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ABUNDANCE AND IDENTIFICATION OF THE LEAFMINING GUILD ON APPLE IN THE MID-ATLANTIC STATES

M. W. Brown[1]

ABSTRACT

The leafmining guild on apple in the northeastern United States was studied from 1983 to 1988. Ten species of leafminers, all Lepidoptera, were encountered during the sampling. *Phyllonorycter* spp. (*P. blancardella* and *P. crataegella*) were the most ubiquitous and most abundant throughout the region. *Lyonetia speculella* was also abundant in both managed and unmanaged orchards, indicating a potential to become a pest. *Bucculatrix pomifoliella* and *Coptodisca splendoriferella* were abundant in unmanaged orchards, but were only rarely found in managed orchards. *Coleophora serratella, Stigmella pomivorella, Parornix geminatella, Tischeria malifoliella,* and *Recurvaria nanella* were also found. A key to the most important leafminer species on apple in the mid-Atlantic states, based on leafmine characteristics, is presented.

Leafminers of recent economic importance on apple in North America are limited to the gracillariids: the spotted tentiform leafminer, *Phyllonorycter blancardella* (Fabricius), and the apple blotch leafminer, *P. crataegella* (Clemens) in the east; and in the west the western tentiform leafminer, *P. elmaella* Doganlar and Mutuura (Lepidoptera: Gracillariidae). These species are the only leafminers identified that currently require chemical control, primarily because of their developing resistance to chemicals commonly used in orchards (Weires et al. 1982, Pree et al. 1986, Barrett and Brunner 1990). *Lyonetia speculella* Clemens (Lepidoptera: Lyonetiidae) has recently become abundant in the mid-Atlantic states (Brown 1989), but has required chemical control only in isolated circumstances. However, several species of leafminers have been major pests in orchards. Those species requiring control in the past include *Coleophora serratella* (Linnaeus) (Lepidoptera: Coleophoridae) (Slingerland 1895), *Tischeria malifoliella* Clemens (Lepidoptera: Tischeriidae) (Jarvis 1906, Houghton 1910, Dunnam 1924), *Parornix geminatella* (Packard) (Lepidoptera: Gracillariidae) (Haseman 1916, Hill and Hough 1957), *Bucculatrix pomifoliella* Clemens (Lepidoptera: Lyonetiidae) (Slingerland and Fletcher 1903), and *Rhynchaenus pallicornis* Say (Coleoptera: Curculionidae) (Houser 1923).

Needham et al. (1928) and Frost (1942) listed 13 and 10 species, respectively, in the leafmining guild (Root 1967) of apple, nine of which were in listed in common. This guild is comprised of those species that live and feed completely between the apple leaf's two epidermal layers for at least part of their life cycle. I have encountered ten leafmining insects on apple (Brown et al. 1988). This paper presents information on the abundance of the most important leafminers of apple in the mid-Atlantic states. A key to species is also presented using characteristics of the leafmine.

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MATERIALS AND METHODS

Data on the abundance of leafminers are taken from two separate studies of the arthropod community structure on apple. In the first study, managed and abandoned orchards were sampled in Ulster Co., New York (1983); Wayne Co., New York (1984); Lehigh and Berks Cos., Pennsylvania (1984); Jefferson and Morgan Cos., West Virginia (1983, 1984); and Augusta and Nelson Cos., Virginia (1983). "Organic" orchards, those with an intermediate level of management, were sampled in Ulster, Berks, and Morgan Co. At each orchard, 5–7 randomly selected trees were sampled 3–7 times per year. A sample consisted of recording all leaf- and sap-feeding insects and mites observed on nine branch sections per tree. A complete description of the sampling procedures, species lists, and analysis of community structure are given in Brown et al. (1988) and Brown and Adler (1989).

