J. Acad. Entomol. Soc. 14: 4-7 (2018)

NOTE

First records of three parasitic wasps of diamondback moth (Lepidoptera: Plutellidae) in Prince Edward Island

C. Noronha and M.H. Bahar

Diamondback moth (DBM), *Plutella xylostella* L. (Lepidoptera: Plutellidae) is considered to be the most destructive insect pest of cruciferous crops globally, including canola, mustard and cole crops such as broccoli, cabbage, cauliflower and rutabaga (Furlong et al. 2013). Newly hatched DBM larvae mine and eat inside the leaf tissue. Larger larvae feed on the underside of the leaves making holes; in severe infestations complete defoliation can occur. DBM larvae also cause severe damage to flower buds, leaving up to 90% yield loss of oilseed crops (Verkerk and Wright 1996). Substantial acres of cruciferous crops including cabbage, cauliflower, rutabaga and brown mustard are grown on Prince Edward Island (PEI) providing a potential food source for several important cruciferous insect pests, including the DBM (Blatt et al. 2016). For instance, 25,000 acres of brown mustard (a cruciferous oil seed) were grown as a rotation crop prior to potatoes for wireworm control on the Island in 2015 (Agriculture and Fisheries PEI 2015). DBM is widespread in PEI with variable pest pressure (Pest Management Centre 2014). Currently, the use of chemical pesticide is the primary control measure for DBM but the ability of this pest to develop resistance to most insecticides has increased importance of biological control agents when developing integrated pest management strategies worldwide (Sarfraz et al. 2005). Biological control using parasitic wasps is an important IPM tool to control insect pests. However, the first step in this strategy is to determine the naturally occurring biocontrol agents and then find ways to enhance their efficacy (Shelton et al. 2002). Several larval parasitoids of DBM have been documented in other parts of Canada and USA (Strickland 1964; Godin and Boivin 1998; Sarfaz et al. 2010; Andrew Bennett, Canadian National Insect Collection (CNC), personal communication). However, despite the appearance of DBM as a damaging pest in PEI, there is no information available on the natural enemy assemblages of this pest. Therefore, the objective of this study was to determine the incidence of DBM larval parasitoids in PEI, Canada.

Second- to fourth-instar DBM larvae were collected from eight locations across PEI: Albany (46.256714°N, 63.561368°W), Crossroads (46.215611°N, 63.040072°W), Dundas (46.318870°N, 62.502160°W), Harrington (46.337360°N, 63.162359°W), North Wiltshire (46.298688°N, 63.332472°W), Souris (46.366691°N, 62.268842°W), Victoria (46.207409°N, 63.466924°W) and York (46.319637°N, 63.090568°W). At each site, larval samples were collected from eight locations and four different crops (mustard, cabbage, canola and rutabaga) during August and September in 2016. Starting 5 m from the edge of the field, each sample consisted of 10 walking sweeps using a standard 38 cm-diameter insect sweep net in the mustard and canola crops and hand-picking larvae from the leaves in the cabbage and rutabaga crops. Larvae were brought to the laboratory and placed in Petri dishes (9 cm) containing host plant leaf tissue on a moistened filter paper and incubated at 21°C with 75% RH until adult eclosion. The number of eclosing moths and wasps was recorded. All eclosed wasps were identified using general morphological features such as body shape, colour, wing venation, ovipositor, antennal segments, legs and abdomen. The identifications were confirmed by Dr. Jose Fernandez-Triana, National Identification Services, Canadian National Collection of Insects (Ottawa, Ontario). Voucher specimens have been deposited in the insect collection facility at Charlottetown Research and Development Centre, Agriculture and Agri-Food Canada, PEI and in the Canadian National Collection of Insects in Ottawa. The images of the wasps

Received 12 October 2017. Accepted for publication on 3 January 18. Published on the Acadian Entomological Society website at www.acadianes.ca/journal.php on 18 February 2018.

C. Noronha and M.H. Bahar: Agriculture and Agri-Food Canada, Charlottetown Research and Development Centre, 440 University Ave. Charlottetown, PEI, Canada, C1A 8K9

Corresponding author (email: christine.noronha@agr.gc.ca)

in Figure 1 were taken using an Olympus microscope mounted with a digital camera captured through the software infinity (Lumenera Corporation, ON, Canada). Difference in parasitoid species abundance was analysed using a one–way Anova in the statistical program R.

Overall parasitism ranged from 12.5 to 44.0% among sites across PEI (Table 1). Three hymenopteran parasitic wasps (*Diadegma insulare* (Cresson), *Microplitis plutellae* (Muesebeck) and *Cotesia* sp.) were found parasitizing DBM larvae. Among them, the abundance of *Microplitis plutellae* was significantly higher ($P = <0.001$, $F = 27.21$, $df = 28$) than the other two parasitoids at all eight locations.

