabditis*, life cycle and biological control, list of suppliers

http://www.microbiogroup.com/Nematac%20Prod.htm
Nematac TM C Biopesticides (nematodes) for the control of cranberry girdler

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BEES

http://www.pollination.com/IPSalfbee.html
Alfalfa leafcutting bees

http://ourworld.compuserve.com/homepages/kbservices/bnestbox.htm
Bumble bee domiciles & nest-boxes

http://www.anet-chi.com/~manytimes/page40.htm
Bumble bee nest box (construction)

WHOLESALE SUPPLIERS

http://www.coopermill.com/index.htm
Wholesale suppliers of insect monitoring traps, pheromones and chemical control products for insect and vegetation management

http://www.pherotech.com/
Wing traps, pheromone lures, suppliers agriculture IPM

PEST MANAGEMENT

http://www.hc-sc.gc.ca/pmra-arla/adifs-e.html
Pest management regulatory agency, PMRA integrated pest management partnership projects, Fact Sheets

http://www.pestmanagementnews.com/news/1999_09/19990828archive.html
Pest Management News PMRA

http://www.pestmanagement.co.uk/library/insect_house/companies/ih034.html
Pest Management Resources Centre - Different companies: suppliers of beneficial insects

http://www.pesp.org/pesp/1999/ci99i.htm
Cranberry news (pest, insecticides, bio-control)

http://whatcom.wsu.edu/ag/comhort/IPM/ipmhome.htm
Washington State University Cooperative Extension - Whatcom Integrated Pest Management pages, berry production

http://www.cranberriesmagazine.com/index.html
Cranberries magazine

http://berrygrape.orst.edu/fruitgrowing/berrycrops/cranberry.htm
Northwest Berry & Grape Information Network

PHEROMONE

www.mmm.com/ca/ag
3M Canada site; 3M Sprayable Pheromone for Mating Disruption of Blackheaded Fireworm and other pheromones for fruit pests

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DISEASES OF CRANBERRY

http://www.scisoc.org/resource/common/names/cranbery.htm
The American Phythopathological Society.

http://www1.uwex.edu/ces/pubs/catalog2000.pdf
University of Wisconsin, Cooperative Extension, Cranberry Publications 2000 - 2001

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BOOKS AND GUIDES

- **A Field Guide to Common Weeds of Cranberries in British Columbia**. 1996. T. Hueppelsheuser and C. Emery. British Columbia Cranberry Growers Association. 76 pages.

- **Beneficial Insects and Common Pests on Strawberry and Raspberry Crops.** 1991. D.E. Henderson and D.A. Raworth. Agriculture Canada Publication 1863/E 33 pages.

- **Berry Production Guide For Commercial Growers 2000 / 2001 Edition.** 2000. M.-M. Gaye and M. Sweeney, Eds. B.C. Ministry of Agriculture & Food. Lower Mainland Horticulture Improvement Association, Abbotsford. 222 pages.

- **Compendium of Blueberry and Cranberry Diseases.** 1995. F. L. Caruso and D. C. Ramsdell, Eds. American Phytopathological Society Press, St Paul, MN. 87 pages.

- **Cranberry Production in the Pacific Northwest.** 1984. A Pacific Northwest Extension Publication Washington, Oregon, Idaho PNW 247. Cooperative Extension, Washington State University. 50 pages.

- **Cranberry Insects of the Northeast.** 1998. A. L. Averill and M. M. Sylvia. University of Massachussetts Cranberry Experiment Station P.O. Box 569, East Wareham, MA 02538. 113 pages.

- **Landscaping for Wildlife in the Pacific Northwest.** 1999. R. Link. University of Washington Press in association with Washington Department of Fish and Wildlife.

- **Weeds of British Columbia Cranberry Bogs.** 1990. I. Bitterlich. British Columbia Cranberry Growers Association. 138 pages.

REGISTERED PEST CONTROL PRODUCTS FOR CRANBERRY PESTS IN CANADA

Information in this table was obtained from the Pest Management Regulatory Agency (PMRA) in July, 2000. Pesticide registrations may change from year to year. Insecticides with the common name AZINPHOS-METHYL or PARATHION are Restricted. Anyone buying or using pesticides labelled Restricted must have an applicator certificate.

