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The Lesser Apple Leaf Folder. The Leaf Crumpler.

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The Lesser Apple Leaf Folder.

*Teras minuta*, Rob.  [*Malivorana, LeBaron.*]

The Leaf Crumpler.

*Phycis [Mincola] indiginella*, Zeller.

By J. M. Stedman, Entomologist.

SUMMARY OF RESULTS.

The experiments conducted by this station during the past year on the lesser apple leaf folder and the leaf crumpler have given results which are briefly summarized as follows:

I. The apple leaf folder may be readily killed by thoroughly spraying the infested trees or nursery stock just as soon as the larvae begin to hatch, and before they have had time to fold the leaves to any considerable extent. The mixture to be used should be the following: Paris green, 1 pound; fresh lime, 3 pounds; water, 150 gallons.

II. Since there are three broods of this insect each year, there are three periods during which spraying can be most successfully done. This can be readily determined by observation; when the adults appear, watch for the young larvae. The first brood of larvae appear while the leaves are unfolding.

III. The leaf crumpler may be readily killed by thoroughly spraying the infested trees while the leaves are unfolding and before the blossoms open with the mixture recommended for the apple leaf folder.

IV. If necessary the trees may be sprayed again immediately after all the blossoms have fallen; but at this time the above amount of Paris green and lime should be mixed with 175 gallons of water.

V. Never spray a fruit tree while it is in bloom. You may injure the delicate stigma and prevent pollination, and there also danger of killing the bees.
VI. Never omit the fresh lime; always use two or three times as much fresh lime by weight as Paris green. This will lessen the chances of 'burning' the leaves with repeated sprayings.

VII. Use the mixture in the same strength as given. To make it weaker is to render it less effective in killing the insects, and to make it stronger is to endanger the foliage under repeated sprayings.

VIII. Always see that the mixture is kept constantly stirred while spraying.

IX. Apply with as much force as possible and use as fine a spray as can be gotten.

X. Spray thoroughly—hold the spray on the tree long enough to saturate it and to reach all parts, and always spray it from at least two sides.

XI. Study the habits and life histories of the insect, and spray at the proper time.

XII. Use pure unadulterated chemicals.

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THE LESSER APPLE LEAF FOLDER.

*Teles Minuta*, Rob. [*Malivorana, Le Baron.*]

GENERAL REMARKS, DAMAGE AND HABITS.

During the past two years considerable damage has been done in Missouri to young apple orchards and to nursery apple stock by the ravages of the Apple Leaf Folder. Our attention has been called to it many times from several localities, the most prominent one being a nursery in Jackson county, where the insect has been unusually destructive.

Through the kindness of Mr. E. H. Graves, of the Jackson County Nursery Company, the station undertook a series of experiments in their nursery to determine an efficient and economic means of controlling this pest. Fortunately the location of the experiment was well chosen, since the nursery proved to be the worst infested region in the state that year, and the insects were unusually numerous in the first brood early in the spring.
It was planned to begin the application of insecticides for the second brood, since heretofore the first brood had caused little damage, while the second and third broods had been so much more numerous as to be very destructive. Unexpectedly, however, the first brood proved to be as destructive as the second and third had been in previous years, and a telegram from Mr. Graves to this effect caused us to proceed to the nursery at once.

The one-year-old nursery apple stock was found to be so badly infested that the field appeared as if a fire had swept through it. Instead of having a green appearance from a distance, it was brown in color. On close inspection it was seen that comparatively few leaves were exempt from the attack of the Leaf Folder. Practically ninety-five per cent of the buds and young unfolding leaves were struggling against this pest, with the result that almost all growth was stopped. In many cases a single cluster of unfolding leaves would contain three or four larvae. Whether upon terminal or lateral shoots and buds or clusters of unfolding leaves, the work of these larvae was the same. They drew the edges of the leaves together, thus folding them, and then fastened them by means of silken thread, thereby preventing the young leaves from unfolding.

Where the leaves were very small, a single larva would frequently fasten a number of them together. This was usually the case with the terminal shoots or buds. Not infrequently two or more larvae would roll and fasten together all the unfolding leaves from a single bud.

