Seasonal Occurrence and Abundance of Lepidopterous Pests and Associated Parasitoids on Collards in the Northwestern United States[1]

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ABSTRACT The three key lepidopterous pests of cruciferous crops, *Artogeia rapae* (L.), *Plutella xylostella* (L.), and *Trichoplusia ni* (Hübner) were monitored throughout the growing season at several locations in Washington and Oregon in 1986 and 1987 on collard plants. Populations of these pests differed markedly from location to location and between years. *Artogeia rapae* was the most abundant, *P. xylostella* was next in abundance, and *T. ni* the least abundant and on many dates it was not observed. Seven species of parasitoids were recovered and rates of parasitization varied significantly over time and among locations. *Diadegma insulare* (Cresson) was the most abundant parasitoid of *P. xylostella*. It parasitized up to 100% (range 0-100) and accounted for 74-100% of the total parasitization. *Cotesia rubecula* Marshall was the dominant species attacking *A. rapae* in Washington (0-50% parasitization) and accounted for 32-100% of the total parasitization. The only parasitoid species recovered from *T. ni* was *Voria ruralis* (Fallen) which parasitized from 0-14% of the larvae.

KEY WORDS Crucifer pests, *Artogeia rapae, Plutella xylostella,Trichoplusia ni,* parasitism, seasonal abundance, population monitoring.

Three lepidopteran species, the imported cabbageworm, *Artogeia rapae* (L.), the diamondback moth, *Plutella xylostella* (L.), and the cabbage looper, *Trichoplusia ni* (Hübner), are serious pests of cruciferous crops in North America. Even though these crops are routinely treated with insecticides, the annual estimated loss due to lepidopterous pest species on cruciferous crops in the United States is $34,500,000 (Schwartz and Klassen 1981). The population dynamics of these three pest species have been studied in various regions of North America (Pimentel 1961, Harcourt 1963, Oatman and Platner 1969, Elsey and Rabb 1970, Biever 1972, Harding 1976, Ru and Workman 1979, Andalaro et al. 1982, Latheef and Irwin 1983, Chamberlin and Kok 1986, Kok and McAvoy 1989). However, only limited information is available on the abundance and occurrence of these three key species and their associated parasitoids in the northwestern U.S. They are reported as pests of commercial crops in both Washington and Oregon (Berry 1978), but because these crops are routinely treated with insecticides, little is known of their population ecology and essentially no information is available regarding their associated parasitoids.

As part of a program to develop a biological control management system for lepidopterous pests of crucifers, we conducted field monitoring programs in 1986 and 1987 for the three lepidopteran species and evaluated parasitoids activity throughout the season at locations in Washington and Oregon.

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Materials and Methods

Seedlings of collards, *Brassoca oleracea,* cv. 'Vates' were transplanted into fields at several locations in Washington and Oregon in both years of the study. In 1986, there were two locations near Yakima, WA; one in Yakima (A) and the other 22 miles east of Yakima at our research farm (B). The plot at Puyallup, WA was located at the Western Washington Research and Extension Center, Washington State University, and the plot at Hermiston, OR was located at the Agricultural Research and Extension Center, Oregon State University. Plots at Yakima and Hermiston consisted of four rows of collards 30 m long. Rows were 1 m apart and plants were spaced ca. 0.5 m apart within rows. The plots at Puyallup were 15 m long. In 1987 there were three plots for population monitoring; one plot each at Yakima (location B), Hermiston and Puyallup. In 1986, collards were transplanted at Puyallup on May 1, Yakima A and B May 6, and Hermiston on May 28, and in 1987 at Yakima on April 28, Puyallup on May 5, and Hermiston on May 20. Plots received preplant fertilization at the following levels (kg/ha): 224N, 85P, and 112K. Two additional applications of 20•20•20 NPK were applied at 15 kg/ha at monthly intervals. Plots were maintained weed free. Collards were used as the host plant to monitor the populations of lepidopterans that attack crucifers as previous studies (Biever, unpublished) established that collards were attractive throughout the growing season to these pests.

Population counts were made by monitoring 20 plants per plot on a regular basis (approximately weekly). Whole plant counts were made by visually inspecting randomly selected plants following a zigzag path so that equal numbers of plants were sampled from each row. For each plant, the number and stages of the pests were recorded. At the same time counts were made, larvae (3rd and 4th stage) of each species were collected, returned to the laboratory, held individually and reared on collard foliage to recover parasitoids. Standard errors of the means were determined for pest population densities for each date and location.

Results

Artogeia rapae. In 1986, the highest population levels of small larvae (first through third stage) occurred at Yakima B (Fig. 1) and Hermiston (Fig. 2). Peak levels of 39.7 larvae per plant were observed at the Yakima location on August 27 and 11.6 at Hermiston on August 26. Population levels of *A. rapae* were intermediate for Yakima A (Fig. 3) and were quite low throughout the season at Puyallup (Fig. 4). With the exception of the Puyallup location, eggs of *A. rapae* were observed on all count dates during the 1986 season.

In 1987, the highest level of small larvae of *A. rapae* (45.8 per plant) occurred at Yakima B on August 20 (Fig. 5). Hermiston population levels of *A. rapae* were intermediate (Fig. 6) with a peak level of 10.6 small larvae per plant on July 28 and 12.4 larvae on September 15. Again in 1987 population levels of *A. rapae* at Puyallup were low throughout the season (Fig. 7). The standard errors were within 10-65 percent of the mean for population densities of *A. rapae* as well as for the other two pest species.