COMMON NAME	TRADE NAME	PCP No. *	REGISTERED FOR USE ON
Z 11- 14: ACETATE	3M Sprayable Pheromone for Mating Disruption of Blackheaded Fireworm	25880	blackheaded fireworm
BACILLUS THURINGIENSIS	Dipel WP Biological Insecticide	11252	green cranberry spanworm, brown cranberry spanworm
PHOSMET	Imidan 50-WP Instapak Agricultural Insecticide	23006	blackheaded fireworm
ACEPHATE	Orthene 75% Soluble Powder Systemic Insecticide	14225	blackheaded fireworm
MALATHION	Clean Crop Malathion 85E	8372	cranberry fruitworm, aphid, leafhopper, leafroller, mite, thrips, strawberry root weevil
MALATHION	Fyfanon 25% WP Wettable Powder Insecticide	4588	blackheaded fireworm, cranberry fruitworm, leafhopper, meadow spittlebug (nymph)
MALATHION	Fyfanon Emulsifiable Concentrate Insecticide	4590	blackheaded fireworm, cranberry fruitworm, leafhopper, meadow spittlebug
CARBARYL	Chipco Sevin RP2 Carbaryl Insecticide Liquid Suspension	22339	cranberry fireworm, cranberry fruitworm, climbing cutworm, bluntnosed cranberry leafhopper
CARBARYL	Sevin 85S Carbaryl Insecticide Sprayable Powder	7446	cranberry fireworm, cranberry fruitworm, bluntnosed cranberry leafhopper, climbing cutworm
CARBARYL	Sevin 85W Insecticide Sprayable Powder	8184	cranberry fireworm, fruitworm, leafhopper, climbing cutworm
CARBARYL	Sevin SL Carbaryl Insecticide Liquid Suspension	16653	cranberry fireworm, cranberry fruitworm, cutworm, bluntnosed cranberry leafhopper
CARBARYL	Sevin XLR Carbaryl Insecticide	17027	cranberry fireworm, cranberry fruitworm, climbing cutworm, bluntnosed cranberry leafhopper
CARBARYL	Sevin 5-D Insecticide Dust	17534	cranberry fireworm, cranberry fruitworm, bluntnosed cranberry leafhopper
CARBARYL	Sevin Brand XLR Plus Carbaryl Insecticide Liquid Suspension	19531	cranberry fireworm, cranberry fruitworm, climbing cutworm, bluntnosed cranberry leafhopper
CARBARYL	Sevin Brand 50W Carbaryl Insecticide Wettable Powder	6839	cranberry fireworm, cranberry fruitworm, bluntnosed cranberry leafhopper
DIAZINON	Ciba-Geigy Basudin 50W Agricultural Insecticide	10975	blackheaded fireworm, cranberry fruitworm, sparganothis fruitworm
DIAZINON	Green Cross Basudin 500EC Commercial Insecticide	19409	blackheaded fireworm, cranberry fruitworm, sparganothis fruitworm
DIAZINON	Chipman Diazinon 50W Wettable Powder Insecticide	11933	blackheaded fireworm, cranberry fruitworm, sparganothis fruitworm

