Guide to the Key Arthropods of Vineyards of Eastern Canada





DIVISION DE AGCORD INC.

Ontario

Agriculture and Agri-Food Canada
Agriculture et Agroalimentaire Canada

Canada

Images on front cover

Vineyard in the Niagara Peninsula in Ontario (Lasnier)

Arthropods from left to right

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Adult Japanese beetle on vine (see p. 30)

Grape berry moth damage on fruit (see p. 75)

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Print version:
Catalogue No.: A59-72/2019E
ISBN: 978-0-660-29714-9
AAFC No.: 12895E

PDF version:
Catalogue No.: A59-72/2019E-PDF
ISBN: 978-0-660-29713-2
AAFC No.: 12895E

Electronic version available at www.publications.gc.ca

Paru également en français sous le titre: *« Guide des principaux arthropodes des vignobles de l'Est du Canada »*

For more information reach us at www.agr.gc.ca or call us toll-free 1-855-773-0241.

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Technical Bulletin of Agriculture and Agri-Food Canada

2019

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Foreword

I was born in Avignon, France, and I belong to the fourth generation of viticulturists. After my studies in viticulture-oenology, I chose to practice viticulture in Canada.

In 1982, as I planted the first grapevines of the Orpailleur vineyard, we faced an environment that was rich in terms of biodiversity and abundance of insect populations. At this time, there were few documents about viticulture in Quebec. To manage grapes in that environment, we obtained our information from guides published in Ontario, New York State and Europe. In 1997, I met Jacques Lasnier, Noubar Bostanian, Charles Vincent and the late Victor Dietrich. Soon after the first formal research project in viticulture started in Quebec. This project, carried out in partnership with Agriculture and Agri-Food Canada, Ag-Cord Inc., the Dietrich-Jooss vineyard and the Orpailleur vineyard, focussed on the identification and the behaviour of insects in our vineyards. We quickly experienced positive outcomes, including several research projects that followed, again with significant gains in productivity and environmental sustainability. Thanks to this sustained and durable collaboration, we apply few insecticides and no acaricides because of a conservation program in place to protect natural enemies. For example, conservation of *Anystis* sp. predators has allowed a dramatic reduction in insecticide treatments during the past 20 years.

Over the past 30 years, the Ontario viticulture industry experienced a tremendous growth thanks to innovative activities in research and marketing. In recent years, the viticulture industries in all Atlantic provinces are also developing. Although the viticulture industries of Eastern Canada are at different stages of maturity and productivity, they share the on-going need for appropriate tools such that they remain competitive, sustainable and respect the environment.

For the last 20 years, we have witnessed a true small revolution. Today, thanks to entomological research, we are not only able to identify the insect pests that may pose a threat to grape yields, but we are able to protect the natural enemies that will decrease pest populations. This also contributes to prediction of percent in yield losses which often so small that interventions are unwarranted.

The publication of this guide about the identification and management of arthropods in vineyards of Eastern Canada, abundantly illustrated with high-quality images, is timely to consolidate and further develop the viticulture industry of Eastern Canada.

I raise my glass to this partnership between viticulturists and scientists, to results obtained and those to come. I would like to sincerely thank Charles Vincent and Noubar Bostanian from Agriculture and Agri-Food Canada, and Jacques Lasnier from Ag-Cord Inc. for their invaluable collaboration.

Long live our viticulture.

Charles-Henri de Coussergues
Viticulturist and co-proprietor of l'Orpailleur Vineyard.
Dunham, Quebec
January 2018

Preface

In Canada, viticulture is mostly practiced in four provinces, namely British Columbia, Ontario, Quebec and Nova Scotia. In the west, British Columbia has a relatively dry and mild climate compared to that of the provinces of Eastern Canada. In comparison to British Columbia, the Eastern provinces have a different situation, notably concerning their plant and insect fauna. In Ontario, Quebec and the Maritime provinces, several species of wild vines were present before cultivated vines were planted and several insect species fed on them. In contrast, no wild vine species were present in the Okanagan valley of British Columbia and the insects that first attacked cultivated grapevines in that region were first indigenous generalist species (Lowery 2014, see **References**). Recently however, both British Columbia and the Eastern Canadian provinces have been threatened by invasive species, such as the spotted wing drosophila and the brown marmorated stink bug, and these could challenge existing protection programs in both regions.

Canadian viticulture has grown tremendously over the past 25 years such that the total economic impact of viticulture, oenology and associated agro-tourism was estimated at 9.2 billion dollars in 2015, 6.7 billion of which is contributed by Eastern Canada (Frank et al. 2017). At the national and international level, the significant increase in acreage and exchanges of nursery material created a demand for information upon which crop protection programs can rely. An important step in the development and continuous upgrade of economically and environmentally sustainable crop protection programs is the identification of key arthropod pests and their natural enemies. This Guide aims to address that need for vineyards of Eastern Canada.

Documents currently available on web sites of the Ministries of Agriculture of Ontario, Quebec and the Maritime provinces provide images, information and crop protection recommendation for arthropods pests (insects, mites) of vineyards which are often regional in nature. This Guide provides a complementary resource to these provincial websites, offering many high resolution images of arthropods and their natural enemies, as well as a systematic presentation of their biology and monitoring protocols. It can also be consulted off line. Spray recommendations, economic thresholds, and other information which may vary from one province to another have not been included. Such information is available in provincial documents.

Images and texts are tools for approximate identification of pests and beneficial species in the field. However, formal identification of specimens requires a thorough examination of taxonomic criteria that calls for high level expertise generally by experienced scientists, whether classical or molecular methods are used. This Guide is a practical tool that will enable improvement of pest management programs in order to reduce risks associated with the use of pesticides.

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Wendy McFadden-Smith,
Debra Moreau,
Patrice Bouchard,
Charles Vincent

Saint-Jean-sur-Richelieu, January 2019

Acknowledgements

The authors thank:

Charles Henri de Coussergues, David Hosteing, Alain Bazinet (Vignoble de l'Orpailleur, Dunham, QC);

Marie Dumoulin (Ag-Cord Inc., Granby, QC);

Ed Hughes (Hughes Vineyard, Beamsville, ON);

Jens Gemmrich (Frogpond Farm Organic Winery, Niagara-on-the-Lake, ON);

Southbrook Vinyards (Niagara-on-the-Lake, ON);

Members of the Grape Growers Association of Nova Scotia and Winery Association of Nova Scotia;

Chris Maund (New Brunswick Ministry of Agriculture, Aquaculture and Fisheries, Fredericton, N.B.);

Frédéric Beaulieu, Shai Ben Shalom, Odile Carisse, Jérémie Côté, Leslie Farmer, Cezarina Kora, Henri Goulet, Tristan Jobin, Jean-François Landry (Agriculture and Agri-Food Canada).

Support for this project was provided by the Pest Management Centre, Agriculture and Agri-Food Canada, Ottawa, ON.

Photo credits

The authors thank the following persons whose names appear under each photo for their photographic contribution:

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Claude Pilon (Entomofaune du Québec Inc.);

Wendy McFadden-Smith, Andréanne Hébert-Haché (Ontario Ministry of Agriculture, Food and Rural Affairs (OMAFRA), Vineland, ON);

Margaret Appleby, M. J. Dreiling (OMAFRA);

Réjean Bacon, Klaus Bolte, Patrice Bouchard, Anthony Davies, Henri Goulet, Peggy Dixon, Jean-François Landry, Serge Laplante, Julien Saguez (Agriculture and Agri-Food Canada);

Roger A. Tremblay (New Brunswick Ministry of Agriculture, Aquaculture and Fisheries, Fredericton, NB);

Ryan Brewster, Kevin W. Ker (KCMS, St. Catharines, ON);

Sean McCann (Simon Fraser University, Burnaby, BC);

Chris Bergh (Virginia Tech, Winchester, Virginia, USA);

Doug Pfeiffer (Virginia Tech, Blacksburg, Virginia, USA);

Ken J. Childs (Beech Bluff, Tennessee, USA);

Margaret E. Greb (United States Department of Agriculture- Agricultural Research Services (USDA-ARS), Beltsville, Maryland, USA);

Mike Reding, Betsy Anderson (USDA-ARS).

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Director of Ag-Cord Inc. and its Division Co-Lab R&D, Jacques started to work in viticulture in 1997. He collaborated with private, institutional and university partners. He is a specialist in entomological and phytopathological research applied to agriculture. He co-authored several scientific papers and technical bulletins on the introduction, conservation and augmentation of natural enemies for biological control of insect pests to foster sustainable protection programs. He has excellent expertise in insect photography.

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Wendy is the Tender Fruit and Grape Integrated Pest Management Extension Specialist with the Ontario Ministry of Agriculture, Food and Rural Affairs in Vineland, Ontario. She has a PhD in plant pathology from University of Saskatchewan and MSc and BSc (Agr) from University of Guelph. She has been involved in pest management in tree fruit, grapes and small fruit since 1990. She is responsible for extension and applied research in diseases and insect pests. She is an adjunct professor and a sessional lecturer in the Department of Biological Sciences and a professional affiliate of the Cool Climate Oenology and Viticulture Institute at Brock University.

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Debra has been working as a Small Fruit Entomologist with Agriculture and Agri-Food Canada at the Kentville Research and Development Centre in Kentville, Nova Scotia since 2014. She has a PhD in biology/entomology from Dalhousie University. Her current research program focuses on the identification, biology, and integrated pest management of insect pests and understanding the status and management of economically important diseases and their associated insect vectors in small fruit and grape. She is an adjunct professor at Acadia University.

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Patrice has been employed as a research scientist at Agriculture and Agri-Food Canada since 2003. He specializes in the study of insects of interest to Canadian agricultural and natural ecosystems. He is the curator for the beetle (Coleoptera) unit at the Canadian National Collection of Insects, Arachnids and Nematodes in Ottawa and his research focuses on the systematics and taxonomy of two diverse, agriculturally-relevant groups of beetles, the darkling beetles and weevils. As coordinator of a project on quarantine and invasive species, he received a Public Service Award of Excellence in 2016 and he was also awarded the C. Gordon Hewitt Award by the Entomological Society of Canada in 2014. Patrice enjoys being involved with scientific organisations; he served as the president of the Entomological Society of Canada and as a commissioner on the International Commission on Zoological Nomenclature.

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After completing a PhD in entomology at McGill University, Charles initiated his career at Agriculture and Agri-Food Canada in 1983. He works on alternatives to insecticides, notably on science-based methods, including biological (e.g., biopesticides) and physical control. He published 180 scientific papers and more than 200 technical papers. He edited 25 books or technical bulletins and gave more than 500 presentations before various national and international audiences. He received several awards, notably Commandeur de l'Ordre du Mérite agronomique by the Ordre des Agronomes du Québec. He has been elected Fellow of the Entomological Society of Canada, the Entomological Society of America, and the Royal Entomological Society (U.K.). He was elected Associate Member of the Académie d'Agriculture de France in 2012. In 2017, Agriculture and Agri-Food Canada presented him with the Gold Harvest Award (exceptional career).

How to Use this Guide

This guide has two sections: one on arthropod pests, the other on natural enemies. In the yellow section, each arthropod pest is presented in a factsheet format showing selected images to illustrate key features and useful points for its management. Each arthropod pest is presented in a factsheet format showing selected images to illustrate key features and useful points for its management. Each factsheet presents, by alphabetical order, the following elements: Order (except for the sub-class Acari), Family, scientific name and common names. At the top of the page, icons indicate the potential severity and localisation of damage (buds, woody structures, leaves, fruits, inflorescences, roots, shoots). For each pest, a brief description of developmental stages (adult, egg, nymph, larva and pupa) is provided. When damage caused by a pest may be confused with that of other pests, elements allowing their differentiation are mentioned. There follows a description of the biology, life cycle, critical period of activity and events, monitoring and management of factors favouring natural control. We used the phenological systems of Baggiolini (letters) and Eichhorn-Lorenz (numbers) as temporal reference points (**in bold-red**) (see **References** and **Annexes - Plate 5**). We chose to use simplified versions of those systems to facilitate monitoring of arthropods according to the phenology of the grapevines. The durations between phenological stages are uneven. Thus, the duration between stages **L 33** to **N 38** (July to harvest) is particularly long compared to other phenological stages that last from a few days to one week maximum. **Table 2** (**Annexes)** allows the reader to quickly monitor pests at different developmental stages according to grapevine phenology.

The blue section is about natural enemies (predators and parasitoids) and presents arthropod Orders in alphabetical order. Figures in this section are numbered. Management strategies, including conservation and augmentation of natural enemy populations, are discussed. A single colour code is used for this section.

At the end of the document is a **Glossary** that explains the main terms used, and a list of selected **References** for readers eager to learn more about arthropods of vineyards.

 B: buds

 W: woody structures (trunk, cordons, canes)

 L: leaves

 Fr: fruit

 F: flowers

 R: roots

 S: shoots

RISK OF DAMAGE:

One icon: **minor**

Two icons: **average**

Three icons: **high**

1. Common name of arthropod (in some cases, synonyms are mentioned)
2. Attacked structure of vines. For a given structure, the number of icons indicates the risk level
3. Order of the arthropod
4. Family of the arthropod
5. Latin name (scientific name) of the arthropod
6. Figure corresponding to a passage in the text (in **bold black**)
7. Phenological stage of the vine (in **bold red**). See **Annexes Plate 5**
8. Author of image. See section "**Photo credits**"

Order Acari
Family Eriophyidae
Scientific name *Colomerus vitis*

Grape erineum mite (syn. eriophyids, vine leaf blister mite)

Description

Adult: The adult is white to yellow, wormlike and about 0.2 mm long and 0.05 mm wide. It has two pairs of legs and two long hairs at the tip of its body.

Egg: The eggs are oval, smooth and whitish.

Nymph: There are two immature stages: the protonymph (PTN) measures about 0.05 mm long. The deutonymph (DTN) is about 0.15 mm long and resembles the adult.

Damage

The adults and the immatures create patches of concave blisters or galls (erinea) visible on the upper surface of leaves **(Fig. A, B)** and are covered with white felt-like hairs on the lower surface of the leaf **(Fig. C)**. Later in the season, the white felt-like hairs turn yellow and then brown **(Fig. D)**. Heavily infested leaves may drop earlier in the fall. In severe infestations, damage causing drying of young shoots may be observed at bud break in stage **E 09** and later on inflorescences **(Fig. E)**.

May be confused with

Downy mildew, a fungal disease that does not produce blisters on the leaf.

Biology and life cycle

The females overwinter under dormant bud scales on the current year's wood. In stage **C 05**, the females emerge from their overwintering sites and begin to feed on the sap. Egg laying begins in stage **E 09**. The

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Arthropod Pests









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eggs are deposited on the mass of felt-like hairs within the gall. The development cycle from egg to adult takes 15 to 20 days. The next generation of adults leaves the blisters and migrates to the young foliage. They move from leaf to leaf during the summer by forming other colonies which produce erinea measuring about 5 to 10 mm in diameter. The species has five to seven generations. Beginning at veraison **M 35**, fertilized adult females move to overwintering sites.

Critical period of activity and events

The first galls usually appear in stage **F 12**. Galls may form during subsequent generations on the susceptible tissues of young leaves.

Scouting

Scouting in the vineyard should begin at stage **H 17**. If there was a severe infestation the previous autumn, examine the foliage beginning at stage **D 06**. Look for blisters on the upper surface of leaves; they may have a reddish tinge on red varieties. Eriophyids should be present within the erinea on the undersides of leaves.

Management

Predatory mites such as phytoseids and anystids are natural enemies. Establish flower beds or cover crops in order to attract natural enemies capable of reducing populations of eriophyids. Sulphur can be used early in the season to control powdery mildew and reduce colonies of eriophyids.

Order Acari
Family Tetranychidae
Scientific name *Panonychus ulmi*

European red mite

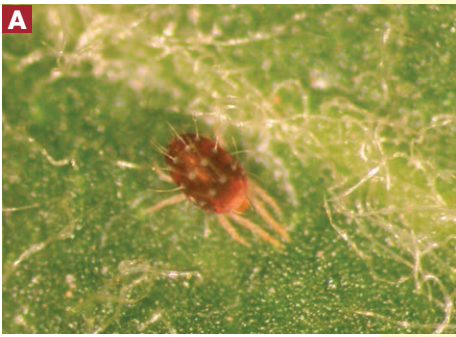
Description

Adult: The female is oval, dark red and about 0.35 mm long **(Fig. A)**. It has 14 small, white symmetrical spots with raised spines on its back. The male is yellowish with some red on its abdomen. It is more slender than the female and about 0.30 mm long with two red spots on each side of its body. The adults have four pairs of legs.

Egg: The egg is about 0.15 mm long **(Fig. B)**, bright red and spherical with small ridges and a hair-like stalk. In the spring and over the summer, eggs are laid on the underside of leaves. Overwintering eggs are slightly larger than summer eggs and can be found laid around cane nodes and under loose bark.

Larva: The three immature stages are the larva (L1) **(Fig. C)**, the protonymph (PN2) and the deutonymph (DN3). The newly hatched nymph (L1) is slightly larger than the egg, orange and has only three pairs of legs. (PN2) and (DN3) have four pairs of legs and are reddish in colour. During the quiescent or resting period between each stage, the immature mite takes on a silvery hue before freeing itself from its exuvium.

A



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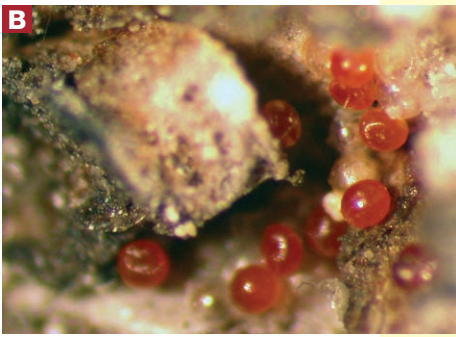
B



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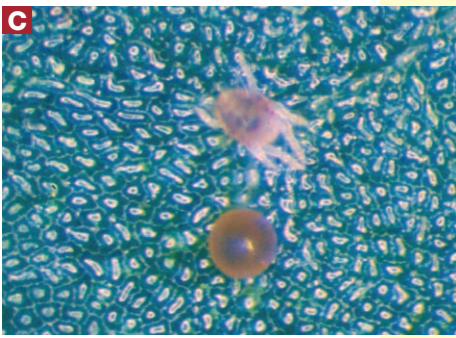
C



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Damage

These mites pierce the cell walls of vine leaves and ingest their contents. Severe infestations early in season, i.e., at stage **E 09**, greatly reduce the growth of young shoots. Later in the season, infested foliage takes on a bronze tinge **(Fig. D)**. Mite-induced damage affects foliar growth of the vine and fruit maturity. These negative effects are greatly exacerbated during periods of moisture stress (drought).

May be confused with

Two-spotted spider mites or certain predatory mites.

Biology and life cycle

The European red mite is a pest of many fruit tree species as well as grapevines. In the spring, the eggs hatch around stage **C 05**. Hatching occurs during the bud swell period when the average temperature is close to 15°C. The eggs may hatch over a longer period if temperatures remain below normal. During severe infestations, adult mites may disperse by spinning a silk thread that is caught by the wind. Beginning in stage **M 35**, the females of the last generation deposit fertilized winter eggs in crevices or under the bark of vines. These eggs hatch the following spring.