The second study investigated the development of the arthropod community on three orchards in Jefferson Co., West Virginia, for the first five years after planting. The first orchard was managed commercially and was composed of two rows adjacent to a large block (40 ha) planted the previous year; the second orchard also was managed commercially except for no insecticides or herbicides; and the third orchard was totally unmanaged except for occasional mowing in the first two years after planting. The three orchards were planted in spring 1984, and each was sampled 4–6 times per year from 1984 to 1988. The commercially managed orchard had a few insecticide sprays in 1985 and a full schedule of insecticide use beginning in 1986. Sampling consisted of searching whole trees and recording the presence of all phytophagous arthropods. Ten trees were sampled randomly from each orchard in 1984 and 1985, and in the two reduced management orchards through 1988. Only five trees were sampled in the managed orchard from 1986 to 1988 due to the large size of the trees and the uniformity of the community among trees.

Species identification was largely by leafmine characteristics, but individuals from all species, except *Parornix geminatella*, were reared and their identity confirmed by personnel at the USDA, ARS, Systematic Entomology Lab, Beltsville, Maryland. Data from both studies are presented as relative abundance, defined as the proportion of branch sections (or trees in the second study) on which a species was found. No comparisons between studies are made because the relative abundances are based on different spatial scales. Due to the lack of replication of orchards, statistical differences among orchard management practices could not be tested. However, the trend in population abundance of leafminers over the six years covered by the two studies does provide information on the composition of this guild in one region.

A key to the most important leafminers of apple in the mid-Atlantic states using only characteristics of the mine was developed using personal observations and descriptions in the literature.

RESULTS AND DISCUSSION

Abundance. Ten species of leafminers were found on apple during the 1983–1984 study (Table 1). *Phyllonorycter* spp. were the most abundant and the only species found in all orchards; they were moderately to very abundant in all abandoned orchards. In the managed orchards of New York, *Phyllonorycter* spp. were extremely abundant, whereas in other regions they were never present on more than 18% of the branches. The resistance of these species to insecticides in New York and Ontario (Weires et al. 1982, Pree et al. 1986) apparently has not developed in the regions sampled south of New York. Throughout the 1984–1988 study, *P. blancardella* was very abundant in all three orchards (Fig. 1). *Phyllonorycter blancardella* was most abundant in unsprayed orchards the first year after planting. The

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Table 1.—Relative abundance[a] of leafminers on apple in the mid-Atlantic states, 1983–1984.

Orchard	*Phyllonorycter* spp.	*Bucculatrix pomifoliella*	*Lyonetia speculella*	*Coptodisca splendoriferella*	*Coleophora serratella*	*Stigmella pomivorella*	*Parornix geminatella*	*Tischeria malifoliella*	*Recurvaria nanella*
1983									
WV-Abandoned	0.46	0.62	0.04	0.69	0.02	0	0	0	0
WV-"Organic"	0.59	0.26	0.22	0	0	0	0	0	0
WV-Managed	0.06	0.01	0.03	0	0	0	0	0	0
NY-Abandoned	0.19	0.62	0	0.31	0.10	0	0	0	0
NY-"Organic"	0.70	0.57	0.02	0.11	0	0	0	0	0
NY-Managed	0.68	0.01	0	0.01	0	0	0	0	0
VA-Abandoned	0.14	0.16	0.06	0.23	0.25	0.02[b]	0.02[b]	0	0
VA-Managed	0.01	0	0.13	0	0	0	0.02[b]	0	0
1984									
WV-Abandoned	0.74	0.24	0.09	0.53	0.07	0	0	0	0.01[c]
WV-"Organic"	1.00	0.39	0.15	0	0	0	0	0	0
WV-Managed	0.18	0.01	0.13	0	0	0	0	0	0
PA-Abandoned	0.48	0.48	0.05	0.27	0.02	0	0	0.02	0
PA-"Organic"	0.25	0	0.20	0.15	0.20	0	0	0	0
PA-Managed	0.02	0.01	0.03	0	0	0	0	0	0
NY-Abandoned	0.96	0.04	0.02	0.21	0.02	0.42	0	0.40	0
NY-Managed	0.90	0	0.01	0	0	0	0	0	0

[a]Proportion of branch sections on which a species was found at the sample period of greatest abundance for that species.
[b]Unverified identification; identification made in laboratory based on field notes and phenology.
[c]A single pupa was collected and reared independent of regular sampling.

