PARASITOIDS REARED FROM THE OBLIQUEBANDED LEAFROLLER (LEPIDOPTERA: TORTRICIDAE) INFESTING RASPBERRIES

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Abstract

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Fourteen species of parasitoids (13 hymenopterans, 1 dipteran) were reared from larvae or pupae of the obliquebanded leafroller, *Choristoneura rosaceana* (Harris), collected from commercial raspberry fields in the Fraser Valley, British Columbia, Canada, over 3 years. Levels of parasitism ranged from 5 to 15%. Among these 14 species, five represent new host records. A polyembryonic wasp, *Macrocentrus nigridorsis* Viereck (Hymenoptera: Braconidae), was the most abundant parasitoid. External feeding on the final host instar is obligatory for *M. nigridorsis* to complete development. On average, each parasitized host larva produced about 36 *M. nigridorsis*, in either unisexual or mixed-gender groups. Overall male to female sex ratio was 1:4. Head capsules of mature parasitized host larvae were significantly larger than those of unparasitized ones, suggesting that *C. rosaceana* larvae parasitized by *M. nigridorsis* might have an extra larval stage.

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Résumé

Quatorze espèces de parasitoïdes (13 hyménoptères, 1 diptère) ont été élevées à partir de larves ou de nymphes de la Tordeuse à bandes obliques, *Choristoneura rosaceana* (Harris), recueillies dans des champs commerciaux de framboisiers dans la vallée du Fraser, Colombie-Britannique, Canada, au cours d'une période de 3 ans. Le degré de parasitisme allait de 5 à 15%. Parmi les 14 espèces, cinq représentaient des relations hôte–parasite encore inédites. Une guêpe polyembryonnaire, *Macrocentrus nigridorsis* Viereck (Hymenoptera: Braconidae), s'est avérée le parasitoïde le plus abondant. Pour compléter son développement, *M. nigridorsis* doit se nourrir obligatoirement à même la larve de stade terminal de son hôte, par l'extérieur. En moyenne, chaque larve hôte parasitée a produit environ 36 *M. nigridorsis*, en

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groupes d'individus du même sexe ou en groupes de mâles et de femelles. Dans l'ensemble, le rapport mâles à femelles était de 1,4. Chez les larves parasitées à maturité, la capsule céphalique était significativement plus grosse que chez les larves non parasitées, ce qui semble indiquer que les larves de *C. rosaceana* parasitées par *M. nigridorsis* comptent peut-être un stade larvaire additionnel.

[Traduit par la Rédaction]

Introduction

In recent years, the obliquebanded leafroller, *Choristoneura rosaceana* (Harris) (Lepidoptera: Tortricidae), has become a major pest of raspberries in the Fraser Valley, British Columbia, Canada (British Columbia Ministry of Agriculture, Fisheries and Food 1996). In the spring, overwintering larvae feed on buds and new leaves, resulting in heavy damage at high population levels. In the summer, second-generation larvae damage the growing tips and berries and contaminate machine-harvested fruits. Control strategies for this pest on raspberries currently rely on insecticides (British Columbia Ministry of Agriculture, Fisheries and Food 1996), but there is considerable interest in finding alternatives. We conducted a survey of parasitoids associated with *C. rosaceana* on raspberries in the Fraser Valley.

Schuh and Mote (1948) listed 25 species of parasitoids attacking immature stages of *C. rosaceana* on raspberries in Oregon. Pogue (1985) found four hymenopterans parasitizing leafroller larvae or pupae collected from foliage of shelterbelt plantings in Wyoming. Hagley and Barber (1991) surveyed unmanaged apple orchards in Ontario, and found 14 hymenopterans and two dipterans parasitizing *C. rosaceana*. More than 20 species of parasitoids have been found in *C. rosaceana* within the Okanagan and Similkameen valleys of British Columbia (J.E. Cossentine, personal communication).

Our objectives were to determine how many species of parasitoids are associated with *C. rosaceana* on raspberries in the Fraser Valley and identify which ones have potential as biocontrol agents for *C. rosaceana* in the future.

Materials and Methods

Overwintered larvae of *C. rosaceana* were collected from commercial raspberry fields in the Abbotsford region (49°01′N, 122°21′W, 57.9 m elevation) between late April and early May of 1993, 1994, and 1996. The field-collected larvae (2nd through 6th instars) were individually reared in 1-oz (28.4 mL) plastic cups (4 cm diameter by 4 cm depth; James River Corp., Norwalk, Connecticut) with pesticide-free raspberry leaves that were replaced as needed. Rearing conditions for larvae were 21 ± 1°C with a 16L:8D photoperiod until either *C. rosaceana* adults or parasitoids emerged. Reared parasitoids were identified by M.J.S. (braconids), J.R.B. (ichneumonids), and J.E.O. (tachinids). Voucher specimens were deposited at the Eastern Cereal and Oilseed Research Centre, Agriculture and Agri-Food Canada, Ottawa, Ontario.

