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NOTE

Parasitism of blueberry spanworm (Lepidoptera: Geometridae) by Ichneumonidae and Tachinidae in Nova Scotia blueberry fields

Alexandre M.M.C. Loureiro and G. Christopher Cutler

The blueberry spanworm, *Itame (Macaria) argillacearia* Packard (Lepidoptera: Geometridae), is a significant pest of lowbush blueberry (*Vaccinium angustifolium* Aiton) (Ericaceae), a high-value crop native to eastern North America (Drummond and Groden 2000; Ramanaidu et al. 2011). The insect ranges from Quebec to Nova Scotia in Canada, and from Maine to West Virginia in the United States (Wagner et al. 2001). Larvae emerge from overwintered eggs in late May or early June, feed until early July, and then pupate in leaf litter or soil. Adults eclose, mate, and oviposit their eggs in leaf litter around the base of blueberry plants in late July (Crozier 1995). Outbreaks of blueberry spanworm, though regular in some fields, are relatively inconsistent and not well understood. Natural enemies may be important in suppressing local populations of this pest. Previous reports from Nova Scotia indicate that parasitism rates of blueberry spanworm by Ichneumonidae and Tachinidae can exceed 50% (Cutler et al. 2015). However, this previous work was done in a single season and from only two field sites. The present one-year study examined parasitism of blueberry spanworm across commercial lowbush blueberry fields in Nova Scotia to provide additional information on parasitism rates of this pest.

Blueberry spanworm larvae were collected in the summer of 2015 from eight fields in Cumberland and Colchester counties, Nova Scotia. Sampling was initially done in 15 fields, but blueberry spanworm populations were low in several sites. Larvae were collected by sweep netting (Ramanaidu et al. 2011), and any field with at least three insects per 25 sweeps was used. The eight sites used in this study were located in: (1) Mt. Thom (45°29'32.32"N; 62°59'18.31"W), (2) Kemptown (45°30'00.11"N; 63°06'19.74"W), (3) Belmont (45°26'09.53"N; 63°22'34.47"W), (4) Masstown (45°24'41.05"N; 63°28'48.54"W), (5) Debert (45°25'11.27"N; 63° 30'36.17"W), (6) East Village (45°26'35.49"N; 63°34'19.66"W), (7) Highland Village (45°24'17.16"N; 63°40'24.43"W), and (8) Newville (45°31'26.67"N; 64°19'48.35"W) (Figure 1). For each field and collection event, spanworm larvae of multiple instars were put in a clear plastic container with fresh blueberry shoots. Collections earlier in the season tended to consist mainly of early instars, whereas later collections contained relatively more late-instar larvae, but samples and sorting in the laboratory were not differentiated based on larval size or instar. Each field was sampled twice except at East Village and Belmont, which were sampled only once due to low pest density following the initial sampling date.

In the laboratory, the larvae from each location collection were randomly placed into 10 cups (mean = 9.2 larvae per cup; range = 4–10 larvae per cup) containing 2–3 blueberry sprigs on which larvae could feed. Cups were labeled, covered with a glass Petri plate or plastic perforated lid, and held under ambient conditions on a benchtop. Defoliated blueberry sprigs were replaced as needed. Cups were checked for parasitoid emergence every 2–3 days. Emerged adult parasitoids were pinned and identified to family (all Ichneumonidae or Tachinidae) (Triplehorn and Johnson 2005). Sometimes parasitoids emerged as larvae and developed into pupae outside the blueberry spanworm cadaver. As adults emerged from some of these pupae, we were able to identify parasitoid pupae based on obvious

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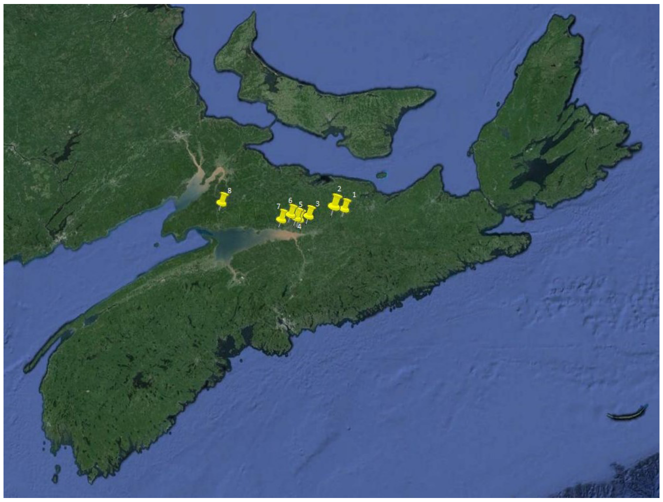
Alexandre M.M.C. Loureiro and G. Christopher Cutler: Department of Environmental Sciences, Faculty of Agriculture, Dalhousie University, Truro, Nova Scotia, Canada.