Under optimal conditions, at average temperatures of 23 to 25°C and about 60% relative humidity, the complete European red mite life cycle is about 10 days. The females in each generation lay their eggs chiefly on the underside of foliage. Population development is fast and conducive to overlapping of generations throughout the summer. During that period, all stages of development from egg to adult are present. Depending on the weather conditions, five to eight overlapping generations may be present during the season.

Critical period of activity and events

Although rare, if a very severe infestation occurred during the previous fall, significant damage may be observed as early as stage **D 06**. Generally, the critical period of infestation begins in stage **J 27** and maximal damage threshold is reached in stage **K 31**.

Scouting

Scouting for European red mites requires the use of a 10X hand lens. In blocks where damage was severe the previous season, look for overwintered mite eggs on canes and spurs starting at stage **A 01**. The first eggs hatch at stage **D 06**.The immature stages and adults can be observed on the lower and upper surfaces of the foliage. Beginning in stage **C 05**, walk the block and look for signs of browning or bronzing of leaves. Detect European red mites on these leaves. To determine whether intervention is necessary, choose 100 leaves at random and count the mobile stages (immature or adults) on them. Since the number of mites can increase exponentially during hot weather, the vines should be checked frequently by examining damage in the basal or apical half of 100 shoots and where the actives are located.

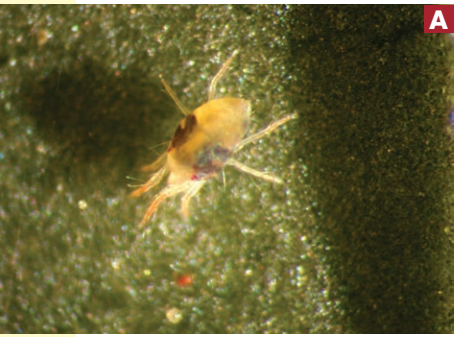
Management

It is crucial to protect populations of predatory mites in the vineyard by using pesticides that are not toxic to them. Predatory mites can be introduced into a vineyard where they are not present (recipient vineyard) by bringing in wood pruned in the spring from a vineyard where predatory mites are present (donor vineyard). During the dormancy period, collect freshly pruned wood from vines in the donor vineyard, and tie the prunings into small bundles. On the same day, distribute the bundles among the vines in the recipient vineyard. In stage **C 05** the predatory mites of the family Phytoseiidae (*Typhlodromus* spp., *Amblyseius* sp.) present on the pruned wood will leave the bundles and colonize the vines in the target vineyard.

Predatory mites of the family Anystidae (*Anystis* sp.) can be transferred as follows: mites can be collected from a donor vineyard beginning in stage **H 17** by holding a net under an inflorescence or the foliage and tapping it three times to dislodge *Anystis* sp. mites (for identification, refer to the section **Natural enemies** - Anystidae). Keep the specimens that are captured and transfer them on the same day to the recipient vineyard by dispersing them on grapevine foliage. The last generation lay their winter eggs on the wood near the buds.

Two-spotted spider mite

Order Acari
Family Tetranychidae
Scientific name *Tetranychus urticae*



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Description

Adult: The two-spotted spider mite is oval with two dark blotches visible through its transparent body wall **(Fig. A)**. The colour of summer adults varies from yellow to green, while that of overwintering females varies from red to orange. Depending on the environment and its diet, the adult may also be orange-red or greenish- yellow. The adult has 12 pairs of dorsal setae (fine hairs). The female is elliptical and about 0.4 to 0.5 mm long. The male has a tapering caudal end and measures about 0.3 mm long.

Egg: The egg is translucent when laid, smooth and less than 0.1 mm in diameter. It turns whitish **(Fig. B)** and then yellowish before hatching.

Larva: The three immature stages are the larva (L1), the protonymph (PN2) and the deutonymph (DN3). The newly hatched larva (L1) has three pairs of legs. (PN2) and (DN3) have four pairs of legs and are morphologically similar to, but smaller than, the adult. During the quiescent or resting period between each stage, the immature mite takes on a silvery hue before freeing itself from its exuvium.

Damage

In general, two-spotted spider mites do not attack grapevines. They preferentially feed on herbaceous plants at ground level. However, when ground cover vegetation is damaged during the summer or during periods of drought in July and August, populations of two-spotted spider mites may invade grapevines and cause significant damage. The damage is similar to that caused by the European red mite.

May be confused with

Other phytophagous mites or predatory mites.

Biology and life cycle

This phytophagous mite species attacks some 200 wild and cultivated plant species. Fertilized females leave their overwintering sites and migrate to herbaceous plants or bark crevices in host vines. After a short period of feeding, they lay about 100 eggs, at a rate of about 10 per day. All motile stages of the two-spotted spider mite spin silk webs on foliage, which retain moisture and provide protection. Development of this mite is optimal at temperatures between 23 and 30°C with relative humidity lower than 50%. Larval development takes about 15 days at an average temperature of 20°C, and about 7 days at an average temperature of 31°C. There are approximately six to eight generations per year. Two-spotted spider mite colonies can spread through contact between adjacent plants, dispersal over the ground or wind currents that transport their webs. At summer's end, fertilized females, which are orange, become predominant and overwinter in a variety of protected locations.

Critical period of activity and events

Two-spotted spider mites migrate to grapevine foliage when drought destroys ground cover vegetation or when excessive and repeated mowing is carried out during hot spells.

Scouting

Scouting for two-spotted spider mites requires the use of a 10X hand lens. The larval stage and the adult mite can be observed on both the upper and lower surfaces of leaves. Beginning in stage **K 31**, walk the block and look for signs of browning or bronzing of leaves. In severe infestations yellowing and webbing are observed. Look for mites on the foliage. To determine whether intervention is necessary, choose 100 leaves at random and count the mobile stages (larvae or adults) on them. Since the number of mites can increase exponentially during hot weather, the vines should be checked frequently by examining damage in the basal or apical half of 100 shoots and where the mobile stages are located.

Management

Predatory mites of the family Phytoseiidae are very effective natural enemies for the control of two-spotted spider mites. They are present on ground-cover plants and attack the eggs and mobile stages of the two-spotted spider mite. In addition, they lay their eggs in two-spotted spider mite colonies, allowing future generations to prey directly on the two-spotted spider mites. It is crucial to protect populations of predatory mites that are present in the vineyard by using pesticides that are not toxic to them. Predatory mites can be introduced into a vineyard where they are not present (recipient vineyard) by bringing in wood pruned in the spring from a vineyard (or other hosts like apple trees) where predatory mites are present. A simple technique can be used. Collect freshly pruned wood during the dormancy period from vines in the donor vineyard, tie the prunings into small bundles and distribute them among the vines in the recipient vineyard on the same day. In stage **C 05** the predatory mites of the family Phytoseiidae (*Typhlodromus* spp., *Amblyseius* sp.) that are present on the pruned wood will leave the bundles and colonize the vines in the target vineyard.

Order Coleoptera
Family Chrysomelidae
Scientific name *Altica chalybea, Altica woodsi*

Grape flea beetle, lesser grape flea beetle (syn. grape steely beetle)

Description

Adult: The grape flea beetle *(Altica chalybea)* **(Fig. A, B)** is oval-shaped, 5 mm long and shiny black with a metallic blue sheen. The lesser grape flea beetle (*Altica woodsi)* **(Fig. C, D)** is 4 mm long and shiny black with a metallic green sheen. Both species have antennae with 11 segments, and their antennae measure about half the length of the body. The body is more elongated in males than in females. Adults have large, powerful rear legs that allow them to jump.

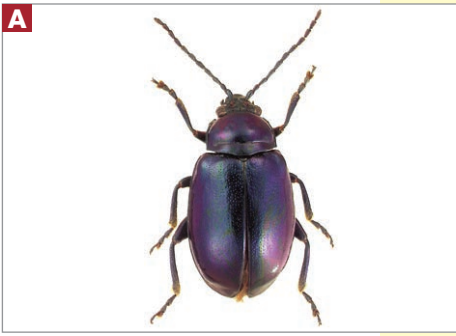
Egg: The eggs are pale yellow and cylindrical with rounded ends. They are 1 mm long and 0.4 mm wide and are laid under the leaves.

Larva: There are three larval stages. The (L1) is dark brown **(Fig. E)**. The young larva is covered with various-sized round or rectangular spots that become more pronounced as its body gradually becomes paler (L3). At maturity, the larva is 9 mm long.

Damage

Adults and larvae feed on a number of plants, including wild and cultivated grapevines. After emergence in the spring, the adult feeds on the buds from stages **B 03** to **E 09** **(Fig. F)**, causing severe economic damage as a result of the destruction of primary buds and developing inflorescences **(Fig. G)**. The risks of damage are heightened if the spring is cold and bud break is delayed. The damage is occasional and varies greatly from year to year. In Quebec

A



Bolte

B

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C

Bolte

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and the Atlantic provinces, the presence of flea beetles is due to migrations as a result of favourable weather conditions, namely, warm winds from the southwest before stage **B 03**. After hatching, which begins in stage **F 12**, the larva feeds on the tissue between the veins of leaves **(Fig. E)**. Over the summer, the adults do not cause any economic damage. Vineyard borders adjacent to woods or other protected areas are most affected.

May be confused with

The early damage in stages **B 03** to **E 09** may be confused with damage caused by climbing cutworm, which is nocturnal and can be found in the soil at the base of the vine, whereas the grape flea beetle can be seen in the daytime. The redheaded flea beetle appears only after stage **I 23**, is 6.5 mm long and has a red spot on its head.

Biology and life cycle

These flea beetles are native to North America and are present in Canada from the Atlantic to the Rockies. These insects have one generation per year. The adults overwinter on the ground, under plant debris. After emergence, which occurs from April to June, the adults feed on buds and young shoots. Soon after, the females lay their eggs near buds or on new canes. Both the females and the males die after egg laying. Larval development lasts three to four weeks. The larvae then fall to the ground, where they pupate. The adults emerge during the month of July.

Critical period of activity and events

The adults emerge in stage **B 03**. After stage **G 15**, flea beetles do not cause any economic damage.

Scouting

Scout for adults and larvae beginning in stage **B 03** until stage **G 15**. Adults can be easily seen with the naked eye and jump when they are disturbed.

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Pest management

In Ontario, remove plant debris from the outer borders of the vineyard. In Quebec and the Atlantic provinces, be on the lookout for flea beetle migrations associated with warm winds early in the spring.

Grape rootworm

Order Coleoptera
Family Chrysomelidae
Scientific name *Fidia viticida*

A

Laplante

B

Davies

Description

Adult: The upper surface of the adult's body (thorax and elytra) is chestnut brown and covered with fine greyish-brown hairs **(Fig. A)**. The legs and underside of the body are brown. The adult measures 8 to 10 mm long and 4 to 5 mm wide. Its antennae are approximately half the length of its body.

Egg: The eggs, which are oval and cream to yellowish in colour, measure 1 to 1.5 mm and are deposited in clusters of 20 to 100.

Larva: The larva is creamy white with a brown head **(Fig. B)**. There are five larval stages or instars (L1 to L5). The larva measures 2 to 7 mm long.

Pupa: The pupa is initially white and gradually turns brown over the course of the following 14 days.

Damage

The larvae cause damage to the roots. The adults damage the leaves and, during heavy infestations, the developing berries. When populations are high, the damage to the roots can slow the growth of the grapevine. Adult feeding damage is visible on the leaves but is usually of no consequence.

May be confused with

The larvae of different species of the family Chrysomelidae. The damage of adult grape rootworm on foliage looks like that caused by grape flea beetle larvae.

Biology and life cycle

The adults emerge from the soil from stage **F 12** to stage **J 27**. They feed on the foliage. Mating occurs 7 to 10 days after emergence from the soil. Egg-laying usually begins 3 to 7 days after mating, and the adult dies during the period (1 to 8 weeks) following egg-laying. However, egg-laying may continue until stage **M 35**. The eggs are deposited in clusters on the bark or underneath loose strips of bark. After hatching, the larvae burrow into the soil. The five larval stages (instars) develop by feeding on the rootlets throughout the season. The eggs that hatch later end their final larval stages the following season. However, most larvae form their pupae before the end of the fall. They overwinter in the soil. The teneral phase occurs several days before emergence the following spring.

Critical period of activity and events

The damage to the leaves caused by the adults occurs from stage **G 15** to stage **M 35**. The damage to the roots caused by larvae occurs from stage **J 27** to stage **O 43**.

Scouting

Scout for adults and damage caused by feeding from stage **J 27** to stage **M 35**. Scout for larvae on roots of vines exhibiting delayed growth or a significant decrease in yield. The larvae are present and can be observed on the roots from stage **G 15** to stage **O 43**.

Management

Grape rootworm is a minor pest. Although it causes little damage, monitoring is necessary in order to prevent population explosions. Because the roots are attacked, the damage is often not detected.

Red-headed flea beetle (syn. cranberry flea beetle)

Order Coleoptera
Family Chrysomelidae
Scientific name *Systena frontalis*

Bolte

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Description

Adult: Adults are shiny black with a reddish spot on the head **(Fig. A)**, and about 3.0 to 6.5 mm long. Their antennae are about half the length of their body. Their well-developed hind legs allow them to jump like fleas. The adults can also fly but not well.

Egg: The eggs are laid singly in the soil close to the surface. They are oval, pale yellow and about 0.9 mm long. In Eastern Canada, the eggs begin hatching in mid-May.

Larva: There are three larval instars. The larvae are creamy white with a brown head and about 5 (L1) to 10 mm (L3) long. Their body is covered with fine hairs and they have a tuft of hairs at the tip of the last abdominal segment.

Damage

The larvae feed on the roots of many weed species and many cultivated plants, including corn. Adults feed on new vine shoots, primarily on the upper surface and edges of leaves. This feeding damage generally does not affect mature vines or berries. The red-headed flea beetle can cause severe damage in young vine plantings **(Fig. B)**.

May be confused with

The adult stage of the potato flea beetle (*Epitrix cucumeris*) and the crucifer flea beetle (*Phyllotreta cruciferae*).

Biology and life cycle

In spring, the larvae are present in the soil and feed on the roots of weeds and a number of cultivated plants. In Eastern Canada, the adults begin emerging in stage **I 23**. They feed on the foliage of a number of plant species, including grapevines. Egg-laying takes place in August and September. There are one to two generations per year in Eastern Canada, depending on the weather conditions and the region concerned.

Critical period of activity and events

Adult populations generally peak between early July and early September. New vine plantings are at risk of severe damage from the red-headed flea beetle, from stage **J 27** to **N 38.**

Scouting

It is important to scout new plantings once a week when the first adult red-headed flea beetles **(Fig. C)** emerge.

Management

After scouting in young (1- and 2-year-old) plantings, take action according to provincial guides as necessary.

Multicoloured Asian lady beetle (syn. Asian lady beetle, halloween lady beetle, japanese lady beetle)

Order Coleoptera
Family Coccinellidae
Scientific name *Harmonia axyridis*

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Description

Adult: Adults are 6 to 10 mm long. There are many (ca. 200) variations in colour patterns of their elytra, from pale yellow to deep red with 1 to 19 black spots. More rarely, the adult may be black with red spots. There is a series of characteristic black spots on the back of the head (pronotum) forming an M **(Fig. A)**. The adult's general appearance is similar to that of most lady beetles.

Egg: The egg is oval, dark yellow and measures about 1.2 mm long. Eggs are laid in clusters of 20 to 30, generally on the underside of a leaf **(Fig. B)**.

Larva: The larva is about 1.5 to 11 mm long. There are four larval stages. Each stage has the following characteristics: (L1) is black **(Fig. C)**; (L2) is black with orange spots **(Fig. D)** on the first or second dorsal segment; (L3) has orange spots on five dorsal segments; (L4) has five dorsal segments with two spiny orange projections on the fourth and fifth dorsal segments **(Fig. E)**.

Pupae: The pupa has a dome shape, ranges in colour from yellow to orange, and is usually found attached to a leaf **(Fig. F)**.

Damage

Adults present in grape clusters at stage **N 38** are of concern. If present in large numbers (i.e., 1 beetle/cluster) during harvest and fruit processing, they may respond to perceived attack by releasing a chemical that can taint the grape must. Tainting caused by the presence of crushed lady beetles is perceptible when there are more than 1.2 adults per litre of grape must **(Fig. G)**. Adult 7-spotted ladybeetle also causes "ladybug taint". Adults do not cause damage to berries but rather are attracted to fruit that is already damaged.

May be confused with

Adults may be confused with most lady beetles. The larvae have an overall shape similar to that of lacewings, which are by contrast tan with brown markings.

Biology and life cycle

The adult is present in stage **B 03**. At a temperature of 26°C, eggs hatch in 3 days and the four larval stages are completed in 10 to 12 days. Pupation lasts for 4 to 5 days. The adult can live as long as 3 years. The female can produce more than 1000 eggs during her lifetime. This lady beetle is a predator of arthropods such as mites and insects.

Critical period of activity and events

Presence of adults in clusters at stage **N 38**.

Scouting

Carry out visual monitoring during stage **M 35**, examining 100 grape clusters at random per block of 4 ha**.** Look for multi-coloured Asian lady beetle adults in the clusters. Adults may be found inside the grape clusters when it gets colder.

D

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E

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F

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Brewster, Ker

Management

In small vineyards, when grapes are harvested manually, the beetles present in grape clusters can be removed by hand and thus prevent lady bug taint. In large vineyards, the beetles can be shaken off from harvested grapes on a shaker table in the winery. Management options can be found in provincial guidelines.

Order Coleoptera
Family Curculionidae
Scientific name *Ampeloglypter ampelopsis* (syn. *A. ater)*

Grape cane girdler

Description

Adult: This shiny black beetle is 3 mm long **(Fig. A)**. The grape cane girdler, like the grape cane gallmaker, has a characteristic curved snout.

Egg: The egg is 0.6 mm long **(Fig. B)**, elliptical and off-white.

Larva: There are three larval instars: larva (L1), immature (I2) and mature (M3). The larvae are white with a brown head and legless. (M3) is about 8 mm long **(Fig. C)**.

Pupa: The pupa is light coloured but becomes darker just before emergence. Like the adult, the pupal stage has legs and a snout.

Damage

The female girdles the cane by puncturing a series of holes in it. She lays her eggs in these holes, and the larvae (grubs) feed and develop within the cane. The oviposition injuries form a row that encircles the shoot. As of stage **H 17** the shoot breaks off at the girdled point and drops to the ground.

May be confused with

The grape cane gallmaker except that its oviposition scars form longitudinally along the shoot and a gall forms.

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Biology and life cycle

The adult overwinters in debris in wooded areas or within the vineyard. It emerges from its overwintering site at stage **E 09**. When the shoots reach a length of 25 to 50 cm, the female makes two series of punctures around the circumference of the shoot: one series is in the middle of the shoot between two nodes **(Fig. D)**, in which it deposits its eggs. The second series of punctures above the node weakens the shoot, which causes it to break off. Egg-laying continues for about one month. Larval development inside the shoot takes 30 to 45 days. The pupa forms when the top part of the shoot falls to the ground around stage **L 33**. The adult beetle emerges and moves to an overwintering site as **M 35**. There is one generation per year.

Critical period of activity and events

The earliest signs of damage caused by oviposition (the girdling of shoots and subsequent breakage) can be observed from stage **H 17** until the fall.