Table 1. Adult eclosion, parasitism rates (%) and mortality (%) of diamondback moth larvae collected from eight locations in Prince Edward Island in 2016.

Location	Crop	DBM larvae reared	DBM adult emerged	Parasitism (%) *Diadegma insulare*	*Microplitis plutellae*	*Cotesia* sp.	Total parasitism	Unknown mortality (%)	Total DBM mortality (%)
Albany	Mustard	145	26	0.7	18.6	3.4	22.8	62.5	85.3
Crossroads	Cabbage	8	2	0.0	12.5	0.0	12.5	32.5	45.0
Dundas	Mustard	150	26	0.7	34.7	8.7	44.0	30.4	74.4
Harrington	Mustard	30	5	0.0	20.0	0.0	20.0	59.3	79.3
North Wiltshire	Rutabaga	40	16	5.0	17.5	5.0	27.5	60.7	88.2
Souris	Mustard	30	8	3.3	16.7	6.7	26.7	38.7	65.4
Victoria	Mustard	145	18	1.4	22.8	2.8	26.9	46.7	73.6
York	Rutabaga	23	11	8.7	8.7	4.3	21.7	63.3	85.0

Short descriptions of the parasitoids identified in this study

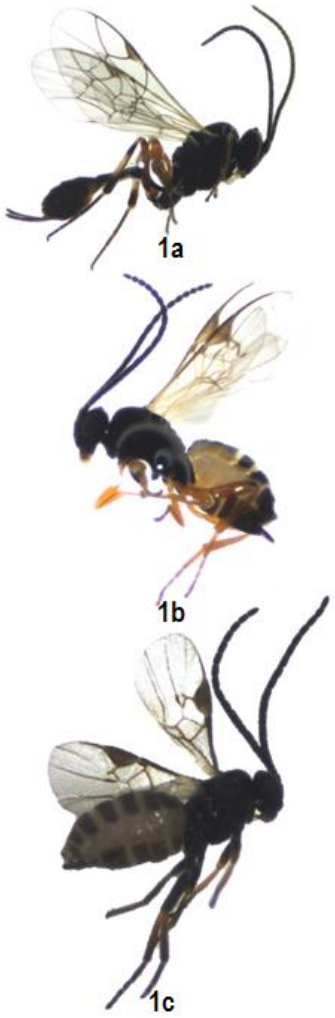
Diadegma insulare

Diadegma insulare (Cresson) (Hymenoptera: Ichneumonidae) is a solitary, host-specific larval endo-parasitoid of DBM and the most abundant biocontrol agent from the Nearctic to the Northern Neotropical regions (Sarfraz et al. 2005). The adult is 6 mm long, with reddish-brown legs and metasoma (Figure 1a). The adult lays a single egg in the host larva; it pupates inside the cocoon made by the mature DBM larva replacing the host pupal covering with its own cocoon (Grafius 1997). In North America it has been reported to account for 50 – 90% of DBM parasitism in the field (Monerat et al. 2002; Sarfaraz et al. 2005; Bahar et al. 2013). *Diadegma insulare* also parasitizes other lepidopteran pests, such as the cabbage webworm, *Hellula undalis* F. (Pyralidae) and *Plutella armoricae* (Busck) (Plutellidae) (Young 2013).

Cotesia sp.

Cotesia sp. (Hymenoptera: Braconidae: Microgastrinae) is a solitary larval parasitoid of DBM (Shi et al. 2002) and is about 2—3 mm long (Figure 1b). One significant difference between *Cotesia* sp. and *Microplitis plutellae* is that the forewing of *Cotesia* lacks an areolate. It is widely distributed throughout Asia, Africa, Europe, North America (Sarfraz et al. 2005). Although there is a range of hosts of *Cotesia* sp., it is predominantly viewed as a parasitoid of DBM (Hiroyoshi et al. 2017).

Figure 1. Parasitoid wasps of diamondback moth found in Prince Edward Island, Canada in 2016: *Diadegma insulare* (a), *Cotesia* sp. (b), and *Microplitis plutellae* (c).



Microplitis plutellae

Microplitis plutellae (Muesebeck) (Hymenoptera:

Braconidae) is a small (2—3 mm), brownish-black parasitic wasp with triangular areolate in the forewings (Figure 1c). The adult lays a single egg in the host larva, a mature parasitic larva emerges from the host and spins its own brown, oval cocoon. It has a widespread distribution in North America and is known to overwinter in western Canada where it is present early in the season to parasitize DBM larvae (Braun et al. 2002). In PEI, *Microplitis plutella* was by far the most dominant wasp species with percentage of parasitism being as high as 34.7% at one site. These high level of natural larval parasitism found in this survey suggest that *Microplitis plutella* can be an effective biocontrol agent in PEI.