Corresponding author (email chris.cutler@dal.ca)

Figure 1. Lowbush blueberry sites in Nova Scotia, 2015, used to examine parasitism of blueberry spanworm (Lepidoptera: Geometridae): (1) Mt. Thom, (2) Kemptown, (3) Belmont, (4) Masstown, (5) Debert, (6) East Village, (7) Highland Village, and (8) Newville.



morphological differences in pupae appearance. However, in other instances parasitoids emerged and died as larvae and were unidentifiable. Percent parasitism by identified and unidentified parasitoids was determined as:

$$\%\,parasitism = \left[\frac{total\ adult\ and\ immature\ parasitoids\ per\ field}{total\ \ spanworm\ per\ field}\right] \times 100$$

Adult emergence for each parasitoid family was determined as

$$\%\,adult\ parasitoid\ emergence = \left[\frac{emerged\ adults\ per\ field}{total\ adult\ and\ immature\ parasitoids\ \ per\ field}\right] \times 100$$

In other cases, blueberry spanworm successfully pupated and eclosed as adults or died from unknown causes.

Each field was considered a replicate. As assumptions of normality and homogeneity of variance could not be met for our data, a Wilcoxon rank-sum test was conducted to compare median percent parasitism by Ichneumonidae and Tachinidae. A correlation analysis was done to determine if the percentage of parasitism and adult emergence of Ichneumonidae or Tachinidae was associated with date. As two fields had a single collection date and durations between collections at a given site were inconsistent (4–16 days), data were combined for fields that had two collections. All analyses were done using Minitab 17 (Minitab 2016).

A total of 1242 blueberry spanworm larvae were assessed. Overall mean parasitism of blueberry spanworm was 21.4% and ranged from 0% to 36.8% across the eight fields sampled (Table 1). Median percentage parasitism differed between parasitoid groups (W = 94.0, P = 0.0052), and the mean percentage parasitism of Ichneumonidae (12.9%) was 15-fold greater than that of Tachinidae (0.9%) across all sites. Whereas parasitism of blueberry spanworm by Ichneumonidae occurred in all fields except Belmont, Tachinidae were found in only the Masstown and Newville locations. At some sites, percentage parasitism by unidentifiable parasitoids (those that did not reach adulthood) equaled or exceeded that by parasitoids identified as Ichneumonidae or Tachinidae (Table1).

Table 1. Mean percent parasitism of blueberry spanworm, *Itame* (*Macaria*) *argillacearia*, by Ichneumonidae, Tachinidae, or unidentifiable parasitoids in Nova Scotia lowbush blueberry fields, 2015.

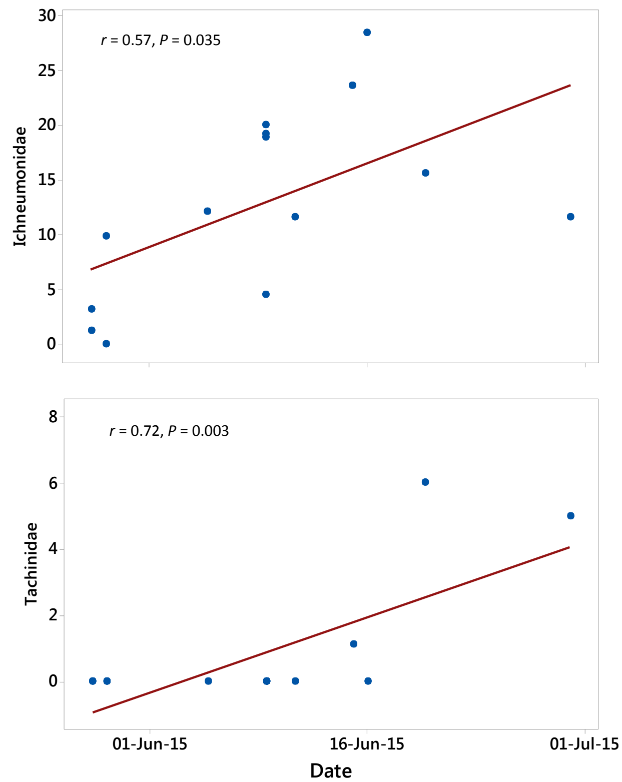
Field	Date of collection	% Parasitism				% Emergence	
		Ichneumonidae	Tachinidae	Unidentifiable	Total	Ichneumonidae	Tachinidae
Mt. Thom	28 May	3.9	0.0	8.5	12.4	10.0	---
	9 June	20.0	0.0	11.7	31.7	11.8	---
Kemptown	28 May	1.3	0.0	2.6	3.9	0.0	---
	9 June	4.5	0.0	3.4	7.9	0.0	---
Masstown	29 May	9.9	0.0	3.3	13.2	0.0	---
	15 June	23.6	1.1	9.0	33.7	4.8	100
Belmont	29 May	0.0	0.0	0.0	0.0	0.0	0.0
Debert	5 June	12.1	0.0	3.0	15.1	16.7	0.0
	9 June	18.9	0.0	3.3	22.2	23.5	0.0
Highland Village	9 June	19.2	0.0	9.6	28.7	16.7	0.0
	16 June	28.4	0.0	8.4	36.8	51.6	0.0
East Village	11 June	11.6	0.0	12.8	24.4	0.0	0.0
Newville	20 June	15.7	6.0	22.9	44.6	0.0	40.0
	30 June	11.7	5.0	8.3	25.0	0.0	66.7
Mean		12.9	0.9	7.6	22.0	9.7	23.0
Std. deviation		8.6	2.0	5.8	12.9	14.5	37.6