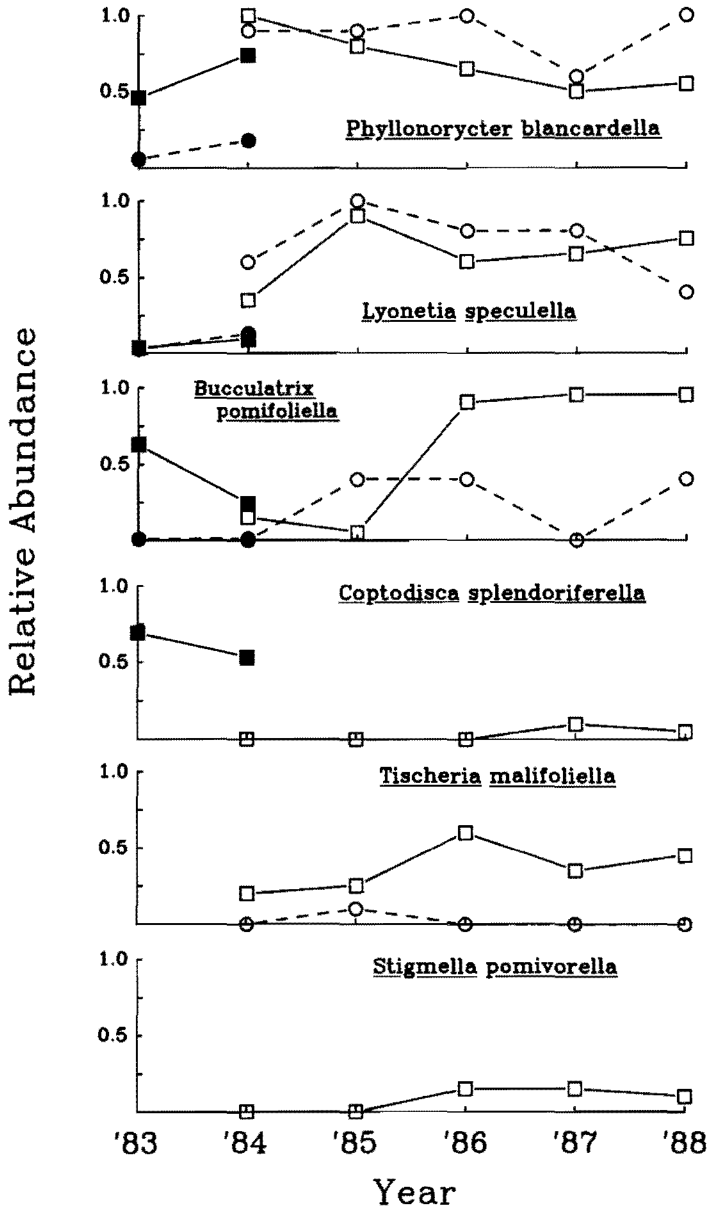


Figure 1. Abundance of the most important leafminers of apple in West Virginia from 1983–1988. Relative abundance, the proportion of branches (1983–1984 study) or trees (1984–1988 study) on which the species was found, presented is at the time of greatest abundance during the year. Solid lines with square symbols are for unmanaged orchards, dashed lines with circles are for managed orchards. Solid symbols represent data from the 1983–1984 study, open symbols the 1984–1988 study.

pattern of abundance is what would be expected for a mobile pest: rapid colonization followed by a gradual decline as natural enemies begin to colonize.

Bucculatrix pomifoliella was the next most abundant leafminer in the 1983–1984 study; it was consistently more abundant in abandoned than managed orchards (Table 1). *Coptodisca splendoriferella* (Clemens) (Lepidoptera: Heliozelidae) followed a similar pattern of abundance with only one individual found in a managed orchard. Both species once were considered pests requiring chemical control (Slingerland and Fletcher 1903, Quaintance and Siegler 1922). These two species are still abundant in the northeastern U.S. (Table 1), even though they are intolerant of currently used insecticides. As orchardists reduce the use of insecticides because of public pressure and/or economic considerations, these former pests may reappear in commercial orchards in large numbers.