Scouting

When scouting in the vineyard, as of stage **G 15** look for canes that have girdling holes or have been broken off **(Fig. E)** by the wind. Cut the shoots longitudinally and check for larvae or excrement (frass). At stage **K 31** try to find shoots that have fallen to the ground and check for pupae inside them.

Management

Damage is frequently overlooked until the shoots break at the oviposition scars. Prune out and destroy infested shoots before stage **L 33** to prevent the emergence of adults. This approach helps to reduce girdler numbers and keep the population at an acceptable level. The grape cane girdler is generally a pest of low impact.

Order Coleoptera
Family Curculionidae
Scientific name *Ampeloglypter sesostris*

Grape cane gallmaker

Description

Adult: The adult is a dark brown beetle about 3 mm long. Like the grape cane girdler, it has a distinctive curved snout **(Fig. A)**.

Egg: The oval-shaped egg is yellowish-white and measures 0.6 mm long.

Larva: There are three larval stages: larva (L1), immature (I2) and mature (M3). The larva is yellowish white **(Fig. B)**, legless, and has a light brown head and dark mouthparts. (M3) is 10 mm long.

Damage

Females make a series of wounds along the longitudinal axis of shoots. The larva develops and feeds on tissues inside the shoot, causing it to swell (inducing gall formation). In red varieties, the galls turn red **(Fig. C)**.

May be confused with

The grape cane girdler, except that the oviposition punctures made by the grape cane gallmaker run longitudinally along the shoot rather than encircling it (girdler).

Biology and life cycle

The adult overwinters in debris in wooded areas. It emerges from its overwintering site around stage **E 09**. When the shoots are 25 to 50 cm long, the female chews a series of holes along the cane above a node. Only the first oviposition cavity contains an egg. Larval development within the gall is completed around stage **J 27**. The larva pupates

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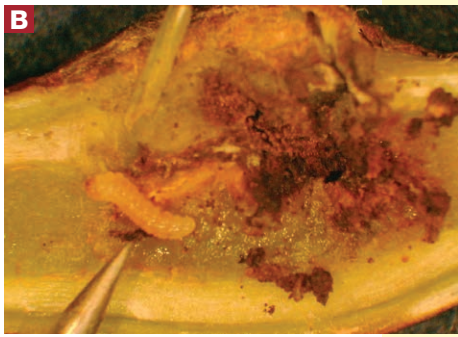

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McFadden-Smith (OMAFRA)

in the gall, and the adult emerges from it around stage **M 35**. It moves to an overwintering site beginning in stage **N 38**. There is one generation per year.

Critical period of activity and events

Oviposition injuries (i.e., holes in the shoots) can be observed from stage **H 17**.

Scouting

When scouting the vineyard, look for canes with holes and galls or wind breakage. Cut these shoots lengthwise and check for larvae, excrement (frass) and pupae.

Management

Prune out and destroy infested shoots before stage **L 33**, to prevent the emergence of adults. This approach helps to reduce gallmaker numbers and keep the population at an acceptable level. The grape cane gallmaker is generally a pest of low impact.

Order Coleoptera
Family Curculionidae
Scientific name *Otiorhynchus sulcatus*

Black vine weevil (syn. vine weevil, cyclamen weevil)

Description

Adult: *Otiorhynchus sulcatus* are oval-shaped, black beetles **(Fig. A, B)** with a broad rostrum and measure 8-10 mm long. The rostrum has a distinct groove in the middle dorsally. The straight first antennal segment (scape) is as long as the rest of the antenna. The surface of the pronotum is covered by rounded tubercles, each of which has a curved, yellow hair. The elytra have scattered clusters of light-colored, narrow scales. All the femora, which are swollen near their apex, have a distinct tooth on the ventral side. Adults cannot fly.

Egg: The eggs are whitish when first laid and gradually become darker. They are spherical, 1 mm in diameter, and are typically laid into crevices on the plants or under the soil surface. This development stage usually lasts approximately 20 days.

Larva: The yellowish to pinkish-white larvae are crescent-shaped and their hardened head capsule is brown **(Fig. C)**. The larvae are legless, covered with fine hairs and have distinct transverse dorsal folds on their abdomen. At maturity, they are approximately 10 mm long and 4 mm wide.

Pupa: The yellowish-white pupa **(Fig. D)**, which can be found in a cell made in the soil, has a maximum length of 10 mm. The pronotum width can reach 2.6 mm.

Dixon

Dixon

Greb (USDA-ARS)

Reding, Anderson (USDA-ARS),

Damage

This polyphagous species attacks more than 150 species of plants. Early larval instars feed on small roots and can eventually tunnel in larger fleshy roots as they grow. The nocturnal adults can cause damage by feeding on the foliage, inflorescence, cluster rachis, buds and new shoots. Notching along the outer leaf margin is characteristic of adult feeding. The most important damage by this species in vineyards is caused by adult feeding on primary buds and new shoots. The black vine weevil, which originates from Europe, is considered an important pest in vineyards of western North America and has been documented in vineyards in eastern Canada.

May be confused with

Nine other species of *Otiorhynchus*, all originating from Europe, are known to occur in eastern Canada. The large size of adults of *Otiorhynchus sulcatus*, combined with the presence of tubercles on their pronotum and patches of light-colored scales on their elytra, will help separate this species from the others. The legless crescent-shaped larvae are difficult to identify and should preferably be reared to the adult stage to allow identification to the species level.

Biology and life cycle

This exotic species is known to occur all across Canada. First records of the black vine weevil in North America date back as far as the 1830s. These weevils typically have one generation per year. While overwintering takes place in the larval stage, adults can also survive winter by finding suitable shelter, for example in dwellings and old buildings. Six to seven larval instars have been documented. After pupating in a cell made in the soil, the adults emerge from **B 03** to **E 09** and feed for a few weeks before laying eggs from July **J 27** to **N 38**. Individuals that have overwintered in the adult stage can resume oviposition for a second season. The parthenogenetic females can usually lay up to 300 eggs in their lifetime.

Critical period of activity and events

Adults can occur throughout an entire growing season but can cause most damage when they feed on primary buds **B 03** and new shoots **E 09**.

Scouting

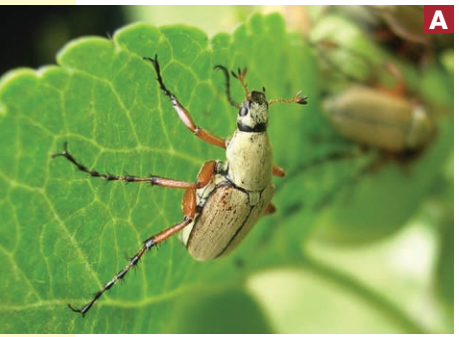
Since adults do not fly and are nocturnal, they are difficult to notice during daytime. Adults can be observed feeding during nighttime. Notching on the outer edge of leaves will confirm the presence of these beetles in a vineyard. Monitoring of adults can also be carried out with pitfall traps.

Pest management

Remove plant debris from the outer borders of the vineyard to reduce the number of hiding places for larvae and adults. Exclusion barriers or traps on the ground can be used to reduce the movement of the flightless adults.

Rose chafer

Order Coleoptera
Family Scarabaeidae
Scientific name *Macrodactylus subspinosus*



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Description

Adult: The adult, which measures about 12 mm long, is a straw-coloured beetle with a dark brown to black head. It has spiny black legs with an orange upper portion **(Fig. A)**.

Egg: The egg is oval, white and shiny, and about 1.3 mm long and 0.7 mm wide.

Larva: The larvae emerge 2 to 3 weeks after the eggs are laid. They are white with distinct legs and a brown head capsule. The larvae feed on roots of grasses and are about 20 mm long by the time they complete their development in the fall. They then overwinter in the soil, emerging from their winter diapause in the spring.

Damage

The adults feed on all parts of the vine. The most significant damage occurs on leaves of young vines **(Fig. B).**

May be confused with

The foliar damage may be confused with that caused by cutworms; however, cutworms are active at night and their damage occurs earlier in the season.

Biology and life cycle

The adults emerge from the soil around stage **G 15**. They are polyphagous; they feed on numerous plants including grapevines during a period of activity lasting 4 to 6 weeks. After mating, beginning at stage **I 23**, the female lays eggs singly in moist soil at a depth of about 5 to 8 cm. There is one generation per year.

Critical period of activity and events

The period when damage is most likely to be observed extends from stage **H 17** to stage **I 23**.

Scouting

The adults emerge about 10 days before flowering. Begin scouting for them in stage **G 15**. Walk through the blocks looking for damage to flower clusters and leaves. Aggregations of adults that gather to mate may be found on different parts of the vine.

Management

This is generally a minor pest in producing vineyards. Occasionally, it can cause significant damage to young vines.

Japanese beetle

Order Coleoptera
Family Scarabaeidae
Scientific name *Popillia japonica*

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Description

Adult: The adult beetle has a metallic green head and thorax with coppery brown elytra. There are two small white tufts just behind the elytra on the last abdominal segment and five tufts of white hair along each side of the abdomen. The antennae are clubbed at the end (three segments) **(Fig. A)**. The adult measures 15 mm long and 10 mm wide. The male and female can be differentiated by the tibial spur, which ends in a sharp point in the male and is more rounded in the female.

Egg: The newly laid egg is oval, white and about 1.5 mm long. Within a week, the egg absorbs water from the soil, doubles in volume and becomes almost spherical.

Larva: There are three larval instars (grubs). The first instar (L1) is whitish and translucent. (L2) measures 18.5 mm long, and (L3) measures 25 mm to 30 mm long. It has three pairs of legs located on the thoracic segments. The larvae are typical C-shaped grubs. With a 15X hand lens, the Japanese beetle grub can be identified from the inverted V shape arrangement of the hairs and spines on the underside of the last abdominal segment (different in other scarabs).

Damage

Damage is caused by the feeding activity of adults. Variable defoliation can be observed chiefly in the upper portion of the canopy **(Fig. B)**.

May be confused with

Japanese beetle adults are easy to detect on foliage. Therefore, their damage cannot be confused with that of other pests.

Biology and life cycle

The adults begin emerging from the soil in late June. They release pheromones that attract other adults. They mate **(Fig. C)** and the females lay their eggs over the following two months. A female lays about 60 eggs during her lifetime. At dusk, the female periodically burrows into the soil and deposits her eggs within about 5 to 8 cm of the soil surface. Around mid-September, after this intensive period of activity, the adults gradually die. The larvae grow rapidly, reaching maturity toward mid-October. In the spring, when soil temperatures reach 10°C, the larvae resume feeding. Beginning in stage **E 09**, the larvae transform into pupae. The adults emerge about 30 days later.

Critical period of activity and events

The adult beetles feed on leaf tissues from stage **J 27** to stage **N 38**.

Scouting

Look for adults and their injury. Adults are often clustered together on the leaves and they feed on the upper surface of leaves in full sun. When disturbed, they will drop to the ground.

Management

The damage caused by the Japanese beetle may be important in young plantings and on mature vines. Parasitoids (*Istocheta aldrichi*- Diptera: Tachinidae; *Tiphia vernalis*- Hymenoptera: Tiphiidae) of the Japanese beetle have been successfully introduced in the United States.

European earwig (syn. common earwig)

Order Dermaptera
Family Forficulidae
Scientific name *Forficula auricularia*

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Description

More than 20 species and subspecies of earwigs have been identified in the United States and Canada. We will discuss here the European earwig, which accounts for the majority of the specimens present in Eastern Canada **(Fig. A)**.

Adult: The adult ranges in colour from dark brown to reddish-brown with a paler ventral surface. It measures 13 to 20 mm long. Its antennae have 14 segments and are approximately 50% of the total body length. At the tip of its abdomen, the adult has two cerci (pincers), which measure 5 to 10 mm long. It has wings, but they are rarely used. The female's cerci are slender and slightly curved at the ends, while the male's cerci are strongly curved over their entire length.

Egg: The egg is whitish and elliptical and measures 1.1 mm long and 0.8 mm wide. After they are laid, the eggs absorb moisture and double in volume before hatching.

Nymph: There are four nymphal stages (instars) (N1 to N4). The nymph is similar to the adult. The cerci are present in all instars, and wing buds develop gradually in each instar. The nymphs are whitish in colour at instar N1 and gradually turn brownish-red by instar N4. The antennae of the N1 nymph have eight segments, while the antennae of the N2, N3 and N4 nymphs have 10, 11 and 12 segments, respectively.

Damage

Earwigs are omnivorous and can be considered as a predator or a minor pest. They cause little damage to grapes.

May be confused with

Its unique characteristics (cerci and colour) make it easily identifiable. This insect cannot be confused with other insects.

Biology and life cycle

The earwig is a cosmopolitan insect that was introduced into North America in the early 1900s. The adult overwinters and emerges in the spring at stage **B 03**. The female, fertilized in the fall, lays its eggs in clusters (30 to 60) in a tunnel approximately 5 cm deep in the soil. Sometimes, the female lays a second clutch of eggs in June beginning at stage **I 23**. The female protects the eggs and nymphs until instar (N2). Depending on the temperature, 65 to 90 days are needed for full development of the earwig, from egg-hatching to the adult stage. Adults of the new generation start emerging at stage **M 35**. There is one generation a year.

Critical period of activity and events

The (N3) and (N4) nymphs are autonomous and hunt at night to feed on arthropod eggs and larvae (or nymphs).

Scouting

Look for them in moist, shady areas such as the inside of grape clusters, under rocks, in cracks and crevices of wooden posts, etc.

Management

Earwigs cause little economic damage on fruit except in cases of heavy infestations. They can also feed on eggs, larvae and adults of many pests.

Grape tumid gallmaker (syn. grape tomato gall)

Order Diptera
Family Cecidomyiidae
Scientific name *Janetiella brevicauda*

McFadden-Smith (OMAFRA)

McFadden-Smith (OMAFRA)

McFadden-Smith (OMAFRA)

Description

Adult: Adults are about 2.5 mm long, dark brown to reddish, fragile flies with plume-like antennae. It is difficult to identify the adults because of the large number of similar gall midges in North America.

Egg: The egg is about 0.25 mm long.

Larva: The number of larval stages is not known. The last larval instar is 3 to 3.5 mm long, and red to orange in colour **(Fig. A)**.

Damage

Upon hatching (about 5 to 10 days after the eggs are laid, depending on the temperature) the larvae bore into green plant tissues where they develop. Larval feeding causes scarring which results in smooth round galls **(Fig. B,C)** ranging in colour from green to red. Fully developed galls on flower clusters (inflorescences) can result in a reduction in the size of fruit clusters or deformed clusters with few grapes.

May be confused with

The damage (galling) resembles that caused by the grape phylloxera or by other midges **(Fig. D,E,F)**. Phylloxera galls are rough and hairy, unlike the smooth, round, hairless galls produced by the grape tumid gallmaker.

Biology and life cycle

In the spring, the overwintering larvae emerge from the soil and continue their development to the adult stage. Adults (midges) live only about 24 to 48 hours. Females deposit their

eggs on shoots, leaves or inflorescences. Each female can lay as many as 200 eggs. When fully developed, the larva exits the gall and drops to the soil, where it pupates within 2.5 to 5 cm of the soil surface. The pupa is about 1.5 mm long and 0.8 mm wide. The grape tumid gallmaker has one to three generations per year, depending on weather conditions and the location of the vineyard.

Critical period of activity and events

Most adults emerge from the soil in the morning (7:00 am to 10:00 am) in the spring when the temperature is over 20°C. They lay their eggs within the next 2 days.

Scouting

Because adult midges live for a very short time and are very small, the grape tumid gallmaker is difficult to detect. The first signs of damage can be observed as of stage **F 12**.

Management

Wet soils promote the establishment of colonies and population growth. Vines growing in this type of environment are attacked relatively more often. In heavy infestations, the first generation can cause significant damage.

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Spotted wing drosophila

Order Diptera
Family Drosophilidae
Scientific name *Drosophila suzukii*

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Pfeiffer

Description

Adult: The adult is 2.6 to 3.4 mm long **(Fig. A)**. The female is larger than the male and has a saw-like ovipositor with thick black teeth extending over two thirds of its length **(Fig. B)**. The male has a distinct black spot along the first nerve near the tip of each wing.

Egg: The egg is translucent white, elongated and about 0.6 mm long and 0.18 mm wide. Eggs are laid under the skin of grapes. Each egg has a pair of filaments that protrude from the oviposition puncture.

Larva: There are three larval instars (L1-L3). L3 are 4 to 6 mm long and legless. They are white **(Fig. C)** and tapered at both ends. They have dark mouth hooks at the front end and a pair of tan caudal spiracles at the rear end.

Pupa: The pupa is brown, cylindrical and about 3 mm long. Pupae have two stalks with small finger-like projections on one end.

Damage

This drosophila species is unusual in that it may attack grapes prior to harvest. The female's serrated ovipositor enables it to lay its eggs in ripening grapes. The larvae hatch and feed inside the fruits, causing the tissues to collapse **(Fig. D)** around the feeding site. When the damage is severe, the fruit flesh is degraded and oxidized. The oviposition injury becomes an entry site for pathogens that cause Botrytis fruit rot or sour rot.

May be confused with

Other *Drosophila* species.

Pfeiffer

Biology and life cycle

In the spring, the adults emerge from their overwintering site when the temperature reaches 10°C. *D. suzukii* has a very short life cycle allowing it to complete multiple generations each year. On average, a female lays more than 350 eggs during her lifetime, at a rate of 7 to 16 eggs per day. The eggs hatch in 1 to 3 days, and the larvae mature in 3 to 13 days. Pupation lasts for 3 to 15 days, either inside or outside the fruit. The adult fly then emerges from its pupa. The adult life span is 3 to 9 weeks. This insect has a wide host range, including cultivated berries, soft fruit and wild hosts.

Critical period of activity and events

The first spotted wing drosophila flies arrive in vineyards beginning in stage **M 35**.

Scouting

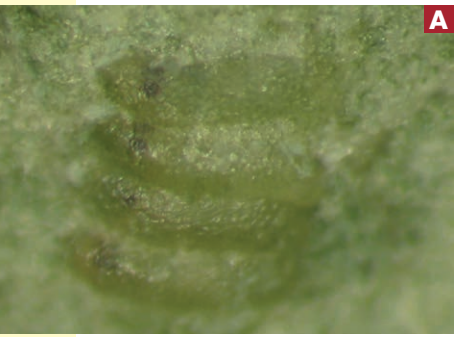
Monitoring of adults is carried out with traps. The males that are captured can be identified using a 10X hand lens. However, the females must be identified under a binocular microscope (50 to 100X). The traps should be installed as of stage **L 33**.

Management

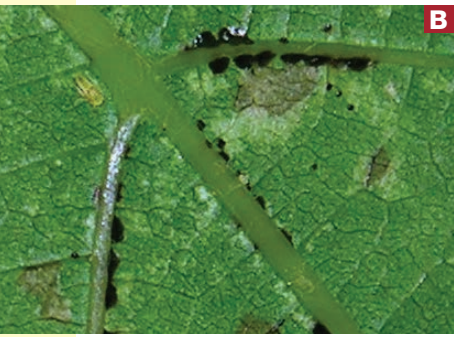
While little damage has been reported in vineyards to date, the situation could change in the future.

Leafhoppers

Order Hemiptera
Family Cicadellidae
Scientific name Several species, see **Table 1**



Saguez



Saguez

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Description

Some 110 species of leafhoppers have been found in Canadian vineyards. Twenty-five of the most abundant leafhopper species have been identified in vineyards in Eastern Canada. Those leafhoppers use grapevine as a primary or alternative host.