Cutler et al. (2015) reported, through morphological and molecular diagnostics of specimens, that the majority of blueberry spanworm parasitism was by *Tranosemella* or *Tranosema* (Ichneumonidae) and *Phryxe pecosensis* (Tachinidae). Inspection of our specimens against voucher material suggests these genera/species were also the parasitoids in our collections. Unidentifiable parasitoids from our samples were possibly also Ichneumonidae and Tachinidae, although *Aleiodes (Tetrasphaeropyx) argyllacearivorax* Fortier (Braconidae) was previously recovered from blueberry spanworm (Fortier 2007), and braconids of this genus probably are present throughout boreal parts of Canada (Shaw 2006). Previous reports found only Ichneumonidae and Tachinidae parasitizing blueberry spanworm in Nova Scotia blueberry fields, with incidence of Ichneumonidae parasitism being 4-fold that of Tachinidae (Cutler et al. 2015), corroborating our finding of parasitism of blueberry spanworm by Ichneumonidae exceeding that of Tachinidae.

Our correlation analyses found that percent parasitism by both Ichneumonidae and Tachinidae was associated with date, with increased parasitism occurring in blueberry spanworm larvae that were collected later in the season (Figure 2). Success of adult parasitoid emergence was not associated with date for Ichneumonidae (r = 0.19, P = 0.51), but was for Tachinidae (r = 0.63, P = 0.016), given that parasitism by Tachinidae only occurred in late-season blueberry spanworm collections. Larvae collected later in the season were generally larger, therefore suggesting ichneumonid and tachinid parasitoids prefer mid to late instars of blueberry spanworm rather than early instars. It would be worthwhile confirming through laboratory experiments (e.g., parasitoid-host life stage choice tests) and additional field studies (e.g., malaise trap collections of ichneumonid and tachinid parasitoids in conjunction with field parasitism assessments) the host preferences and population dynamics of blueberry spanworm parasitoids in order to maximize their impact in pest management. For example, it would be useful for blueberry producers to know when these parasitoids have "run their course" so they can determine if and when further pest management is required.

The overall parasitism range of 0–37% we detected was lower than the 50% parasitism reported by Cutler et al. (2015) from two fields in close proximity to some of our sites. The variable rate of parasitism across sites and years is not surprising and could be due to multiple factors. Differences in natural abiotic (e.g., daily or seasonal weather/climate, soil temperature or moisture) or biotic (e.g., host availability, disease, predators, parasites, hyperparasitoids) factors could have differentially affected population dynamics of blueberry spanworm or its Ichneumonidae and Tachinidae parasitoids across sites or years. Host-parasitoid populations are known to fluctuate in agricultural systems. For example, parasitoid attacks on diamondback moth, *Plutella xylostella* (Linnaeus), ranged 10–80% across multiple sampling years (Liu et al. 2000). Crop management practices may not have accounted for the observed differences in parasitism across sites. For example, six sites (Mt. Thom, Kemptown, Masstown, Debert, Belmont, Highland Village) were maintained by the same producer, who applied the same insecticide regime (acetamiprid, Assail 70WP, for *Rhagoletis mendax* Curran suppression in late summer; no insecticide application in spring 2015), and yet those fields were highly variable in their levels of parasitism.

Figure 2. Correlation of parasitism of blueberry spanworm (Lepidoptera: Geometridae) in Nova Scotia, 2015, by Ichneumonidae and Tachinidae by date.



In addition to larvae that were killed by parasitoids, 303 larvae (24% of all larvae) were killed by unknown causes. Most of these larvae were dark and shriveled at death, while others were 'liquefied' or covered with fungus. We are uncertain what caused death of these larvae, but bacterial, viral or fungal infection probably were causal agents in many cases. It is possible that some of these larvae contained undeveloped parasitoids.

Our results, and those from previous reports, demonstrate that parasitism of blueberry spanworm can be common in commercial lowbush blueberry fields, but that this can vary by site and year. It is important that growers be aware of the valuable contributions of parasitoids and predators (e.g., Renkema et al. 2014) in suppressing blueberry insect pests, and that they utilize pest management strategies and tactics that optimize conservation and promotion of natural enemies around their blueberry fields (Landis et al. 2000).

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