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Short communication

First record of blueberry maggot in Lac Saint-Jean, Quebec

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Abstract

Up to 2017, the Lac Saint-Jean region (Quebec, Canada) produced lowbush blueberries (*Vaccinium angustifolium* Aiton) without insecticide treatments. In 2018, the Canadian Food Inspection Agency detected adults of the blueberry maggot (*Rhagoletis mendax* Tephritidae) in the Regional County Municipality (RCM) of Maria-Chapdelaine. Monitoring programs of adults and larvae conducted in 2019, 2020, and 2021 confirmed the establishment of *R. mendax* in the RCM of Maria-Chapdelaine, as well as in the RCM Domaine-du-Roy. In compliance with Directive D-02-04 of the Canadian Food Inspection Agency, blueberry growers of infested areas of Lac Saint-Jean that ship blueberries to noninfested areas must implement an integrated pest management program or a calendar spray program.

Key words: blueberry maggot, *Rhagoletis mendax*, distribution, lowbush blueberry, *Vaccinium angustifolium*

Résumé

Jusqu'en 2017, la région du Lac Saint-Jean (Québec, Canada) produisait des bleuets nains (*Vaccinium angustifolium* Aiton) sans traitements insecticides. En 2018, l'Agence canadienne d'inspection des aliments a détecté des adultes de la mouche du bleuet (*Rhagoletis mendax* Tephritidae) dans la municipalité régionale de comté (MRC) de Maria-Chapdelaine. Des programmes de dépistage d'adultes et de larves effectués en 2019, 2020 et 2021 ont confirmé l'établissement de *R. mendax* dans la MRC de Maria-Chapdelaine, ainis que dans la MRC du Domaine-du-Roy. En conformité avec la Directive D-02–04 de l'Agence canadienne d'inspection des aliments, les producteurs des zones infestées qui livrent des bleuets à des zones non-infestées doivent mettre en œuvre un programme de lutte intégrée ou effectuer des traitements insecticides sur une base de calendrier.

Mots-clés : mouche du bleuet, *Rhagoletis mendax*, bleuetier sauvage, Lac Saint-Jean, *Vaccinium angustifolium*

Introduction

Lowbush blueberries (*Vaccinium angustifolium* Aiton) are typically grown in semiwild systems, using slash and burn techniques traditionally used by indigenous people (Agrinova et al. 2013). Harvested from wild populations across eastern North America, the regions of major commercial production are located in USA in Maine, and in Canada, in Nova Scotia, New Brunswick, Prince Edward Island, and the region of Lac Saint-Jean in Quebec. They are mostly valued in the processed market (Agriculture and Agri-Food Canada 2021).

Native to North America, the blueberry maggot (*Rhagoletis mendax* Curran) (Diptera: Tephritidae) is an insect that feeds on the fruit of a number of wild (Smith et al. 2001) and cultivated (Rodriguez-Saona et al. 2015) ericaceous plants. Based on reviews by Neilson and Wood (1985), Geddes et al. (1987), and Rodriguez-Saona et al. (2015), a summary of its biology and management related to blueberry protection follows.

Blueberry maggot females lay their eggs, most often singly, in developing berries. Larvae feed on internal tissues and attacked berries fall on the ground, often prematurely. Last instar larvae enter the soil where they mostly (99.9%) pupate in the first 6.35 cm and where they undergo an obligatory diapause to overwinter, usually for 1 year. The blueberry maggot is univoltine. Management is generally achieved by treating adults with insecticides before eggs are laid in berries.

For a long time, blueberry growers believed that overwintering conditions and host plants were factors limiting the establishment of *R. mendax* in the Lac Saint-Jean area. The supercooling point of overwintering pupae collected in southern Quebec and Nova Scotia averaged −22.6 °C (Vincent et al. 2016). Due to snow cover, the lowest temperatures determined at 3 cm depth in the soil were rarely lower than −12.0 °C while air temperatures hovered around −20.0 °C in several localities of Quebec (Vincent et al. 2016). It is concluded that winter temperatures are not a limiting mortality factor. Adults emerge the following year from late June to early July.

In Michigan, Smith et al. (2001) demonstrated that several wild plants can be suitable hosts for the blueberry maggot. Blueberry maggot adults emerged from *Vaccinium corymbosum*

L., *Vaccinium angustifolium* Aiton, and *Gaylussacia baccata* (Wangenheim) K. Koch fruits collected in the region of Montérégie, Quebec, indicating that these plants are suitable for larval development (Vincent et al. 2016). In Canada, Directive D-02-04 of the CFIA(2020*c*) states that all *Vaccinium* spp. and *Gaylussacia* spp., except *Vaccinium macrocarpon* Aiton and *Vaccinium oxycoccos* L., are regulated for *R. mendax*, including lowbush blueberry (*V. angustifolium*, including *V. pennsylvanicum* Lam.), sourtop blueberry (*V. myrtilloides* Michaux, including *V. canadense* Richards), highbush blueberry (*V. corymbosum*, including *V. ashei* Rehder and *V. atrococcum* (A. Gray) Heller, small cranberry (*V. oxycoccus*), deerberry (*V. stamineum* L.), lingonberry (*V. vitis-idaea* L.), black huckleberry (*G. baccata* (Wangenheim) K. Koch), dangleberry (*G. frondosa* (L.) Torr. & A. Gray), dwarf huckleberry (*G. dumosa*) (Andersson) Torrey & Gray, and hillside blueberry (*V. pallidum* Aiton, including *V. vacillans Kalm ex Torr.*). As several of these species are present in the Lac Saint-Jean area, plant hosts are not a limiting factor.