This study reports the first recorded presence of three larval parasitoids of DBM in PEI, Canada. Conservation of these natural enemies would fit well into an IPM program for DBM. Our survey also revealed high DBM larval mortality due to unknown reasons. We speculate that this mortality may be due to: the failure of the parasitoid to develop and reach maturity; an insect pathogen; or, an insecticide application even though no insecticides were used in the mustard fields where high larval mortality was also found. Further investigation into these unknown reasons for mortality is required to determine their potential role in a DBM suppression strategy.

ACKNOWLEDGEMENT

The authors would like to thank Dr. José Fernandez-Triana and Owen Lonsdale, Canadian National Collection, Ottawa, ON for assistance with identification of wasp species. Thanks also to Andrew Ryan (PEI Horticulture Association), Natasha Boyle, and Samantha Gauthier for assisting in field collection of DBM larvae.

REFERENCES

Agriculture and Fisheries PEI. 2015. Agriculture on Prince Edward Island. Available from http://www.gov.pe.ca/agriculture/AgonPEI [accessed 18 November 2016].

Pest Management Centre. 2014. Crop profile of rutabaga in Canada, 2012. Agriculture and Agri-Food Canada. Pest Management Centre. Catalogue Number AAFC No. 12198E.

Bahar, M.H., Soroka, J., Dosdall, L.M., and Olfert, O. 2013. Occurrence of diamondback moth, *Plutella xylostella* (Lepidoptera: Plutellidae), and its larval parasitoids across Saskatchewan, Canada. Biocontrol Science and Technology **23**: 724-729.

Blatt, S., Ryan, A., Adams, S., Franklin, J., and Driscoll, J. 2016. Use of *Trichogramma* and Bt for control of *Pieris rapae* in cabbage on Prince Edward Island. Journal of Acadian Entomological Society **12**: 1-6.

Braun, L., Olfert, O., Soroka, J., Mason, M., and Dosdall, L.M. 2002. Diamondback Moth Biocontrol Activities in Canada. *In* The International Symposium on improving biocontrol of *Plutella xylostella*. *Edited by* A.A. Kirk, D. Bordet. CIRAD, Montpellier, France. pp. 144-146.

Furlong, M.J., Wright, D.J., and Dosdall, L.M. 2013. Diamondback moth ecology and management: problems, progress, and prospects. Annual Review of Entomology **58:** 517-541.

Godin, C., and Boivin, G. 1998. Lepidopterous pests of *Brassica* crops and their parasitoids in southwestern Quebec. Environmental Entomology **27**: 1157-1165.

Grafius, E.J., and Idris, A.B. 1997. Know your friends: *Diadegma insulare*, parasite of diamondback moth. Midwest Biological Control News Online **4:** 1-1**.**

Hiroyoshi, S., Harvey, J.A., Nakamatsu, Y., Nemoto, H., Mitsuhashi, J., Mitsunaga, T., and Tanaka, T. 2017. Potential host range of the larval endoparasitoid *Cotesia vestalis (=plutella)* (Hymenpoters: Braconidae). International Journal of Insect Science 9: 1-12.

Monnerat, R.G., Kirk, A.A., and Bordat, D. 2002. Biology of *Diadegma* sp. (hymenoptera: ichneumonidae), a parasitoid of *Plutella xylostella* (L.) (Lepidoptera: Yponomeutidae), from Reunion Island. Neotropical Entomology **31**: 271-274.

Sarfraz. R.M., Dosdall, L.M., Blake, A.J., and Keddie, B.A. 2010. Leaf nutrient levels and the spatio-temporal distributions of *Plutella xylostella* and its larval parasitoids *Diadegma insulare* and *Microplitis plutellae* in canola. Biocontrol **55**: 229-244.

Sarfraz, M., Keddie, A.B., and Dosdall, L.M. 2005. Biological control of the diamondback moth, *Plutella xylostella*: A review. Biocontrol Science and Technology **15**: 763-789.

Shelton, A.M., Wilsey, W.T., Hoebeke, E.R., and Schmaedick, M.A. 2002. Parasitoids of cabbage Lepidopteran in Central New York. Journal of Entomological Science **37**: 270-271.

Shi, Z.-h., Liu, S.-s., and Li, Y.-x. 2002. *Cotesia plutellae* parasitizing *Plutella xylostella*: Host-age dependent parasitism and its effect on host development and food consumption. BioControl **47**: 499-511.

Strickland, E.H. 1946. An annotated list of the Ichneumonoidea of Alberta. The Canadian Entomologist **78**: 36-46.

Verkerk, R.H.J., and Wright, D.J. 1996. Multitrophic interactions and management of the diamondback moth: a review. Bulletin of Entomological Research **86**: 205-216.

Young A. 2013. War of the Wasps: Is *Diadegma insulare* or *Microplitis plutellae* a more effective parasitoid of the diamondback moth, *Plutella xylostella*? Canadian Field-Naturalist **127**: 211–215.