* Pest control product number

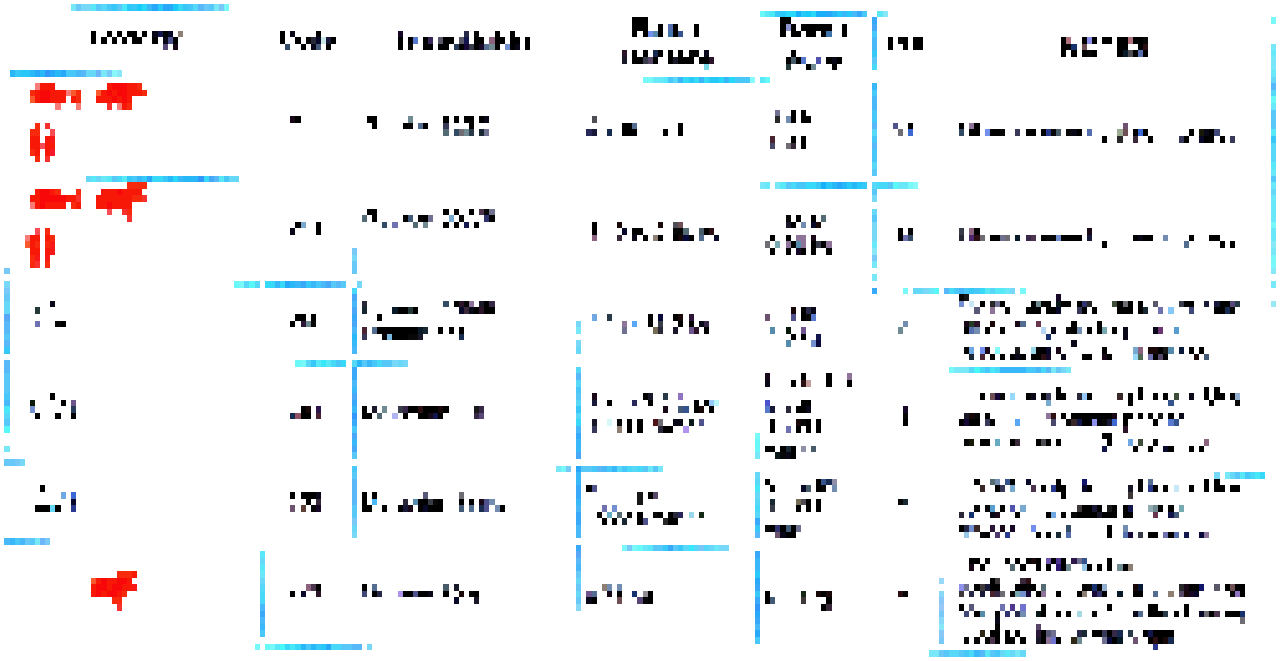
DIAZINON	Clean Crop Diazinon 500 E Insecticide	11889	blackheaded fireworm, cranberry fruitworm, sparganothis fruitworm
DIAZINON	Clean Crop Diazinon 500	12461	blackheaded fireworm, cranberry fruitworm
DIAZINON	Clean Crop Diazinon 50W Insecticide	19576	blackheaded fireworm, cranberry fruitworm, sparganothis fruitworm
DIAZINON	Diazol 50 EC Emulsifiable Concentrate Insecticide	15921	blackheaded fireworm
DIAZINON	Diazol 50W (Diazinon) Insecticide	16885	blackheaded fireworm, cranberry fruitworm
DIAZINON	D.Z.N 600 EW Insecticide	26146	blackheaded fireworm
DIAZINON	Guardsman Diazinon 500 E.C. Insecticide	12224	blackheaded fireworm, cranberry fruitworm, sparganothis fruitworm
DIAZINON	IPCO Diazinon 500 Agricultural Insecticide	25926	blackheaded fireworm
DIAZINON	Plant Products Diazinon 500 EC (Agricultural)	24418	blackheaded fireworm, cranberry fruitworm
DIAZINON	Sanex Diazinon 50EC Emulsifiable Concentrate Insecticide	16518	blackheaded fireworm, cranberry fruitworm, sparganothis fruitworm
AZINPHOS-METHYL	APM 50W Wettable Powder Insecticide	16412	cranberry fireworm, cranberry fruitworm, cranberry tipworm, midge
AZINPHOS-METHYL	APM 50W Instapak Wettable Powder Insecticide	22864	cranberry fireworm, cranberry fruitworm, midge cranberry tipworm
AZINPHOS-METHYL	Azinphos Methyl 50W Wettable Powder 50% Insecticide	15645	cranberry fireworm, cranberry tipworm, midge
AZINPHOS-METHYL	Azinphos Methyl 240 EC Emulsifiable Insecticide	17533	cranberry fireworm, cranberry fruitworm, cranberry tipworm, midge
AZINPHOS-METHYL	Clean Crop Azinphos-M 50W Insecticide	22087	cranberry fireworm, cranberry fruitworm, midge, cranberry tipworm, sparganothis fruitworm
AZINPHOS-METHYL	Clean Crop Azinphos-M 240EC Insecticide	22562	cranberry fireworm, fruitworm, midge, cranberry tipworm, sparganothis fruitworm
AZINPHOS-METHYL	Guthion 50% WP Crop Insecticide	10101	cranberry fireworm, cranberry fruitworm, midge, cranberry tipworm, sparganothis fruitworm
AZINPHOS-METHYL	Guthion Solupak 50% Wettable Powder Crop Insecticide	21374	cranberry fireworm, cranberry fruitworm, midge, cranberry tipworm, sparganothis fruitworm
AZINPHOS-METHYL	Guthion Spray Concentrate Crop Insecticide	8106	cranberry fireworm, fruitworm, midge, cranberry tipworm
AZINPHOS-METHYL	Sniper 50W Azinphos Methyl Insecticide	23287	cranberry fireworm, cranberry fruitworm, sparganothis fruitworm
AZINPHOS-METHYL	Sniper 50W Clean Pak Insecticide	23323	cranberry fireworm, cranberry fruitworm, midge, sparganothis fruitworm, cranberry tipworm
AZINPHOS-METHYL	Sniper 240 E Insecticide	23337	cranberry fireworm, fruitworm, midge, sparganothis fruitworm, cranberry tipworm
PARATHION	Aqua-Parathion 800-E Insecticide Liquid Emulsifiable Concentrate	14731	cranberry fireworm, cranberry fruitworm, leafhopper
PARATHION	Guardsman Parathion 960 EC Insecticide	12556	cranberry fruitworm
PARATHION	Clean Crop Parathion 960 Insecticide	13956	cranberry fruitworm, leafhopper

