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NOTE

Parasitoids of the diamondback moth (Lepidoptera: Plutellidae): new records for Newfoundland and Labrador

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The diamondback moth (DBM), *Plutella xylostella* (L.) (Lepidoptera: Plutellidae), is a globally important pest of plants in the family Brassicaceae, including cultivated crops like broccoli, cabbage, cauliflower, rutabaga and canola (Howard et al. 1994; Furlong et al. 2013). Larval feeding on plant parts reduces yield, and crop value can be further reduced by the presence of larvae in produce (Zalucki et al. 2012; Philips et al. 2014). In Newfoundland and Labrador (NL), DBM is a serious invasive pest of vegetable brassica crops and endangered wild brassica species (Squires et al. 2009) and in the future, DBM could pose a threat to the currently small, but expanding, canola industry. Diamondback moth are thought to rarely, if ever, overwinter in Canada (Dosdall 1994; Dancau et al. 2018), as they are killed by biotic and abiotic factors, including low fall and winter temperatures. Populations in Canada are thought to originate annually by immigration of moths carried on storms and air currents from the US and Mexico (Smith and Sears 1982; Dosdall et al. 2004; Hopkinson and Soroka 2010). In Canada, the DBM is host to several species of hymenopteran parasitic wasps including *Cotesia* sp., *Diolcogaster claritbia* (Papp) and *Microplitis plutellae* Muesebeck (Braconidae), *Oomyzus sokolowskii* (Kurdjumov) (Eulophidae), as well as *Diadegma insulare* (Cresson) and *Diadromus subtilicornis* (Gravenhorst) (Ichneumonidae) (Howard et al. 1994; Noronha and Bahar 2018; Mason et al. 2022). The most recent and comprehensive information on the status and biology of parasitoids of the DBM in Canada is given in Mason et al. 2022. The release and conservation of parasitic wasps for biological control can be an effective tool in integrated pest management (IPM). Little is known about the existing parasitoid fauna of the DBM in NL. Our goal was to determine the occurrence of DBM parasitoid species in the province.

We mostly used two methods, commercial farm collections and destructive sampling, to collect DBM for assessment of its parasitoid community in NL (Figure 1). Diamondback moth were collected once from commercial farms in Markland (47.3753°N, 53.5528°W), Lethbridge (48.2998°N, 53.9310°W), Gambo (48.7396°N, 54.2785°W), Campbellton (49.2948°N, 54.9809°W), Comfort Cove (49.3894°N, 54.8822°W), Reidville (49.2129°N, 57.4263°W), Jeffrey's (48.2292°N, 58.8436°W), Loch Leven (48.1742°N, 58.8702°W) and Happy-Valley Goose-Bay (53.3203°N, 60.2376°W) in late summer or fall of 2018 and 2019 (Figure 1; Table 1). Cabbage and rutabaga plants with visible DBM damage were inspected for larvae and pupae, collected along with host plant leaf material and transported to the AAFC Research and Development Centre in St. John's (SJRDC). The second method, destructive sampling, was carried out over four years (2017–2020) at the SJRDC, as part of a larger study on the mortality of DBM in different regions of Canada (for detailed methods see Mason et al. 2022). Destructive sampling was done once in 2018 and 2019 (31 July and 24 July, respectively), twice in 2017 (17 July and 28 August) and six times in 2020 (17, 24 and 30 September; 8, 14 and 29 October). In addition to these two sampling methods, in 2016, a small number of DBM were collected from rutabaga at the SJRDC. The individuals recovered from the collections were counted, except for the 2016 sample and four commercial farm sites where numbers of DBM were estimated and reported to the nearest 25 individuals, as indicated in Table 1. DBM larvae and pupae from all samples were maintained in rearing containers in a Percival (PERI-30BLL) growth chamber (20 ±1 °C, 70% relative humidity, 16-hour light) until moth or parasitoid emergence. DBM eggs were collected in