Until the mid-1990s, the Canadian distribution of the blueberry maggot was restricted to Nova Scotia, Prince Edward Island, and New Brunswick (Guibord et al. 1985; Vincent and Lareau 1989). The insect was first noted in southern Quebec in 1996 and in southern Ontario in 1999 (CFIA 2020*a*). Over the years, the blueberry maggot steadily extended its geographical distribution northward in Quebec and Ontario (CFIA 2020*a*). As the distribution of *R. mendax* progressed, the boundaries of the regulated areas were redefined accordingly. Implemented on regional county municipality (RCM; i.e., an area that may comprise several municipalities) as a defined administrative area in Quebec, these changes were based on monitoring *R. mendax* associated with highbush blueberry (*V. corymbosum*) plants that are typically cultivated south of the St. Lawrence River (CFIA 2020*a*). As of 2017, the blueberry maggot was absent from the Lac Saint-Jean region, where most (ca. 85% of the managed area) Quebec lowbush blueberries were produced without insecticide treatment (Ministère de l'Agriculture, des Pêcheries et de l'Alimentation 2011).

In 2018, *R. mendax* was detected for the first time in the Lac Saint-Jean area in the RCM of Maria-Chapdelaine (CFIA 2019). The industry was formally notified of the finding (CFIA 2020*b*). We here document the change in the distribution of the blueberry maggot that occurred from 2018 to 2021 in the Lac Saint-Jean region.

Materials and methods

In the context of a systematic surveillance program, the Canadian Food and Inspection Agency (CFIA) deployed traps to detect adults in the Lac Saint-Jean region from 1996 to 2019. The procedures were adapted from section 6.2 of CFIA (2020*c*). Briefly, yellow sticky traps baited with ammonium acetate (i.e., Pherocon AM® traps, Trécé Inc., Adair, Oklahoma, USA, 74330-2817) were placed evenly inside the perimeter of the managed area within 8 m of the edge, with their V shape facing down. They were placed at least 2 weeks before the expected emergence of adults and checked and changed every month for adult captures until the end of harvest. In 2019, CFIA increased monitoring efforts to 39 sites (belonging to nine municipalities) on all the Lac Saint-Jean region, including 25 sites in the RCM Maria-Chapdelaine. In 2020, the region of Lac Saint-Jean was regulated (CFIA 2020*a*), while the regions of Côte-Nord, l'Abitibi, and La Tuque are still nonregulated as of 2021. CFIA withdrew from monitoring *R. mendax* in 2020 and was replaced by the Ministère de l'Agriculture, des Pêcheries et de l'Alimentation du Québec (MAPAQ) who monitored 30 sites chosen as % of area of all farmland in the Lac Saint-Jean region (Table 2). In 2021, MAPAQ pursued monitoring activities in all lowbush-producing municipalities. A total of 662 traps were deployed in 40 lowbush blueberry farms. Two weeks after the first capture of adults, detection of larvae berries was done with brown sugar test as described in section 6.3.1 of CFIA (2020*c*).

Results and discussion

In 2016 and 2017, monitoring of *R. mendax* adults in 14 municipalities of RCM Lac-Saint-Jean-Est, Maria-Chapdelaine, and Fjord-du-Saguenay (i.e., ca. 33% of the territory) yielded negative results (Table 1).

In 2018, five adults were captured in a blueberry field in the RCM Maria-Chapdelaine but no larvae were found. The criteria requiring regulation by CFIA in a given area are >2 captured adults or the presence of larvae. The capture of one adult near a berry-freezing facility did not require regulation. As only one site was found positive and regulated in 2018, an eradication strategy was implemented by MAPAQ and stakeholders in 2019. The elements of this strategy were as follows: (*i*) starting on 30 June 2019, biweekly monitoring of adults; (*ii*) starting on 10 July 2019, systematic insecticidal treatments of sprout blueberry fields every 10–12 days (those fields that produced fruit in 2018 were mowed and burned in fall 2018 and were treated with registered insecticides in 2019 while they were nonproducing because they were in their vegetative stage); (*iii*) as in New Brunswick, insecticidal sprays of fields in production was done 5 days after the first capture of adults and every 7–10 days until harvest in sites where adults were captured; (*iv*) harvest the fruit as early as possible; and (*v*) at the grower's initiative, the field where flies were captured was burned.

In 2019, adult *R. mendax* were captured at nine sites at RCM Maria-Chapdelaine, including sites near adjacent RCMs, and at one site in RCM Domaine-du-Roy. Following a first adult capture on 26 July 2019, an insecticidal treatment was done on 1 August 2019. Insecticidal treatments were done on 7, 10, and 24 August 2019 near the traps where adults were captured. Subsequently, capture levels were <1–2 adults per week. No larvae were found in fruits.