Adult: The adults are 2.5 to 5 mm long on average and vary in colour depending on the species. Adults mate 7 to 10 days after emerging. Adult colouration evolves from little to full colouration patterns in a few hours. Adults typically live for about a month.

Egg: Depending on the species, the eggs, which are about 0.5 to 1 mm long, are deposited on various leaf structures. They vary in shape and their colouration ranges from light green to dark brown. In some cases, they are translucent **(Fig. A, B)**. Depending on the species, eggs are laid in clusters, deposited singly along the veins or laid singly under the epidermis.

Nymph: Embryonic development within the egg lasts 10 to 15 days. Newly hatched nymphs (N1) measure about 1 mm and are very vulnerable to desiccation and natural enemies. There are five nymphal stages (N1 to N5) which last 21 days on average. The cast skins (exuviae) may be visible on the underside of leaves. Wing pads increase in size between each nymphal stage, and the antennae become smaller.

Damage

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Leafhoppers are piercing-sucking insects and their damage may vary. Some species feed on the xylem (crude xylem sap), some on the phloem (elaborated plant sap) and some on the mesophyll (chlorophyll-containing parenchyma). The feeding activity of species in the genus *Erythroneura* spp. causes white stippling on the leaves **(Fig. C)**. This is due to depigmentation of the leaves associated with the removal of chlorophyll from leaf cells as the insect feeds. Early in the season, punctures generally appear on the lower leaves of the vine in the fruiting zone. Later in the season the leaves gradually become discoloured in heavy infestations and damage progresses apically on the shoots. Potato leafhopper feeding cause leaf chlorosis, and leaf margins turn yellow **(Fig. D)** and curl downwards.

Leafhoppers feed on the sap they suck from the leaves and young shoots of grapevines. While feeding, the insect injects saliva containing compounds that block the plant's vascular system, reducing its vigour and growth. Major infestations cause leaves to brown and drop.

In addition, some of these leafhoppers act as vectors of various diseases. While feeding, leafhoppers can acquire and transmit phytoplasmas present in plant vascular tissues. Phytoplasmas can cause grapevine yellows.

May be confused with

Leafhoppers are sometimes confused with certain aphid species. In the case of the potato leafhopper (*Empoasca fabae*), the symptoms of feeding damage may be confused with those caused by a lack of water, manganese deficiency, herbicide injury or leafroll virus.

Biology and life cycle

The adults emerge in the spring at around stage **E 09** and feed on the foliage of cultivated or wild grapes. During summer, the generations overlap with both nymphs and adults being present until after the harvest. Leafhopper development takes a variable amount of time depending largely on environmental conditions. Leafhoppers can have two or three generations per year, depending on the species, and can overwinter in various forms. *Scaphoideus titanus* deposits its eggs in the bark of shoots and canes. Some *Erythroneura* species overwinter as adults under leaf debris.

Some species do not overwinter in Canada and migrate every year. For example, *Empoasca fabae* **(Fig. E)** is transported to Canada on wind currents from the northern United States in early June. This pest feeds on more than 200 plant species.

Critical period of activity and events

Leafhoppers are found starting stage **E 09.** They reach their maximum density as of stage **L 33**. In Eastern Canada windborne migration of *E. fabae* begins in early June (after the first cut of hay in Ontario) depending on warm winds from the southwest.

Scouting

Leafhopper adults and nymphs can be identified and counted through visual monitoring. With experience or using a hand lens, they can be detected from stage **H 17** to stage **M 35**. Walk in the block and examine the undersides of 100 leaves at random in the canopy. The observation of eggs can provide an idea of the size of future populations. Leafhoppers are generally found on the undersides of leaves. Drought accentuates the damage caused by leafhoppers, whereas heavy rainfall reduces the incidence of damage.

Management

The diversity and relative abundance of leafhopper species will vary according to several factors: grapevine variety, the history of leafhopper populations present the previous year and, for some species, the intensity of migrations. Cool weather with temperatures below normal seasonal values and periods of heavy rain help to reduce the numbers of leafhoppers that are native to vineyards. Flowering cover crops in row middles of the vineyard can encourage the presence and establishment of natural enemies. Populations of the predatory mite *Anystis* sp. and parasitoids (e.g., *Anagrus* spp.) promotes natural suppression of leafhopper populations in the vineyard.

About 110 cicadellid species have been found in vineyards of Canada (Saguez et al. 2014). Below is a list of 25 important species that are most abundant (**Table 1**). However, few are of economic importance (**Plate 1**).

Table 1 – 25 Most Abundant Leafhopper Species in the Vineyards of Eastern Canada. (Saguez et al. 2015).
Letters in parentheses correspond to the images in Plate 1.

Species	(Fig.)	ON	QC	NB	NS	PEI
Empoasca fabae	(E, F)	X	X	X	X	X
Erythroneura bistrata		X				
Erythroneura coloradensis		X				
Erythroneura comes	(M, N)	X	X			
Erythroneura elegantula		X	X			
Erythroneura nigra		X	X			
Erythroneura tricincta	(G, H)	X	X			
Erythroneura vitifex		X	X			
Erythroneura vitis	(K, L)	X	X			
Erythroneura vulnerata	(O, P)	X	X			
Erythroneura ziczac	(I, J)	X	X	X		
Fieberiella florii		X				
Macrosteles fascifrons		X	X	X	X	
Macrosteles quadrilineatus	(Q, R)	X	X	X	X	X
Neokolla hieroglyphica		X	X	X	X	X
Norvellina chenopodii		X	X			
Scaphoideus carinatus		X	X	X	X	
Scaphoideus cinerosus		X	X			
Scaphoideus cylindratus		X	X		X	X
Scaphoideus major		X	X			
Scaphoideus melanotus		X	X			
Scaphoideus opalinus		X	X			
Scaphoideus titanus		X	X		X	
Scaphytopius acutus		X	X	X	X	X
Xestocephalus superbus		X	X	X	X	

Plate 1 – Leafhopper nymphs and adults

ADULT ↓ NYMPH ↓

Potato leafhopper - Saguez

Three-banded leafhopper - Saguez

Virginia creeper leafhopper - Saguez

Grapevine leafhopper - Saguez

Eastern grape leafhopper - Lasnier © Ag-Cord Inc.

Wounded leafhopper - Saguez

Aster leafhopper - Saguez

European fruit lecanium scale (syn. brown apricot scale)

Order Hemiptera
Family Coccidae
Scientific name *Parthenolecanium corni*

McFadden-Smith (OMAFRA)

McFadden-Smith (OMAFRA)

McFadden-Smith (OMAFRA)

Description

Adult: The female has a shiny protective scale (shell) and starts out tan in colour and gradually becomes darker brown **(Fig. A, B)**. It is 0.4 to 0.6 mm long and 0.4 mm in diameter. The female reproduces with or without mating (parthenogenesis). Winged males are rarely observed.

Egg: The egg is oval, white and about 0.3 mm long. Eggs are laid in clusters and remain beneath the female's protective scale.

Nymph: The eggs hatch under the female's scale. The emerging immature is about 0.4 mm long, flat, oval and may range in colour from greenish to orange or tan. The immatures go through two moults (I1 and I2).

Damage

The main concern is transmission of viruses, notably grapevine leafroll-associated virus. This pest can reduce the growth and vigour of grapevines. In Eastern Canada foliar damage is rarely observed. Fruit covered with honeydew (excretions) may be downgraded in quality by the presence of sooty mould.

May be confused with

Other scale species.

Biology and life cycle

After overwintering in the crevices or loose bark strips, the immature nymphs (I2) resume activity in stage **C 05**. Some females mate with males, producing both male and female individuals. The majority of females do not mate and produce only females. Over the following weeks, they develop a protective scale. Afterwards, they remain attached in the same spot and their legs atrophy. The female lays 2,000 eggs on average over a period of 1 month. The duration of incubation is 15 to 30 days, such that new immatures are present starting stage **G 15**. Around stage **J 27**, the female dies after egg laying and her scale protects the eggs during their embryonic development. The first instars (I1) then move to the surface of the canes and may be transported by the wind. They attach themselves to the underside of leaves primarily along the veins. The first nymphal moult takes place at stage **M 35**. The nymphs (I2) migrate to crevices in the canes and move under grapevine bark fragments to overwinter. There is one generation per year. Ants feed on the honeydew produced by scales and are often associated with scale infestations.

Critical period of activity and events

Infestations can appear at stage **E 09** and are observed until harvest **N 38**. All parts of the vine may be colonized.

Scouting

When conducting visual monitoring during dormancy, spot the (I2) instars beneath grapevine bark. Starting at stage **G 15,** look for scales that are attached to shoots. Subsequently, in stage **K 31**, the (I1) are difficult to detect with the naked eye on grapevine foliage. In stage **N 38** the instars (I1 and I2) can be found on the canes and under the bark.

Management

Few studies have been carried out on parasitism of scale insects that are pests of grape **(Fig. C** – parasitized adult**)**. European fruit lecanium scale is preyed upon by generalist predators such as predatory mites (Anystidae, Trombidiidae and Erythraeidae), predatory bugs, spiders and coccinellids.

Cottony maple scale

Order Hemiptera
Family Coccidae
Scientific name *Pulvinaria innumerabilis* (syn. *Neopulvinaria innumerabilis*)

McFadden-Smith (OMAFRA)

McFadden-Smith (OMAFRA)

Description

Adult: The adult female has an oval, slightly convex shell (carapace) that ranges in colour from reddish to brown with black mottling. At maturity, with its egg mass **(Fig. A)**, it measures 4 to 6 mm long. The males are winged and shell-less. Only the mature male is winged.

Egg: The egg, which is oval and white and measures 0.3 mm long. Eggs are laid in clusters (>1000) in a white cottony ovisac which is attached to the female's shell.

Nymph: There are two nymphal stages. On emergence from the ovisac, the (N1) nymph measures 0.4 mm long; it is oval, flat and light brown. The (N2) nymph measures approximately 4 mm long.

Damage

Reduces the growth and vigour of grapevines. During heavy infestations, the leaves are affected. Some scale species vector the viruses that cause grapevine leafroll disease.

May be confused with

Pulvinaria acericola, which deposits its ovisac and eggs under leaves. *Pulvinaria innumerabilis* deposits its ovisac and eggs on stems **(Fig. B)**.

Biology and life cycle

This species is one of the largest scale insects indigenous to North America. The fertilized, immature female overwinters under loose bark. Beginning at stage **B 03**, the female produces wax in order to quickly enlarge its shell and complete its development. At around stage **E 09**, attached to a shoot, it begins to lay its eggs (>1000) in a white cottony ovisac. At around stage **I 23**, the eggs begin to hatch and the immatures (N1) emerge from the ovisac and move toward the undersides of the leaves. The nymphs then become sedentary and feed on sap on the veins of the undersides and upper surfaces of the leaves until stage **M 35**. Mating begins in late summer. The winged males die in the days following mating. Just before leaf fall, the females move from the leaves to overwinter on the canes or trunks. There is one generation a year. Ants feed on the honeydew produced by scales and are often associated with scale infestations.

Critical period of activity and events

Infestations can occur beginning at stage **E 09** and last until harvest, **N 38**. Cottony maple scale colonizes all parts of the grapevine at different stages.

Scouting

Beginning at stage **B 03**, look for the cottony shells of the immatures on the canes and trunks. Carry out scouting during the growing season beginning at stage **I 23**; locate the immature larvae attached to the undersides and upper surfaces of the leaves. At stage **O 43**, locate the shells of immatures overwintering on the canes and trunks.

Management

This insect is of minor importance in Eastern Canada. However, bio-vigilance is necessary in view of the northward expansion of its range in recent years and its ability to vector grapevine leafroll-associated virus. Few studies have been conducted on the parasitism of scale insects. Scale insects are preyed upon by generalist predators and parasitoids.

Tarnished plant bug

Order Hemiptera
Family Miridae
Scientific name *Lygus lineolaris*

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Description

Adult: The adult tarnished plant bug is brown with a cream-coloured to white triangle on the back **(Fig. A)**. It is about 6 mm long. When disturbed, it hides or flees quickly.

Egg: The egg is cylindrical, greenish and measures 1.7 mm long and 0.5 mm wide.

Nymph: There are five nymphal stages measuring from 1 mm (N1) to 5 mm (N5) long. The first instar (N1) is yellowish-green and has a triangular head. The antennae of the nymphs have alternating brown and light brown bands. The third instar (N3) has a black spot on its back **(Fig. B)**. Five black spots are visible on the back of the fourth instar (N4). Wing pads are visible on the fifth instar (N5). The larvae move rapidly.

Damage

The tarnished plant bug is a piercing-sucking insect that can go through its full life cycle on vines. The foliar damage caused by adults and nymphs throughout the season is of low economic impact. However, the nymphs (N1 to N5) may pierce the pedicels of berries after stage **J 27**, causing economic damage if no insecticide has been applied at this stage.

May be confused with

The first nymphal instars (N1 to N3) of the tarnished plant bug may be confused with green aphids. Tarnished plant bug nymphs are very mobile and move faster than aphids, which have cornicles near the tip of their abdomen.

Biology and life cycle

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The tarnished plant bug has three to five generations in Eastern Canada. It overwinters as an adult in plant debris. With the regrowth of vegetation in the spring, the adults emerge when temperatures reach about 8°C. After mating, the females lay their eggs on the flower stalks **(Fig. C)** and buds of a multitude of host plants (more than 300 in North America). Depending on the average temperature, hatching occurs 1 to 2 weeks after egg laying, and the nymphal stages last about 15 to 30 days. The nymphs and adults puncture and feed on leaves, flower buds, shoots, meristem tissues and grapes, with all the generations overlapping during the season. In the fall, the adults migrate to soil debris where they overwinter.

Critical period of activity and events

The nymphs that hatch from eggs laid on the flower stalks in stages **F 12** and **G 15** **(Fig. D)** feed in the nectaries (nectar-secreting structures) located on a disc at the base of the flower; this feeding does not cause damage. However, as of stage **J 27**, the nymphs that are present puncture the pedicels, which can cause berries to drop.

Scouting

The nymphs can be identified and counted through visual monitoring. They can be detected from stage **F 12** to stage **K 31**. Walk the block and examine 100 inflorescences at random. Hold a white plastic container (about 500 mL) under the inflorescence and tap it three times with your hand to dislodge any nymphs that may be present. They can easily be observed in the container.

Management

The tarnished plant bug is present in many crops in Eastern Canada. Interventions carried out prior to stage **K 31** to control other vineyard pests are generally effective for the suppression of nymphs and adults. Herbaceous plants and flower beds along the perimeter of and inside the vineyard attract adult tarnished plant bugs, thereby reducing egg laying on grape flower stalks.

Brown marmorated stink bug

Order Hemiptera
Family Pentatomidae
Scientific name *Halyomorpha halys*

Pfeiffer

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Description

Adult: The female measures about 16 mm long and 9 mm wide, and the male about 14 mm long and 7.5 mm wide. The adult is brown with tan or white mottling. Its abdominal edges have alternating white and black triangular-shaped spots. The hind wings have a pinkish tinge. The legs have white bands. On the edge of its smooth shoulders, a spine is visible near each eye. Its antennae are distinctive in that there are two white bands on the second segment: one at the apical end and one at the base. The last segment is white at the base only **(Fig. A)**.

Egg: The egg is barrel-shaped **(Fig. B)** and approximately 1.6 mm long and 1.2 mm wide. Eggs are laid in clusters of about 25 on the undersides of leaves and are initially pale green but subsequently turn yellow with red eye spots before hatching.

Nymph: There are five nymphal instars. (N1) **(Fig. C)** is 2.4 mm long, has a black head and legs; its abdomen is orange with dark markings. Its eyes do not extend beyond the surface of the head. (N2) is about 3.7 mm long, dark coloured with a yellowish abdomen and a white band on its antennae. Its eyes are spherical and extend beyond the surface of the head. (N3) **(Fig. D)** is about 5.5 mm long, and dark in colour with a white band on each tibia. (N4) measures approximately 8 mm long and has features similar to the adult. The anterior wing pads are visible. (N5) **(Fig. E)** is about 12 mm long and its hind wing pads are visible.

Damage

Damage is caused by the insect's feeding, by the odour and the disagreeable off-flavour associated with the repulsive liquid it releases. The brown marmorated stink bug inserts its piercing-sucking mouthparts into buds, stems, leaves and fruits on the vine. Digestive enzymes released into the plant result in the formation of necrotic areas at the feeding site. Its feeding activity can cause the following symptoms: destruction of buds, abscission of flower stalks, leaf stippling, missing or stained grapes, delayed ripening and sap flow on canes. During grape pressing, the brown marmorated stink bug excretes a noxious chemical that can contaminate and give an unacceptable off-flavour (i.e., brown marmorated stink bug taint) to the must. This is currently the most problematic issue.

McFadden-Smith (OMAFRA)

Pfeiffer

May be confused with

Rough stink bug (*Brochymena* spp.) and brown stink bug (*Euschistus* spp.). However, both rough and brown stink bugs lack the two white bands on the antennae and have toothed edges on the shoulders (pronotum). Eggs and nymphs of beneficial stink bugs may also be mistaken for brown marmorated stink bug.

Biology and life cycle

There is one generation per year. The adult emerges from its overwintering site around mid-May. It feeds on a wide variety of cultivated or wild plants. The adults mate about 15 days after emergence. The female lays eggs from mid-June to early August. Development from the egg to the adult stage takes about 50 days. Egg laying is spread over such a long period that all stages (N1 to N5 and the adult) are present simultaneously during the summer season. From mid-August to mid-October, the adults move to overwintering sites. Aggregation pheromones emitted by the males bring together large numbers of these insects at overwintering sites.

Critical period of activity and events

The adults are present from mid-May to early October, and the nymphs from late-June to late September. Both nymphs and adults can cause damage.

Scouting Scout for adults from stage **C 05** to stage **N 38**. Check for egg masses or nymphs on the undersides of leaves as of stage **H 17**.

Management

This pest has been found in vineyards in Eastern Canada; however, there is no documentation of injury as of yet.

Order Hemiptera
Family Phylloxeridae
Scientific name *Daktulosphaira vitifoliae*

Grape phylloxera

Description

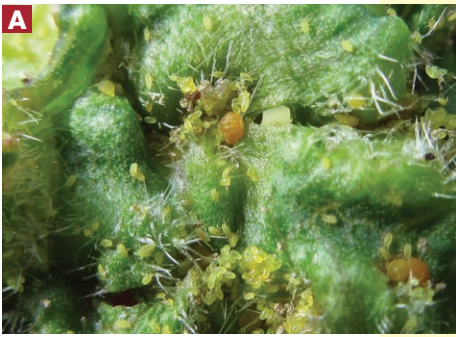
Adult: There are three types of adults: apterous (wingless) females **(Fig. A)**, apterous males and winged females. Females found in leaf galls or on roots are wingless, oval, 0.7 to 1 mm long and 0.5 mm wide. Young adults present in galls are pale yellow to orange, becoming golden brown with maturity. Radicola females, present on the roots, are pale green, light brown or orange **(Fig. B)**. The winged adult females, which leave the roots and migrate to the foliage in late summer and early fall, are orange with a gray-black head and thorax and two pairs of lightly veined wings.