Bucculatrix pomifoliella became abundant in the unsprayed orchards of the 1984–1988 study two years after planting (Figure 1), possibly because of a lower rate of dispersal than *P. blancardella*. There also may have been a general area-wide depression in population density from 1983–1985, as Fig. 1 suggests. More data are needed to confirm either hypothesis. The moderate abundance of *B. pomifoliella* in the managed orchard was unexpected. This result could be explained by inadequate insecticide coverage or because the trees sampled were on the edge of a large block, resulting in an edge effect phenomenon.

Lyonetia speculella was of low to moderate abundance in 1983–1984 (Table 1) and was equally abundant in managed and unmanaged orchards throughout both studies. These two data sets (Fig. 1) document the area-wide increase in its abundance (Maier 1988, Brown 1989).

Coleophora serratella, formerly a major pest (Slingerland 1895), was infrequently found, and only in unmanaged and "organic" orchards. The cigar casebearer was found only in one sample in the 1984–1988; it had a relative abundance of 0.2 in the unsprayed orchards in 1988. The use of modern insecticides and/or environmental changes seem to have reduced the threat to apple production once caused by this insect.

The remaining leafminer species were found only sporadically, with the exception of *P. geminatella*, in abandoned orchards. *Stigmella pomivorella* (Packard) (Lepidoptera: Nepticulidae), and *T. malifoliella* were abundant in Wayne Co., New York, in 1984, and were at low and moderate densities, respectively, in West Virginia, in 1984–1988. Although *P. geminatella* and *T. malifoliella* have been pests (Haseman 1916, Dunnam 1924, Hill and Hough 1957), they appear to be of little threat to orchards, except possibly the latter in western New York.

KEY TO THE MORE IMPORTANT LEAFMINES OF APPLE IN THE MID-ATLANTIC STATES

This key is designed to be used for leafmines that are fully developed. Only characteristics of the leaf mine or other structures associated with the insect's feeding are used. Frost (1942) presents a key to most of the same leafminers, but uses characteristics of mines, larvae, and adults. Use of the key on a mine that has not been completed, either through larval mortality or because the mine is still being enlarged by the larva, may give incorrect results. Descriptions of the mines of *Parornix geminatella, Rhynchaenus pallicornis, Recurvaria nanella*, and *Baliosus nervosus* are taken from the literature and have not been seen by the author. References to each species' biology and life history are given as a source of more detailed information.

1. Mine tented or inflated with upper and lower epidermis separated, forming a cavity within leaf. 2

1'. Mine not tented or inflated, upper and lower epidermis not separated, cavity not formed within leaf. 4

2(1). Mine appearing inflated, usually at leaf margin, brick-red, with small linear mine leading to blotch portion. Apple flea weevil[2], *Rhynchaenus pallicornis* (Houser 1923, Frost 1924).

2'. Upper epidermis of mine tented, lower epidermis drawn together in creases; usually not at leaf margin; pale green to brown or translucent. 3

3(2'). Upper surfaces of mine spotted in appearance from patches of leaf tissue not eaten; leaf moderately distorted; no evidence of pupation site exterior to mine, pupal exuviae extruded from mine; Figure 2. Spotted tentiform leafminer[2], *Phyllonorycter blancardella* or apple blotch leafminer[2], *Phyllonorycter crataegella* (Pottinger and LeRoux 1971). (These two may be distinguished by cremaster of pupa, see Weires et al. [1980]).

3'. Upper surface not spotted, entire leaf tissue eaten within mine; pupation site (a leaf fold with silk at leaf margin or midrib) usually near mine; leaf usually greatly distorted. Unspotted tentiform leafminer, *Parornix geminatella* (Haseman 1916, Hill and Hough 1957).

4(1'). Mine linear, margins of mine parallel or only gradually enlarging 5

4'. All or a portion of mine blotchlike 7

5(4). Long, serpentine mine, mostly filled with continuous black deposit of frass, Figure 3, but sometimes blotchlike if abutting leaf margin or major leaf vein. Serpentine leafminer, *Stigmella pomivorella* (Quaintance and Siegler 1922).