Plutella xylostella. In 1986, population levels of *P. xylostella* were the highest at Yakima A with a peak level of 8.7 small larvae per plant on August 14 (Fig. 1). Populations of *P. xylostella* at the other three locations were low throughout the

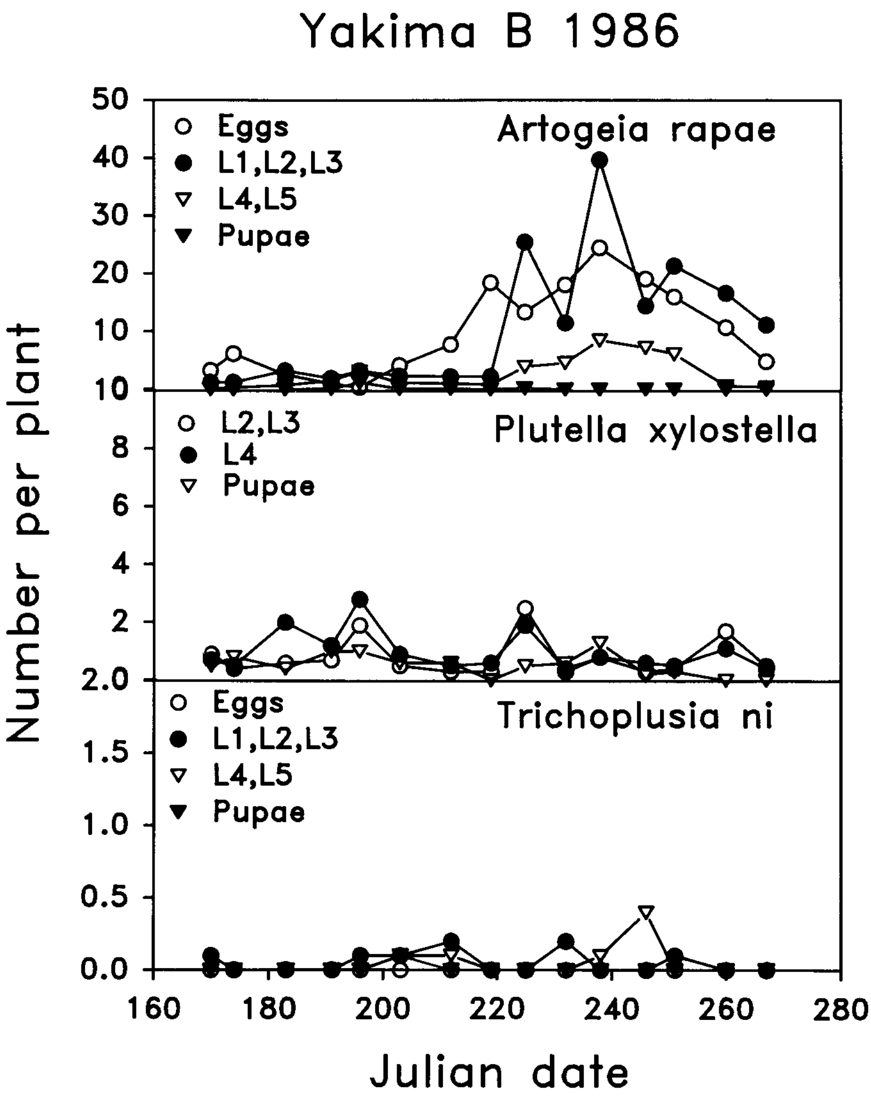

Fig. 1. Seasonal abundance of lepidopterous pests of crucifers during 1986 at Yakima (location B), WA.