Egg: The newly deposited eggs are oval, bright yellow and about 0.4 mm long **(Fig. C)** and 0.2 mm wide. Prior to hatching, the eggs turn dark yellow and have two red eye spots at one end.

Nymph: Emerging nymphs are similar in size to the eggs. They go through four developmental stages before reaching maturity.

Damage

Two types of damage can be observed: gall formation on leaves, and formation of nodosities and tuberosities (rounded protuberances) on roots. Gall formation results from the scarring of tissues due to puncture injuries and feeding by nymphs and adults on the leaves **(Fig. D, E)**. The foliar symptoms peak as of stage **K 31** on some varieties when galls occasionally invade the entire leaf blade **(Fig. F)**. In this case, galls compromise



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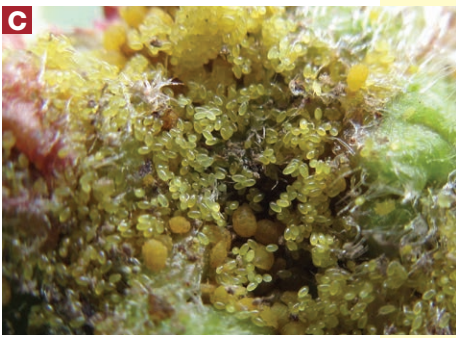

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the photosynthetic potential of affected leaves. Phylloxera have little impact on some hybrids and vinifera varieties grafted on resistant rootstocks. Nodosities result from phylloxera puncture injury on rootlet tips in susceptible rootstocks. Tuberosities form on roots larger than 5 cm. These types of damage impair the ability of vines to take up water and nutrients and allow the entry of root rot micro-organisms.

May be confused with

Foliar damage may be confused with that caused by grape erineum mite (p. 3) and grape tumid gallmaker (p. 34).

Biology and life cycle

The grape phylloxera has a complex life cycle. Two forms of the pest develop simultaneously on the vine. The gallicola form consists of wingless or winged individuals that develop on the foliage. The radicola form develops on the roots. There are five to seven generations per year. The female produces a new generation asexually (parthenogenesis). Each female that develops on the foliage lays up to 600 eggs that can be found inside galls. There are four nymphal stages. The cycle is repeated through several generations over the summer. Some nymphs emerge from galls during the summer, inducing the formation of new galls on foliage. Later, some nymphs migrate to the roots; these may be referred to as "radicola" nymphs.

The radicola females develop on the roots, where they lay fewer than 100 eggs. Their progeny are neogallicolae-radicicolae and produce nymphs, the majority of which will become adults. Some nymphs overwinter until the following spring. During the summer, some females undergo an additional moult and give rise to the winged phylloxera form which lays its eggs on the vine

foliage. They in turn produce winged males and females. These individuals live only a few days, during which they mate and lay a winter egg under the bark of grapevines. The overwintering egg gives rise to a female which induces the first galls on the foliage the following spring.

Critical period of activity and events

Females are present on the roots throughout the year. The first galls appear on the foliage in stage **E 09**. Subsequently, the formation of new galls on leaves continues until the first fall frost.

Scouting

Nymphs and first galls can be detected through visual monitoring. Begin the visual survey in stage **D 06**. Walk the block and examine 100 young leaves at random.

Management

If large populations were present during the previous season, interventions should be synchronized as soon as the first eggs are observed in the galls. Later in the season, all stages of the phylloxera (eggs, larvae and adults) are within the galls and beyond the reach of most insecticides. Establish beds of early blooming flowers in order to attract parasites (Braconidae, Ichneumonidae, Tachinidae) early in the season. These natural enemies can parasitize the grape phylloxera inside the galls throughout the season.

Grape mealybug

Order Hemiptera
Family Pseudococcidae
Scientific name *Pseudococcus maritimus*

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Description

Adult: The female, about 5 mm long, is apterous (wingless) and has a flat, oval body. It is pink to orange in colour and covered with a powdery wax. The adult female **(Fig. A)** has two long whitish setae at its extremity. The winged male **(Fig. B)** is brown to black and about 0.5 mm long, and is rarely observed.

Egg: The egg is oval and yellow to orange in colour. Eggs are deposited in masses surrounded by a cottony egg sac **(Fig. C)**.

Nymph: There are three nymphal instars (N1 to N3). The (N1) are orange and gradually become salmon (N3) **(Fig. D)** with a light waxy coating.

Damage

The primary concern is that mealybugs act as vectors of viruses that cause grapevine leafroll disease. They can reduce grapevine growth and vigour. Fruits covered with honeydew (excretions) and sooty mould **(Fig. E)** may be downgraded in quality.

May be confused with

The honeydew symptom can be mistaken for that produced by scale insects.

Biology and life cycle

Mealybugs attack a variety of plants, particularly fruit trees. They feed on the vascular tissues (phloem) of plants. They overwinter

as eggs within a cottony sac or as first instars (N1) in diapause. Beginning in stage **B 03**, the first instars (N1) emerge from diapause and feed on the base of buds. In stage **C 05**, the (N1) move to the new shoots and the newly developing leaves. Depending on the overwintering site (in the sun or more in the shade), emergence of first instars (N1) may extend over a longer period to stage **I 23**. The first generation of mature nymphs (N3) and adult females appear around stage **H 17**, and the males (rarely observed) mate with some of them. The female moves to a safe shelter and lays eggs, then dies in its egg mass. There are two generations per year. Over the growing season, mealybugs can colonize all parts of the grapevine **(Fig. F)**. They regularly colonize under the bark of vine trunks and heads. In stage **M 35**, the nymphal instars (N1 to N3) settle between the pedicel and the fruit. Ants feed on the honeydew produced by scales and are often associated with mealybug infestations.

Critical period of activity and events

Infestations may occur as early as stage **E 09** and may last until harvest **N 38**. Except the trunk, other parts of the grapevine are rarely colonized.

Scouting

The best time to carry out monitoring is when the vines are dormant. Gently peel the bark from grapevine trunks and look for egg masses enveloped in a cottony sac. First instars can be monitored using double-sided tape wrapped around the trunk of vines.

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Scouting during the growing season begins in stage **C 05**. Identify instars (N1 to N2) on the first buds warmed by the sun and observe their movements at the base of the buds. As of stage **J 27** and throughout the season, the females and the nymphs (N1 to N3) can be seen with the naked eye under the bark of the grapevine.

Management

Few studies have been carried out on parasitism of grape mealybugs; however, they are preyed on by generalist predators such as predatory mites (Anystidae, Trombidiidae, Erythraeidae), predatory bugs, spiders and ladybugs.

Wasps, Bees

Order Hymenoptera
Family Vespidae; Apidae
Scientific name *Vespula* spp. (syn. *Paravespula vulgaris*), *Dolichovespula* spp.; *Apis* spp.

Description

Adult: They are yellow with black bands **(Fig. A)** or black with white bands **(Fig. B)**. Black, yellow or white spots may be present. The different species are between 10 and 25 mm long. One distinguishing characteristic of wasps is the habit of folding their wings longitudinally over the body rather than the back when at rest

Egg: As several species are involved, no description is provided here.

Larva: As several species are involved, no description is provided here.

Damage

Adult feeding on the pulp and juice of ripe grapes can cause damage **(Fig. C, D)**. The adults use their mouthparts to pierce the skin of the grapes or they exploit existing injuries. The grapes are then emptied of their contents.

May be confused with

The damage caused by wasps and bees **(Fig. E)** can be confused with that caused by birds.

A

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B

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C

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Biology and life cycle

The family Vespidae (yellowjackets, paper wasps, hornets) includes several subfamilies of wasps and a multitude of species found in Eastern Canada. The eggs are generally laid in cells within a nest. Generally, the larvae that develop in the cells are fed by the adults.

Critical period of activity and events

Wasps and bees appear in vineyards beginning in stage **N 38**. The risk of damage increases as the grapes ripen.

Scouting

Monitoring is carried out when grapes are ripening on the vines in stage **N 38**. Wasps and bees can be seen on the grapes.

Management

Check the ripening of the different grape varieties. Remove grapes before they become over-ripe to prevent losses due to feeding by wasps and bees.

Order Lepidoptera
Family Crambidae
Scientific name *Desmia funeralis*

Grape leaffolder

Description

Adult: The wingspan is 21 to 28 mm. The female **(Fig. A)** is black with four white spots on each side of its wings; it has straight antennae. The male has an irregular white spot on its hind wings and its antennae curve at the midpoint **(Fig. B)**.

Egg: The egg is flat, elliptical and translucent. The eggs are 0.88 mm long. They are deposited singly, generally against the veins on the underside of the leaf.

Larva: The colour of larvae varies from yellow-green **(Fig. C)** to pink **(Fig. D)** with a light brown head. There are five larval stages (L1 to L5). The larva measures between 1.6 mm (L1) and 22 mm (L5). The third instar (L3) has a black spot on the thorax, the fourth instar (L4) has two black spots and the fifth instar (L5) three black spots **(Fig. D)**.

Damage: The larvae (L1 to L5) defoliate the vines. The grape leaffolder is an occasional pest of vineyards in Eastern Canada.

May be confused with

The adult may be confused with the eight-spotted forester. The grape leaffolder is black with white spots; it does not have yellow spots on the hind wings or orange filaments on the two pairs of forelegs like the forester does.

The damage may be confused with that caused by the grape plume moth, the larva of which is green with white hairs and measures 20 mm in length. It is usually the

Childs

Childs

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terminal leaves that are affected and these are webbed together with the larva feeding inside.

Biology and life cycle

The adults are nocturnal. The first generation emerges from an overwintering pupa which gives rise to the adult around stage **C 05**. From stage **C 05** to stage **N 38**, there are two to three generations. The first and second instars (L1 to L2) feed for about 2 weeks **(Fig. E)** within two leaves that they hold together with bands of silk threads **(Fig. F)**. The next two instars (L3 to L5) live within a folded leaf attached with silk threads, which becomes a pupation site.

Critical period of activity and events

Damage is caused by the feeding of larvae that are present from stage **F 12** to stage **M 35**.

Scouting

The larvae are monitored by looking for rolled leaves. Adult males can be monitored by using traps baited with synthetic pheromones.

Management

This pest has little economic impact in vineyards of Eastern Canada. Their natural enemies consist mainly of hymenopterans and dipterans.

Order Lepidoptera
Family Heliozelidae
Scientific name *Antispila viticordifoliella*

Blotch leafminer

Description

Adult: The blackish-brown moth is about 3 mm long with three gray spots on each hind wing.

Egg: The egg is very small and is laid individually inside leaves.

Larva: The larva is yellowish-white **(Fig. A)**.

Damage

Tan coloured spot up to 1 cm diameter containing larvae and/or dark coloured frass and a hole at one side of the spot. Damage is caused by the larvae feeding between the upper and lower epidermis of the leaves **(Fig. B)**.

May be confused with

Black rot foliar lesion. This fungal pathogen produces black fruiting bodies within the lesion.

Grapevine leaves can also be mined by several dipteran species (scientific names undetermined) of the family Agromyzidae such as serpentine leafminer **(Fig. C)**. Similar leaf-mining damage can be caused by the native species *Phyllocnistis vitegenella* (Lepidoptera- common name: grapevine leafminer) **(Fig. D)**.

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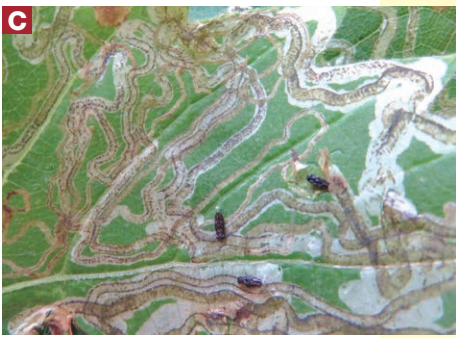

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Biology and life cycle

The eggs are laid on leaves around stage **I 23**. Leafminers pupate in the soil beneath the grapevine. The female lays the egg under the epidermis of the leaf and when the larva hatches, it feeds on the green tissues between the upper and lower leaf surfaces of the leaf. As the larva feeds, it deposits frass inside the mine, which appears dark.

When the blotch leafminer is fully developed and ready to pupate it cuts out a section of the upper and lower epidermis to enclose itself in a “shield” which protects the larva as it descends from the foliage to the soil to pupate **(Fig. E, F)**.

Critical period of activity and events

Damage becomes noticeable in stage **J 27**. The mature larvae drop to the ground around stage **M 35**.

Scouting

Check for tan blotches containing dark spots on their margins. Later in the season, look for shield-shaped holes in the leaves.

Management

No economically significant damage occurs except in severe infestations.

Eight-spotted forester

Order Lepidoptera
Family Noctuidae
Scientific name *Alypia octomaculata*

Description

Adult: The moth is black with eight spots, two on each wing. There are two yellow spots on each forewing and two white spots on each hind wing **(Fig. A)**. They have two yellow patches or "epaulets" (tegulae) on either side of the thorax near the wings. The moth has tufts of orange hairs on the upper part of the first two pairs of legs. With its antennae, it is about 20 mm long. It has a wingspan of 30 mm.

Egg: The egg is round, flat, striated and about 0.1 mm.

Larva: The larva is about 3.3 cm long when mature, has wide orange stripes with black spots, and alternating narrow black and white stripes. It has long sparse hairs on its dorsal surface **(Fig. B)**.

Damage

The caterpillars chew entire leaves, leaving only the largest veins **(Fig. C)**. Virginia creeper and wild grape are alternate hosts. Damage is rarely severe and is often concentrated along the borders of vineyards and in rows adjacent to shrubs, woods or areas of herbaceous vegetation.

May be confused with

Damage caused by the grape plume moth, the larva of which is green with white hairs and measures 20 mm in length. Plume moth is usually active much earlier than eight-spotted forester. It is usually the terminal leaves that are affected and these

A

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B

McFadden-Smith (OMAFRA)

C

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are webbed together with the larva feeding inside while eight-spotted forester are completely exposed. Damaged leaves are covered with silk webbing. Japanese beetle adults skeletonize leaves by feeding between the smaller veins giving leaves a lacy appearance and the beetles are very different in appearance from forester larvae.

Biology and life cycle

The adults overwinter as pupae and in late spring at stage **E 09**, they emerge and mate. Eggs are laid singly on grape shoots and leaves. Larvae hatch around stage **I 23** and begin feeding on the foliage, completing their development over the summer. The mature larvae drop to the ground and pupate in tunnels they construct a few centimeters beneath the soil surface or in crevices in wood. In Eastern Canada, there are one to two generations per year depending on the weather conditions and the region concerned.

Critical period of activity and events

Defoliation of leaves from stage **I 23** to **M 35**.

Scouting

When scouting for grape berry moth larvae along the borders of vineyards, watch for eight-spotted forester adults or shoot injury from larvae on cultivated vines, wild grape or Virginia creeper.

Management

This pest usually causes very little economic damage, and intervention is rarely required. Insecticides that control grape berry moth are also effective against the larvae of this insect.

Order Lepidoptera
Family Noctuidae
Scientific name *Euxoa messoria*

Climbing cutworm (syn. darksided cutworm)

Description

Adult: This nocturnal moth is about 25 mm long and 5 mm wide **(Fig. A)**. The forewings are brown with greyish tan spots. The hind wings are pale tan. The wingspan is 32 to 36 mm. The antennae of females are simple and elongated; those of the males are segmented and comb-like.

Egg: The egg is laid in soil at a depth of about 6 to 12 mm.

Larva: The larva has a light brown back and a whitish abdomen. It has one to two bands on each side **(Fig. B)**. It is 32 to 38 mm long and 6 mm wide when mature. The larva curls up tightly when disturbed.

Damage

Damage is caused by larval feeding and is visible on buds and leaves from stage **C 05** to **H 17** **(Fig. C).** Dormant buds can be completely hollowed out by feeding. Holes are chewed in the leaves or they are completely defoliated except for the main veins.

May be confused with

Damage may be confused with that caused by grape flea beetle larvae, which can be seen in the daytime, unlike the cutworm larva, which are nocturnal. Damage caused by the Japanese beetle occurs later, in stage **L 33**.

Biology and life cycle

There is one generation per year. The overwintering egg hatches in the spring in stage **C 05**. The larva is nocturnal and

Appleby

Appleby

Appleby

feeds preferentially on leaves, but may also feed on young shoots or roots. The larva continues to develop until stage **J 27.** When mature, the larva stops feeding and pupates in the soil. The pupa matures in 3 to 4 weeks. The male and female moths emerge beginning in stage **M 35**. The females mate and lay their eggs in light soils right through to October. This pest is present in all provinces in Eastern Canada.

Critical period of activity and events

The climbing cutworm feeds on grapevines from stage **C 05** to **H 17**. The larvae are active during the night.

Scouting

Scout for foliar damage in new plantings on light soils regularly from bud break **C 05** to the shoot lengthening stage **H 17**. Carry out scouting in the evening when the larvae feed on the vines. A great deal of damage can occur in just a few days when the nights remain warm.

Management

New vines planted on untreated land previously in pasture are prone to damage from cutworm populations. Inspect for signs of damage in the spring and treat locally when necessary.

Order Lepidoptera
Family Pterophoridae
Scientific name *Geina periscelidactylus*

Grape plume moth

Description

Adult: Adults are about 8 to 9 mm long, and are light brown with tan markings **(Fig. A)**. Their antennae are straight and about 4 mm long. Their wings are narrow, plumed, about 14 mm wide, and similar in colour to their body.

Egg: Invisible to the naked eye, the eggs are laid in groups of two to ten.

Larva: At maturity, the larvae are about 20 mm long, and light green with white hairs **(Fig. B)**.

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Damage

Entire leaves or parts of leaves are chewed and webbing may be present on foliage. The terminal leaves on shoots are folded and held together by webbing.

May be confused with

Damage may be confused with that caused by eight-spotted forester larvae, which are longer (about 35 mm) and have orange, black and white bands with black spots. However, foresters are present later in the growing season.

Biology and life cycle

The grape plume moth overwinters as a pupa. In stage **D 06** the adults emerge and mate. The eggs are laid in stage **E 09** on the wood or on shoots near the foliar tissues of the vine.

Critical period of activity and events

From stage **E 09** to stage **I 23.**

Scouting

Look for feeding damage on the leaves or on terminal shoots held together with webbing. Check for larvae within folded, webbed leaves. When scouting for grape berry moth on the perimeters of vineyards, take note of any grape plume moth larval activity. They often show up first in wild grapevines.

Management

This pest has little economic impact, causing only minor, localized damage.

Grape root borer

Order Lepidoptera
Family Sesiidae
Scientific name *Vitacea polistiformis*

Description

Adult: The adult is a brown moth with narrow yellow bands on the abdomen and orange on the head **(Fig. A)**. The antennae are orange with brown or black markings. The top of the legs is orange with black spots. The wings are brown and mostly opaque. Males are distinguished from females as they have four tufts of scales at the tip of their abdomen. Males are about 1.5 cm long while females measure about 1.9 cm.

Bergh

Egg: The egg is brown and slightly flat with an indentation in the centre. It is smaller than the head of a pin.

Larva: The larvae are creamy white **(Fig. B)** and cylindrical with three pairs of legs near the head. The mature larva is about 25 mm long and has a brown retractable head. It has five pairs of abdominal prolegs each bearing tiny hooks.

