Pupa. STLM now enters a non-feeding stage, the pupa, in which it completes metamorphosis from larva to adult. The fifth instar larva moves to one end of the mine and pupates without forming a cocoon. The pupa is bright yellow at first but turns brown with a darker brown head. In the first two generations the insect stays in the pupal stage from 5 to 12 days. When the adult moth is ready to emerge from the pupa, it pokes a small hole in the bottom of the mine (lower leaf surface) and wiggles part way out of the leaf. The adult then flies away, leaving the gold brown pupal skin protruding from the mine. The pupal skin often drops off or blows away but may persist for a month or longer.

Seasonal Life History

STLM undergoes three complete generations a year in Wisconsin. First brood adults begin to emerge on warm days at about bud break or green tip, and mating and egg laying begins on the new spring foliage. The first generation is completed in about seven weeks, with peak flight of second brood adults occurring in early July. The second generation requires only about 4 to 5 weeks, with peak flight of third brood sometime in mid-August.

Third generation pupae form in September or October and do not go on to produce new adults in the fall. Instead they remain dormant inside the mine and overwinter inside the leaf on the ground, with adults emerging the following spring.

Monitoring for STLM Activity

The key to successful control of spotted tentiform leafminer is developing a routine program to monitor its activity. Populations can develop very rapidly during the course of a season, and casual or infrequent observation will not allow sufficient time to apply controls when needed. There are three stages of STLM that are important to recognize.

Adult. There can be a few adults flying at any time from green tip stage of bud development to the first hard freeze in fall. However, there are three distinct broods of adults, and determining the period of peak flight activity for each of these broods will help plan when to apply chemical controls if needed. When populations are very large, adults can be seen simply by walking the orchard at dusk, which is the beginning of their daily flight activity. The tiny, silvery-appearing moths will be seen on the foliage and flying in and around the tree.

A more efficient means of monitoring adult activity is to use sticky traps baited with a material called sex pheromone. The sex pheromone is the natural scent given off by the female moth to attract the male for mating. The bait is a man-made copy of pheromone. Male moths detect the odor and fly into the trap in search of a nonexistent female and are then caught in the sticky material on the sides of the trap. In this way they are held for counting. By comparing weekly trap catches, the peak flight period of each brood can be determined.

When populations are large, traps may completely fill up in a single night during the peak of the flight period. Therefore, it is necessary to check traps frequently (at least twice each week), and clean or change them when they are filled.

The traps and baits are available commercially, and are very efficient for trapping male moths. Accurate monitoring can be achieved with only two trapping locations per orchard.