Emerged parasitoids of the polyembryonic *Macrocentrus nigridorsis* Viereck (Hymenoptera: Braconidae) from a total of 80 colonies (= hosts) were counted and sexed. To compare mean numbers of *M. nigridorsis* per host larva among emergence groups of all males, all females, and both males and females, data were transformed as $\ln(x + 1)$, where x is the number of *M. nigridorsis* emerged from one host larva, and subjected to analysis of variance followed by Tukey's multiple range test (Zar 1984). To determine if there were any differences in host larval size, we measured head capsules of parasitized and unparasitized larvae obtained as follows. Approximately 200 newly hatched *C. rosaceana* larvae were transferred to the leaves of fresh, pesticide-free raspberry branches with their cut ends in water. Approximately 40 pairs of newly emerged

TABLE 1. Parasitoids reared from *Choristoneura rosaceana* infesting raspberries in the Fraser Valley, British Columbia

Family and species	Emerged from*	No. of parasitoids†		
		1993	1994	1996
Tachinidae				
Hemisturmia tortricis (Coquillett)	P	14	5	na
Braconidae				
Apanteles polychrosidis Viereck	L	15	9	na
Meteorus trachynotus Viereck	L	5	0	na
Microgaster leechi Walley	L‡	9	12	na
Macrocentrus exartemae Walley	L	12	7	na
Macrocentrus nigridorsis	L	77	62	42
Oncophanes americanus (Weed)	L	3	1	na
Ichneumonidae				
Apechthis ontario (Cresson)	P‡	7	4	na
Apophua simplicipes (Cresson)	L	10	9	na
Campopleginae sp. A	L‡	5	8	na
Campopleginae sp. B	L‡	3	1	na
Diadegma interruptum pterophorae (Ashmead)	L	6	3	na
Itoplectis quadricingulatus (Provancher)	P‡	7	8	na
Scambus brevicornis (Gravenhorst)	L	9	5	na

NOTE: na, not available.
*P, emerged from pupa; L, emerged from larva.
†A total of 2054, 1645, and 1102 *C. rosaceana* were collected in 1993, 1994, and 1996, respectively.
‡New parasitoid–host record.

adult males and females of *M. nigridorsis* were released into a cage (0.3 × 0.3 × 0.3 m) containing the branches, and provided an 8% sugar solution. Host larvae and parasitoid adults were maintained under rearing conditions described above. When host larvae were late 3rd instars, they were individually transferred from the cage into 1-oz plastic cups that contained pesticide-free raspberry leaves. The head capsule width of final-instar larvae was measured using an eyepiece micrometer on a binocular microscope. Measurements of head capsule were categorized as parasitized or unparasitized based on whether *M. nigridorsis* or *C. rosaceana* emerged. Data were transformed as $\ln(x + 1)$, where x is the width of the head capsule, and both groups were compared using a two-tailed, unpaired-sample t test (Abacus Concepts 1989).

Results and Discussion

Fourteen species of parasitoids were reared from *C. rosaceana*, 11 emerging from host larvae, and three from host pupae (Table 1). Parasitoids were more diverse in one abandoned field than in managed fields where pesticides had been used. Parasitism of *C. rosaceana* ranged from 5 to 15% of collected larvae from managed fields, and was as high as 30% in abandoned fields. Based on previous records of parasitoids reared from *C. rosaceana* (Schuh and Mote 1948; Raizenne 1952; Arnaud 1978; Krombein et al. 1979; Pogue 1985; Hagley and Barber 1991; Huber et al. 1996), five species represent new host records (Table 1).

