

***PHYTOMYZA KRYGERI* HERING (DIPTERA:
AGROMYZIDAE), A NEW INVASIVE SPECIES FOR NORTH
AMERICA ON COLUMBINE**

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Abstract

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The European *Phytomyza krygeri* Hering (Diptera: Agromyzidae) is recorded for the first time in North America, with specimens collected in Ottawa, Ontario. Additional records represented by immature stages and characteristic larval feeding damage from Massachusetts and Wisconsin require confirmation. Ottawa adults have been observed on European columbine (*Aquilegia vulgaris* L. [Ranunculaceae]), mostly on flowers where oviposition occurs, and larvae and puparia have been recovered from seed pods in which the larvae feed on seeds.

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Introduction

Over 450 species of Agromyzidae are recorded as occurring in Canada (Spencer 1969; Spencer & Steyskal 1986; Zlobin 1996; Boucher & Wheeler 2001; Boucher 2002, 2003, 2004, 2009, 2012a, 2012b; Lonsdale 2017), with nearly 40% of these belonging to *Phytomyza* Fallén, the most diverse genus of Agromyzidae. The actual number of species in this genus is much higher, however, with many undescribed species known to the author. A revision of this immense genus in Canada is under development, but advance publication of distributional records for one species in particular is here deemed necessary because it is both invasive and occurring on a commercially available ornamental plant: *Phytomyza krygeri* Hering, a seed-feeder on the introduced European columbine (Ranunculaceae: *Aquilegia vulgaris* L.), is here recorded for the first time in North America.

In the spring of 2015, the author noticed adults of an unknown species of Agromyzidae on cultivated European columbine at his home in Ottawa, Ontario. These adults were immediately collected as they differed strikingly in colour and size compared to other local Agromyzidae on this host. They aggregated and oviposited not on the leaves, but on the flowers, which are held quite high above the leafy base. Larvae and puparia were subsequently located in infested plants in the Ornamental Gardens at the nearby Central Experimental Farm. Specimens continue to be found at both of these locations in 2017. The identity of this species as *Phytomyza krygeri* was established upon the dissection and ex-

amination of the phallus (Figs 9, 10; also see Spencer (1976: figs 763, 764)), which is highly diagnostic. Larvae and puparia were also located in the developing seed pods (Fig. 3); some were reared to adulthood and some were preserved in ethanol. This species is photographed, diagnosed and discussed, and the male genitalia illustrated.

The known European distribution of *Phytomyza krygeri* is England (Spencer 1972), Germany (Hering 1949), Denmark (Spencer 1973), the Netherlands, the Czech Republic, Poland (Martinez 2017), Slovakia (Straka 2005), Norway, Finland (Spencer 1976) and Sweden (Spencer 1992). Confirmed Nearctic records are restricted to Ottawa, Ontario, although additional records requiring validation includes feeding damage and immatures of what is likely to be *P. krygeri* in Northfield, Massachusetts (C.S. Eiseman pers. comm.), and in Wisconsin at Battle Bluff Prairie State Natural Area, Vernon County (Linden 2017).

Since its host plant is widely cultivated as an ornamental, it likely entered North America via the nursery trade. Ornamental industry sales represent the largest horticultural sector in Canada, with sales of \$2.02 billion in 2015 and the production of 11.7 million outdoor perennial plants domestically (Agriculture and Agri-Food Canada 2016). Global imports of live trees and plants, including roots and mushroom spawn into Canada is also immense, totalling nearly \$178 million in 2017 (Statistics Canada 2017). With this volume of plant products being imported and circulated within Canada each year, it is not a question of whether non-native species will be introduced, but how frequently they will arrive, establish and spread.