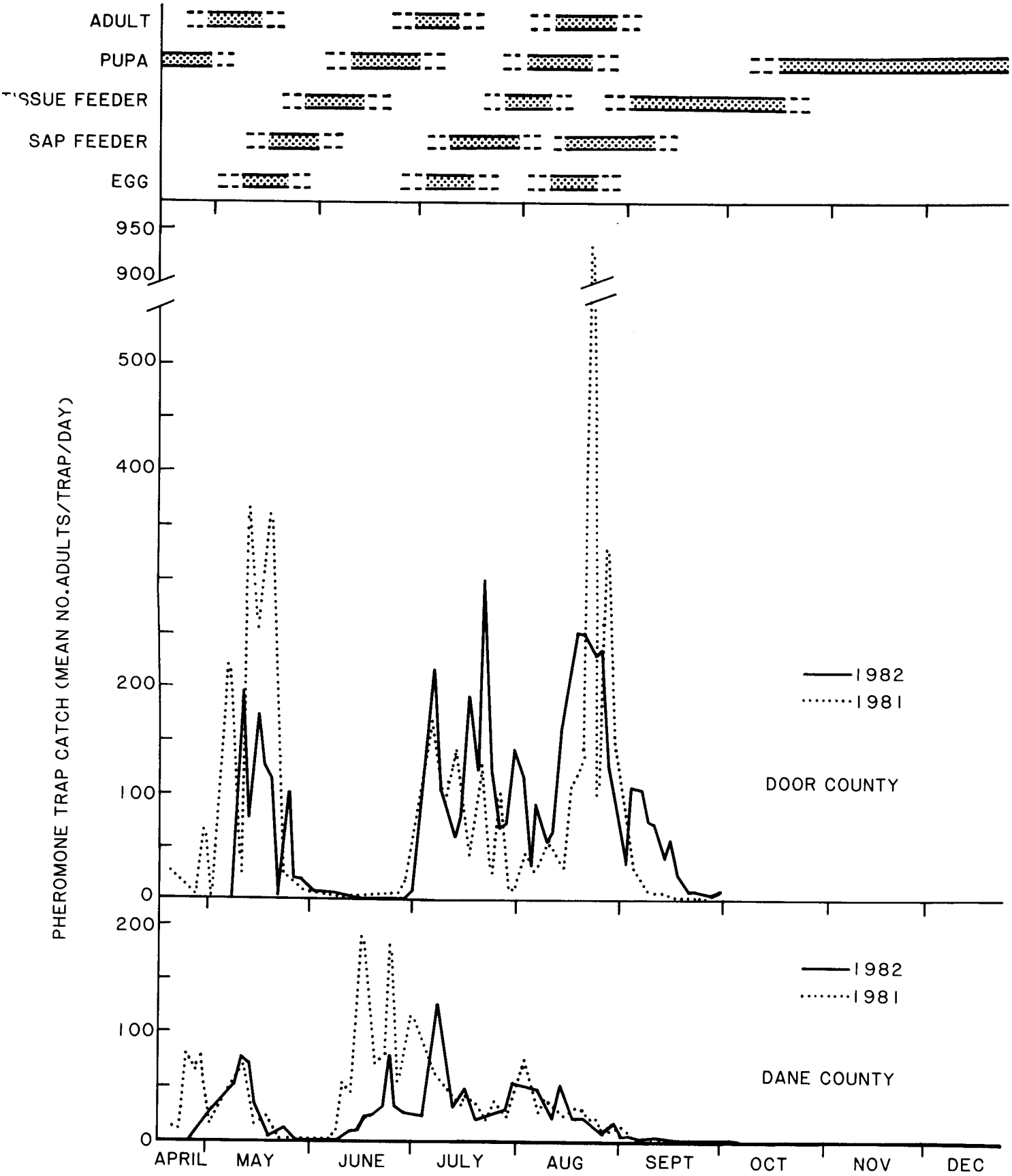

Figure 2. *Approximate time of occurrence of each stage of spotted tentiform leafminer. Top illustration is for all stages. Graphs are actual pheromone trap catches of adult males for two years and two locations. Note that Door County flight periods are 10 to 14 days later than in Dane County, illustrating the need for monitoring activity locally.*

Tissue-feeder mine. The tissue-feeder mine is the most obvious and easily monitored stage of the leafminer life cycle. Once mines have been formed, they will be apparent until the leaves fall off. It is important to understand that there are three generations of leafminers, and the mines seen in late season have accumulated from the activity of all three generations. **Although the tissue-feeder mine is the most easily observed stage, it has relatively minor use for making control decisions.** However, by opening these mines from the lower side of the leaf and observing the small larva within each, the developmental stage of that generation can be determined. Examination of a given tissue-feeder mine will reveal one of the following conditions:

1) A pale yellow worm within (tissue-feeding stage still feeding).
2) A yellow to dark brown pupa within (larva has finished feeding; adult moth will soon emerge).
3) A small, brown, dried pupal skin lodged half-way out of the leaf membrane on the undersurface of the mine (from a previous generation; mine is no longer active).
4) A hole in the undersurface of the mine (mine is no longer active).

Sap-feeder mine. The ability to recognize the sap-feeder mine is very important to the monitoring program. The sap-feeder mine can only be seen on the lower leaf surface, and appears as an area paler in color than the surrounding leaf (see earlier section on life cycle). All chemical sprays used against the larvae within the mines are effective only against the sap-feeding stage. In order to determine if a spray is needed for any given generation, and when that spray should be applied, it is very useful to monitor for the sap-feeders.

How to count mines. When counting either sap-feeder or tissue-feeder mines, it is important to count several leaves on several trees and then calculate the average. To do this, randomly select 10 terminals and fruit spurs per tree and count the total number of leaves and the number of mines. Do this for at least 2 to 3 trees in each area of the orchard. Total the number of mines counted and the number of leaves counted in each area, and then divide to calculate the average number of mines per leaf. Study the following example of this procedure.

EXAMPLE.

Location: Cortland Block. Sample Date: July 25
Comments: Only tissue-feeder mines counted.