The larvae are sheltered and protected by these folded leaves and feed extensively within these folds, eating the inner epidermis and the parenchyma, and occasionally the outer epidermis also, thus making holes or partially skeletonizing the leaves in some cases. They appear to prefer the young, tender, unfolding leaves, and, in their efforts to obtain them, frequently eat directly into the bud, thus allowing only three or four leaves to appear, and these are then folded and fed upon where the insects are as numerous as they were in this field. No
doubt the larvae feed more or less on portions of the leaves that are not completely folded, but this is not as extensive as their work within. Usually a single leaf is sufficient food to enable one larva to reach maturity. The infested leaves turn brown, either in patches or more or less entirely so; and this coloration

Fig. 1.—One-year-old nursery apple trees infested with the Lesser Apple Leaf Folder. One-fourth natural size. (Original.)

in connection with the folding of the individual leaves, and the fastening together of the clusters of young leaves, causes the infested field of nursery apple stock, or the infested young
orchard, to have the appearance of having been scorched by a fire.

A few samples of infested one-year-old nursery apple trees from this field were photographed. These are reproduced in figure 1. They are one fourth natural size, but will serve to give a fair idea of the condition of the entire field, since these samples were selected with a view to give the average degree of injury from this insect. Some plants were much more and some much less injured.

It would be an exceptional case to find even a young orchard as badly infested as this field of nursery stock; but this is largely due, no doubt, to the fact that we usually take better care of each individual tree in an orchard, and if it be a bearing one, it usually receives several sprayings each year for the codling moth. These sprayings tend to kill any larvae of the Leaf Folder that may be there. However that may be, the fact is that this Leaf Folder does damage to nursery apple stock and to young apple orchards, and rarely attracts our attention in a bearing orchard.

It might be well to note here that this Leaf Folder is extremely troublesome and injurious to cranberry bushes.

It may occasionally happen that the Leaf Folder and the Leaf Skeletonizer are both found working together. We suspected this to be the case in this field of nursery stock, but examination failed to reveal the presence of the Leaf Skeletonizer, and hence in this instance at least we must attribute the injury to the Leaf Folder.

**DESCRIPTION, LIFE HISTORY AND HABITS.**

The Lesser Apple Leaf Folder is an extremely interesting little creature, and presents what is called dimorphism. Of the three broods each year, the adults of the first two are a beautiful orange color, while those of the third are ash gray. They were therefore described as distinct species even as late as 1871, but now that the entire life histories of this insect is known by actual breeding and rearing, we find that they are simply two different forms of the same insect or species, just as a number of
other insects that present this peculiar characteristic—dimorphism, trimorphism, et. al.—were at first supposed to be distinct species.

The adults of the third brood appear during the first week in September. Those in our breeding cages in the station laboratory began to emerge on the twentieth of August. The front wings of these moths are of a uniform ash-gray or light slate color with a reddish lustre as the light is reflected obliquely;

![Figure 2: The Lesser Apple Leaf Folder, Teras minuta, Rob. [malivorana, Le Baron]; a, b, adult moths; c, larvae; d, pupae; e, folded leaves with pupae skins protruding. All natural size. (Original.)](image)

the hind wings are light colored and semi-transparent. The moths are small, the wings expanding only about eleven sixteenths of an inch. A good idea of the general size, shape and appearance of these moths can be had by observing figure 2, a, b, which represents a photograph of an adult moth with the wings expanded, and one with the wings folded as they appear
when at rest. Both of these are natural size. An enlarged
drawing of the moth is shown in figure 3, c.

These gray colored
moths seek some sheltered
place and hibernate during
the winter, coming forth
early in the spring to de-
posit their eggs on the
opening buds or more fre-
quently on the unfolding
leaves. The eggs hatch
in a few days into larvae
that crawl into the crevices
of the unfolding leaves and
begin at once to feed upon
the tender tissues, and to
fold one, sometimes more, of the leaves and fasten them with
a silken web, thus preventing them from unfolding.

The larvae when full grown are about seven sixteenths of
an inch in length, and of a nearly uniform yellowish green color
with a light brown head. A photograph of two of these larvae
is represented natural size in figure 2, c. A drawing somewhat
enlarged is represented in figure 3, a. Like most larvae of the
Leaf Folders (Tortricidae) they are very active and nimble.
When disturbed they will rapidly crawl to the more secluded
folds and enter in order to escape danger, or they will rapidly
wriggle out of the folded leaf and drop to the ground, espe-
cially if continually disturbed.