Other recent invasive Agromyzidae in North America include the Palaearctic *Phytomyza petoei* Hering, reported by Boucher (2009) on cultivated *Mentha* L. (Lamiaceae, likely peppermint) in Montreal. The Palaearctic *P. gymnostoma* Loew, a pest on *Allium* L., has been detected on leeks in Pennsylvania (Pennsylvania Department of Agriculture, 2017). *Ophiomyia kwansonis* Sasakawa is a leaf miner on the ornamental daylily (*Heemerocallis* L. [Hemerocallidaceae]) that was accidentally imported from east Asia to the United States via commercial trading prior to 2008, and is likely now distributed throughout the lower 48 states (Williams and Steck 2014); it is expected to eventually invade Canada.

Materials and Methods

Adults, larvae and puparia were all collected into 95% ethanol, with adults subsequently moved to a 100% ethanol bath and critical point dried, followed by gluing on pinned paper points. Abdomens were prepared by maceration in hot Lactic Acid followed by washing in demineralized water; dissected abdomens are stored in glycerine in genitalia vials pinned with the specimen. Genitalia were illustrated on a slide in glycerine using a camera lucida attached to a Nikon Optiphot. Larvae and puparia were reared in Petri dishes with a moist paper towel; puparia were overwintered in a fridge for five months. All material is deposited in the Canadian National Collection of Insects, Arachnids & Nematodes (CNC). Terminology follows Lonsdale (2017). Illustrated structures are shown proportionately in size to each other, except for the epandrium, which is reduced.



FIGURES 1–4. *Phytomyza krygeri*, adult male: 1, dorsal; 2, left lateral. 3, Seed pod of *Aquilegia vulgaris* L., opened, with brown damaged seeds to left and *P. krygeri* puparium (dark brown) and larva (yellow, recovered from separate pod) to right. 4, Examples of seed pods affected by feeding of *P. krygeri* larvae, with unaffected sample at far right.

Material Examined

CANADA. Ontario: Ottawa, 695 Malibu Tr., 45°22'16.29"N 75°42'57"W, O. Lonsdale, adults on *Aquilegia*, 23.v.2015, CNC422989-422996 (5♂ 3♀), 10.v.2016, CNC586948-586952 (5♂), 27.vii.2017, CNC799449-799452 (1♂ 3♀), ex seed pod *Aquilegia*, 30.iv.2015, CNC457768 (6 larvae + puparia), ex seed pod *Aquilegia*, 30.vi.2015, em. 4-7.iii.2016, CNC507014-507046 (16♂ 17♀), ex seed pod *Aquilegia*, 20.vi.2017, CNC799655 (6 larvae + puparia), Ottawa, Central Experimental Farm, Ornamental Gardens, 45°23'21"N, 75°42'28"W, O. Lonsdale, ex seed pod *Aquilegia*, 30.iv.2015, CNC457769 (11 larvae + puparia), ex seed pod *Aquilegia*, 2.vii.2015, em. 4-7.iii.2016, CNC507006-507013 (6♂ 2♀).