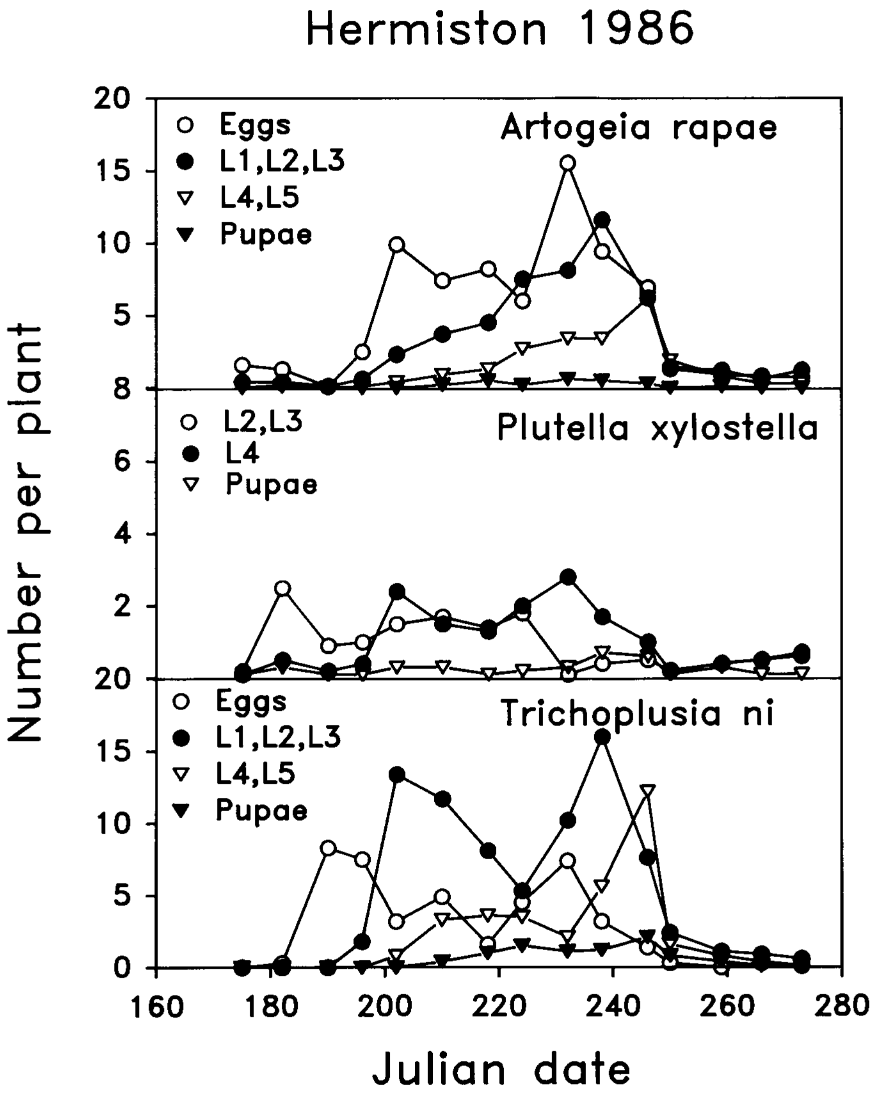

Fig. 2. Seasonal abundance of lepidopterous pests of crucifers during 1986 at Hermiston, OR.

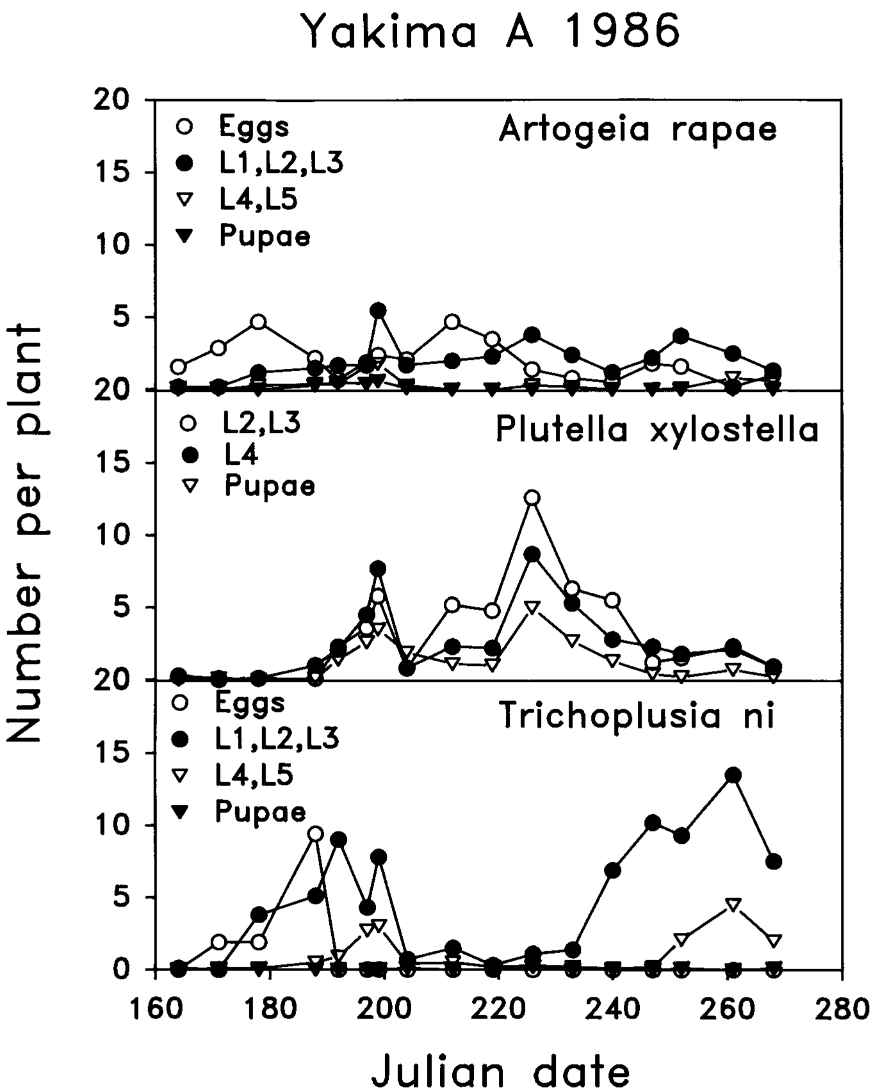

Fig. 3. Seasonal abundance of lepidopterous pests of crucifers during 1986 at Yakima (location A), WA.