	Tree 1		Tree 2		Tree 3	
Terminal	Leaves	Mines	Leaves	Mines	Leaves	Mines
1	12	3	9	4	8	0
2	8	0	9	3	6	0
3	7	2	13	1	12	1
4	9	2	11	2	9	0
5	12	1	10	3	7	2
6	12	0	8	0	11	2
7	11	4	9	2	10	0
8	14	4	11	5	13	1
9	8	2	11	3	9	1
10	10	3	11	1	11	0
	103	21	102	24	96	7

Total Leaves= 103 + 102 + 96= 301
Total Mines = 21 + 24 + 7 = 52
Average Mines Per Leaf = 52/301 = 0.2

Monitoring to check spray effectiveness. Monitoring is also important to check the effectiveness of recently applied sprays aimed at controlling adult or larval leafminers. Walk the orchard the first couple of evenings after applying a spray for adult control. If the spray was effective, you should see virtually no moths flying, as compared to the large numbers seen just before the spray was applied. A drastic reduction in pheromone trap catches immediately

In the following discussion, the term “adulticide” refers to those materials which are specifically aimed at controlling the adult moths. Some of these will not be effective for controlling the larvae within the mines. Materials which are effective against the mining larvae are called “larvicides.” Refer to publication A1932, “Apple Pest Control,” for currently approved insecticides. Consult the pesticide label for specific amounts to use and other important handling and application information.

After a spray also indicates good adult control. However, the pheromone bait is so efficient that males can be attracted from outside the orchard, so don’t be surprised to see a continued low level of trap catches after a spray.

The effectiveness of larval sprays can be determined by regularly counting tissue-feeder mines. Randomly select 10 stem terminals each on 10 randomly selected trees, and count all the mines on these 100 terminals. If this number stays relatively unchanged from one generation to the next, then larval sprays probably have been effective.

Control

Although STLM is not new to the state, it has achieved new status as a pest. That status is unlikely to change. Orchards which have had a previous history of STLM damage can be expected to have continued future problems with the insect. This is not to say that STLM will be seriously damaging every year; it will probably undergo natural population changes similar to other orchard pests. For example, in a given location codling moth can be much more severe some years than others. However, because STLM has three generations per year and can build up to such very large numbers, there will always be at least the potential for serious damage.

Growers who have not yet experienced problems with this insect **must** be aware of the potential for this insect to move into their orchards and cause damage. No orchard should be considered immune to infestation. Recognizing this fact is the first important step in controlling the infestation during the first problem year.

Natural Control.

Weather. STLM is well adapted to weather conditions in Wisconsin. Summer larvae and pupae inside the mines are well protected from rain, excess drying, dust and wind. Adults may succumb to heavy rains or be blown away by winds.

A hard freeze of 20° F or lower is required to kill fall larvae. Thus, these late insects may continue to pupate as late as November, even if leaves are already on the ground. Overwintering pupae can tolerate temperatures at least as low as -10°F and are usually protected from extreme cold by snow cover.

Geographic areas experiencing extreme weather conditions, as mentioned above, may achieve some degree of STLM population reduction in any given generation or growing season. However, such control cannot be counted on. Even if a temporary population decline occurs, many individuals will survive to begin the next generation.

Disease. No bacterial, fungal or viral diseases are known to infect STLM.

Predators. Birds, rodents and predatory insects are known to feed on STLM larvae and pupae. Predation is sporadic and probably does not significantly affect populations in most locations.

Parasites. There are several insects which parasitize STLM tissue feeders, and to a lesser extent, the pupae. The female inserts an egg inside the leaf mine, and the hatching maggot-like worm feeds on the leafminer. One type of parasite pupa looks like a tiny white football and can be easily seen upon opening a tissue feeder mine.

In abandoned orchards, parasites and predators are largely responsible for keeping STLM populations under control. Unfortunately these natural enemies are very susceptible to insecticides and may be killed by many of the orchard sprays currently being used to control insect pests. Most commercial orchards have very low parasite and predator populations. In the future we may learn how to time pesticide applications so that we can use natural enemies to help control STLM. At the present time, however, these beneficial insects cannot be depended on in any orchard using the full pesticide spray program required for other pests.

Cultural Controls. Cultural controls involve manipulation of the crop environment in such a way as to directly destroy the pest or make the crop unfavorable for the buildup of the pest. Although there are no really effective cultural control techniques available for STLM, the following suggestions should be considered.

Destruction of fallen leaves. Theoretically, if all apple leaves were destroyed in autumn after they have fallen from the trees, the overwintering pupae within those leaves would also be destroyed and there would be no infestation the following year. However, this is not practical. To be successful, virtually all pupae would have to be destroyed. This cannot be accomplished by cultivation. Raking and burning of leaves may provide some degree of control, but is practical only for homeowners, with a small number of isolated trees.