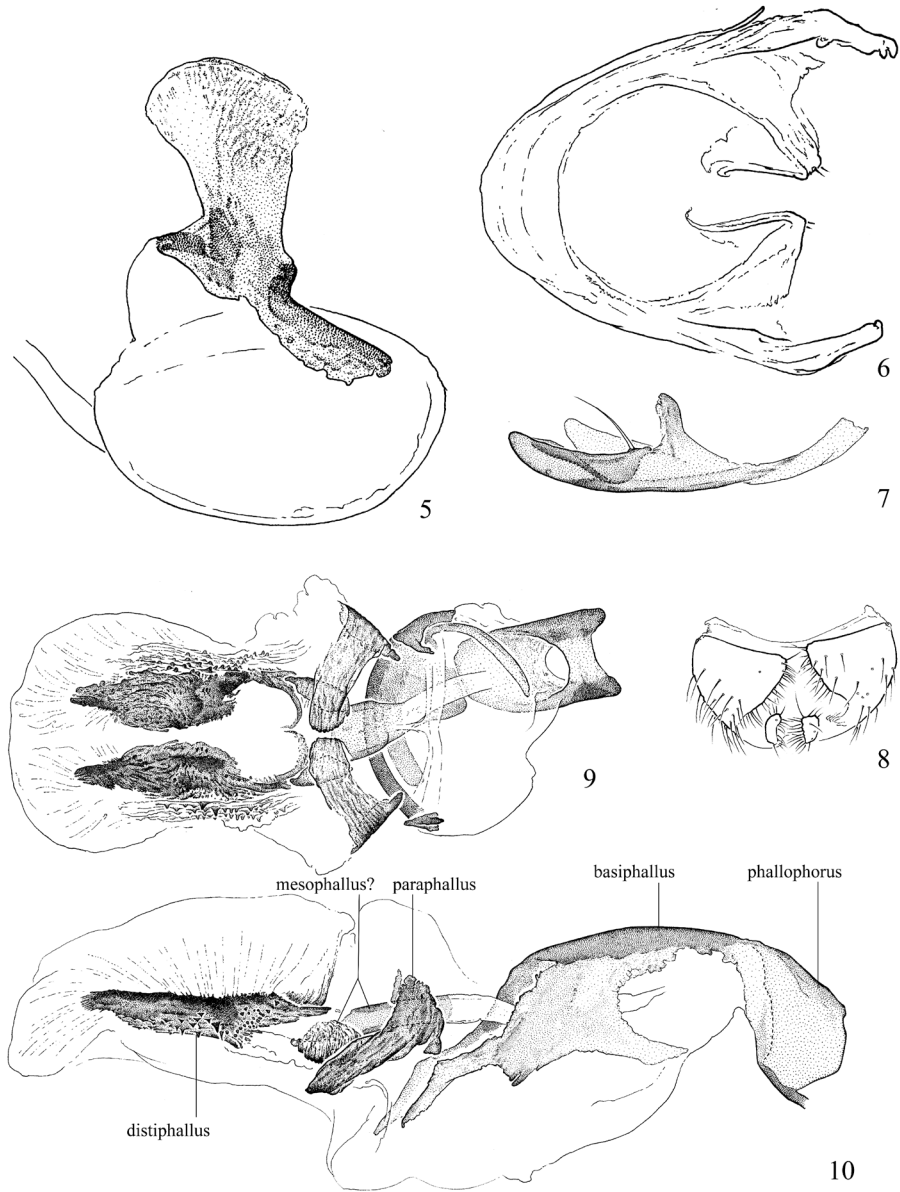
Species Diagnosis

The adult (Figs 1, 2) is predominantly dark brown to black with a slight greyish pruinosity that is denser on the dorsum of the thorax. The halter, the membrane between the sclerites, the apices of the femora, and most of the head are contrastingly yellowish-white to light yellow; the scape and pedicel are brownish, the first flagellomere and large ocellar spot are black, the back of the head is similarly dark, and the orbital plate is partially dark brownish-black posteriorly with dark spots at the base of the fronto-orbitals; the acrostichal setulae are very scattered and usually in approximately four rows at the level of the transverse suture, although there sometimes are as few as three or two; wing length is 2.2–3.0 mm. Typical of *Phytomyza*, *P. krygeri* also has the costa extending to vein R_{4+5} and the orbital setulae are proclinate (some erect), and like most other *Phytomyza*, cross-vein dm-cu is absent and the radial veins are inserted more basally on the costa.

Confident diagnosis of the species is best made via examination of the highly atypical male genitalia (Figs 5–10); while larger and greyer than other species on columbine, verification of genitalic structures is always recommended, especially to eliminate the possibility of misdiagnosis of other incidental *Phytomyza*. The plates of the basiphallus are wide, broadly fused dorsobasally, and apically extend as one pair of narrow, chevron-shaped processes. The paraphalli are wide, dark and striated. The homology of the apical components of the phallus are uncertain due to their highly derived appearance, but the mesophallus appears to form a pigmented and slightly widened apical section of the ejaculatory duct with one pair of striated dome-like accessory sclerites, and the distiphallus appears to be a heavily striated and minutely spinulose bifid plate with a large membranous dorsal fringe. The ejaculatory apodeme is small with a large, clear sperm sac.