Bergh

Damage

The grape root borer is potentially the most destructive pest of grapevines. The larvae tunnel into the largest roots and up to the crown of the vines. Larval damage causes poor vine growth and fruit set and may even lead to the loss of vines. Since larval activity is limited to the vine structures below ground, the symptoms become apparent only when the vines are severely damaged **(Fig. C)**. That is why this pest is often ignored until it becomes a serious problem in a vineyard.

Bergh

May be confused with

The adult resembles a paper wasp.

Biology and life cycle

The grape root borer is an occasional pest in Eastern Canada. Over the past 10 years, however, an increase has been observed in this pest's numbers, along with its migration to the northern part of the United States. The life cycle generally takes 2 years to complete. Some studies have reported a life cycle of 3 years in the northern part of its range and 1 year in the southern part. The adult emerges from its pupa at the soil surface between mid-July and mid-August. The female begins laying its eggs within 7 to 10 days. The female lays 350 eggs on average, which it deposits on the soil surface, on weeds, and on the different aboveground vine structures. The egg hatches in 14 to 20 days, and the larva begins burrowing into the soil in search of a vine root. About 95% of them die before finding a root, fewer than 1% die after penetrating a root. Larvae spend about 22 months developing in the roots. During the second season, around mid-June, pupae are formed in a cocoon near the soil surface. The adults emerge 30 to 45 days later.

Critical period of activity and events

The adult is present from stage **J 27** to **K 31**.

Scouting

Scouting is advisable when unexplained vine death occurs. Beginning in stage **J 27**, check close to the base of vines (within 40 cm) for pupal cases on the soil surface. Monitor for adult males using pheromone traps from stage **J 27** to stage **N 38**. When a damaged vine is pulled, check for larvae inside the roots and crown. The grape root borer is rarely observed in new plantings. In general, damage is reported in blocks after several years of production.

Management

Various biological control methods are used, including mating disruption of adult males, along with physical control (destruction of larvae and pupae using machinery). The use of parasites and entomophagous nematodes is under development.

Order Lepidoptera
Family Tortricidae
Scientific name *Paralobesia viteana* (syn. *Endopiza viteana*)

Grape berry moth

Description

Adult: The adult moths are 4 to 6 mm long **(Fig. A)** and predominantly brown and tan with a grey band across their wings.

Egg: The egg is round, flat, translucent, slightly convex and measures about 0.8 mm **(Fig. B)**.

Larva: There are four larval stages. (L1) is 1 mm long and greenish to yellowish with a black head capsule; these larvae spin a web in the inflorescence **(Fig. C, D, E)** or grape cluster. (L2 to L4) become progressively darker and turn purple at maturity **(Fig. F)**.

Damage

The damage caused by the first generation on the developing clusters starts at stage **H 17** but it is less severe than that caused by the second generation. Flower buds and early-set berries are destroyed by the feeding activity of larvae. Second generation larvae, which appear as of stage **L 33**, within the expanding berries **(Fig. G)**. Infested berries of red cultivars will turn red to purple prematurely (before veraison **N 38**). From stage (L1) to stage (L4) the larvae move from grape to grape as they develop. The injuries they cause promote the spread of the causal fungus of grey mould (*Botrytis cinerea*), which may damage part or all of the affected clusters.

May be confused with

Grape berry moth damage can be confused with the damage caused by other occasional lepidopteran pests.

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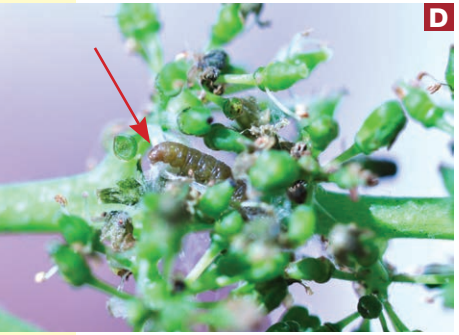
D

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E

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F

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Biology and life cycle

In stage **F 12** the adults begin emerging from overwintered pupae. The adult has a lifespan of 1 to 3 weeks, with an average of 18 days at 18.5°C. The first flight coincides with stage **I 23** and continues for a few weeks. Females lay their eggs singly on flower stalks or berries. A female lays about 30 eggs during her lifetime. The majority of eggs are laid about 1 hour before and after darkness. On average, hatching takes place 4 days later. After feeding from within a web that it spins, a mature first generation larva (L4) emerges from the grape cluster. It cuts a section from a leaf, folds it and spins a web around this shelter in which it pupates. The new pupa is blue or greenish and turns dark brown prior to emergence of the second generation adult, around stage **L 33**. The second generation female lays its eggs on young expanding berries. The newly hatched larva (L1) burrows into a berry. (L1 to L4) enter and feed within multiple berries (two to six) until they complete their development. Subsequently, (L4) moves to a leaf and spins a web around it, creating a shelter within which it pupates **(Fig. H)**. In southern Ontario, usually a third and partial fourth generation occurs. Depending on degree-days accumulated before stage **M 35** a full fourth generation and partial fifth may occur. The pupa enters diapause and overwinters in the rolled-up leaf, which falls to the ground at first frost.

Critical period of activity and events

From stage **G 15** to **I 23** the first generation of larvae appear. From stage **K 31** to **N 38** damage caused by second generation larvae appear. Third and fourth generations may overlap and extend until harvest or first frost. At harvest, larval damage increases the risk of grey mould and sour rot development.

Scouting

Two techniques are used for scouting: installation of pheromone traps to capture male moths and visual observation of larvae or damage on flower stalks or berries.

Scout for the adult males by installing pheromone traps (one set of five traps per 4 ha) in stage **E 09**. Place traps on the top wire of the trellis **(Fig. I)**. Install one trap at each corner of the vineyard and one mid-row on the windward side of the block. If there is a significant source of grape berry moth adjacent to the block (wild grapevines, unmanaged vineyard), place another trap midway along that border. Traps should be no less than 40 m apart. Count the catches in traps at least once a week throughout the season; remove grape berry moth from the trap after each count. Keep track of captures. Lures must be replaced: consult manufacturer for intervals. From stage **J 27** to **K 31** carry out visual surveys for larvae as follows: examine 100 clusters in the outer rows and panels per 4 ha block. Look for webs in the clusters and check whether there are larvae or frass in them.

Management

A chemical treatment of first generation larvae has little impact on damage levels at harvest. Control efforts should be carried out when necessary against second generation larvae (or third and fourth in Ontario). Trap catches are used to time insecticide sprays. Establish flowering cover crops in order to attract parasitoids and predators of lepidopterans. Mating disruption programs have been developed and are commercially used.

G

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H

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I

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Natural Enemies









Management strategies

The natural enemies of vineyard arthropod pests include spiders, predatory mites, and predatory or parasitoid insects. Since these groups contain several hundred species, we will present here only a few chosen examples and discuss strategies for promoting them. There are three strategies involving natural enemies that are generally used to promote natural control of grapevine pests: conservation, augmentation and classical biological control.

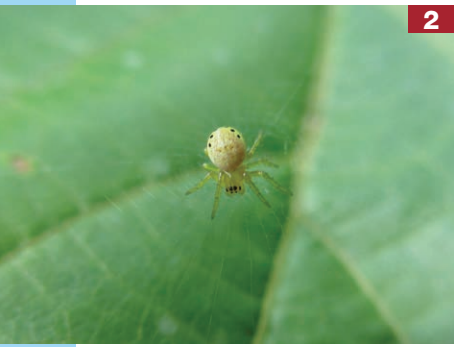
The **conservation** of natural enemies present in vineyards is an important strategy for the sustainable use of natural enemies to control pests. In order to protect natural enemies, it is essential to use low-toxicity pesticides and time their application so as to minimize their impact on natural enemy populations. In addition, certain cultural practices can adversely affect beneficial insects and their habitats.

Augmentation is a direct or indirect strategy that involves introducing new colonies of additional natural enemies or promoting the development of existing natural enemies in the vineyard. Various methods and management practices can be used to attract or protect natural enemies. For example, providing and protecting suitable overwintering sites and ensuring that alternative resources (pollen, nectar, etc.) are available to promote the augmentation of colonies of natural enemies in the vineyard. Predators or parasitoids can be introduced by inoculative or inundative releases. In inoculative releases, natural enemies are introduced either upon emergence of the first stages of the target pest or before the pests infest the vines. Inundative releases are carried out to control a severe infestation of the target pest. The biological stage of the target pest can influence the choice of the timing of releases. For example, egg parasitoids should be released during the pest's egg-laying period, determined based on systematic monitoring.

Classical biological control is the introduction of a new natural enemy species into an environment where the species is not indigenous or naturally present; for example, this method can be used to control an exotic pest that has no natural enemies in North America.


1

McCann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Arachnida

Spiders (Araneae)

Spiders are the easiest arthropods to identify visually. However, identifying them to the species level is difficult. The spider body is made up of two parts: the prosoma (cephalothorax), which is the fused head and thorax, and the abdomen (opisthosoma), which contains the silk glands. These glands produce the silk that spiders use to protect their eggs, spin webs for capturing and imprisoning prey, and move over long distances (up to 50 km/day) with the help of the wind. Spiders have two to eight eyes and four pairs of legs attached to the prosoma. Some species eat their webs daily in order to recycle them. Spiders usually have a life span of 1 to 2 years and, depending on the species, lay from 10 to more than 1000 eggs during their lifetime.

A number of species of spiders are present in vineyards. These spiders are generalist predators that attack many insects and mites at different stages (adults, larvae or eggs). The predation of insect pests by spiders is often underestimated. When spiders are present in large numbers, they suppress the growth of populations of many grapevine pests. For the purposes of this guide, we will discuss two visually identifiable groups. In the first group are spiders that trap their prey using webs attached to various structures **(Fig. 1, 2)**; these webs have different shapes (orbicular, funnel-shaped, etc.). The second group consists of spiders that hunt without webs, primarily wolf spiders (family Lycosidae) **(Fig. 3)** and crab spiders (family Thomisidae) **(Fig. 4)**, also called flower spiders. Wolf spiders are dark-coloured (brown, grey or black), providing them with effective camouflage. They generally move and hunt on the ground. The female carries her eggs behind her abdomen in an egg sac that looks like a cocoon and is attached to her spinnerets; upon hatching, the young climb onto and cling to her back. The crab spider gets its common name from its

ability to move sideways quickly and from its front legs, which are longer than its back legs. It hides in ambush, usually in flowers, to wait for prey.

Conservation

Pieces of porous wood or wood with holes, strips of geotextile, or other insulating material added to the physical structures of the vineyard provide protection and overwintering sites for spiders, which encourage them to be active in the vineyard early in the spring. According to various studies, the abundance and diversity of groundcover plants influence the presence of spiders both quantitatively and qualitatively. Using mulch to control weeds and reducing herbicide use provide refugia for spiders and have beneficial effects on spider populations.

Goulet

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Mites (Acariformes)

Predatory mites are cosmopolitan arthropods present in the environment of many crops. These mites measure 0.35 to 4 mm long and have four pairs of legs. The prosoma (cephalothorax) and opisthosoma (abdomen) are fused, forming a body composed of a single mass. In Eastern Canada, indigenous predatory mites are hardy and well adapted to the climate. They attack a wide range of prey at different life cycle stages (eggs, larvae, nymphs and adults). Predatory mites are easy to manipulate since they are present on the canes during the vine dormancy period or on the leaves during the growing period. They can be used successfully in conservation and augmentation strategies in vineyards.

– Anystidae

The names *Anystis baccarum* and *Anystis agilis* are synonyms for the same species; both names are used in the scientific literature. For the purposes of this guide, we will use the name *Anystis* sp. The adult, which is visible to the naked eye, resembles a small spider and is fast-moving. It ranges in colour from orange to red **(Fig. 5)** and measures approximately 3 mm in length. The eggs are spherical and measure approximately 0.15 mm. They are laid in clusters of approximately

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Saguez

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20 and are attached by silken threads to moist surfaces, such as the ground and the base of trunk of grapevines. There are five immature stages: prelarva (PL), larva (L), protonymph (P1), deutonymph (D2) **(Fig. 6)** and tritonymph (T3), which measure from 0.2 mm (PL) to 2 mm (T3) in length. There are two or three generations a year in Eastern Canada. *Anystis* sp. is a highly voracious generalist predator. It is frequently observed in the vineyards of Eastern Canada. Population growth occurs through asexual reproduction by females (parthenogenesis). In Eastern Canada, the first immature stages emerge from late April to mid-June. The adults **(Fig. 7)** and immatures are predatory and practice cannibalism and intraguild predation under certain conditions. They feed on many arthropod species. In the vineyard, their prey includes phytophagous mites, aphids, lepidopteran eggs and young larvae, and leafhopper eggs and nymphs. Like Phytoseiidae and Stigmaeidae, *Anystis* sp. is capable of quickly developing resistance or tolerance to various pesticides (insecticides and fungicides) used in agriculture.

The predatory mite *Anystis* sp. is an excellent candidate for **conservation-augmentation** strategies. Inundative releases of *Anystis* sp. are carried out as follows: collect *Anystis* sp. specimens in a donor vineyard starting at stage **H 17**, by holding a net (or a 2 litre container) under the inflorescence or foliage and tapping lightly three times to dislodge the *Anystis* sp. That same day, transfer the specimens collected to a recipient vineyard by dispersing them on the foliage of the vines. It is possible to capture specimens of the new generation of *Anystis* sp. in the vineyard after stage **L 33 (Fig. 8).** From late July to late August, *Anystis* sp. specimens can also be captured outside the vineyard in habitats such as wild raspberry suckers, strips of wildflowers such as goldenrod, and apple orchards.

– Erythraeidae and Trombidiidae

In the vineyards of Eastern Canada, predatory mites of the families Erythraeidae and Trombidiidae are, respectively, from the genera *Balaustium* sp. and *Allothrombium* sp. **(Fig. 9)**. Adults measure approximately 0.7 to 2 mm in length and are visible to the naked eye **(Fig. 10)**. The genera *Balaustium* sp. and *Allothrombium* sp. range in colour from reddish-brown to red. They have a velvety look with cavities on the dorsal surface, giving these mites a tick-like appearance. Few taxonomic studies have been conducted on these two genera. The information on their biology is incomplete and sometimes contradictory. They are highly voracious predators of insects and mites. However, these species are less numerous in vineyards than *Anystis* sp. The conservation strategy is the same as for Phytoseiidae and Stigmaeidae.

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McFadden-Smith (OMAFRA)

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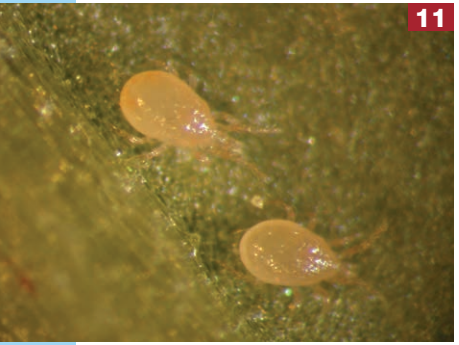
– Phytoseiidae and Stigmaeidae

Phytoseiidae are important biological control agents in some integrated pest management programs. The main species of Phytoseiidae **(Fig. 11)** present in the vineyards of Eastern Canada are *Typhlodromus caudiglans* (= *Amblydromella caudiglans*), *Typhlodromus pyri* and *Neoseiulus fallacis* (= *Amblyseius fallacis*). The main species of Stigmaeidae **(Fig. 12)** are *Agistemus fleschneri* and *Zetzellia mali*. The adults of these two families measure approximately 0.35 mm in length. Phytoseiidae eggs are oval and whitish **(Fig. 13)**. Stigmaeidae eggs are round and lemon-yellow and are suspended on strands of silk **(Fig. 14)**. The eggs are laid on the underside of leaves. There are three immature stages: larva (L1), protonymph (PN2) and deutonymph (DN3). Phytoseiidae and Stigmaeidae have five to eight generations a year.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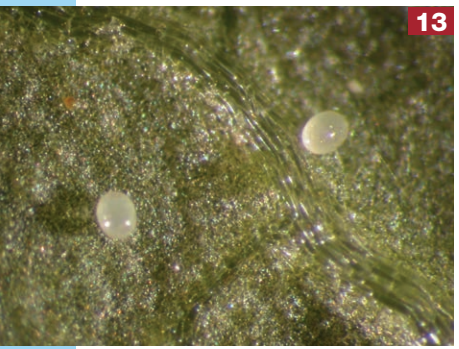
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The above-mentioned species feed on spider mites, eriophyid mites, aphids and insect eggs on vines **(Fig. 15).** The fertilized females enter diapause in the fall at stage **N 38**. They emerge at stage **C 05** and lay their eggs on shoots near the eggs of their prey. During ideal conditions (hot, dry weather), the populations of spider mite pests grow rapidly. The adult females of predatory mites adjust the number of eggs that they lay based on the quantity of prey available and are effective in controlling spider mite pests. Stigmaeidae show a particular preference for colonizing the pubescent leaves of vines. The mites of this family have the ability to quickly develop resistance or tolerance to various pesticides used in agriculture. Although the two families may cohabit on vines, Stigmaeidae can be fed upon and killed by Phytoseiidae (i.e., intraguild predation), when prey are no longer available. Stigmaeidae and Phytoseiidae predatory mites are easy to capture and reintroduce, since they are found on the foliage over the course of the summer or on the wood (shoots or canes) of vines from late fall, stage **O 43**, to early spring, stage **A 01**.

For the **conservation** of these predatory mites, it is imperative to protect the populations present in the vineyard by using pesticides that have low toxicity to these species. Phytoseiidae also feed on pollen, the availability and abundance of which encourage the predatory mites to remain in the vineyard throughout the season.

Augmentation involves inundative releases of these predatory mites in the vineyard. These mites can be introduced into a vineyard where they are absent or present in insufficient numbers (recipient vineyard). The procedure must be carried out before vine bud break at stage **B 03**. In a donor vineyard, collect wood (canes > 2 years old) freshly pruned during the dormant period and tie the wood into small bundles. That same day, place the bundles near the trunks in the recipient vineyard. The diapause of the Phytoseiidae and Stigmaeidae predatory mites present on the pruned wood ends at stage **C 05**. They then leave the canes in the bundles and colonize the vines of the recipient vineyard. In the summer, the same procedure is used to carry out additional releases using shoots with foliage, as is commonly practiced in Europe. Some hosts may be placed around vineyard to serve as refugia.

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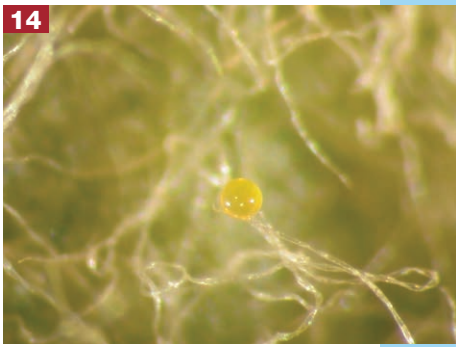

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COLEOPTERA

Carabidae

The species of ground beetles (Carabidae) found in vineyards live most of their life cycle in, or on the surface of the soil. These beetles are typically active at sunset or during the night and can be scouted using pitfall traps. Since the adults are nocturnal, they can be found during the day under rocks and stones or debris. Each species has its environmental preferences, and the composition of species in vineyards varies depending on the type of soil. Ground beetles are a bio-indicator of the environmental quality of the vineyard in terms of the non-target effects of pesticides.