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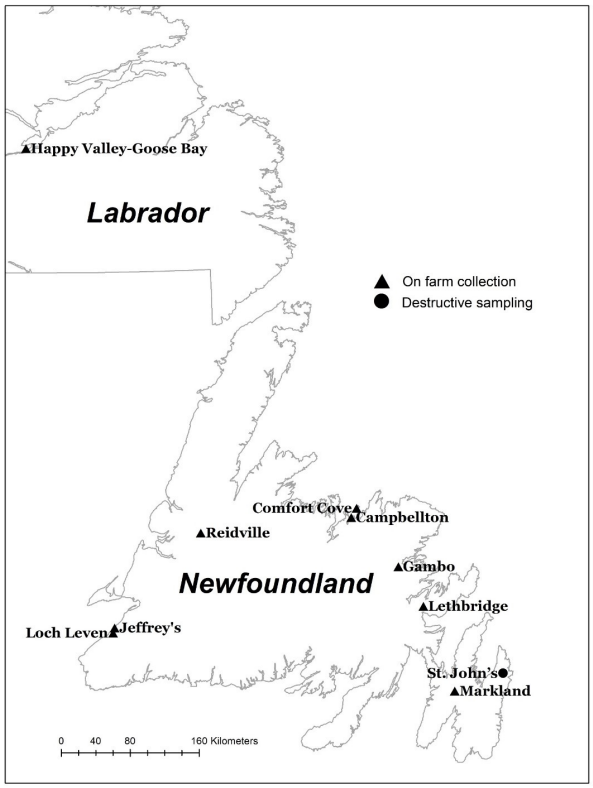
Figure 1. Map showing diamondback moth collection sites on the island of Newfoundland and southeastern Labrador.



the destructive sampling at St. John's only and reared as described above. Emerged parasitoids were dry pinned or preserved in 70% ethanol, labelled and separated by Family before being sent to Dr. J. Fernandez-Triana and Dr. A.M.R. Bennett of the Canadian National Collection, Ottawa, for further identification. Voucher specimens of parasitic wasp species were deposited in the Canadian National Collection of Insects, Arachnids, and Nematodes, Ottawa, ON and in the insect collection at the SJRDC, NL.

Across all collections, we found five species of DBM parasitoids (Table 1) in three Families: *Diadegma insulare*, *Diadromus subtilicornis*, *M. plutellae, Cotesia* sp. and *O. sokolowsii*. The *Cotesia* sp. from Happy Valley-Goose Bay (HVGB), Labrador is a potential undescribed species (Fernandez-Triana, personal communication 2021). *Diadegma insulare*, *Diadromus subtilicornis*, and *O. sokolowsii* represent new provincial records, and *M. plutellae* was recorded for the first time in Labrador.

The total numbers of DBM reared from commercial farms varied at each site, from ~25 in Campbellton, to ~250 in HVGB (Table 1). These results are snap-shots only, based on single collections at each location in late summer and fall, and parasitoid data are unlikely to be reflective of the parasitoid communities at these sites. Nevertheless, it is still valid to examine these data, and we note several observations. *Diadegma insulare* was present at six of the nine sites sampled across the island and in Labrador but was not recovered from Lethbridge, Gambo or Loch Leven. Few *M. plutellae* were recovered from any site other than Comfort Cove, where it comprised ~82% of the two species of parasitoids present (Table 1). Seven individuals of the ichneumonid *D. subtilicornis* were recovered, all from the collections on commercial farms in 2019: four from HVGB and three from Jeffrey's. No parasitoids emerged from DBM collected in Gambo and Loch Leven, and just a single individual, *M. plutellae*, was recovered from Lethbridge. Four species of parasitoids, including the potentially undescribed *Cotesia* sp., were recovered from HVGB, more than from any other location. Approximately 14% of the ~250 DBM reared from HVGB were parasitized. Rates of parasitism varied between commercial farm sites, for example, ~54% of DBM from Comfort Cove was parasitized (Table 1). However, as mentioned previously, it is not known how well these "snap-shots" represent the parasitoid community at these sites. Overall from the St. John's site, 307 DBM were reared from collections on 11 dates between 2016–2020 (Table 1). The most common parasitoid from St. John's was *D. insulare* (n = 99). Nine *O. sokolowski* emerged from DBM collected in St. John's in 2020, the only recovery of that species in the study (Table 1).