Discussion

Phytomyza krygeri was described by E.M. Hering (1949) from 32 specimens, including one male and one female, each of which were treated as a “Type” (=syntypes); 30 specimens of unspecified sex were designated as paratypes, one examined female of



FIGURES 5–10. *Phytomyza krygeri*, male genitalia: 5, ejaculatory apodeme; 6, hypandrium, ventral; 7, postgonite, left lateral; 8, external components, ventral; 9, phallus, ventral; 10, phallus, left lateral.

which (ex "*Aquilegia*") is deposited in the CNC. The specimens were reared by J.P. Kryger from *Aquilegia* L. in Thoreby, Denmark, which on at least one specimen label is clarified as being the species *Aquilegia vulgaris* (Siedlar 1996). Specimens emerged from puparia from 10–13.iii.1948.

So far, this fly has only been reared from two cultivars of *Aquilegia vulgaris*, a perennial species in the family Ranunculaceae. The plant was introduced to North America as an ornamental and now occurs throughout much of Canada from Manitoba to Newfoundland and Labrador, and in much of the eastern United States including Iowa, Wisconsin, Illinois and Georgia, but also in the state of Washington (United States Department of Agriculture Natural Resources Conservation Service 2017). Host plants in Ottawa have not been found near native species of *Aquilegia*, which so far are not known to be attacked, but the fly's affinity for other host species should be more closely examined to discover its potential for spread to the native Nearctic flora. Until then, the fly's potential for damage in introduced regions can only be speculated upon.

Aquilegia species are mostly attacked by leaf-miners aside from the seed-feeding *Phytomyza krygeri*, the root-mining (and possibly stem-mining) *P. aquilegiophaga* Spencer [Canada] and the external stem-mining *Ophiomyia aquilegiana* Lundqvist [Europe]. These leaf-miners include the polyphagous *Liriomyza sativae* Blanchard [widespread] (Martinez 1993) and seven other *Phytomyza* species; of the *Phytomyza* species, *P. aquilegiana* Frost, *P. aquilegioides* Sehgal, *P. aquilegiovora* Spencer, *P. columbinae* Sehgal and *P. sonorensis* Spencer are Nearctic, *P. aquilegiae* Hardy is European and *P. minuscula* Goureau (Spencer 1990) is Holarctic. Spencer (1990) suggested that these species (possibly referring to all *Aquilegia*-feeding *Phytomyza*) belonged to a single species group, but this will likely not stand up to scrutiny based on an overview of the male genitalia, even when the root-, stem- and seed-feeding species are excluded.

Spencer (1973, 1990) noted a similar species feeding in seed heads of columbine meadow-rue (*Thalictrum aquilegifolium* L. [Ranunculaceae]) in Switzerland, *Phytomyza thalictri* Escher- Kündig, which is very similar in genitalic morphology (Spencer, 1990: figs 189, 190) and the likely sister-species to *P. krygeri*. This host plant occurs in the Nearctic in Ontario and New York as an introduced species (United States Department of Agriculture Natural Resources Conservation Service 2017). There are also obvious similarities in morphology to *P. delphinivora* Spencer (Spencer 1990: figs 56, 57), which is known from Canadian *Delphinium* L. (Ranunculaceae).

In Ottawa, adult *Phytomyza krygeri* are seen in the spring on developing and fully formed flower-heads, which are suspended on long stalks above the rest of the leafy plant body. Specimens rest and fly around the flower heads and sometimes the stem and lower leafier parts; copulation occurs on the flower, and they return to the plant within one or two minutes if disturbed. Minute female feeding punctures made by the ovipositor may be seen on the petals, which grow and distort as the petals grow. Additional feeding punctures were sometimes seen on the leaves, but these may be attributable to *P. aquilegiovora* Spencer, which was found leaf-mining on the same plant.