When full grown the larva spins a delicate silken web
within the folded leaf and there changes to the pupa stage. In
the field, and also in our breeding cages in the laboratory, the
larvae of this first brood began to pupate on the eighth of May;
but I am informed that this was a more advanced season than
usual.

The pupa or chrysalis is quite characteristic, and can be
readily distinguished from any other pupa likely to be found in
similar places, by the presence of a knob projecting from the
head end. This can be seen in the photograph in figure 2, $d$, which represents two pupae natural size, and also in the drawing in figure 3, $b$, which is enlarged.

When the pupae are about to transform to adults, they wriggle and work their way out of the folded leaves, sometimes entirely so and hang suspended by their posterior end, but more frequently they remain about half way within the folded leaves. Here they soon transform; the pupa skin splits open, and the adult moth emerges. One may obtain a good idea of the way the pupae and pupae skins appear protruding from the folded leaves by observing the photograph of the same in figure 2, $e$, which represents them natural size.

The adults of this first brood began to emerge in our breeding cages in the laboratory on the fourteenth of May. Thus this pupa stage was passed in something less than a week. These first brood adults differ from those of the hibernating third brood in that their front wings are of a beautiful bright orange color, while the hind wings are light cream color and semi-transparent.

These adult moths now pair and at once begin to deposit their eggs singly on the leaves, and especially on those of the terminal twigs or shoots where growth is rapid and the leaves young. A single moth usually requires from three to five days to deposit her eggs; and since the moths do not all emerge at one time, but are upwards of a week in appearing, it follows that the eggs for the second brood of larvae are being deposited during a period of about ten days, whereas the eggs for the first brood of larvae appear to be all deposited in about a week. If the leaves be comparatively young, the larvae soon fold them as previously described; but if the leaves be fully developed, the young larvae are frequently unable to fold them as much as above described, and they will then fold over only a part of the edge of the leaf.

In the field the larvae of this second brood first appeared on the twenty-third of May, and commenced to pupate in our breeding cages on the twentieth of June. It was ten days more before they had all pupated in the field. The adults of this
second brood commenced to emerge in our laboratory breeding cages on the twenty-eighth of June, and the last one emerged on the ninth of July. They also appeared in the field during the same period. These second brood adults are orange colored like the first brood.

After pairing, these second brood adults deposit eggs for the third brood of larvae, which first appeared in the field on the tenth of July. These larvae first pupated in the laboratory breeding cages on the ninth of August, and in the field the larvae had apparently all pupated on the twenty-fourth of August. The adults of this third brood first emerged in the laboratory breeding cages on the twentieth of August, but they were not noticed in the field until the twenty-fifth of August.

**REMEDIES.**

It has heretofore been the usual practice in this state to send boys or men through the young apple orchard or field of nursery stock infested with this Leaf Folder, and have them pinch the folded leaves and thus kill the delicate larvae within. Under ordinary circumstances this method of combating the pest is not as tedious as one would at first thought suppose, since a man can usually cover about one acre of young trees or one half an acre of nursery stock in a day. Evidently this method suggested itself from the fact that the larvae live and feed largely within the folded leaves, and are thus apparently protected from ordinary insecticide sprays.

While a single leaf is usually more than sufficient food for a single larva, they appear to come forth quite frequently and to feed upon portions of the leaf not folded, and also on adjacent leaves, especially when the leaves are small and close together. Hence a thorough spraying with the arsenites has proven to be very effective. This is especially the case when the spraying is done while the larvae are hatching and before they have folded the leaves, at which time one will have no difficulty in holding this pest in check.

One or two thorough sprayings during or immediately after the larvae have hatched will usually suffice for that year,
since, if we practically exterminate the larvae of any one brood, the few that always escape will be unable to multiply rapidly enough to cause trouble that same season. It will be much less satisfactory to spray after the larvae are well advanced, since we can not then reach as large a per cent. But, if one has neglected to spray before, and the trees are being injured to any considerable extent, it would be advisable to spray at once, and thereby kill a certain per cent; and then to keep watch for the appearance of the adult moths of that brood, and just as soon as they appear in quantities, to begin spraying in order to kill the brood to follow.