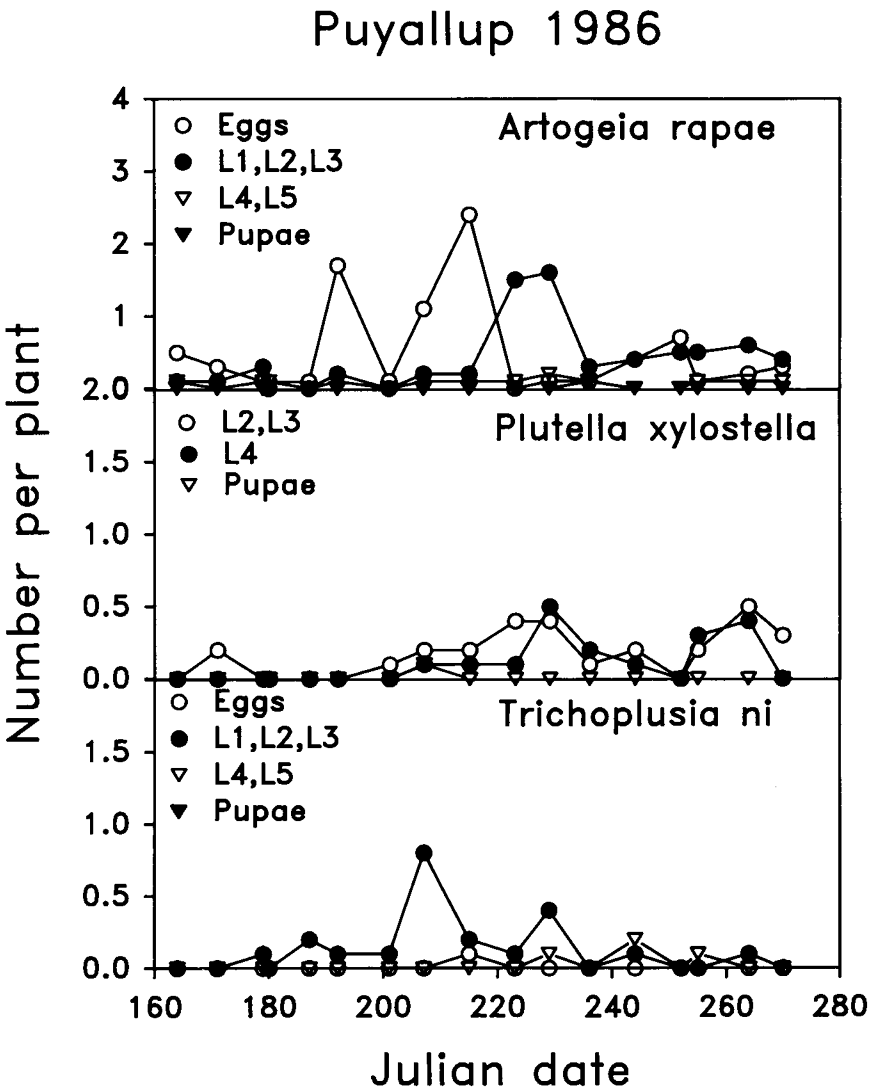

Fig. 4. Seasonal abundance of lepidopterous pests of crucifers during 1986 at Puyallup, WA.

