Population Dynamics of Leafminers and Their Parasitoids in Massachusetts Apple Orchards: 1999 Studies

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In the preceding article, we presented information on the species composition of third-generation leafminers found in 12 commercial and four abandoned Massachusetts apple orchards during 1997, 1998, and 1999. Results showed that each year, all four abandoned orchards and three of the commercial orchards were dominated by spotted tentiform leafminers (STLM). Conversely, each year seven of the commercial orchards were dominated by apple blotch leafminers (ABLM). Two of the commercial orchards were dominated by ABLM in 1997 but by STLM in 1998 and 1999. We concluded that the degree to which apple is a preferred host of STLM relative to ABLM and the degree to which STLM relative to ABLM is susceptible to insecticides could be principal factors associated with dominance by STLM vs. ABLM but suggested that parasitoid species composition and abundance might also be contributing factors.

Here, we present information on the species composition and abundance of leafminers and their principal parasitoids for each of the three generations of leafminers that occurred in 1999 in these 12 commercial and four abandoned orchards.

Materials & Methods

In June, August, and November of 1999, we sampled 10 leaves on each of 30 trees in each commercial and abandoned orchard for total numbers of first-, second-, and third-generation mines, respectively, in each 300-leaf sample. After taking each sample, we collected as many infested leaves (containing tissue-feeding mines) as possible during a 1-hour search of the orchard up to a maximum of 100 mines per orchard for the first and second generations and 300 mines per orchard for the third generation.

Mined leaves were returned to the laboratory for examination under a microscope to determine presence and identity of parasitoids and identity of leafminers. A complete categorization of the extent of parasitism of mined leaves would include presence of holes in leaf tissue made by parasitoid adults seeking to feed upon leafminer larvae as well as presence or evidence of parasitoid eggs. Because such evidence of parasitism was very difficult to determine with certainty, we confined our confirmation of parasitism to presence of parasitoid larvae, pupae (or their remains), and adults. Consequently, the values presented here for extent of parasitism of leafminers were undoubtedly lower than actual percentages occurring in orchards.

Results

Data in Table 1 show the abundance of leafminers in each generation in each orchard. Data in Table 2 show the species composition of leafminers and percentages of leafminer larvae parasitized by the two dominant parasitoids (*Sympiesis marylandensis* and *Pholetesor ornigis*) in each generation in each orchard. Owing to insufficient abundance of first-generation mines in some orchards, there are some unfortunate gaps in the data set for this generation of leafminers.

In the four abandoned orchards (M, N, O, P), STLM was the exclusive (or nearly exclusive) leafminer species present in each of the three generations. In five of the commercial orchards (A, D, F, G, I), STLM dominated in the second and third generations. STLM dominated also in the first generation in two of these orchards (A and I). ABLM slightly dominated STLM in the first generation in Orchard D, and no first-generation data were available for Orchards F and G. In the other seven commercial orchards (B, C, E, H, J, K, L), ABLM was markedly dominant in the second and third generations as well

Table 1. Density of first-, second-, and third-generation leafminers in 12 commercial and four abandoned apple orchards in Massachusetts in 1999.

Orchard	Number of mines per 100 leaves: First generation	Second generation	Third generation
A	6.7	2.5	21.0
B	4.3	9.5	14.5
C	0.7	22.5	8.5
D	1.3	0.5	12.5
E	1.0	5.0	23.0
F	0.3	29.0	89.0
G	0.0	2.5	10.5
H	1.0	3.0	7.0
I	19.7	6.5	21.5
J	0.0	0.0	7.0
K	0.3	2.0	10.5
L	5.3	0.5	4.5
M*	23.7	8.0	15.0
N*	17.5	4.5	23.0
O*	70.0	17.0	8.0
P*	15.7	2.0	11.0

* Abandoned orchards.

as in the first generation where data were available (B, C, E, J). Thus, with the exception of Orchard D, data indicate that the leafminer species that dominated in the first generation remained dominant in the second and third generations.

To facilitate comparisons, the 16 orchards were categorized into four groups (Table 3). Data in Table 3 show that for abandoned orchards M, N, O, and P, all of which were dominated by STLM and none of which received insecticide in 1999, LM population density decreased (on average) by more than half from the first to the third leafminer generation. In contrast, for commercial orchard F, likewise dominated by STLM and likewise having received no insecticide treatment against LM in 1999, LM population density increased 89-fold from the first to the third leafminer generation. In commercial orchards A, D, G, and I, also dominated by STLM but having received an insecticide treatment against LM in May of 1999, LM population density increased by an average of about two-fold from the first to the third leafminer generation. Finally, in commercial orchards B, C, E, H, J, K, and L, dominated by ABLM and having received an insecticide treatment against LM in May of 1999, LM population density increased by an average of about five-fold from the first to the third leafminer generation.

For all four categories of orchards, parasitism by *S. marylandensis* decreased progressively from the first to the third LM generation, averaging (across all generations) 36% for abandoned orchards, 26% for commercial orchards dominated by STLM and treated against LM in 1999, and 18% for commercial orchards dominated by ABLM. Parasitism by *P. ornigis* across all three generations averaged 11% for abandoned orchards, 9% for commercial orchards dominated by STLM and treated against LM in 1999, and 2% for commercial orchards dominated by ABLM, with no consistent trend toward increasing or decreasing abundance across generations.

