

*Agrilus oblitus* Wat.

One specimen. Madeira-Mamoré R.R., Camp 39.

*Agrilus molestus* Wat.

Independencia (Parahyba). One specimen taken by sweeping.

## MITES ASSOCIATED WITH THE OYSTER-SHELL SCALE (*LEPIDOSAPHES ULMI* LINNE).

BY H. E. EWING and R. L. WEBSTER.

### INTRODUCTION.

The fact that mites frequently attack scale insects and so play an important part in the natural control of those insects, is by no means new, and most of the literature on this subject is not of very recent date. The observations of Walsh (1868), Shimer (1868), followed by other notes by Riley (1873), show us that the importance of these mite enemies was even better appreciated in a general way then, than at present. Some further careful observations by Lignières (1893) in Europe threw much more light on the exact relations of two of the most common mites which are found under the oyster-shell scales, many of which observations the present writers have been able to verify in the work reported on in this paper.

The notes on which this paper is based were made by the writers in Iowa, largely in the vicinity of Ames, although by no means restricted to that locality. The determinations of the mites are on the authority of Mr. Ewing. This paper represents a part of a larger article on the oyster-shell scale, to be published at some future time as a bulletin from the Iowa Agricultural Experiment Station, but it was thought best to present this portion of the work in advance.

### NATURE OF MITE ATTACKS.

The most efficient mite found attacking the oyster-shell scale in Iowa is one which feeds for the most part on the eggs of the scale insect, although it feeds also on the insects themselves. This mite is *Hemisarcoptes malus* (Shimer). Another mite, *Monieziella entomophaga* (Laboulbène), which was about as common under

the scales as the first, did not feed on the sound eggs of the scale insect, but acted only as a scavenger, feeding among shriveled egg shells and following the first named mite in its work beneath the scales. Besides these, several other mites were noticed in connection with the oyster-shell scale, and observations thereon are given in this paper.

In order to understand the relations of these several mites to the oyster-shell scale it will be necessary to give a brief outline of the life history of that insect. Near Ames the eggs of the scale insect begin to hatch from about the 10th of May to the 1st of June, depending upon the season. The tiny crawling nymphs soon settle down on the bark of the infested tree when a suitable position has been found, and proceed to secrete their scale covering. This is completed in July, and late in that month the eggs of the scale insect begin to appear under the scales. Thus, from the first of August until about the middle of May, a period of nearly ten months, the eggs may be found beneath the scales. It is no wonder that the mites frequently have an almost unrestricted sway during this period.

#### IMPORTANCE OF MITE CONTROL.

Walsh (1868) said that in examining six hundred scales about the last of October in Illinois, he found "that at least two-thirds of the whole number were either already gutted, or were undergoing the process of being gutted, by the minute larva of a mite." From the description of the injury *Hemisarcoptes malus* was probably the mite that was doing the work mentioned.

On October 29, 1908, a lot of scales from apple twigs obtained at Ames were examined, and many of them were found to be infested with mites (probably *Hemisarcoptes malus*) which were feeding on the eggs. Of 100 scales examined, 35 showed evidences of mite injury, or revealed the presence of the mites.

In the early spring of 1911 a lot of apple twigs infested with the oyster-shell scale were taken from different orchards around Ames, and at other localities in the state to the north of Ames. In practically all of these samples mite injury was evident beneath the scales. In some cases the mites had done very effective work in checking the scale, elsewhere they were not so effective.

One sample taken from an orchard near Ames showed consid-

erable benefit occasioned by mites. Out of 100 scales counted February 27, 1911, sixty-five showed indications of mite work. Of the remainder, 32 scales were empty, while 3 were sound, *i. e.* contained sound eggs quite unaffected by mites. *Hemisarcoptes malus* was the mite concerned in this case.

In this connection it must be mentioned that many oyster-shell scales remain on the trees long after the insects themselves are gone. The presence of 32 empty scales in the count just given would refer to scales which had probably remained on the bark for a year, or perhaps even more, rather than to those which had been cleaned out by mites.

From other counts made in 1911 it was found that a great variation existed in the condition of the scales at different places in the state. In some of the infested orchards near Ames as low as 3.7% of the scales contained sound eggs that spring. The remainder were either empty, or had been gutted by mites. At this time in the orchard at Ames that showed the scale in the best condition, only 16.48% of the scales contained sound eggs. These last counts were made for another purpose than to find mite injury, so that this factor was disregarded in making them. If a scale had any sound eggs in it, it was counted as such, so that a scale might be half gutted by mites, and still contain sound eggs. Many of the empty scales, however, were made so on account of mite attacks, and so these counts are given here.