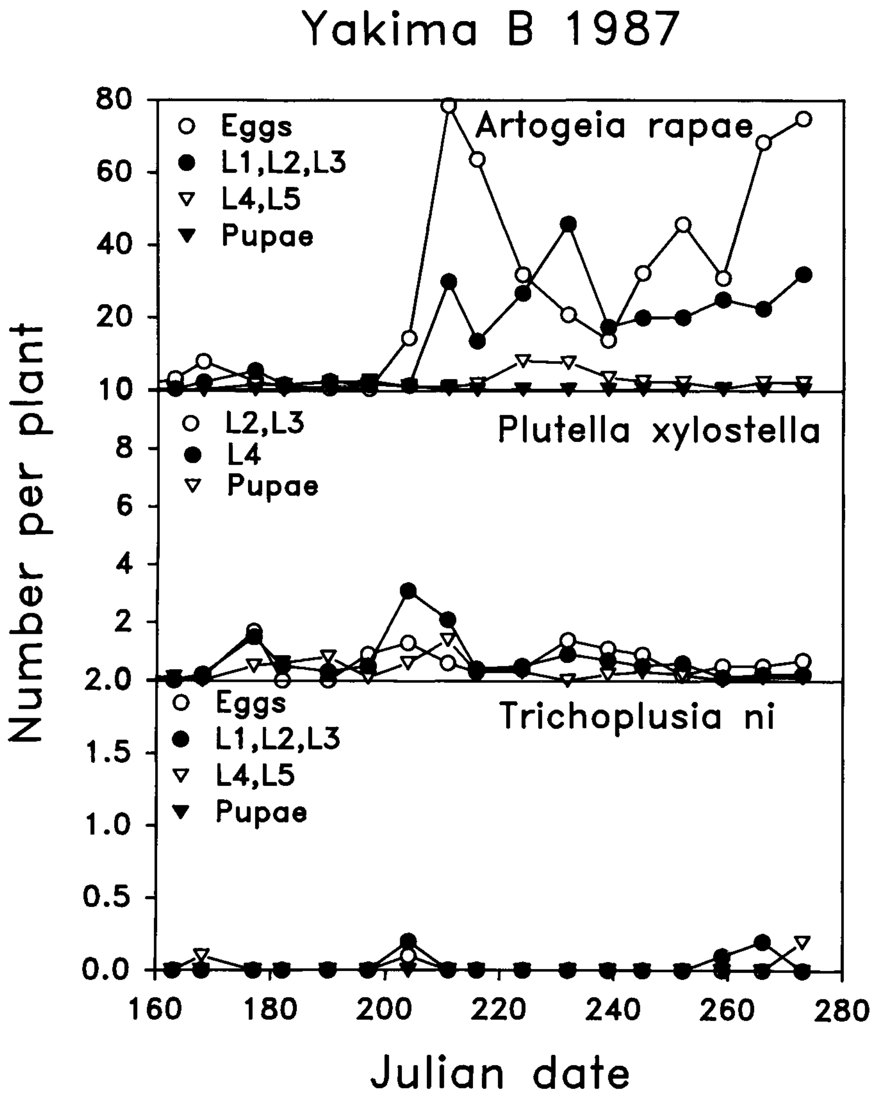

Fig. 5. Seasonal abundance of lepidopterous pests of crucifers during 1987 at Yakima (location B), WA.

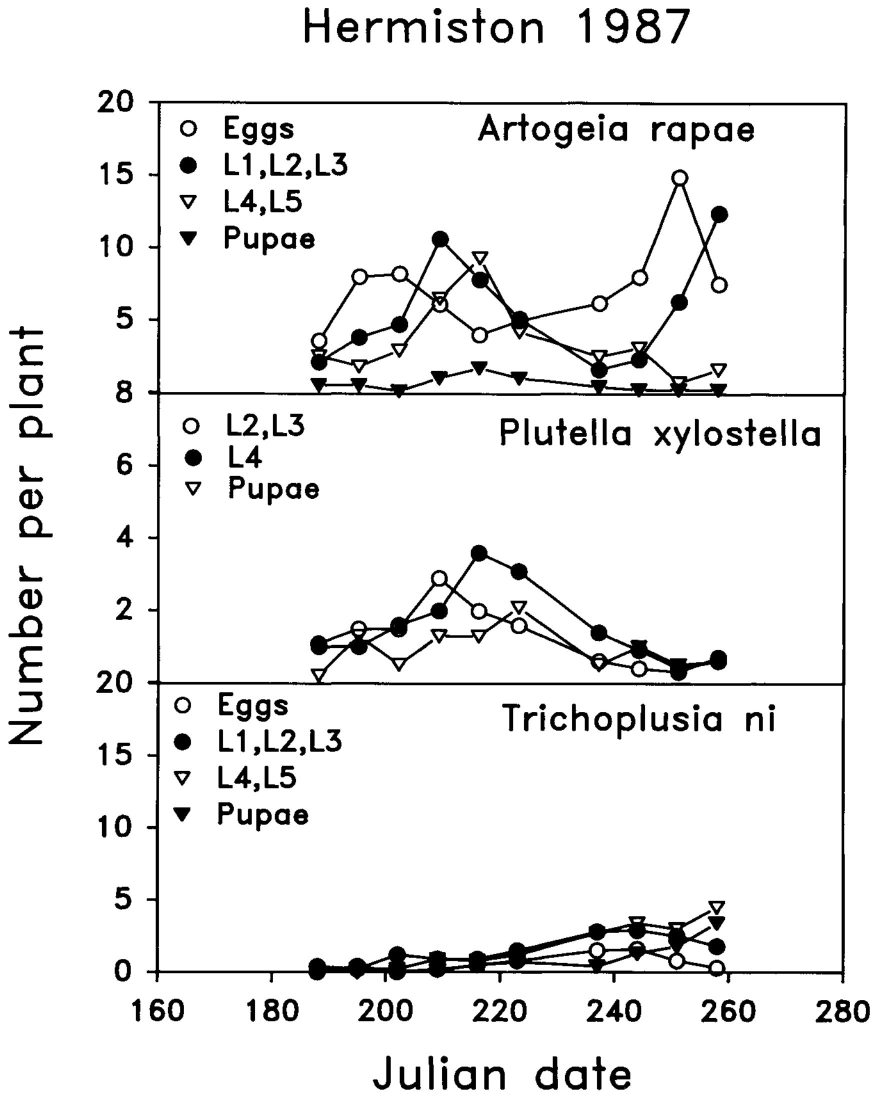

Fig. 6 Seasonal abundance of lepidopterous pests of crucifers during 1987 at Hermiston, OR.