Together, data in Table 3 suggest that the high amount of total parasitism of LM (47%) in the abandoned orchards may have been a principal factor associated with the decrease rather than an increase in LM population density from the first to the third LM generation. The level of total parasitism in Orchard F was only about one-third that in the abandoned orchards and was insufficient to prevent the 89-fold increase in LM population density from the first to the third generation. The substantially greater amount of total parasitism (35%) in STLM-dominated orchards treated against LM in 1999 than total parasitism (20%) in ABLM-dominated orchards treated against LM in 1999 may have played a role in the lower rate of first-to-third-generation LM population growth in the former (two-fold) compared with the latter (five-fold).

Finally, the data in Table 3 indicate that *P. ornigis* parasitoids were considerably more abundant in abandoned as well as LM-treated orchards dominated by STLM than in LM-treated orchards dominated by

Table 2. Species composition of leafminers and percentages of leafminer larvae parasitized during the first, second, and third generations of leafminers in 12 commercial and four abandoned apple orchards in Massachusetts in 1999.

	First generation (%)				Second generation (%)				Third generation (%)			
Orchard	No.*	ABLM**	S.m.***	P.o***	No.	ABLM	S.m.	P.o.	No.	ABLM	S.m.	P.o.
A	87	13	26	20	98	20	15	4	58	4	6	38
B	103	100	9	0	100	100	12	0	57	100	23	7
C	43	100	9	7	93	100	10	2	88	100	9	2
D	100	55	53	0	68	42	31	2	57	8	1	7
E	88	100	55	0	98	97	15	0	145	93	2	0
F	-	-	-	-	104	7	15	1	15	24	10	0
G	-	-	-	-	100	18	47	2	8	8	0	0
H	-	-	-	-	100	98	15	0	126	89	-	-
I	38	17	50	16	102	8	39	4	202	4	4	6
J	50	100	22	2	97	70	32	0	177	69	8	0
K	-	-	-	-	102	100	26	9	113	87	2	0
L	-	-	-	-	90	79	43	0	49	100	7	0
M	100	0	52	11	103	0	41	18	12	0	43	12
N	88	0	46	14	50	0	12	2	86	0	27	6
O	92	0	69	1	58	0	52	2	8	0	0	13
P	-	-	-	-	77	0	30	12	47	14	6	30

* Numbers of mature mines examined.
** Percent of total pupae identified as ABLM; remaining percent was STLM.
*** Percent of LM larvae parasitized by *Sympiesis marylandensis* (S.m.) *or Pholetesor ornigis* (P.o.).

Table 3. Relationship between leafminer-targeted insecticide treatments, dominant species, and population buildup of leafminers and extent of parasitism of leafminers in Massachusetts orchards in 1999.

			Number of mines per 100 leaves			Parasitism by *S. marylandensis* (%)			Parasitism by *P. ornigis* (%)		
Orchards	Insecticide treatment against LM in 1999	Dominant species of LM	First gen.	Second gen.	Third gen.	First gen.	Second gen.	Third gen.	First gen.	Second gen.	Third gen.
Abandoned (M,N,O,P)	No	STLM	32	8	14	56	34	19	9	9	15
Commercial (F)	No	STLM	1	29	89	--	15	10	--	1	0
Commercial (A,D,G,I)	Yes	STLM	7	3	16	43	33	3	12	3	13
Commercial (B,C,E,H,J,K,L)	Yes	ABLM	2	6	11	24	22	9	2	2	2

ABLM, suggesting a possible preference *of P. ornigis* for STLM.

Conclusions

Several of the data trends shown and discussed here and in the preceding article for Massachusetts orchards are similar to trends reported earlier by Chris Maier, whose outstanding work on leafminers in Connecticut orchards inspired our studies. Notable among the trends for both Connecticut and Massachusetts are (1) a strong tendency toward a shift in dominance from ABLM to STLM with decreasing frequency of annual insecticide treatment against LM, (2) a strong tendency toward lower parasitism of LM in sprayed than unsprayed (abandoned) orchards, and (3) generally greater levels of LM parasitism by *S. marylandensis* than by *P. ornigis*, especially among populations of ABLM.

Parasitoids alone appear to be sufficient to exert effective population suppression of LM in abandoned orchards and may have contributed to population suppression of LM in those commercial orchards designated here as A, D, F, G, and I, which received no insecticide treatments against LM in 1997 and 1998. Even so, four of these five STLM-dominated orchards (A, D, G, I) did require a LM-targeted treatment in 1999, suggesting that parasitoids alone were insufficient to effectively suppress STLM below potentially damaging levels. The lowest levels of LM parasitism found in 1999 were in orchards designated here as B, C, E, H, J, K, and L, all of which were dominated by ABLM and all of which received a LM-targeted insecticide in 1999 (all seven of these orchards also received a LM-targeted insecticide in 1997 and/or 1998).

The 89-fold level of first- to third-generation population increase in STLM-dominated Orchard F in 1999 was explosive in comparison with the decrease in average first- to third-generation population density that characterized STLM-dominated abandoned orchards in 1999. For reasons yet unknown but possibly associated with apple being the principal host of STLM and only one among many different hosts of ABLM, unattended populations of STLM in commercial orchards could represent a greater threat than populations of ABLM. We hope to explore this possibility in future research.

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