Five (out of 30) sites were positive, four in RCM Maria-Chapdelaine and one in RCM Domaine-du-Roy. Out of these five sites, three had only one capture of an adult for the whole season. The fourth and fifth sites had 10 and 493 adults captured, respectively, for the whole season. Larvae were found only in the fifth site located in Dolbeau-Mistassini. The first captures done in the least infested site occurred in late July 2020, while at the most infested site (i.e., 5), the first capture occurred on 10 July 2020. No insecticidal treatment was done in 2020 in these sites.

Table 1. Results of monitoring of adults and larvae of *Rhagoletis mendax* in Lac Saint-Jean from 2016 to 2021.

Locations	2016 (8, 201)*	2017 (6, 203)	2018 (5, 244)	2019 (9, 683)	2020 (22, 536)	2021 (22, 662)
RCM Maria-Chapdelaine	0-A; 0-L†	0-A; 0-L	6-A; 0-L	100-A; 0-L	504-A; 27-L	644-A; 87-L
RCM Domaine-du-Roy	–‡	–	–	9-A; 0-L	1-A; 0-L	1-A; 0-L
RCM Lac-Saint-Jean-Est	0-A; 0-L	–	0-A; 0-L	0-A; 0-L	0-A; 0-L	0-A; 0-L
Ville de Saguenay	–	–	–	–	0-A; 0-L	0-A; 0-L
RCM Fjord-du-Saguenay	0-A; 0-L	–	–	0-A; 0-L	0-A; 0-L	0-A; 0-L

*(*X*, *Y*): in parentheses, *X* = number of municipalities monitored; *Y* = number of traps positioned.
†0-A: Total number of adults captured in the season. Here, 0 adult captured. 0-L: Number of larvae found in fruit. Here, 0 larva found.
‡–: no monitoring of adults or larvae.

Table 2. Locations where *Rhagoletis mendax* monitoring was done by the Ministère de l'Agriculture, des Pêcheries et de l'alimentation du Québec in 2020 and 2021.

Territories	Number of farms	Area of farms (ha)	Area of farmland (%)	Number of monitored sites
RCM Domaine-du-Roy	95	6180	20	6
RCM Maria-Chapdelaine	189	15 065	50	15
RCM Lac-Saint-Jean-Est	36	5516	18	5
Ville de Saguenay	6	277	1	0
RCM Fjord-du-Saguenay	14	3198	11	4
TOTAL	340	30 236	100	30

In 2021, 17 (out of 40) sites were positive. Out of these 17 sites, 10 had <10 adult captures per season. The most heavily infested sites were RCM Maria-Chapdelaine and RCM Domaine-du-Roy. In Dolbeau-Mistassini, insecticidal sprays were done in at least five farms. *R. mendax* adults were captured in Saint-Eugène d'Argentenay, Girardville, Albanel, Sainte-Jeanne-d'Arc, Dolbeau-Mistassini, Saint-Augustin, Saint-Méthode, and Péribonka. The first capture of adults occurred on 23 June 2021 while the berries were still green.

Since 2020, in compliance with Directive D-02-04 (CFIA 2020*c*), blueberry growers have applied biosecurity measures to impede the transport of *R. mendax* from infested to noninfested sites. These measures include thorough machinery and container cleaning. Posters were positioned in several blueberry-related enterprises to inform visitors about these biosecurity measures. Furthermore, the local industries involved in managing leaf residues have been under stringent biosecurity measures. It is no longer allowed to dispose of leaf residues (that can presumably involve soil contaminated with *R. mendax* pupae) in agricultural fields and the majority of these residues are processed in a cogeneration facility.

Conclusion

The absence of the blueberry maggot as well as the very low damage caused by any insect species allowed to produce insecticide-free blueberries in the Lac Saint-Jean region. This was a considerable advantage for the industry. The establishment of the blueberry maggot in some localities of the Lac Saint-Jean region is likely to impact protection programs. As a consequence, in compliance with Directive D-02-04 of CFIA (2020*c*), blueberry growers of infested areas of Lac Saint-Jean that ship blueberries to noninfested areas must now implement an integrated pest management program with insecticides or a calendar spray program. Noninfested areas of Lac Saint-Jean are now under phytosanitary scrutiny because they can harbour *R. mendax* populations.

The advent of another dipteran pest is likely to compound the problem caused by *R. mendax*. The spotted wing drosophila, *Drosophila suzukii* (Matsumura) (Diptera: Drosophilidae), a frugivorous pest able to develop on a much higher number of host plants and native to Asia, was reported in the Lac Saint-Jean region. Studies conducted in lowbush blueberries from 2016 to 2018 confirmed that *D. suzukii* is established in the Lac Saint-Jean region (Champagne-Cauchon et al. 2020). In some major blueberry-producing regions such as New Jersey and Michigan, this pest superseded *R. mendax* as the defining driver of entomological protection programs (Rodriguez-Saona et al. 2019). Both dipteran pests will be major entomological challenges for the Lac Saint-Jean blueberry industry.

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