The adults are dark-coloured and shiny. A few species have a metallic sheen. A number of species have longitudinally-striated elytra. The adults have a groove running down the tibia of their first pair of legs. The first segments of the hind legs extend backwards over the first abdominal segment. The filiform antennae emerge between the two eyes and the mandibles. The pronotum is always larger than the head region where the eyes are located.

Ground beetles have a complete life cycle (egg, larva, pupa, adult). Depending on the species, adults can live 1 to 4 years. The females usually lay their eggs (between 30 and 600) individually in the soil and cover them with earth to protect them from predation. The eggs generally take 1 week to hatch. Depending on the species, ground beetles go through two to four larval stages (instars) before reaching the pupal stage. As a general rule, species that reproduce in the spring spend the winter in adult form, while species that reproduce during the summer spend the winter in larval form and become adults the following spring.

A number of species of ground beetles release defensive repellent chemicals when they feel threatened. Most species move by walking on the ground. Flying is sometimes observed, but mainly for travel over medium distances, such as from one habitat to another.

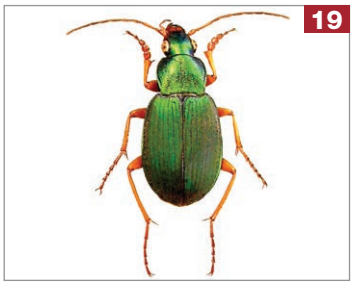
Ground beetles are opportunists that eat many types of food. They are primarily predators of insects (including many pest species), arthropods and other organisms (such as slugs). Most species engage in random search for prey. Several species of ground beetles are phytophagous and have a significant beneficial impact by eating and destroying weed seeds. Typically, ground beetles do not cause any damage to vines.

Plate 2 – Carabid adults

Agonum placidum - Goulet

Anisodactylus sanctaecrucis - Goulet

Bembidion quadrimaculatum oppositum - Goulet

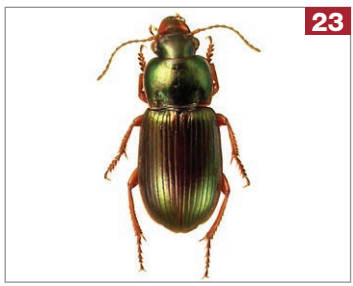


Chlaenius sericeus - Goulet

Chlaenius tricolor - Goulet

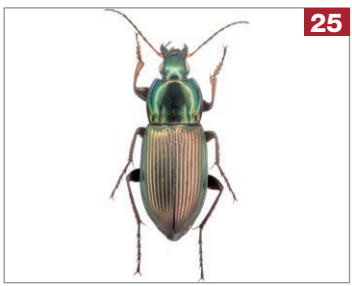
Clivina fossor - Goulet

Elaphropus incurvus - Goulet



Harpalus affinis - Goulet

Harpalus pensylvanicus - Goulet



Poecilus lucublandus - Goulet

Pterostichus melanarius - Goulet

Stenolophus comma - Goulet

McFadden-Smith (OMAFRA)

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Coccinellidae

In Eastern Canada, there are approximately 20 species of ladybugs (syn. lady beetles, ladybird beetles) associated with vineyards. They measure 1 to 10 mm in length. The adults are winged, and the females are larger than the males. Depending on the species, the eggs are laid in clusters **(Fig. 28)** or singly on different leaves. The complete cycle from egg-hatching to adult is approximately 40 days. The larvae look like tiny alligators and are black, blue or brownish in colour **(Fig. 29)**. They sometimes have yellow, orange or red spots on the back. There are four larval stages (instars) over a period of 14 to 21 days before pupation **(Fig. 30)**. Ladybugs can have one to five generations a year depending on the species. The adults and larvae of ladybugs are predators of soft-bodied invertebrates (aphids, mites, psyllids, gall-inducing insects, mealybugs, etc.), as illustrated by **(Fig. 31)** showing a *Hippodamia variegata* adult preying on an aphid. Ladybugs reproduce by locating colonies of their prey and laying their eggs there. When prey is absent, cannibalism of eggs and larvae is frequent. Under those conditions, some species also eat honeydew left on the leaves by aphids or nectar in flowers. The last instars usually migrate in order to isolate and protect themselves when reaching the pupal stage. The pupa has no protection against cannibalism. Adults secrete a foul-smelling, bitter-tasting orange-yellow fluid (hemolymph) from glands located in the joints between the tibia and femur that repels potential predators. In the larva, these glands are in the abdomen.

Ladybugs overwinter as adults in litter, under leaves, in natural cavities or in buildings and usually form aggregations of several tens to thousands of individuals. The populations of several ladybug species indigenous to Eastern Canada, for example *Coleomegilla maculata*

(Fig. 32), are on the decline, primarily because of their exposure to pesticides and due to some introduced invasive species that are in competition with them, in particular the multicoloured Asian lady beetle (*Harmonia axyridis*) **(Fig. 33)** and the seven-spotted ladybug (*Coccinella septempunctata*) **(Fig. 34)**. *Harmonia axyridis* is a voracious predator and is also considered as a pest in Ontario (see entry- **Arthropod pests** section of this guide). Adults are attracted to the volatiles in injured grape berries and frequently aggregate for a sugar feed before hibernation.

Conservation and augmentation

In viticultural regions where *H. axyridis* do not pose recurrent ladybug taint problems, it may be advisable to conserve coccinellid predators. Ladybugs are tolerant to fungicides but are affected by certain non-selective insecticides. In the fall, the adults of many species emit aggregation pheromones that enable the ladybugs to form aggregations for hibernation. Ladybugs most often head toward structures such as cliffs, tree trunks or buildings. Overwintering sites tend to be found in the same locations from year to year. The persistence of these pheromones that cause the aggregation behaviour of ladybugs is a characteristic that you can take advantage of to create overwintering sites using natural or synthetic materials (wooden boxes, piles of stone, straw, etc.) to enable the insects to survive during their winter diapause. At the first frost, locate the ladybug aggregations, collect the ladybugs and transfer them to the overwintering sites that you have constructed in the vineyard. A number of other ladybugs will be attracted by the aggregation pheromones emitted by the ladybugs that you have placed in your constructed sites. The following spring, the

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ladybugs will leave the constructed sites and establish new populations in the immediate habitat of the vineyard. The following fall, because of the persistence of the aggregation pheromones from the previous winter, the ladybugs will find their way back to their overwintering sites and take refuge there to hibernate.

Diptera

Asilidae

Depending on the species, adult Asilidae measure 3 to 50 mm in length, with the average being 9 to 15 mm. They have various shapes and colours in shades of black, brown or grey **(Fig. 35)**. Adults have a very mobile head and simple eyes (ocelli) located in a depression between two large, prominent eyes. The antennae are three- to five-segmented, depending on the species. The legs are long and robust. The eggs are not visible to the naked eye **(Fig. 36)**. The larva, which has four stages (instars), is cylindrical, elongate and tapered at each end. The larva overwinters in the soil and metamorphoses to a pupa, in the spring. At maturity, the adult emerges from the soil. The larvae and adults are predators of arthropods. Asilidae larvae feed in the soil during their development. The adults are formidable predators, capturing prey that are often larger than themselves in mid-flight, earning them the common name robber fly (**Fig. 37**). Robber flies also hunt their prey by lying in wait and ambushing it. Captured prey are quickly paralyzed by the injection of toxins. The enzymes in the saliva then liquefy the internal tissues of the prey, which are sucked out by the Asilidae. Robber flies are often solitary insects that are widespread in many habitats **(Fig. 38, 39)**.

Syrphidae

Syrphidae, commonly called flower flies or hoverflies **(Fig. 40, 41, 42, 43)**, are a large and very diverse group, certainly one of the most visible and most colourful of the order Diptera. These flies are brightly coloured, displaying different patterns of yellow, brown or orange. The adult often resembles a small wasp and measures 5 to 15 mm in length. The eggs are usually attached singly to leaves or bark close to their prey. The larvae (maggots) of several species of the subfamily Syrphinae **(Fig. 44)** are important predators of leafhoppers, aphids, thrips and phylloxera. At maturity, they pupate in various substrates (e.g., in galls, under the leaves, in the soil). The number of generations is variable depending on species. The adult males' eyes are so close together that they touch, while those of the females are spaced apart. The adults are attracted by flowers and feed on pollen and nectar.

Plate 3 – Diptera larvae and adults

Goulet

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Goulet

Goulet

Goulet

Goulet

Goulet

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Goulet


45

Pilon


46

Pilon


47

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Hemiptera

Plant bugs (also called true bugs) are members of the suborder Heteroptera. This group includes numerous families and subfamilies. We will discuss below the main families that are considered potential natural enemies of grapevine pests.

Miridae

Many species of the family Miridae are considered phytophagous pests. However, a few species are beneficial. The glassy-winged mirid bug (*Hyaliodes vitripennis* (**Fig. 45)**, *Hyaliodes harti* **(Fig. 46)**, the mullein bug (*Campylomma verbasci*), and *Blepharidopterus* sp. are examples of mirid plant bugs that are predators of mites and several insect pest species.

Nabidae

The plant bugs of the family Nabidae prey exclusively on arthropods. These bugs range in colour from black to brownish to greyish. Depending on the species, they measure from 5 to 12 mm in length. They have long, thin legs and a long head with large eyes on either side. These bugs lay their eggs in plant tissue. *Hoplistoscelis* and *Nabis* **(Fig. 47)** are the most common genera in the vineyards of Eastern Canada.

Pentatomidae

Pentatomidae usually exhibit varying shades and colours and measure 10 to 20 mm in length. However, some species are smaller, 5 to 10 mm in length, and have different colours and patterns. Some have scent glands

that emit a strong, repulsive odour when the bugs feel threatened. They lay their eggs in clusters on leaves **(Fig. 48)** or stems. The nymphs **(Fig. 49)** have five stages (N1 to N5). The antennae of the nymphs are four-segmented, while adults' antennae are five-segmented. In stages (N4) and (N5), the wing pads are visible. In stage (N4), the wing pads reach the posterior margin of the metanotum (third segment of the thorax), and in stage (N5), they extend well past it. There are approximately 50 species present in Eastern Canada, including *Perillus bioculatus* **(Fig. 50, 51)**, *Perillus circumcintus* **(Fig. 52)** and *Perillus exaptus* **(Fig. 53)**. The majority are phytophagous or omnivorous. Some 15 species are beneficial since they feed on numerous arthropod species. Stink bugs **(Fig. 54)** are sometimes the prey of birds, predatory insects, spiders and parasitoids. When their prey is rare, stink bugs are also victims of intraguild predation.

Reduviidae

Reduviidae, commonly called assassin bugs, reduviid bugs or ambush bugs, are predators that attack numerous arthropods. Depending on the species, they measure 4 to 20 mm in length. They are black, brown or green. The genera *Empicoris* spp., *Phymata* spp. and *Zelus* spp. are the most common. They have an incomplete metamorphosis that consists of three stages: egg **(Fig. 55)**, nymph **(Fig. 56)** and adult **(Fig. 57)**. Approximately 20 species have been inventoried in Eastern Canada. They can use their rostrum to make the shrill sound

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49

Pilon

50

Pilon

Plate 4 – Hemiptera eggs, nymphs and adults

Pilon

Pilon

Pilon

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Pilon

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that is characteristic of the plant bugs in this family. They have highly developed forelegs, which they use to catch and eat their prey **(Fig. 58)**. They generally hunt by lying in ambush, using their camouflage, to catch approaching insects.

Conservation and augmentation

The presence of flowering plants in the vineyard attracts various pentatomid species early in the season since they are omnivores and feed on nectar and pollen. Using pesticides that have low toxicity to these species promotes their conservation in the vineyard.

Neuroptera

Chrysopidae and Hemerobiidae

Chrysopa carnea (Chrysopidae) is the main species present in the vineyards of Eastern Canada. It is commonly called green lacewing or golden-eyed green lacewing **(Fig. 59)**. The adult measures 12 to 20 mm in length and has long antennae and golden eyes. Its body is thin with long, transparent, fine-veined wings. Its eggs, which measure approximately 0.8 mm in length, are oval and greenish and are attached to the end of a long, silken stalk. They are laid individually or in clusters on the same leaf, berry or shoot **(Fig. 60)**. There are three larval stages (instars), which measure from 1 mm (L1) to 8 mm (L3) in length. The larva is elongated, cylindrical and tapered at the ends. It has large mandibles **(Fig. 61)** and is beige in colour with two rows of dark brown spots running along each side of the back.

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The brown lacewing, *Hemerobius humilinus*, is from the family Hemerobiidae. The adult is reddish-brown to greyish in colour and measures approximately 10 mm in length. The larva is nearly hairless. The eggs are laid individually on leaves.

Despite a few morphological differences, the green lacewing and the brown lacewing have similar biological cycles. The adult overwinters under leaf litter at the edges of fields. After emergence in the spring, the female lays her eggs (more than 100) near potential prey. The adult is nocturnal and feeds on honeydew, pollen and nectar. Unlike the adult, the larva is a voracious predator of mites and insects **(Fig. 62)**. Depending on weather conditions, Chrysopidae and Hemerobiidae have two or three generations a year.

Conservation and augmentation

The presence of strips of flowering plants in the vineyard promotes the development of colonies of Chrysopidae and Hemerobiidae since they feed on nectar, pollen and honeydew before and during the egg-laying period.

Parasitoid insects

Diptera

Tachinidae

Adult Tachinidae are colourful, with black, brown, orange or red patterns. In some adults, the thorax and abdomen are decorated with patterns of metallic blue, green or brown. The adults are found in different habitats: on leaves, trunks, flowers **(Fig. 63, 64, 65)**, rocks or even soil. All species of Tachinidae are parasitoids and are mainly diurnal, particularly active at dusk. The adults vary widely in morphology, colour and size. Depending on the species, adult Tachinidae measure 2 to 20 mm in length, with the average being 5 to 10 mm in length. The head is approximately the width of the thorax. The antennae are short. The eyes are normally the same size as the head, except for a few species whose eyes are half the size of the head. They are protected by a row of bristles. The abdomen and thorax are covered with moderately dense hairs. The Tachinidae are parasites of insect larvae. Different species have evolved different modes of parasitism: eggs may be injected into **(Fig. 66)** or attached onto the host **(Fig. 67)**; numerous eggs may be deposited on the food of the host, which ingests the eggs; or first-instar larvae are deposited near the insect to be parasitized.

63

Goulet

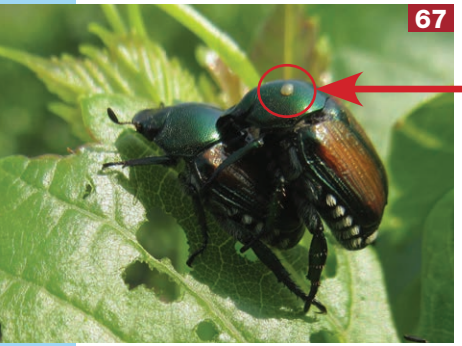
64

Goulet

65

Goulet

Goulet



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There are three larval stages (instars). The (L1) larva develops slowly on the inside of the host, so that the host develops normally, and it usually hibernates in its host. The following spring, the host is devoured by the larva in the (L2) and (L3) stages. The (L3) larva subsequently forms a pupa inside the exuviae of its host, from which adult emerge. The Tachinidae are very effective natural enemies, particularly against lepidopteran larvae. Adult Tachinidae feed on nectar and pollen.

Hymenoptera

Braconidae

There are significant morphological differences among adult Braconidae. The adults measure at least 15 mm in length. They are usually blackish or brownish, sometimes with reddish or orange patterns. The antennae have at least 16 segments. The female generally has a long ovipositor adapted to reach its prey, which are often deeply hidden in the vegetation layer or in a trunk cavity. The majority of Braconidae parasitize their hosts at the egg or larval stage by depositing their eggs inside or on the host. The most commonly parasitized orders are Coleoptera, Diptera, Heteroptera and Lepidoptera. A few species use an endosymbiotic virus that inhibits the host's immune system, so that the larva of the parasite can develop inside the insect without being detected. Generally, when the larva reaches maturity, it forms a pupa in a silk cocoon outside or inside its host. Some species complete their larval development in the pupa of their host.

Goulet

Goulet

Ichneumonidae

Adult Ichneumonidae are often dark-coloured with different patterns depending on the species **(Fig. 68)**. They measure 5 to 40 mm in length (average 10 mm). The abdomen has a petiole and is often longer than the thorax **(Fig. 69)**. They have long, segmented antennae similar to those of Braconidae. Some Ichneumonidae species have very long ovipositors. Some females lay their eggs on the ground; after the egg hatches, the larva parasitizes a passing prey. The majority of the species lay their eggs on or inside their prey. After hatching, the larva develops by feeding on the internal tissues of its host. Depending on the ichneumonid species, the parasitized prey may either be paralyzed during egg laying and stop development or continue to develop while harbouring the parasite larva. The most common prey are the larvae or pupae of Lepidoptera and Coleoptera. Following its development inside its host, the Ichneumonidae larva forms its pupa, from which the adult emerges. Adult Ichneumonidae feed on nectar **(Fig. 70)**, sap and sometimes small arthropods.

Goulet

Chalcidoidea (superfamily)

Chalcidoidea are a superfamily of parasitoids. Three important families for natural control of vineyard pests are Aphelinidae, Encyrtidae and Trichogrammatidae. A few species of these families are hyperparasites. Adult Chalcidoidea are tiny, rarely more than 5 mm in length. They are dark-coloured, typically black or brown, with a metallic blue or green sheen. They have very reduced wing venation. There is a bend in the antennae between the scape and the pedicel.

Aphelinidae

Adult Aphelinidae measure 0.6 to 2 mm in length and vary in colour from pale yellow to dark chestnut brown, rarely with a metallic lustre. The eyes are separated, and the antennae have three to nine segments. The great majority of Aphelinidae are ecto- or endo-parasitoids of mealybugs, aphids, whiteflies, eggs of Lepidoptera and all stages of Diptera. Some species are hyperparasitoids. Reproduction by parthenogenesis is frequent in the species of this family. Females lay 200 to 500 eggs.

Encyrtidae

Depending on the species, adult Encyrtidae measure 0.5 to 3.5 mm in length, with the average generally being 1 mm. The adults have a short, flattened body. They are yellow, orange, red or brown in colour with a metallic sheen. The antennae have 5 to 13 segments in the female. The eggs are tubular and often polyembryonic, and females lay 100 to 200 eggs. Depending on the species, the complete cycle is 5 to 50 days. The majority of Encyrtidae are solitary endoparasitoids of Hemiptera, mainly *Lecanium* spp. and mealybugs. A few species parasitize the eggs, larvae or nymphs of gall midges, chrysomelids (including flea beetles) and lepidopterans.

Trichogrammatidae

Trichogrammatidae are primarily oophagous parasitoids of Lepidoptera. Adult Trichogrammatidae measure 0.3 to 1.2 mm in length and range in colour from yellow to dark chestnut brown, with no metallic

sheen. The antennae of Trichogrammatidae have five to nine segments. The pronotum is very short. The wings are feathery. Females lay 25 to 90 eggs, depending on the species. The larva develops inside the egg of the host insect and feeds on the embryo and yolk, allowing the larva to develop and metamorphose from nymph to adult. The number of generations of Trichogrammatidae is variable, depending on the region. Some species are sold commercially for biological control.