5'. Short mine with few changes in direction; frass, if present, not in a continuous strand ....

6(5'). Short straight mine, often branched; mine constructed only in July and August. Lesser bud moth[2], *Recurvaria nanella* (Chapman and Lienk 1971).

6'. Narrow mine following midrib or major vein for 1–2 cm (this portion of mine difficult to see), making a sharp turn and enlarging, usually at a vein junction, slightly serpentine for a short distance; sometimes found throughout the summer; often accompanied on leaf by silvery silken molting cocoons and skeletonized patches near leaf margin on upper surface made by the free-feeding stages of the larva; Figure 4. Ribbed cocoon maker, *Bucculatrix pomifoliella* (Slingerland and Fletcher 1903).

7(4'). Mine partially linear and partially blotchlike 8

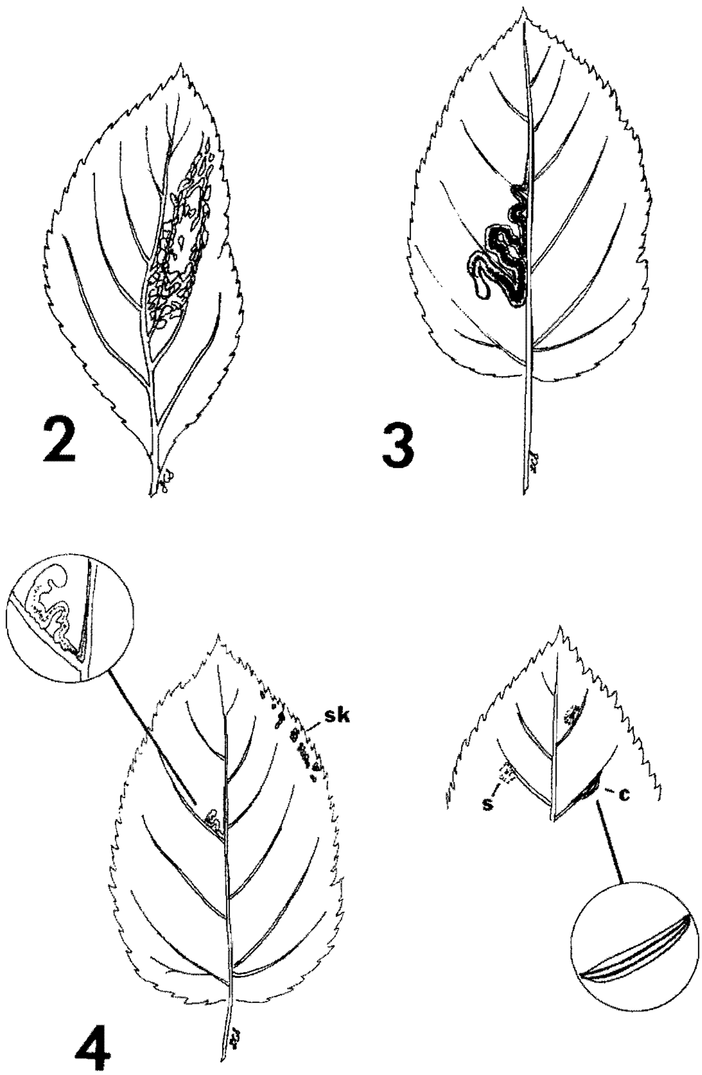
7'. Mine entirely blotchlike 9

8(7). Long, serpentine linear mine abruptly enlarging into an irregular blotch, frass often hanging from underside of mine in tendrils; more or less visible from both sides of leaf; active mining only in young leaves on expanding shoots, Figure 5. Apple leafminer, *Lyonetia speculella* (Forbes 1923, Frost 1924).