The larva (Fig. 3) is bright yellow, very motile, and described in detail morphologically by Dempewolf (2001). Formation of puparia (Fig. 3) is completed by the end of June, with no more than one puparium forming within a pod (the larva in Fig. 3 was taken

from a second pod and did not develop alongside the puparium shown). The larva may not be restricted to a single pod, however, as suggested by the presence of a large hole at the inner base of the pod that is about as wide as the larva and positioned opposite a similar hole in an adjacent pod. The puparium is small, subshining and dark brown, almost black; it is similar in size and appearance to the remains of the slightly paler brown seeds (Fig. 3) fed upon by the larva. These are in contrast to the untouched seeds, which are larger, fuller and shinier, with a hue that is bright green in the young seed and deep black in the mature seed. Adults emerged from puparia in early March after overwintering.

The affected seed pods are less robust than those unaffected, being distorted and discoloured from light to dark brown (Fig. 4). Seed pods affected early in development are more severely stunted and reduced in size. Damage to the host plant is less conspicuous than that of a leaf-miner and easily overlooked, although as a cultivated ornamental this may still cause impact on aesthetic value and subsequently commercial value. Furthermore, because the seeds are fed upon, larval damage reduces the reproductive potential of the plant.

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References

- Agriculture & Agri-Food Canada. 2016. *Statistical Overview of the Canadian Ornamental Industry 2015*. Market Analysis and Information Section, Horticulture and Cross Sectoral Division, Agriculture and Agri-Food Canada. 35 pp. [online].
www.agr.gc.ca/resources/prod/doc/pdf/OrnaRep_2015-eng.pdf [accessed June 2017]
- Boucher, S. 2002. Revision of Nearctic species of *Cerodontha* (*Cerodontha*) (Diptera: Agromyzidae). *The Canadian Entomologist* **134**(5): 577–603.
doi: 10.4039/Ent134577-5
- Boucher, S. 2003. The New World species of *Cerodontha* (*Xenophytomyza*) Frey (Diptera: Agromyzidae). *Zootaxa* **178**: 1–8. doi: 10.11646/zootaxa.178.1.1
- Boucher, S. 2004. The New World fauna of the genus *Pseudonapomyza* (Diptera: Agromyzidae). *The Canadian Entomologist* **136**(6): 781–791.
doi: 10.4039/n03-121
- Boucher, S. 2009. *Phytomyza petoei* (Diptera: Agromyzidae), a leaf miner on cultivated mint, newly recorded in the Nearctic Region. *The Canadian Entomologist* **141**: 126–128. doi: 10.4039/n08-064
- Boucher, S. 2012a. Revision of the Nearctic species of *Cerodontha* (*Icteromyza*) (Diptera: Agromyzidae). *The Canadian Entomologist* **133**: 122–157.
doi: 10.4039/tce.2012.12
- Boucher, S. 2012b. Revision of the Canadian species of *Amauromyza* Hendel (Diptera:

