Species Composition of Third-generation Leafminers in Massachusetts Apple Orchards: 1997-1999

Starker Wright, Baige Zhao, and Ronald Prokopy
Department of Entomology, University of Massachusetts

In Massachusetts, leafminers (LM) have been a consistent threat to the quality of apple foliage in commercial orchards ever since their initial rise to prominence in the late 1970s due largely to the onset of resistance to organophosphate insecticides. Over the past 10 years or so, LM in Massachusetts orchards exhibited three rather distinctly different patterns of population growth. In some orchards, growth has been slight or at most moderate, never exceeding a threshold requiring insecticide treatment. In other orchards, growth also has been slight, owing to annual or biannual application of a preventative insecticide spray against LM. In still other orchards, populations have undergone a period of explosive growth, followed by rapid decline subsequent to insecticide treatment, only to be followed by another period of explosive growth.

Several factors might account for these observed differences in characteristic form of LM population growth. They include: (1) amounts, types and timings of pesticides directed against other orchard pests, (2) amounts, types and timings of pesticides directed against LM, (3) the nature of the habitat adjacent to commercial orchards, (4) the species composition and diversity of parasitoids that can provide biocontrol of LM, and (5) the species composition of LM themselves.

In regard to the latter, through the 1980s, commercial orchards in Massachusetts were dominated by the apple blotch leafminers (ABLM) *Phyllonorycter crataegella*, which is native to the USA and infests a rather wide variety of plant species. During the 1990s, however, we saw a rise in numbers of spotted tentiform leafminers (STLM) *Phyllonorycter blancardella*, which is an introduced species from Europe and infests only apples and crabapples.

Here, we report results of a study conducted from 1997-1999 aimed primarily at characterizing the species composition of third-generation LM in 12 commercial apple orchards in Massachusetts during this three-year period. Our secondary aim was to attempt to relate LM species composition with LM population density and patterns of insecticide use against LM. Other articles in this and future issues of *Fruit Notes* will deal with LM populations as influenced by parasitism, border area composition, and type of perimeter-row cultivar.

Materials & Methods

In November in each of three years (1997-1999), we sampled 10 leaves on each of 30 trees in each of 12 commercial orchards, pointing blindly toward the tree canopy and picking the first leaf encountered by hand. We counted the total number of third-generation mines in the 300-leaf sample. After this, we picked as many mine-infested leaves as could be found in a one-hour search of the orchard (maximum of 300 leaves) and returned them to the laboratory for examination of pupae under a microscope. Pupae can be classified according to LM species on the basis of the structure of minute "hooks" present on the posterior end. In 1999, we also sampled mined leaves from four orchards that had been abandoned for at least 5 years.

Results

To facilitate presentation of results, sampled commercial orchards are grouped according to three geographical areas in Massachusetts: Orchards A, B, and C in the west, orchards D, E, F, and G in the center, and orchards H, I, J, K, and L in the east.

Data in Table 1 show that in each of these three geographical regions, at least one sampled orchard experienced a rather high LM density level in at least one of the three years, and at least one sampled orchard

Table 1. Density of third-generation leafminers in 12 commercial and 4 unmanaged apple orchards in Massachusetts (1997-1999).

Orchard	Location	Number of. mines per 100 leaves 1997	1998	1999
A	Ashfield	54	104	21
B	Shelburne	11	3	15
C	Colrain	5	6	9
D	Belchertown	31	11	13
E	Brimfield	65	38	23
F	Warren	304	80	89
G	Brookfield	51	191	11
H	Princeton	9	33	7
I	Leominster	203	311	22
J	Sterling	11	9	7
K	Sterling	6	7	11
L	Northboro	--	305	5
M	Ashfield*	--	--	15
N	Deerfield*	--	--	23
O	Leominster*	--	--	8
P	Sterling*	--	--	11

* Abandoned orchards.

remained at a rather low LM density throughout the three years. Similarly, data in Table 2 show that in each of the three geographical regions, at least one sampled orchard was dominated by ABLM across the three years and at least one other commercial orchard was dominated by STLM across the three years. Thus, neither the population density nor the species composition of LM appeared to be affected by geographical location within Massachusetts.

In all, there were five commercial orchards (A, F, G, I, L) wherein the density of third-generation mines reached 100 per 100 leaves in at least one of the three years (Table 1). In three of these five orchards (A, F, I), the dominant species each year was STLM (Table 2). In the fourth orchard (G), ABLM dominated in 1997 but STLM in 1998 and 1999. In the fifth orchard (L), ABLM dominated each year. In the remaining seven orchards (B, C, D, E, H, J, K), the density of third-generation mines did not reach 100 mines per 100 leaves in any of the three years (Table 1). In six of these seven orchards, the dominant species each year was ABLM (Table 2). In the seventh orchard (D), ABLM was distinctly dominant in 1997 but STLM was distinctly dominant in 1998 and 1999. Thus, the highest densities of leafminers were associated largely with dominance by STLM, whereas lower densities were associated largely with dominance by ABLM.