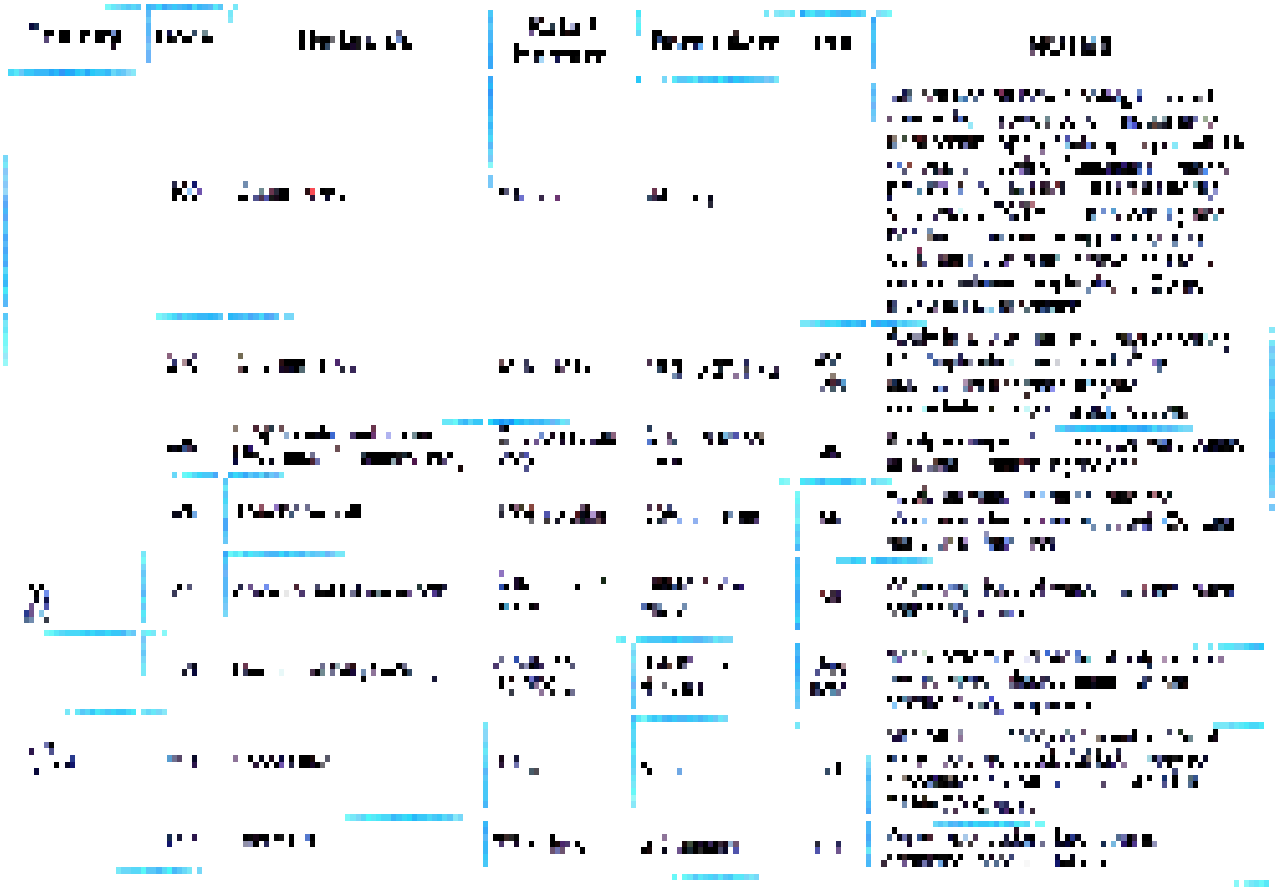
2000 CANADA CRANBERRY PESTICIDE CHART

THIS GUIDE IS NOT A SUBSTITUTE FOR READING AND FOLLOWING THE LABEL. It is the applicator's responsibility to read the label to confirm information found in this chart. Please be aware that ALTERNATIVE TRADE NAMES AND REGISTRANTS EXIST FOR MANY OF THE ACTIVE INGREDIENTS LISTED BELOW and that this is NOT an exhaustive list of all pesticides registered for use on cranberry. No product endorsement is implied by the Cranberry Institute nor does the Cranberry Institute accept any responsibility for personal injury, crop damage or property damage.

Pesticides which should be handled with extra caution due to acute toxicity are denoted by the following symbols:

Toxicity	Code	Insecticide	Rate / Hectare	Rate / Acre	PHI	NOTES
	100	Nematodes	See label	See label	0	Apply in late afternoon or evening. Consult label and with Provincial or AAFC specialist or cranberry crop consultant regarding use of nematodes. Irrigate thoroughly to wash nematodes into the soil.
	120	3M Sprayable Pheromone – Mating Disruption for Blackheaded Fireworm	222 ml	90 ml	0	To disrupt mating of adult moths. Consult label and with Provincial or AAFC specialist or cranberry crop consultant regarding use of this pheromone product.
	149	Dipel	0.55 to 1.10 kg	0.22 to 0.45 kg	0	Bacillus thuringiensis (Bt) based product. Consult label and with Provincial or AAFC specialist or cranberry crop consultant concerning specific target pests. Most effective against early-stage larvae. Addition of a sticker may be necessary for effective control.
	201	Parathion 9.6 EC	0.60 to 1.50 L	0.25 to 0.6 L	30	Observe re-entry time.