- Agromyzidae). *The Canadian Entomologist* **144**: 733–757.
doi: 10.4039/tce.2012.80
- Boucher, S. and Wheeler, T. 2001. Diversity of Agromyzidae (Diptera) in disjunct grasslands of the southern Yukon Territory. *The Canadian Entomologist* **133**(5): 593–621.
doi: 10.4039/Ent133593-5
- Dempewolf, M., 2001. *Larvalmorphologie und Phylogenie der Agromyzidae (Diptera)*. Ph.D. dissertation, University of Bielefeld, Bielefeld, Germany [online].
<http://bieson.ub.uni-bielefeld.de/volltexte/2003/162/>
- Hering, E. M. 1949. Neue palaearktische Agromyziden. *Notulae entomologicae* **29**: 18–32.
- Linden, J. van der. 2017. Agromyzid in developing columbine fruits - *Phytomyza*. Bug Guide. Iowa State University, Department of Entomology, Ames, Iowa [online].
<http://bugguide.net/node/view/1380475> [accessed June 2017]
- Lonsdale, O. 2017. The *Liriomyza* (Agromyzidae: Schizophora: Diptera) of Canada & Alaska. *Zootaxa* **4234**: 1–156. doi: 10.11646/zootaxa.4234.1.1
- Martinez, M. 1993. Liste des espèces de *Liriomyza* d'importance agronomique, leurs synonymes et leurs régions biogéographiques. Pp. 1–5 In *Liriomyza*": *Conference on leaf-mining flies in cultivated plants*. 24-25 et 26 mars 1993, Montpellier, France, Communications/Papers
- Martinez, M. 2017. Fauna Europaea: *Phytomyza krygeri* Hering, 1949 [online].
<http://www.fauna-eu.org>. [accessed June 2017]
- Pennsylvania Department of Agriculture. 2017. *Allium Leafminer* [online].
<http://www.agriculture.pa.gov/protect/plantindustry/pages/allium-leafminer.aspx> [accessed November 2017]
- Siedlar, E. 1996. The type material of family Agromyzidae [Diptera] in the Museum and Institute of Zoology PAS, Warsaw. *Bulletin of the Museum and Institute of Zoology PAS, Supplement to Annales zoologici* **1**: 101–124.
- Spencer, K.A. 1969. The Agromyzidae of Canada and Alaska. *Memoirs of the Entomological Society of Canada* **64**: 1–311.
- Spencer, K.A. 1972. *Handbooks for the Identification of British Insects*. Diptera, Agromyzidae. Royal Entomological Society, London.
- Spencer, K.A. 1973. Agromyzidae (Diptera) of economic importance. *Series entomologica*, **9**: xi + 418 pp. Dr. W. Junk B.V., The Hague.
- Spencer, K.A. 1976. The Agromyzidae (Diptera) of Fennoscandia and Denmark. *Fauna Entomologica Scandinavica*, **5**: 606 pp. Scandinavian Science Press, Ltd., Klampenborg, Denmark.
- Spencer, K.A. 1990. Host specialization in the world Agromyzidae (Diptera). *Series Entomologica*, **45**, xii + 444 pp. Kluwer Academic Publishers, continued as Springer Science + Business Media Netherlands.
- Spencer, K.A. 1992. *Flycatcher. Memoirs of an amateur entomologist*. xv + 414 pp.; SBP Academic Publishing, The Hague.
- Spencer, K.A. and Steyskal, G.C. 1986. Manual of the Agromyzidae (Diptera) of the United States. *USDA Agricultural Research Service Agriculture Handbook* **638**: 1–478.
- Statistics Canada. 2017. *Canadian International Merchandise Trade Database* [online].
<http://www5.statcan.gc.ca/cimt-cicm/home-accueil?lang=eng> [accessed June 2017]

- Straka, V. 2005. K poznaniu švábov (Blattaria), rovnokrídlovcov (Orthoptera), modliviek (Mantodea), a dvojkrídlovcov (Diptera) z Dielnic pri Kláštore pod Znievom [=Contribution to the knowledge of the Blattaria, Orthoptera, Mantodea and Diptera in Dielnice near Kláštor pod Znievom (Turčianska kotlina Basin, Central Slovakia)]. - *Kmetianum: Zborník Slovenského Národného Múzea v Martine* (= *Jahrbuch des slowakischen Nationalmuseums*) **10**: 191–197.
- United States Department of Agriculture Natural Resources Conservation Service. 2017. *The PLANTS Database*. National Plant Data Team, Greensboro, NC 27401-4901 USA [online]. <http://plants.usda.gov> [accessed June 2017]
- Williams, G.L. and Steck, G.J. 2014. *Ophiomyia kwansonis* Sasakawa (Diptera: Agromyzidae), the Daylily Leafminer, an Asian Species Recently Identified in the Continental United States. *Proceedings of the Entomological Society of Washington* **116(4)**: 421–428. doi: 10.4289/0013-8797.116.4.421
- Zlobin, V.V. 1996. The genus *Amauromyza* Hendel (Diptera, Agromyzidae): a clarification of species of the subgenus *Annimyzella* Spencer. *International Journal of Dipterological Research* **7(4)**: 271–280.