It is not often that the first brood does enough damage to cause one to spray for it, but the second and third broods are frequently so numerous as to cause great destruction.

From the life histories of this Leaf Folder it is evident that we have three excellent opportunities during each season to combat it, namely, at the beginning of each of the three broods. The exact date of the appearance of each of these three broods can not be given, since they vary in different localities and also in different years in the same locality, but one may readily determine the exact time by observing the appearance of the adults or by examining the trees for the larvae and pupae. The first brood of larvae appear, however, at about the time the buds open and the leaves begin to unfold, so that there need be no difficulty in determining the proper time to spray for the first brood.

In our experiments with the Lesser Apple Leaf Folder we used the following mixture with perfect success: Paris green, 1 pound; fresh lime, 3 pounds; water, 150 gallons. This was thoroughly sprayed on the nursery stock at the time the second brood of larvae were hatching, and was so successful in killing the larvae that further spraying was rendered unnecessary, and the trees soon recovered from their injury and made a good growth. The very few larvae that escaped injury attracted no attention whatever, and were not sufficiently numerous to multiply enough to cause any injury from the third brood.
The above mixture was applied by means of an ordinary barrel force pump mounted in a wagon, to the rear of which was fastened two strong two-by-four poles about ten feet long and projecting up and behind at an angle of about thirty-five degrees. Across these near the top a plank was nailed to serve as a seat for the man who managed the nozzles. Across the ends of the poles was placed a three-fourths inch iron pipe about twelve feet long, to the side of which was fastened, at regular intervals, four "Bordeaux" nozzles, in such a position that each nozzle would be over a row of trees. This iron pipe was then connected with the force pump which was operated by another man, while a third drove the team. In this way four rows of nursery apple stock were sprayed at once.

There are several precautions to be taken in order to reap success with this, or in fact with most any other arrangement, but they are easily understood and guarded against. They are:

First.—Spray while the larvae are hatching or have just hatched and before they attain much headway, otherwise they will have folded the leaves to such an extent that one can not reach them readily.

Second.—The mixture in the barrel must be constantly stirred while spraying. This is best accomplished by means of a second hose with a solid stream nozzle reaching to the bottom of the barrel. We find this more reliable than any patent agitator yet devised. If the mixture is not well stirred the Paris green will settle, and at first not enough and towards the last too much will be sprayed on the plants.

Third.—The spray nozzle should be so adjusted as to throw a fine spray, and considerable force should be exerted in pumping so as to throw the spray with force and thereby give a finer spray and reach all parts of the plant better.

Fourth.—The team should be driven as slowly as possible in order to apply the spray more thoroughly; and after the field has been sprayed in this way, you should go right over it again the same day if possible, beginning at the first starting point. This will enable you to do the work thoroughly, and to distribute the Paris green over the field at the rate of one pound to
the acre. Be sure and apply the mixture so that you distribute at least one pound of the poison to the acre, otherwise you will not apply a sufficient quantity of the Paris green to kill all the larvae that may eat of it. Do not try to save this second spraying by using a stronger mixture in the first, since you may injure your trees. The team passes along so rapidly at best, that thorough work can not be done without the second application. We speak of all this as one spraying, although in reality the field has been gone over twice in the same day. If we could walk the team one half as fast as the slowest possible gait, then then this second application would not be necessary, but this is impossible.

If the weather be dry or there be no heavy rains for a week after the application, this single spraying as above described will usually suffice; but should it rain within a few days, the bulk of the poison will have been washed off, and another application should be made at once.

We have met with some success in trapping the adult moths by means of lanterns, but this is not a success when compared with the spraying. A lantern placed in a shallow pan of kerosene will attract and kill many adult moths of the Lesser Apple Leaf Folder, and may be of some benefit in lessening the number of moths that emerge from their winter sleep preparatory to depositing their eggs for the first brood. This is, however, much more trouble and certainly as expensive as spraying with Paris green, and the spraying is more effectual.

THE LEAF CRUMPLER.

*Phycis [Mineola] indiginella, (Zeller).*

GENERAL REMARKS, HABITS AND LIFE HISTORY.