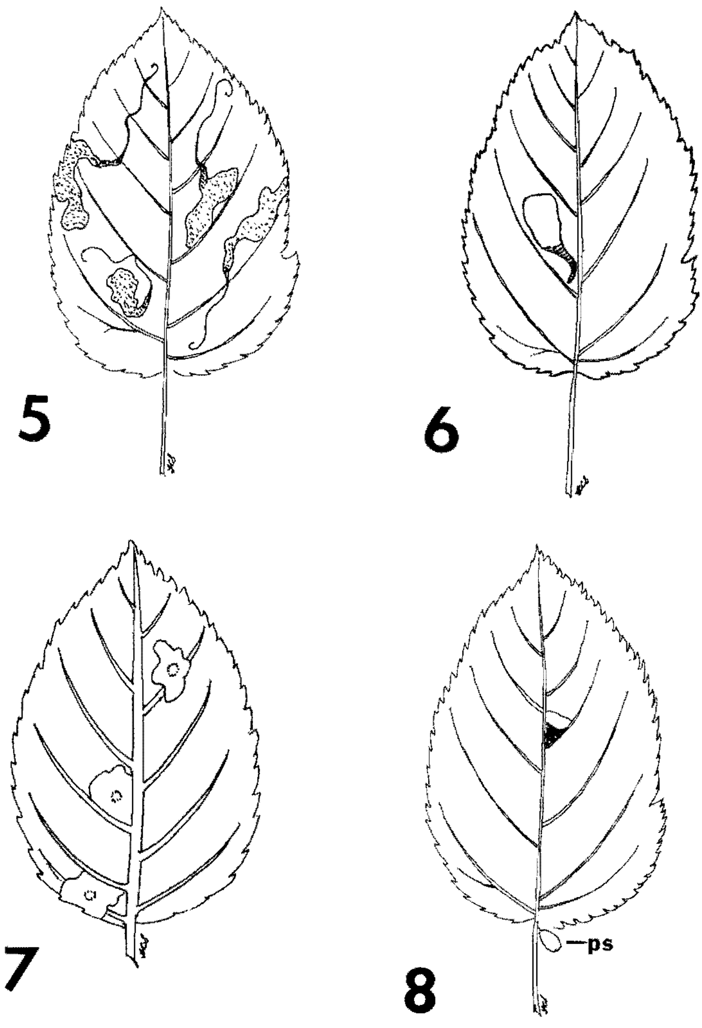
8'. Short, slightly serpentine linear mine gradually enlarging into irregular blotch; basal portion of mine with alternating bands of white tissue and crescent-shaped deposits of frass; mine nearly invisible from lower side of leaf, Figure 6. Apple leaf trumpet miner[2], *Tischeria malifoliella* (Jarvis 1906, Houghton 1910, Dunnam 1924).

9(7'). Irregular blotch mine, translucent, clear of frass, circular hole in only one epidermis located centrally in mine, Figure 7. Cigar casebearer[2], *Cole-*

[2]ESA approved common name.



Figures 2–4. Illustration of leaf mines on apple made by the most important species in northeastern U.S.: 2—*Phyllonorycter* spp.; 3—*Stigmella pomivorella*; 4—*Bucculatrix pomifoliella*, c = cocoon, s = silken molting cocoons, sk = skeletonized injury caused by free-living larva.



Figures 5–8. Illustration of leaf mines on apple made by the most important species in northeastern U.S.: 5 – *Lyonetia speculella*; 6 – *Tischeria malifoliella*; 7 – *Coleophora serratella*; and 8 – *Coptodisca splendoriferella*, ps = pupation shield.

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ophora serratella, or cherry casebearer[2], *Coleophora pruniella* (Slingerland 1895, McDunnough 1933, Waddell 1952).

9'. Mine not as above 10

10(9'). Large mine, > 1 cm in diameter, adjacent to skeletonized portion of leaf created by adult feeding. Basswood leafminer[2], *Baliosus nervosus* (Chittenden 1904, Baker 1972).

10'. Small mine, ca. 0.5 cm in diameter; partially filled with frass; usually in crotch between two veins; oval pieces of both upper and lower epidermis cut out for pupation case; Figure 8. Resplendent shield bearer[2], *Coptodisca splendoriferella* (Britton 1922, Quaintance and Siegler 1922).

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