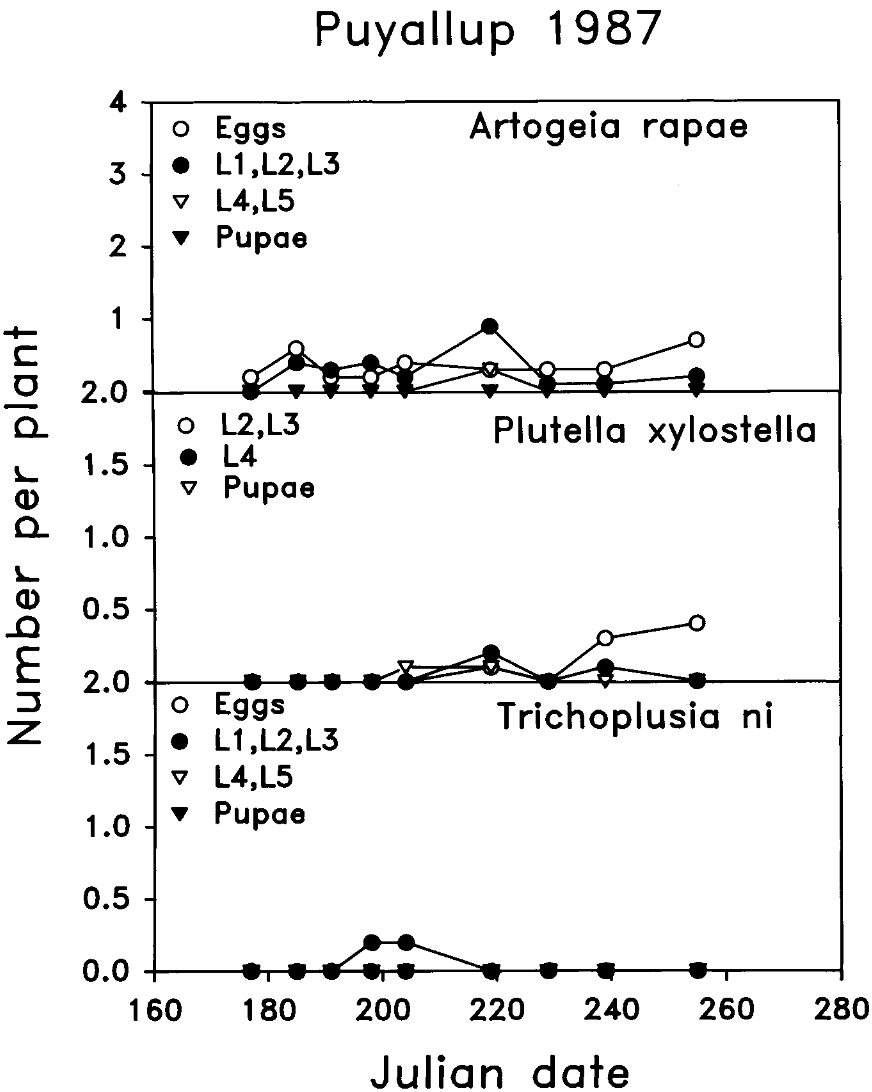

Fig. 7. Seasonal abundance of lepidopterous pests of crucifers during 1987 at Puyallup, WA.

season (Figs. 2-4). During the 1987 season, *P. xylostella* population levels were low at Hermiston and Yakima B and almost undetectable throughout the season at Puyallup (Figs. 5-7).

Trichoplusia ni. In 1986, the highest population levels of *T. ni* occurred at Hermiston and Yakima A (Figs 1, 3), The Hermiston population had two distinct peaks of small larvae, one on August 22 (13.4/plant) and one on September 26 (16.0/plant). The Yakima A population also had two peaks of small larvae, one on August 11 (9.0/plant) and one on September 18 (13.5/plant). In both 1986 and 1987, *T. ni* were very low at both Yakima B and Puyallup (Figs. 2, 4, 5, 7). In 1987, at Hermiston the maximum population level reached only 2.9 small larvae per plant on September 1 (Fig. 6).

Parasitoids. Seven species of parasitoids were recovered during this study. From *A. rapae* we recovered three species: *Cotesia rubecula* Marshall, *C. glomerata* (L.) and *Phryxe vulgaris* (Fallen); from *P. xylostella* we recovered three species: *Diadegma insulare* (Cresson), *Tetrastichus sokolowskii* Kurdjumov, and *Micropletis plutellae* Muesebeck; and from *T. ni* we recovered one species, *Voria ruralis* (Fallen). Parasitism of *P. xylostella* was consistently higher in both years at all locations than for either of the other two pest species (Fig. 8, 9). In both years, parasitization of our *P. xylostella* samples reached 100% on one or more dates at Hermiston and Puyallup, which were low host density locations. At Puyallup, for both years, parasitization peaked in early July and at the end of the season in September. At all other locations, for both years, parasitization of *P. xylostella* generally increased as the season progressed. The highest levels of parasitization (over 40%) of *A. rapae* were also at Hermiston and Puyallup in 1986, while in 1987 consistently higher levels occurred at Hermiston than did at the other two locations. Throughout the study, parasitization of *T. ni* was very low, only nine parasitized larvae were collected in 1986 and one in 1987 (Table 1).

The dominant parasitoid species attacking *A. rapae* at Yakima A and Puyallup was *C. rubecula; P. vulgaris* accounted for the most parasitization at Yakima B; while at Hermiston *C. glomerata* and *P. vulgaris* were the most abundant parasitoid species in 1986 and 1987 respectively (Table 1). The cabbage looper, *T. ni.*, was only parasitized by *V. ruralis*. The dominant parasitoid species attacking *P. xylostella* was *D. insulare* at all locations during both years. This species accounted for 74 to 100% of the larvae that were parasitized. Of secondary importance was *T. sokolowskii,* while *M. plutellae* contributed very little to the overall parasitization of *P. xylostella* populations.

