STATUS OF *AGENIASPIS FUSCICOLLIS* (HYMENOPTERA: ENCRYTIDAE), AN INTRODUCED PARASITOID OF THE APPLE ERMINE MOTH (LEPIDOPTERA: YPONOMEUTIDAE)[1]

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The apple ermine moth, *Yponomeuta malinellus* Zeller, is a univoltine pest species that defoliates apple, *Malus domestica* (Borkh) (Rosaceae), in the temperate region of the Palaearctic. First instars overwinter within a communal hibernaculum beneath the covering of the egg batch (Kock 1998). In spring, larvae emerge to initially mine apple leaves and subsequently feed externally within a communal tent (Menken *et al.* 1992). During heavy infestations, the communal tents may envelop the entire apple tree, resulting in total defoliation (Parker and Schmidt 1985). There have been several accidental introductions and subsequent eradications of the apple ermine moth in eastern North America (Hewitt 1917; Parker and Schmidt 1985) but, by 1989, the pest was found in the Fraser River Valley in British Columbia, in Whatcom county, Washington, and in northwestern Oregon (Antonelli 1991; Unruh *et al.* 1993).

A biological control project was initiated in 1987, to determine the impact of natural enemies on the generational mortality of this pest in its region of origin and to select candidate biological control agents for introduction into Canada (Kuhlmann *et al.* 1998*a*). The univoltine egg–larval parasitoid *Ageniaspis fuscicollis* Dalman, the only species to attack the egg stage of *Y. malinellus*, was recommended by Affolter and Carl (1986). The parasitoid eggs do not hatch until the host has reached the third instar. The parasitoid develops polyembryonically and produces over 80 larvae from a single parasitoid egg (Junnikkala 1960). Parasitized host larvae become swollen and are killed in the fifth instar by mummification as the parasitoids pupate (Blackman 1965). The impact of the parasitoid and its ovipositional behaviour was studied by Kuhlmann *et al.* (1998*b*).

Releases of *A. fuscicollis* in Chilliwack and Langley and on Galiano and Salt Spring islands (British Columbia) from 1988 through 1990 resulted in low (0–6%) parasitism rates of *Y. malinellus* (Smith 1990). In 1995, a cooperative research project to follow up the establishment of *A. fuscicollis* in earlier release sites and to introduce the parasitoid in other areas of British Columbia infested by *Y. malinellus* was initiated.

To obtain a large number of *Yponomeuta* Latreille larvae mummified by *A. fuscicollis* for release in Canada, *Y. malinellus* moth larvae feeding on *Malus* Miller and *Yponomeuta padellus* L. larvae feeding on *Prunus spinosa* L. and *Crataegus monogyna* Jacquin (Rosaceae) were collected in the German Rhine Valley (49°47′N, 8°27′E; 50°34′N, 8°40′E; and 47°34′N, 7°37′E). Mummified larvae were sent to the quarantine facility in Ottawa, Ontario. After adult emergence, *A. fuscicollis* were identified, counted, and shipped to British Columbia for release. Additional *A. fuscicollis* were obtained for redistribution from sites where the parasitoid had established.

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TABLE 1. Summary of *Yponomeuta malinellus* densities and *A. fuscicollis* releases and percentage of parasitism in 1995–1998.

	No. of host-sites sampled	No. of prepupae/ 10 leaf clusters ± SE	No. of imported *A. fuscicollis* released the previous year	No. of parasitized sites sampled	No. of sites showing occurrence of *A. fuscicollis*	No. of *Y. malinellus* larvae collected (*n*)	Parasitism by *A. fuscicollis* (%)
			Vancouver Island—Victoria*				
1995	na	na	0	6	0	6146	0
1996	2	47.3±15.1	4900	4	1	2064	<1
1997	1	29.4	3450	4	4	3695	8.7±4.0
1998	1	6.9	2400 (1800)†	7	7	2569	22.8±12.6
			Vancouver Island—Saanich*				
1995	na	na	0	0	0	na	na
1996	3	4.7±1.6	6700	9	6	3213	0.9±1.2
1997	3	19.3±24.0	7500	9	5	3429	3.6±5.6
1998	3	10.0±6.1	3292 (6200)†	7	6	4331	12.7±9.5
			Salt Spring Island*				
1995	na	na	0	5	0	238	0
1996	1	6.4	0	1	0	103	0
1997	1	13.8	600	2	1	762	4.1±5.8
1998	1	8.1	6000	7	3	1029	12.8±29.8
			Langley*				
1995	na	na	0	10	10	796	<1
1996	2	1.4±0.7	9800	6	1	58	1.1±2.7
1997	2	2.8±1.7	3700	4	3	297	4.3±4.2
1998	2	0.1±0.1	0	3	2	91	8.6±9.7
			Chilliwack*				
1995	na	na	0	14	0	240	0
1996	1	1.8	0	1	1	29	20.7
1997	1	0.1	300	2	0	15	0
1998	1	0.1	0	1	0	2	0