During the 3-year survey, *M. nigridorsis* was the most abundant parasitoid species. In fields heavily infested by *C. rosaceana*, parasitism by *M. nigridorsis* alone sometimes reached 25%. *Macrocentrus nigridorsis* was found in *C. rosaceana* larvae

TABLE 2. The size and sex ratio of colonies of *Macrocentrus nigridorsis* reared from larvae of *Choristoneura rosaceana* collected from raspberry fields in the Fraser Valley, British Columbia

		Parasitoids per host larva		
Colony*	*n*	Range	Mean ± SE	Sex ratio (male:female)
Male	8	7–62	38.1 ± 6.6	1:0
Female	48	2–72	35.7 ± 3.0	0:1
Male and female	24	4–66	35.7 ± 3.8	1:2.2
Overall	80	2–72	35.9 ± 2.2	1:4.0

*Male, each host larva produced exclusively male *M. nigridorsis*; female, each host larva produced exclusively female *M. nigridorsis*; male and female, each host larva produced male and female *M. nigridorsis*.

collected from most raspberry fields sampled, suggesting that *M. nigridorsis* is distributed throughout raspberry-growing areas of the Fraser Valley.

Among the 80 colonies of *M. nigridorsis*, most produced exclusively females (Table 2). Other species of the genus *Macrocentrus* are known to be polyembryonic (Clausen 1940). Because Hymenoptera have a haploid–diploid mode of sex determination, it is possible that hosts yielding both sexes of *M. nigridorsis* initially contained at least one fertilized egg and one unfertilized egg. Mean numbers of parasitoids produced per host larva were not significantly different among emergence groups (all males, all females, or mixed males and females) ($F_{2,77} = 0.18$, $P = 0.8323$) (Table 2). Overall, size of the colony was about 36 parasitoids per host larva. From the 24 colonies producing both sexes, 270 males and 587 females were observed, giving a male to female sex ratio of 1:2.2. Of these 24 colonies, males predominated in five, females predominated in 17, and males and females were equal in two. From all 80 colonies, 575 males and 2299 females of *M. nigridorsis* emerged, giving a female-biased sex ratio (Table 2).

The larval stage of *M. nigridorsis* can be divided into an internal phase and an external phase. During the internal phase, larvae feed and develop inside the host. Prior to the 4th instar, parasitized host larvae did not differ from unparasitized ones in appearance or behaviour. However, when parasitized host larvae reached late 5th instars, they were noticeably larger in size and distinctly less active than were unparasitized ones, although the parasitized ones were still able to feed. At this point, the colour of the parasitized larvae became more yellowish than green. Emergence of *M. nigridorsis* larvae from the host occurred only after the host larva reached its final (6th) instar. The parasitized larvae did not feed as late last instars, could no longer crawl, and were larger than the unparasitized larvae. Head capsules of parasitized mature larvae were significantly larger than those of unparasitized larvae ($t_{84} = 3.125$, $P = 0.003$) (Table 3). We speculate that *M. nigridorsis* larvae might secrete a chemical or chemicals during the internal phase which might stimulate host larvae to increase body size or go through an extra moult.

The external phase begins with the emergence of each parasitoid larva through an individual exit hole in the host's body. We observed that parasitoid larvae emerged simultaneously from a host larva, and that emergence lasted 1–2 h. After emergence, external feeding began. Parker (1931) found that external feeding was not necessary for larvae of *Macrocentrus grandii* Goidanich. However, we observed that the larvae of *M. nigridorsis* did not survive if removed from the host immediately after emergence. Once parasitoids finished external feeding, nothing but the host exoskeleton remained. After external feeding, parasitoid larvae spun cocoons such that the whole group of

TABLE 3. Comparison of head capsule widths of mature *Choristoneura rosaceana* larvae parasitized by *Macrocentrus nigridorsis* or parasitoid free in the laboratory

Host status	n	Range (mm)	Mean (±SE) width of head capsule (mm)
Parasitized	43	1.65–2.50	1.98 ± 0.04a
Unparasitized	42	1.45–1.90	1.76 ± 0.04b

NOTE: Means followed by the same letter are not significantly different (two-tailed, unpaired-sample t test, $P > 0.05$).

parasitoids was bound together in an elongate mass, with the longitudinal axis of all cocoons nearly parallel. Individual larvae of *M. nigridorsis* placed separately on a flat surface were unable to form their cocoons properly and could not pupate, though they were able to spin.

Additional studies on the biology of this species, especially on its reproductive strategies, are needed. Although we observed that *M. nigridorsis* oviposited in larvae of *C. rosaceana* before they reached the 3rd instar, we do not know if the parasitoid attacks all larval instars or prefers particular ones. Wishart (1946) reported that *M. grandii* oviposits in any of the five instars of *Ostrinia nubilalis* (Hübner). Dittrick and Chiang (1982) found that developmental time of *M. grandii* and the number of parasitoids emerging from each *O. nubilalis* host were significantly affected by temperature. Further studies of *M. nigridorsis* associated with *C. rosaceana* should determine optimum laboratory rearing conditions.

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