Based on season long larval collections, parasitization of *T. ni* was the lowest and parasitization of *P. xylostella* was the highest while that of *A. rapae* was intermediate (Table 2). The highest incidence of parasitism on *T. ni* was at Yakima B in 1986 (7.7%). For *A. rapae* the seasonal parasitization rates ranged from 4.7 to 27.0% depending on location and year; Hermiston and Puyallup locations had the highest rates for both years. For *P. xylostella* the seasonal parasitization rates ranged from 17.1% at Hermiston in 1986 to 65.6% at Yakima in 1986. The parasitization rate of *P. xylostella* exceeded 42% on 5 out of 7 data sets.

Discussion

Population levels of the three pest species varied significantly depending both on location and year. In general, *A. rapae* was the most abundant and *T. ni* the

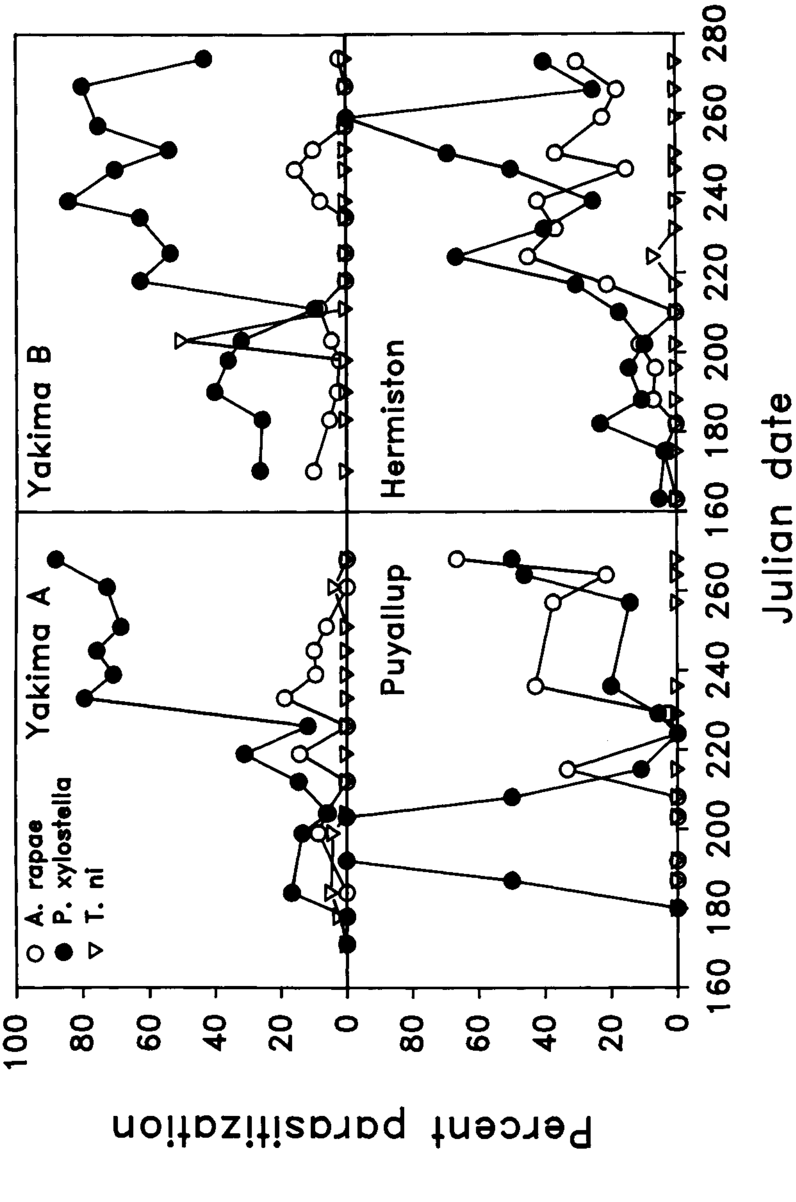

Fig. 8. Parasitization of lepidopterous pests of crucifers at 4 locations in Washington and Oregon in 1986.