	201	Parathion Aqua 800E	0.70 to 1.75 L	0.3 to 0.7 L	30	Observe re-entry time.
	205	Imidan 50WP Instapak	2.2 kg	0.9 kg	30	Strictly observe label pollinator warnings. For blackheaded fireworm only.
	210	Diazinon 50WP	4.5 to 7.3 kg	1.8 to 2.9 kg	7	
	211	Diazinon 50EC/500	4.0 to 7.0 L	1.6 to 2.8 L	7	
	221	Sevin XLR	6.4 to 7.6 L	2.6 to 3.0 L	2	See label for information on bee toxicity.
	223	Sevin 50WP	6.25 to 7.00 kg	2.5 to 2.8 kg	2	See label for information on bee toxicity.





Toxicity	Code	Fungicide	Rate/ Hectare	Rate/ Acre	PHI	NOTES
	[illegible]	Copper Oxychloride [illegible]	4.0 kg	1.6 kg	[illegible]	Maximum of three applications per season
	540	Ferbam 76WDG	6.5 kg	2.70 kg	[illegible] see note	Do not apply later than 25 days after mid-bloom (equivalent to a 50 day PHI). Maximum of three applications per season
	550	Funginex 190EC	3.0 L	1.2 L	30	Maximum of four applications per season
	550	Bravo 500	5.8 to 11.5 L	2.7 to 4.7 L	50	Do not apply to bogs when flooded or allow release of irrigation water from bogs for [illegible] days following application to these applications. Maximum of three applications per season
	600	Copper [illegible]	10 kg	4.0 kg	[illegible]	Do not apply more than [illegible] kg per acre per season
	[illegible]	Topas 250E	0.5 L	0.2 L	45	Maximum of four applications per year. For [illegible] only

- This list is for PRODUCING BEDS only. **PHI** = Pre-Harvest Interval. Always consult with label and with Provincial or AAFC specialist or cranberry crop consultant concerning recommendations for use.

Produced by the Cranberry Institute, 266 Main Street, Wareham, Massachusetts, USA 02571 for the benefit of the cranberry commodity.

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