Overall in the current study, *D. insulare* was the most abundant species, comprising 95.6% of the two ichneumonids and 58.6% of all parasitoids reared from the DBM (data from commercial farms and all St. John's collections combined). This species was widespread, present across the island and in Labrador, and in all years (Table 1). In contrast, in PEI *M. plutellae* was the most abundant parasitoid of the DBM (Noronha and Bahar 2018). *Diadegma insulare* is a well-known, solitary larval parasitoid of the DBM in North America (NA), and with the NL record reported here, has now been found in all Canadian provinces (Mason et al. 2022). See Sarfraz et al. (2005) for a review of its biology. *Microplitis plutellae* was the second most common species in NL, accounting for 34.5% of the parasitoids reared although the majority of these were from Comfort Cove. This larval parasitoid is widespread across NA and because it overwinters in Canada (Bolter and Laing 1984; Braun et al. 2002), can be an important early season parasitoid of the DBM. Although *M. plutellae* was not recovered at St. John's in

Table 1. Numbers of diamondback moth (DBM) collected, species of hymenopteran parasitoids emerged, and % parasitism from either nine commercial farms in 2018 and 2019, or from the St. John's Research and Development Centre (Agriculture and Agri-Food Canada). DBM were collected at the St. John's site through destructive sampling (2017-2020) and a small rutabaga planting in 2016. See text for details. Table is arranged by location from east to west.

				% parasitism				
Location	**Year collected**	**Date(s) collected**	**Total DBM collected**	***Diadegma insulare***	***Diadromus subtilicornis***	***Microplitis plutellae***	***Cotesia* sp.**	***Oomyzus sokolowskii***
St. John's	2016	September	25*	24.0	0	0	0	0
	2017	17 July; 28 August	147	42.2	0	0	0	0
	2018	31 July	36	36.1	0	0	0	0
	2019	24 July	29	55.2	0	0	0	0
	2020	17, 24, 30 September; 8, 14, 29 October	70	11.4	0	0	0	12.8
Markland	2019	1 October	81	3.7	0	0	0	0
Lethbridge	2019	29 August	54	0	0	1.8	0	0
Gambo	2019	20 August	90	0	0	0	0	0
Campbellton	2018	21 August	25*	4.0	0	4.0	0	0
Comfort Cove	2018	21 August	175*	9.7	0	44.5	0	0
Reidville	2019	8 October	50*	22.0	0	0	0	0
Jeffrey's	2019	5 October	44	4.5	6.8	0	0	0
Loch Leven	2019	9 August	51	0	0	0	0	0
Happy Valley-Goose Bay	2019	29 September	250*	8.0	1.6	3.6	0.8	0

*indicates estimated number

this study, the first NL record of this species was from DBM collected at the SJRDC in 2017 (Mason et al. 2022). Although common in other areas of Canada (Mason et al. 2022), few of the prepupal and pupal parasitoid *D. subtilicornis* were recovered in this study, and only in 2019. *Diadromus subtilicornis* emerged from DBM collected from the west coast of the island (Jeffrey's) and Labrador (HVGB) but from no other sites. The larval-pupal parasitoid *O. sokolowskii* was uncommon, reared only from St. John's in 2020. The two most common parasitoids recovered in this study, *D. insulare* and *M. plutellae*, are well known and common parasitoids of the DBM elsewhere in Canada and NA. It is likely they were not previously recovered in NL due to lack of research on the DBM. The parasitoid data from commercial farms in this study are from single collections, and more frequent sampling over multiple years would provide a more complete picture of the parasitoid communities in these areas. However, the results have added to the knowledge base for this insect in NL and may be useful in guiding the future development of IPM of the DBM using biological control.

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