Salmon Arm*							
1995	na	na	0	0	0	0	na
1996	2	0.2±0.1	8000	2	0	6	0
1997	2	7.8±1.9	6000	2	2	258	8.0±4.4
1998	2	1.9±1.5	1900	2	1	106	5.9±8.4
Westside–Fintry*							
1995	na	na	0	3	0	21	0
1996	3	8.1±10.3	6100	2	1	259	<1
1997	3	13.5±3.4	7300	2	2	1452	6.4±7.0
1998	3	6.1±1.6	4500	2	2	350	28.4±11.1

* The coordinates for the release sites are listed in Sarazin (1992–2000).

† The value in parentheses is the number released from local collections.

Apple ermine moth densities were assessed at a total of 14 sites from Vancouver and Salt Spring islands and the Fraser and Okanagan valleys from 1996 through 1998. Each year, 16 apple tree branches per density site were chosen at random, and the total number of fifth instars and (or) prepupae per 10-leaf clusters was recorded from the tip down on each branch. On each sampling occasion, additional sites in the area were visited to collect as many *Y. malinellus* fifth instars and (or) prepupae as possible. Because *Y. malinellus* egg batches are difficult to detect in the field and younger-instar larvae are difficult to rear without high rates of mortality, only the later-developmental stages were sampled. Prepupae and fifth instars were counted and placed in 1-L plastic containers at room temperature (20–22°C) with fresh apple leaves, until pupation or mummification of *Y. malinellus* larvae. The percentage of parasitism was recorded as the number of mummified larvae per total number of larvae collected at each sampling site.

In 1995, larvae were collected, if present, at all previously recorded release sites. The recovery of *A. fuscicollis* at Langley in 1995 and at Chilliwack in 1996 indicated that establishment had occurred, as no releases had been made since 1990. The parasitism rates were low and similar to those recorded in the years immediately after releases (Smith 1990). The selected new release areas of Victoria, Salmon Arm, and Fintry showed no parasitism by *A. fuscicollis* in 1995 or 1996. By opening containers of adults into apple-tree canopies, a total of 35 509 adult *A. fuscicollis* were released in 1995, 28 850 in 1996, and 26 104 in 1997 on Vancouver and Salt Spring islands, Chilliwack and Langley, and in the interior of British Columbia. The number of adult *A. fuscicollis* released in each area, the mean apple ermine moth density, the number of hosts collected, and the mean rates of parasitism by *A. fuscicollis* per site are summarised for 1995–1998 in Table 1.

Apple ermine moth population densities in both Langley and Chilliwack decreased from 1987 to 1995. At the three Langley sites, where 10 000 adult *A. fuscicollis* were released in 1987, Smith (1990) recorded collecting 5418 apple ermine moth larvae in 1989 to assess parasitism; however, only 796 larvae could be found after inspecting 21 sites (including the above release sites) in Langley in 1995. Only 240 apple ermine moth larvae were found in 1995 in Chilliwack after inspecting 18 sites, whereas Smith (1990) collected 4648 larvae in 1990 from only five sites. Only 29 apple ermine moth larvae were found in Chilliwack in 1996 and 20.7% were parasitized by *A. fuscicollis*. Additional releases of *A. fuscicollis* on Salt Spring Island and in Langley between 1995 and 1997 resulted in increased rates of parasitism of *Y. malinellus*.

Similar results were found for the new release areas of Victoria, Salmon Arm, and Fintry, where rates of parasitism increased from 0% in 1995 to 22.8, 5.9, and 28.4%, respectively, in 1998. In general, densities of *Y. malinellus* decreased at release sites. It can be concluded that *A. fuscicollis* currently appears to be established in apple ermine moth populations in all areas where it has been introduced.

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