The large number of inquiries received at this station in regard to the Leaf Crumpler, led us to conduct a series of experiments on this insect, which appeared to be doing considerable damage last spring to nursery stock as well as to young and to bearing orchards.
The work of this insect seems to be well known to all fruit growers and nurserymen throughout Missouri, not only on account of its depredations in the spring, but largely because of its conspicuous winter quarters. These are recognized by all, since just as soon as the tree sheds its leaves, these clusters
of brown shriveled or crumpled and partially eaten leaves are seen, more or less fastened together and securely anchored to the twigs by means of silken threads. A good idea of the general appearance of these clusters, or winter homes, as seen upon a plum tree during winter, may be had by observing the photograph in figure 4, which is one half natural size. Also, in figure 5, c, we have a photograph of a single cluster, natural size, and this will convey a better idea, perhaps, of the appearance of the individual cluster.

Comparatively few people recognize or are familiar with the appearance of the adult moth. A photograph of the adult is shown natural size in figure 5, a, and an enlarged drawing in figure 6, d. The moth is about six-eighths of an inch across its expanded wings, the fore pair of which are of an ash-gray color with brown markings, while the hind wings are of a uniform dusky-gray color. Last summer these adults began to emerge on the seventh of June, and were quite plentiful by the second week in June, although they evidently had not all emerged at that time, since the last one did not emerge in the laboratory breeding cages until the twenty-first of June.

The adult moths appear to be in no great hurry to deposit their eggs, but fly about and busy themselves for some time laying their eggs on several varieties of fruit trees. We have observed the larvae of the Leaf Crumpler feeding on apple, plum, cherry, peach, and quince, and have seen their winter cases on crab apple and wild cherry, thus indicating that they have been feeding on these trees. They have also been recorded feeding on wild crab apple and wild plum, but we have not yet observed them on these trees.

The eggs hatch in about a week and the young larvae, which are of a brown color with but a few scattered hairs, begin at once to feed upon the leaves of the tree, preferring those of the tender shoots. Each one now makes a tube or case by spinning a silken thread about its body and interweaving some of its excrement and other debris. The case is then neatly lined with silk. It is horn shaped, open and large at the head end and gradually tapering to a point at the other,
and is usually somewhat curved or twisted and crooked, as
may be seen by referring to the photograph in figure 5, d,
which represents the case of a full grown larva, natural size,
or, still more crooked, in the drawing in figure 6, a. The
case is enlarged as the larva grows by addition around the head
end, and thus the case is considerably longer than the larva
when both are full size.

The larvae are shy and apparently cautious for they feed
upon the tender leaves principally at night, and then do not

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Fig. 5.—The Leaf Crumpler, *Phycis* (Mincola) *indiginella*, Zeller. a, adult
moth; b, larva one-third grown; c, winter shelter of crumpled leaves con-
taining hibernating larva; d, larva case. Natural size. (Original.)

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often venture far from their case, but frequently draw and
fasten the leaves together near the entrance to their case, in
which they remain concealed when not feeding or when fright-
ened or disturbed. A badly infested tree will show signs of
the presence of these larvae by having its leaves, especially
along the growing shoots, more or less eaten and fastened to-
gether in bunches. At the approach of cold weather these
larvae are from one third to one half grown. Figure 5, 6 shows one of these larvae at this stage, natural size. They now fasten their cornucopia-shaped case securely to a twig or limb by means of a strong silken cord, sometimes eating the bark away to admit of a more secure hold. The larva draws a few, usually more or less eaten, leaves about its case and fastens them securely together and to the limb by silken threads, thus forming a protection for its case. It then enters its case and there passes the winter in a dormant state as a partially grown larva.

It is in this condition that they are so familiar to all fruit growers and nurserymen in this state. If the bunches of crumpled leaves be picked off the trees and opened, the crooked, horn-shaped case will be readily found within and securely fastened to the twig, and if this case be opened, the little reddish-brown larva will be found.

Up to this stage the Leaf Crumpler does comparatively little injury, but all know that the presence of the bunches of crumpled leaves in fruit trees during the winter is a sure indication of serious trouble in the spring.