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Flowering strips and cover crops

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Over the last 20 years, a number of studies have demonstrated that natural enemies, particularly various families of the orders Hymenoptera and Diptera, are attracted to the flowers of a number of plant species. The plants most commonly used in those studies were from the family Asteraceae: shasta daisy (*Chrysanthemum maximum*), common yarrow (*Achillea millefolium*), brown-eyed Susan (*Rudbeckia* spp.), aster (*Aster tongolensis*) and goldenrod (*Solidago canadensis*); and from the family Apiaceae: wild carrot (*Daucus carota*). The objective is to provide flower resources on a continuous basis from stage **F 12** to stage **N 38** **(Fig. 71)**. These plants provide natural enemies with pollen and nectar in addition to serving as refuges in the fall and as overwintering sites. The minimum width of flower strips around vineyards **(Fig. 72)** should be 2 m. According to various studies, they can attract and disperse, on either side, natural enemies over a distance ranging from 50 to 100 m. Flower strips can be planted around the perimeter of the vineyard, in small islands at the end of rows **(Fig. 73)** or between rows **(Fig. 74)**. Flower strips must be maintained since they can be invasive.

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To make these flower strips more attractive to pest enemies, mixtures of flowering ground-cover plants **(Fig. 75)**, such as white clover (*Trifolium repens*), buckwheat (*Fagopyrum esculentum*) and brown mustard (*Brassica juncea*), can be sown between several rows of vines so as to have a continuous source of flowers, pollen and nectar. These plants are suggested because they have been used in experiments. However, if you identify the flowering plants naturally present in the habitat surrounding the vineyard, you can use them as resources to attract natural enemies. When planting a new block of vines, it is advisable to leave enough space in the layout plan to intersperse flower strips.

Annexes

Plate 5 – Phenological Stages of the Grapevine According to the Systems Baggiolini (letters) and Eichhorn-Lorenz (numbers). Plate modified after Carisse et al. (2006), used with permission.

A 01: Winter bud

B 03: Wooly bud

C 05: Bud swell

D 06: Green shoot

E 09: 2 to 3 leaves unfolded

F 12: Inflorescences clearly visible

G 15: Single flowers in compact groups

H 17: Flowers separating

I 23: Flowering

J 27: Fruit set

K 31: Berries pea-sized

L 33: Beginning of berry touch

M 35: Veraison

N 38: Berries ripe

Plate modified after Carisse et al. 2006, used with permission.

O 43: Leaf fall

McFadden-Smith (OMAFRA)

Table 2 – Presence of Arthropods According to the Phenological Stages of Grapevine (systems of Baggiolini (letters) and Eichhorn-Lorenz (numbers)).

PHENOLOGICAL STAGES	A 01 WINTER BUD	B 03 WOOLY BUD	C 05 BUD SWELL	D 06 GREEN SHOOT	E 09 2 TO 3 LEAVES UNFOLDED	F 12 INFLORES-CENCES VISIBLE
ACARI						
Grape erineum mite			F	F	F, E, IM	F, E, IM
European red mite	E	E	E	N	N	N
Two-spotted spider mite	A	A	A	A	A, E	N, E
COLEOPTERA						
Grape flea beetle		A	A	A, E	A, E	A, L
Lesser grape flea beetle		A	A	A, E	A, E	A, L
Grape rootworm				L, P	P	A
Redheaded flea beetle		P	A	A	A	L
Multicoloured Asian lady beetle		A	A	A	A	A
Grape cane girdler					A	A
Grape cane gallmaker					A	A
Black vine weevil	L, P, A	A	A	A	A	A
Rose chafer						
Japanese beetle				L	L, P	P
DIPTERA						
Grape tumid gallmaker				>20°C	A	L
Spotted wing drosophila		>10°C	A	A	A, L	A, L
HEMIPTERA						
Potato leafhopper					N, A	N, A
Leafhoppers					N, E	N, E
European fruit lecanium scale		F, IM	F, IM	F, IM	F, E	F, E
Cottony maple scale		F	F	F	F, E	F, E
Tarnished plant bug					A	A, E
Brown marmorated stink bug			A	A	A	A
Grape phylloxera				N	N, F	N, F, E
Grape mealybug		N, E	N, E	N	N	N
HYMENOPTERA						
Wasps, bees						
LEPIDOPTERA						
Grape leaffolder		P	A	A, E	A, E	L
Blotch leafminer						
Eight-spotted forester					A	A
Climbing cutworm		E	L	L	L	L
Grape plume moth			P	A	A, E	A, L
Grape root borer						
Grape berry moth						A
Serpentine leafminer (p. 63)						

A- Adult; **A2**- Adult second generation or more; **E**- Egg; **F**- Female adult; **IM**- Immature; **L**- Larvae; **L2**- Larvae second generation or more; **N**- Nymph; **P**- Pupae; **P2**- Pupae second generation or more; >10°C, >20°C: present when temperature is respectively greater than 10°C and 20°C; ?- Unknown.

White	Presence in or near the vineyard
Red	Risk of damage

Blue	Monitoring recommended
Yellow	Overwintering stage

G 15	H 17	I 23	J 27	K 31	L 33	M 35	N 38	O 43
FLOWERS IN COMPACT GROUPS	FLOWERS SEPARA-TING	FLOWERING	FRUIT SET	BERRIES PEA-SIZED	BEGINNING OF BERRY TOUCH	VERAISON	BERRIES RIPE	LEAF FALL
F, E, IM	F, E, IM	F, E, IM	F, E, IM	F, E, IM	F, E, IM	F, E, IM	F	F
A, N, E	A, N, E	A, N, E	A, N, E	A, N, E	A, N, E	A, N, E	A	E
N, E	N, A, E	N, A, E	N, A, E	N, A, E	N, A, E	N, A, E	N, A	A
A, L	A, L	L	L, P	P	P	P	P	P
A, L	A, L	L	L, P	P	P	P	P	P
A, L	A, L	A, L	A, L	A, L	A, L	L	L, P	L, P
L	L	L	A2	A2	A2	L2	L2	P
A, E	A, E	A, E, L	A, E, L	A, E, L, P	A, E, L, P	A, L, P	A	A
A, E	A, E	A, E	E, L	L, P	L, P	P, A	A	A
A	A, E	A, E	L	P	P	P, A	A	A
A	A	A	A, E	A, E	A, E, L	A, E, L	A, L	A, L
A	A	A	A	A, E	A, E	L	L	L
P	P	P, A	P, A	A, E	A, E	A, E	A, L	L
L	L	L	P	P	P	P	P	P
A, L	A, L	A, L	A, L	A, L	A, L	A, L	A, L	A
N, A	N, A	N, A	N, A	N, A	N, A	N, A	N, A	?
N, E	N, E	N, A, E	N, A, E	N, A, E	N, A, E	N, A, E	N, A, E	A
F, IM, E	F, IM, E	F, IM, E	F, IM	IM	IM	IM	IM	F, IM
F, E	F, E	F, N	N	IM	IM	IM	A	F
N, E	N	N	N	N	A, N	A, N	A	A
A	A, E	A, E	A, E, N	A, E, N	A2, N	A2	A2	A2
N, F, E	N, F, E	N, F, E	N, F, E	N, F, E	N, F, E	N, F, E	N, A	N, F
N	N, A	N, A	A, E	A, N, E	A, N, E	N, E	N	N, E
							A	A
L	L	L	L	P, L	A, L	A, L	P	P
A	A	A, E	L	L	L	L	P	?
A	E	L	L	L	L	L	P	P
L	L	L	L	P	P	A	A	E
A, L	A, L	A, L	L	L, P	P	P	P	P
	P, L	P, L	A, L	A, L	L	L	L	P, L
A, L	A, L	L, P	A2, L2	A2, L2	P2, A2, L3	A3, L3	L3	P3 **
			L	L	L	L	L	?

** In Quebec and the Atlantic provinces, 2-3 generations occur. In Southern Ontario, a fourth or sometimes a partial fifth generation of grape berry moth occur, depending on degree-days accumulated before stage **M 35.**

Glossary

Alate: Having wings; winged.

Antenna segments: Insect antennae are composed of several elements called segments or articles. The number of segments varies widely with insect families. The first segment, called the scape, is attached to the head.

Apterous: Pertaining to an insect that is wingless. These insects cannot fly.

Arthropod: In the context of this guide, term that encompasses insects, spiders and mites.

Bioindicator: A living species whose presence, absence, abundance or rarity provides an indication of the condition of a habitat.

Biotope: A portion of habitat that provides stable conditions for a set of species of arthropods or plants.

Bivoltine: Pertaining to a species that has two complete generations per year.

Cephalothorax: The head and thorax united as a single part, in certain arachnids

Cercus: (pl. cerci). Appendage located at the tip of the abdomen in certain insects, for example earwigs.

Chelicerae: Pincer-like appendages near the mouthparts in spiders and mites.

Cornicles: Structures at the tip of the abdomen of aphids.

Cosmopolitan: Describes a species that is found in all regions of the world.

Deutonymph: The second nymphal stage or instar of mites.

Diapause: A period of arrested development in an insect, generally occurring in the winter, which is triggered by specific abiotic conditions often related to temperature and photoperiod. Diapause may also occur when temperatures exceed optimum for development.

Ectoparasite: A parasite that lives on the outside of its host.

Elytra: The tough, hard forewings of a member of the order Coleoptera which protect the membranous hind wings. The elytra are raised during flight.

Endoparasite: A parasite that lives inside its host.

Endosymbiosis: Symbiotic association in which one organism (e.g., a virus), called the endosymbiont, lives within the cells of another organism (the host).

Entomofauna: All the insect species associated with a given habitat (e.g., the entomofauna of vineyards).

Entomology: The scientific study of insects.

Entomophilous: A plant that attracts insects through its nectar, pollen, scent and colours, in order to benefit from certain services provided by insects (e.g., pollination).

Erinea: Raised blisters on upper surface of grape leaves produced by grape erineum mite.

Exuvium: The cast-off outer skin of an arthropod after a moult.

Family: A taxonomic rank below the order and above the genus. Family names end in -idae.

Gall: A swelling of the tissues of a plant resulting from the attack of an arthropod.

Genus: A taxonomic rank between family and species.

Halteres: A pair of short projections in dipterous insects, consisting of modified hind wings, which help balance the insect in flight. Syn. balancers.

Head capsule: Hardened head cuticle of a larva.

Hemolymph: The circulating fluid or "blood" of arthropods. Some lady beetles (e.g., *Harmonia axyridis*) release hemolymph in response to a threat. Also spelled haemolymph.

Hibernation: The dormant state in which some organisms pass the winter.

Honeydew: A sweet, sticky substance secreted by some insects, including mealybugs and scales, from glands located near the tip of the abdomen.

Hyperparasite: A parasite whose host is itself a parasite.

Imago: An adult insect. Syn. adult.

Indigenous: Originating and occurring naturally in a specific habitat.

Inoculative release: In biological control, a release of natural enemies aimed at increasing populations of biological control agents (indigenous or exotic) so they can have a suppressive effect on the populations of a given pest.

Insect: An arthropod that has six legs in the adult stage.

Intraguild predation: Biological interaction in which one natural enemy attacks another natural enemy that consumes similar prey.

Inundative release: In biological control, a release of large numbers of natural enemies that have been mass reared in order to control a pest.

Larva: Larvae (plural) are immatures of holometabolous insects.

Mandibles: A pair of appendages near the mouth of certain arthropods which are used to grasp and chew prey or food.

Nectary: A flower organ that secretes nectar.

Neogallicola-radicicolae: In phylloxera, individuals emerged from the root form (radicicolae) that cause galls to leaves of vines.

Nomenclature: International system of rules for assigning scientific names to living organisms which is designed to ensure continuity and universality.

Nymph: The intermediate stage between egg and adult in insects that undergo partial metamorphosis (hemimetabolous) as well as in mites. Examples: 1) nymphs of the tarnished plant bug (*Lygus lineolaris* Miridae); 2) deutonymphs of the two-spotted spider mite (*Tetranychus urticae* Tetranychidae).

Ocellus: Simple eye used to detect light intensity and infrared radiation. Dipterans and hymenopterans typically have three ocelli arranged in a triangle.

Oophagous: Pertaining to an organism that feeds on eggs.

Order: Taxonomic rank below the class and above the family. Order names end in -a.

Ovipositor: The egg-laying apparatus located on the hind part of the abdomen of a female insect.

Parthenogenesis: Reproduction in which the egg develops without being fertilized. The female does not mate with a male and she produces a clone.

Pedicel: The second segment of the antennae**.**

Petiole: Constriction between the first and second abdominal segments which characterizes certain hymenopterans.

Pheromone: Volatile compound emitted by an insect, frequently females, to attract the males for reproductive purpose or for aggregation (e.g., multicoloured Asian lady beetle).

Phyllophagous: Pertaining to an organism that feeds on leaves.

Phytophagous: Pertaining to an organism that feeds on plants.

Pilosity: All the hairs on the body of an insect.

Polyembryonic: An egg that divides into a number of embryos.

Pronotum: The different segments of the thorax are fused. The pronotum refers to the entire dorsal part of the thorax.

Protonymph: In mites, the instar between larva and deutonymph.

Prosoma: Syn. cephalothorax.

Pubescence: Short, fine hairs on the body of an insect.

Pupa: The stage of development between larva and adult in insects that undergo complete metamorphosis (holometabolous). The pupa of a moth is generally contained in a silk case (cocoon).

Pupation: Process by which insect larvae transform into pupae.

Rostrum: Extension of the head of weevils with the mouthparts being found at its tip.

Scape: The basal segment of the antennae (i.e., the segment closest to the head).

Species: A population that is composed of living organisms capable of interbreeding, and that is genetically isolated from other species.

Spinneret: The silk-spinning organ of a spider, mites or an insect larva.

Teneral: In this state the insect is soft, and has not fully attained its mature colouring and hardness.

Tritonymph: Last immature stage in Anystidae (mites).

Vitellus: The nutritive material in the insect egg that provides energy reserves for the use of the embryo. Syn. yolk.

References

Bloesch, B. and O. Viret 2008. Stades phénologiques repères de la vigne. Revue Suisse de Viticulture, Arboriculture, Horticulture 40: 1-4.

Bolduc, E., C.M. Buddle, N. J. Bostanian and C. Vincent 2005. The Ground-Dwelling Spiders (Araneae) of two vineyards in Southern Quebec. Environmental Entomology 34: 635-645.

Bostanian, N. J., Vincent, C., H. Goulet, L. LeSage, J. Lasnier, J. Bellemare and Y. Mauffette 2003. The Arthropod Fauna of Quebec Vineyards, with particular reference to phytophagous species. Journal of Economic Entomology 96: 1221-1229.

Bostanian, N. J., C. Vincent and R. Isaacs (Eds.) 2012. Arthropod Management in Vineyards: Pests, Approaches, and Future Directions, Springer, Dordrecht, The Netherlands, 505 p.

Bouchard, P., L. Lesage, H. Goulet, N. J. Bostanian, C. Vincent, A. Zmudzinska et J. Lasnier 2005. Weevil (Coleoptera: Curculionoidea) diversity and abundance in Quebec vineyards. Annals of the Entomological Society of America 98: 565-574.

Carisse, O., R. Bacon, J. Lasnier and W. McFadden 2006. Identification Guide to the Major Diseases of Grapes. Agriculture and Agri-Food Canada, Ottawa, Catalog number. A52-74/2006E-PDF, 30 p.

Craig, B, R. Cheverie and S. Wood 2018. A guide to weed, insect and disease management in grapes in Nova Scotia. Perennia, Nova Scotia, 22p. http://www.perennia.ca/wp-content/uploads/2018/03/Grapes_2018.pdf

Daane, K. M., C. Vincent, R. Isaacs and C. Ioriatti 2018. Entomological Opportunities and Challenges of Sustainable Viticulture in a Global Market. Annual Review of Entomology 63: 193-214.

Frank, A., Rimerman & Co. LLP. 2017. The Economic Impact of the Wine and Grape Industry in Canada 2015. A Frank Rimerman & Co. LLP Report commissioned by the Canadian Vintners Association. 37p. http ://www.canadianvintners.com/wp-content/uploads/2017/03/Canada-Economic-Impact-Report-2015.pdf

Goulet, H., L. LeSage, N. J. Bostanian, C. Vincent and J. Lasnier 2004. Diversity and seasonal activity of ground beetles (Coleoptera: Carabidae) from two vineyards in southern Quebec. Annals of the Entomological Society of America 97: 1263-1272.

Lasnier, J., C. Vincent and C.-H. de Coussergues 2016. Évolution de la viticulture québécoise depuis trente ans. Phytoma No. 696: 37-40.

Lowery, T. 2014. Insect and mite pests of grapes. Chapter 5.3 *In* Best Practices Guide for Grapes for British Columbia Growers. 29 pp., BC Wine Grape Council and BC Ministry of Agriculture and Land. Posted online, BC Wine Grape Council website (www.bcwgc.org).

MAPAQ 2018. Agriréseau Vigne et Vin. https://www.agrireseau.net/vigne-vin

Martinson T. E., C. J. Hoffman, T. J. Dennehy, J. S. Kamas and T. Weigle 1991. Risk Assessment of Grape Berry Moth and Guidelines for Management of the Eastern Grape Leafhopper. New York's Food and Life Science Bulletin 138, New York State Agricultural Experiment Station, Geneva, NY, 10 p.https://ecommons.cornell.edu/bitstream/handle/1813/5202/FLS-138.pdf;jsessionid=19F7DBD53D00A-37F1E992EFBE63CB8B2?sequence=1 (Acessed January 2018)

OMAFRA 2018. Ontario GrapeIPM http://www.omafra.gov.on.ca/IPM/english/grapes/index.html

Saguez, J., C. Olivier, J. Lasnier, A. Hamilton, L. Stobbs and C. Vincent 2015. Biology and integrated management of leafhoppers and phytoplasma diseases in vineyards of Eastern Canada. Technical Bulletin A59-32/2015E-PDF, Agriculture and Agri-Food Canada, 67 p.

Saguez. J., C. Olivier, A. Hamilton, T. Lowery, L. Stobbs, J. Lasnier, B. Galka, X. Chen, Y. Mauffette and C. Vincent 2014. Diversity and abundance of leafhoppers (Hemiptera: Cicadellidae) in Canadian vineyards. Journal of Insect Science 14.73 (open access, http://dx.doi.org/10.1093/jis/14.1.73)

Vincent, C., J. Lasnier and N. J. Bostanian 2002 (Eds.). La viticulture au Québec, Vol. 1, Technical Bulletin, 42 p. Downloadable from: http://eduportfolio.org/6644

Vincent, C. and J. Lasnier 2016. Les arthropodes des vignobles québécois. Phytoma No. 697: 45-48.

Vincent, C., N. J. Bostanian and J. Lasnier (Eds.) 2005. La viticulture au Québec. Vol. 2, Technical Bulletin, 53p. Downloadable from: http://eduportfolio.org/6644

Vincent, C., N. J. Bostanian, C. Buddle, H. Goulet and J. Lasnier 2016. Les ennemis naturels des arthropodes des vignobles du Québec. Antennae 23(2): 10-13.

Vincent, C., N. J. Bostanian and J. Lasnier 2009. Biodiversity and management of arthropods in cool-climate vineyards. pp. 189-199 *in* 2nd International Conference on Northern Viticulture, Saint-Hyacinthe, Qc, Canada, 9-11 November 2009, 208 p. Downloadable from: http://eduportfolio.org/6644