As summarized in Table 3, none of the four abandoned orchards (M, N, O, P) received an insecticide treatment against LM during any of the three years, and five of the commercial orchards (A, D, F, G, I) received no insecticide treatment against LM in 1997 and 1998, although four of the five received such treatment in 1999. All nine of these orchards were dominated by STLM in 1998 and 1999. In contrast, seven of the commercial orchards (B, C, E, H, J, K, L) received an insecticide treatment targeted against LM in two or all three years. Each year, all seven of these orchards were dominated by ABLM.

Thus, no or infrequent spraying against leafminers appears to be associated with the rise of STLM to the status of dominance, whereas frequent spraying seems to be associated with dominance by ABLM. Our data are insufficient for establishing a relationship between time since application of an insecticide against leafminers and the rise of ABLM to dominance, although the data in Table 3 for 1999 for orchards A, D, G, and I suggest that such a rise to dominance by ABLM does not occur during the same year that insecticide is applied.

Conclusions

Results of this three-year study suggest that dominance in species composition of LM in Massachusetts orchards was (1) not associated with any particular geographical region within the state, (2) was apparently associated with LM density, and (3) was apparently associated with frequency of insecticide

Table 2. Species composition of third-generation leafminer pupae in 12 commercial apple orchards (1997-1999) and four abandoned apple orchards (1999) in Massachusetts. Apple blotch leafminer = ABLM. Spotted tentiform leafminer = STLM.

		1997			1998			1999		
Orchard	Location	No. pupae	ABLM (%)	STLM (%)	No. pupae	ABLM (%)	STLM (%)	No. pupae	ABLM (%)	STLM (%)
A	Ashfield	25	16	84	20	20	80	245*	4	96
B	Shelburne	19*	100	0	20	100	0	90*	100	0
C	Colrain	24	100	0	33*	91	9	178*	100	0
D	Belchertown	109	80	20	90	28	72	121*	8	92
E	Brimfield	181*	98	2	76*	96	4	139*	93	7
F	Warren	250	29	71	83	11	89	86	24	76
G	Brookfield	199	71	29	124	2	98	13*	8	92
H	Princeton	18*	100	0	44*	98	2	161*	89	11
I	Leominster	19	11	89	94	14	86	164*	4	96
J	Sterling	113*	90	10	84*	94	6	189*	69	31
K	Sterling	102*	95	5	58*	99	1	184*	87	13
L	Northboro	23*	100	0	33	100	0	79*	100	0
M**	Ashfield	--	--	--	--	--	--	18	0	100
N**	Deerfield	--	--	--	--	--	--	122	0	100
O**	Leominster	--	--	--	--	--	--	14	0	100
P**	Sterling	--	--	--	--	--	--	58	14	86

* Indicates that either Pounce, Asana, Provado, or Agri-Mek was applied against first-generation LM that year.
** Abandoned orchards.

Table 3. Relationship between frequency of application of insecticide against leafminers and dominant leafminer species in Massachusetts orchards.

	Insecticide applied against LM			Dominant species of LM		
Orchards	1997	1998	1999	1997	1998	1999
Abandoned (M,N,O,P)	None	None	None	STLM	STLM	STLM
Commercial (A,D,F,G,I)	None	None	A,D,G,I	STLM*	STLM	STLM
Commercial (B,C,E,H,J,K,L)	B, E,H,J,K,L	C,E,H,J,K	B,C,E,H,J,K,L	ABLM	ABLM	ABLM

* ABLM in orchards D and G

application targeted against LM. With little exception, dominance by STLM in commercial orchards was associated with higher LM population density and no or infrequent use of insecticide to control LM. Conversely, dominance by ABLM was associated with lower LM population density and rather frequent use of insecticide to control LM.

In any scientific investigation, establishment of a strong association or correlation between two variables should not be taken to imply cause and effect. Further study is needed to determine the true cause or causes underlying the dominance of ABLM or STLM in a given orchard.

Even so, one can postulate a possible scenario with the following steps: (1) dominance of STLM in abandoned apple orchards either because of apple being a more favored host of STLM than it is of ABLM, because STLM is less susceptible to parasitism than is ABLM, because STLM is a better competitor for host resources than is ABLM, or a combination of these, (2) movement of STLM adults into an orchard currently colonized by ABLM, (3) more rapid and extensive buildup of STLM in commercial orchards than is characteristic of ABLM, leading to (4) application of a targeted insecticide against LM that exerts a greater effect on STLM than ABLM and results in (5) temporary dominance by ABLM. Further study is needed to evaluate this possible scenario.

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