In the spring just as soon as warm weather appears and the buds begin to swell and open, the hibernating larvae revive their activities. They cut the silken thread that securely held their case during the winter, and,
carrying the case with them, travel along the limb in search of food. Their winter fast has given them a renewed appetite, and they now feed not only upon the unfolding leaves, but they also attack and eat into both the leaf and flower buds. They continue to feed in this manner, and to cause considerable damage, until they become fully grown, which is usually about the fifteenth or twentieth of May. The larvae are now a trifle over a half an inch in length and have become quite green in color. They now fasten their cases to the limb again, close up the entrance to their cases with silken thread, and transform to pupae within the larval case. The larvae in the station laboratory breeding cages first commenced to pupate on the twentieth of May.

The pupa stage is soon passed, the adult moths emerging in about two weeks. Thus the life cycle of this Leaf Crumpler is completed with a single brood each year.

REMEDIES.

The Leaf Crumpler is known to be subject to the attack of two parasitic insects, but we were not fortunate enough to breed any of them in the laboratory. One of them is a small Ichneumon-fly, *Limneria* [Branchus] *fugitiva*, Say., and the other is a Diptera or true fly, *Tachina phycita*, Le Baron. These parasitic insects undoubtedly do considerable good in helping to hold this pest in check.

The Leaf Crumpler is another insect which has heretofore been, so far as our knowledge extends, exclusively fought in Missouri by the old method of hand picking during the winter months. This is really a tedious, troublesome, and, if one's time is worth anything, a costly method of combating this pest. Then again, if, as is usually the case, the gathered bunches are burned, one has done nearly as much harm as he has good, since the parasites are also destroyed. If hand picking is to be resorted to, the gathered bunches of crumpled leaves containing the larvae should be placed in a pile in some field away from the orchard. In this way the parasites can develop and escape, while the larvae of the Leaf Crumpler, which can not
crawl far and being unable to find a fruit tree upon which they can feed, will perish.

The station undertook some experiments last spring with a view to ascertain the advisability of spraying for the Leaf Crumpler, and, as expected, the results of these experiments go to prove that this pest is very easily, cheaply and effectually combated by the use of Paris green. The infested trees that were sprayed included apple, plum and cherry, and nursery apple stock. During the winter the badly infested trees that were found to contain the largest number of hibernating larvae were marked. Early in the spring, just after the larvae had become active and commenced their depredations, threatening to cause considerable damage, the labeled trees were thoroughly sprayed with a mixture made as follows: Paris green, 1 pound; fresh lime, 3 pounds; water, 150 gallons. This was applied with an ordinary hand force pump mounted on a barrel, and having a return hose and solid stream nozzle for an agitator. Thus one thorough spraying was given just before the flowers opened. One half of the above sprayed trees were again thoroughly sprayed soon after the flowers (petals) fell, using this time a weaker mixture—the same amount of Paris green and lime being mixed with 175 gallons of water instead of 150. The result of the experiment was:

The trees that were not sprayed were considerably damaged and retarded in growth from the defoliation, and, as near as we could judge, about one fifth to one fourth of the fruit had been destroyed, either directly by having the buds eaten into, or indirectly by the eating of the petioles near the stem. The trees that were sprayed once just before the flowers opened showed no signs of further injury having been done after the spray had been applied, and the trees overcame all traces of the injury within a week. The larvae were practically all killed, only an occasional one could be found after the closest search on all the sprayed trees. There appeared to be no difference between the trees sprayed once and those sprayed the second time soon after the blossoms had fallen.
From the above experiments, it appears that this Leaf Crumpler can be much more easily and cheaply combated by spraying than by hand picking during the winter. The spraying should be done just as soon as the leaves appear and before the blossoms open, in order to kill the larvae before they do much damage. If this spraying be not done then, it can be applied just after the blossoms fall, but it will not be as satisfactory, since we will then have to use a weaker spray, the increased foliage will lessen the chances of thorough work, and the larvae will have already done considerable damage, especially to the fruit, which might have been largely prevented by the other application.

It will probably never be necessary nor advisable to spray late in the season for the young larvae—better wait until spring, unless the pest does more injury in the fall than it is known to have yet accomplished. No doubt where trees are regularly sprayed with the arsenites for curculio, codling moth, etc., the Leaf Crumpler will be killed also and never attract attention on such trees.