Elimination of wild hosts. The elimination of alternate host plants such as fence row apple seedlings, woodlot trees and ornamental flowering crabs has been proposed as a means for reducing the population levels of STLM. Again, this is not practical on an area-wide basis. Perhaps more importantly, however, these unsprayed trees contain a pool of natural enemies which may be of some benefit in suppressing the numbers of STLM. We have found that the miners developing in unsprayed trees are heavily attacked by natural enemies, and relatively few moths emerge from these trees.

Chemical Control. Reliable control of STLM is based on the utilization of insecticides. However, the long used standard orchard insecticides (primarily in the organophosphate group) do not provide adequate control in orchards that have experienced problems with this insect. Therefore, it is necessary to use materials that have not been widely used in Wisconsin orchards. Refer to UW-Extension publication A1932, “Apple Pest Control,” for current insecticide recommendations for controlling STLM.

The most effective chemical control is based on killing the larvae within the mines. However, currently available materials are effective for controlling only the sap-feeding stage. Keep in mind that this is the stage which is not visible from the upper side of the leaf, and the lower leaf surface must be examined to determine if sap-feeders are present. Chemicals for control of the sap-feeding stage should be applied after egg hatch (once the sap feeding mines become visible). This will be about 10 to 14 days after peak flight of the adults of any given generation.

Some materials are only effective at controlling the adult moths; that is, they do not penetrate into the leaf tissue to kill the miner within the leaf. To be effective, these materials must be applied during the peak of the adult flight period (see Monitoring section).

The number of special sprays required to control leafminer will usually be 1 to 3, depending upon local conditions. Some growers have had luck with making a single properly timed application for control of first generation sap-feeders, and have not needed additional follow-up sprays during the season. This has not worked in other cases, and control of second generation has been necessary. Generally, if first and second generation are adequately controlled, there is no need for additional sprays for third generation. This is important because third generation sprays would be applied during harvest of some early varieties.

Chemical Control Options.

At the time this publication was written, many orchards in the state had not yet had a problem with spotted tentiform leafminer. In those situations, standard orchard sprays, that is, the standard insecticides which were being used, were still providing good control of the pest. In such cases initiating a special spray program is not recommended. STLM insecticides are generally rather expensive, and it is not necessary to expend this extra cost unless the problem is actually at hand. **However,** all growers should be aware of this insect's potential to cause damage virtually "overnight", and should make routine use of the monitoring practices suggested earlier. In orchards where STLM has become a problem, there are several options for chemical control.

First Brood Adults/First Generation Miners:

Option I: Apply an adulticide **plus** a larvicide. The adulticide should be applied during the peak of the flight period (based on trapping) which will usually occur during early pink stage of bud development. The larvicide can be applied either at full pink or petal fall, depending on which material is used.

Option II: Apply a larvicide only. This can be applied at pink or petal fall. This option can be chosen 1) when populations were low the previous season, or 2) when a highly effective larvicide is used.

Option III: Do nothing except monitor for sap-feeder mines. If mines average one or more for every two leaves, treat with an effective larvicide at petal fall.

Note: There can be a 20-fold or more increase from one generation to the next. If first generation mines average more than one per 10 leaves, a damaging population may develop by second generation. A first generation application will reduce the likelihood of this.

Second Generation Miners.

Option I: Apply a larvicide 10 days after peak flight or three days after appearance of sap-feeding mines (treat before larvae change to tissue feeders).

Option II: Do nothing until sap-feeding mines are counted (in some cases, control of first generation will result in season-long control). If an average of one mine per leaf, treat as in Option 1.

Third Generation Miners.

Treatment of the third generation should only be necessary in an emergency, and should only be needed when first and second generation controls were not applied or were not effective. In Wisconsin, the earliest maturing apple varieties are being harvested during third brood flight and development of third generation sap-feeders. If second generation control was adequate, no sprays will be needed on these early varieties, even if it appears that third generation numbers will be high; the crop will be harvested before the damage is done. Also, the length of the preharvest interval of the chosen insecticide must be observed.

Damage may occur on late varieties if a total of 5 to 10 tissue-feeder mines (accumulated from all three generations) per leaf exist before harvest. If such levels are expected, treat with an insecticide that has a short preharvest interval.

The color fact sheet A8NYIS09, "Spotted Tentiform Leafminer," has excellent illustrations of life stages and damage and should be used as a companion to this bulletin.

Information in this publication is based on research conducted within the College of Agricultural and Life Sciences, University of Wisconsin-Madison.

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