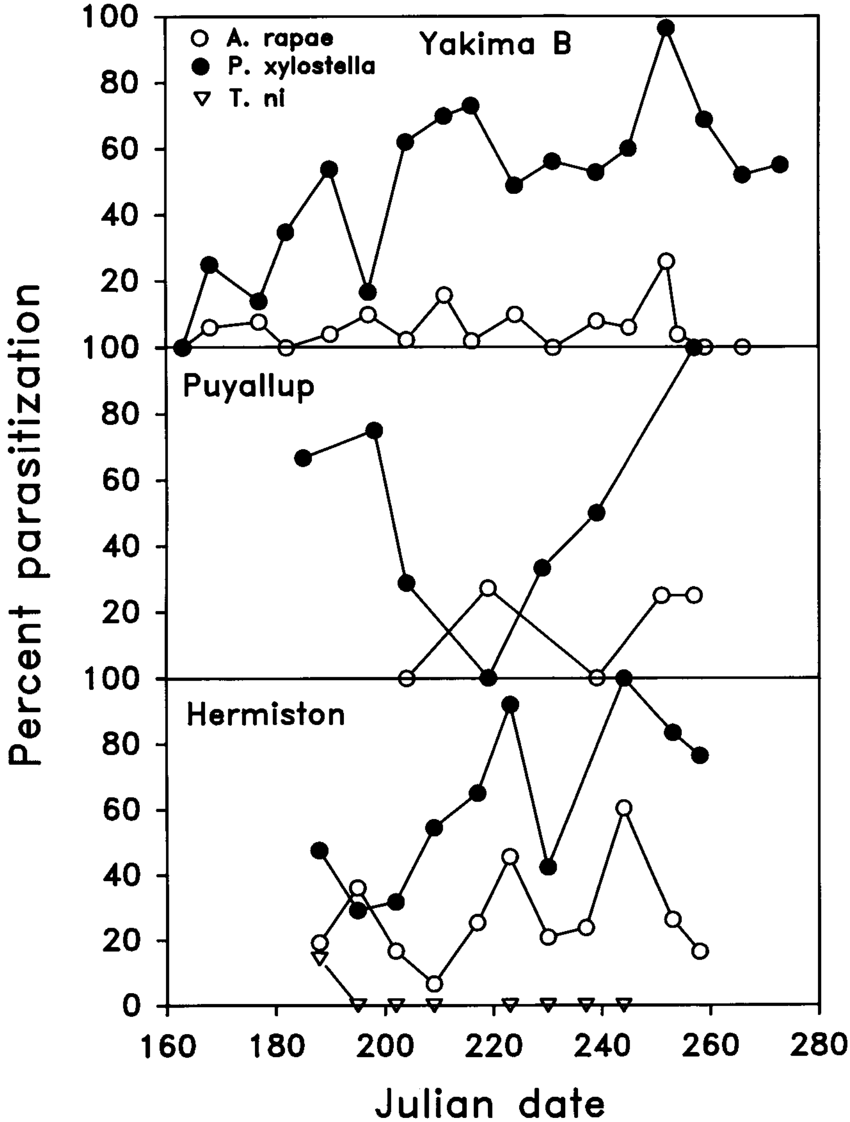

Fig. 9. Parasitization of lepidopterous pests of crucifers at 4 locations in Washington and Oregon in 1987.

Table 1. Percent contribution of each parasite to the total number of hosts parasitized during the 1986 and 1987 seasons by location.

		Location (% Parasitism)						
		Yakima A	Yakima B		Hermiston		Puyallup	
Parasite	Host	1986	1986	1987	1986	1987	1986	1987
	A. rapae	n = 12	n = 33	n = 50	n = 88	n = 193	n = 15	n = 9
C. rubecula		84	12	32	25	2	67	100
C. glomerata		8	24	24	51	16	20	0
P. vulgaris		8	64	44	24	82	13	0
	T. ni	n = 7	n = 1	n = 0	n = 1	n = 1	n = 0	n = 0
V. ruralis		100	100	0	100	100	0	0
	P. xylostella	n = 330	n = 202	n = 246	n = 50	n = 129	n = 17	n = 12
D. insulare		74	80	80	78	92	100	83
T. sokolowskii		22	20	15	20	5	0	17
M. plutellae		4	0	5	2	3	0	0

Table 2. Percent parasitization of the total number of hosts collected by location.

		Location			
Host	Year	Yakima A	Yakima B	Hermiston	Puyallup
A. rapae	1986	4.9 (n = 247)	4.7 (n = 708)	19.9 (n = 442)	14.4 (n = 104)
	1987	—	6.4 (n = 782)	27.0 (n = 716)	25.0 (n = 36)
T. ni	1986	2.8 (n = 252)	7.7 (n = 13)	0.4 (n = 291)	0.0 (n = 15)
	1987	—	0.0 (n = 4)	0.4 (n = 243)	0.0 (n = 0)
P. xylostella	1986	65.6 (n = 503)	42.7 (n = 202)	17.1 (n = 292)	22.3 (n = 76)
	1987	—	53.9 (n = 456)	55.6 (n = 232)	42.0 (n = 28)

least. The Puyallup location had the lowest levels of all three pest species regardless of year. Our study indicates that one cannot generalize about pest population abundance and occurrence even when locations are relatively close (Yakima A and B) and emphasizes the need to develop management strategies that are site specific. Throughout most of our study and at most locations the cabbage looper populations were at such low levels that they did not attain levels which would have required any control activity to protect a crop. A previous study demonstrated that when commercial fields of cabbage were not sprayed with chemical insecticides, the cabbage looper populations often did not reach treatment threshold levels (Biever and Hostetter 1978).

A complex of parasitoid species was present and appears to have an impact on the pest populations, but rates of parasitization varied significantly over time and location in Washington and Oregon. All parasitoid species recovered in this study have previously been reported from field population studies on cruciferous crops from one or more regions of the U.S. with the exception of *C. rubecula,* a parasitoid of the imported cabbageworm. The first record of this species occurring in North America was from British Columbia (Wilkinson 1966) and more recently this species was studied in Washington and Oregon by the first author.

In many cases the level of parasitoid activity we observed would not provide sufficient protection of cruciferous crops from the lepidoteran pest complex. To maximize the impact of the beneficial complex in suppressing these pests it will probably require the use of manipulative tactics such as seasonal inoculations of selected parasitoid species (Biever 1990). Although traditional control practices with chemical insecticides exclude these parasitoids a switch to a system that utilizes the judicious use of *Bacillus thuringiensis* could take advantage of the beneficial species (Biever 1990). Control needs and management strategies will likely vary with location and year in response to specific pest population pressures. The data generated in this study has provided us with the baseline information needed to assist in the development of a biological control management system that emphasizes the augmentative use of parasitoids through early season inoculation programs.

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