At Northwood, Iowa, near the Minnesota line, a variety of conditions were found. Much mite injury (*Hemisarcoptes*) was noticed. From samples of scale collected in one orchard 82.4% of the scales contained sound eggs; from another orchard 69%; from a third, 34%; from a fourth, 23%.

Samples taken from three orchards near Iowa Falls contained 15.2%, 23.8% and 41.2% scales with sound eggs. Other samples from additional places in the northern half of the state showed that from 10% to 20% of the scales contained sound eggs, the proportion occasionally running as high as 30%.

Considering that a large proportion of the empty scales are left over from the previous year, the percentage of scales not injured must be larger than appears from the figures. A count made at Ames, August 5, 1909, shows how these old scales remain on the trees. Out of 500 scales from a mountain ash tree, 218 contained

live insects, while 282 were empty. That is, 43.6% of the scales contained living insects; the remainder, more than half of the scales counted, had been left over from the year before.

In computing the percentages of scales given herein, 500 scales were usually counted, rather more, than less.

From these observations, as well as from others not mentioned here, it is quite evident that the oyster-shell scale is in many places kept in check by mites. At the time these notes were made the mites were the only agents of natural control in evidence, and they are therefore given the credit for keeping the scale in check. Of these mites the most efficient was *Hemisarcoptes malus*.

#### THE REAL MITE ENEMIES OF THE OYSTER-SHELL SCALE.

Of the total of nine species of mites found in connection with the oyster-shell scale, six were either parasitic or predaceous. These six species will be taken up in order of their importance.

##### *Hemisarcoptes malus* Shimer.

*Identity and Synonymy.* This, the most important enemy of the oyster-shell scale, was first described by Dr. Henry Shimer (1868). Riley (1873) gave a drawing of a different species of mite found with the oyster-shell scale, which he rather suspected was not the same as Shimer's species. In regard to this figure, Riley said:

"I present, herewith, a side and ventral view of the species which so effectually destroyed the contents of the Georgian scales, in order that the reader may get a correct notion of the appearance of these mites. It may be a form of the *Acarus malus* of Shimer, but differs from his description in being almost four times, instead of twice, as long as broad, as well as in other details."

This drawing is of no other species than *Monieziella entomophaga* (Lab.), a scavenger species found in association with the oyster-shell scale both in this country and in Europe. It is by no means a drawing of the (*Acarus*?) *Hemisarcoptes malus* described by Shimer. Riley's description, however, refers both to *Monieziella*, and to the species we are considering, *Hemisarcoptes malus* (Shimer). This fact, with the misleading reference to Shimer's species, has done much to confuse the identity of these two common mites found beneath the oyster-shell scales.

Lignières (1893) found both these species in Europe, and,

strange to say, he described the real (*Acarus*?) *Hemisarcoptes malus* of Shimer as a new species, *coccisugus*, erecting for it at that time the genus *Hemisarcoptes*. On the other hand the name of *Tyroglyphus (Acarus) malus* Shimer was given to the second mite present, which is no other than Laboulbène's *Monieziella entomophaga*. That Lignières had confused the names of these two species has already been shown by Micheal and also by Banks. An examination of Lignières' paper and figures shows that their conclusions were correct.

To summarize, we may make the following statements regarding the identity of the species under consideration and its confusion with *Monieziella entomophaga* (Lab.).

1. *Acarus malus* Shimer is the same as *Hemisarcoptes coccisugus* Lignières.
2. The name should be written *Hemisarcoptes malus* (Shimer), since Lignières' genus is a good one, although his species is not.
3. The mite figured by Riley (1873) as a possible variety of Shimer's *Acarus malus* is *Monieziella entomophaga* (Lab.).
4. The description accompanying Riley's figure (1873) refers both to *Monieziella entomophaga* and to *Hemisarcoptes malus*.
5. The species considered by Lignières as *Tyroglyphus malus* Shimer is *Monieziella entomophaga* (Lab.).

In this connection it must be stated that Banks (1906) has described a species which he calls *Monieziella angusta*, which may or may not be the same as *Monieziella entomophaga* (Lab.). Banks has considered that his species and the one figured by Riley (1873) were probably the same, while Michael thinks that Riley's figure refers to *Monieziella entomophaga* (Lab.).

*Habits.* The individuals of this species are about the same size as the eggs of the oyster-shell scale. They can easily be distinguished from other mites present under these scales by the fact that the tarsi of their legs end each in a rather short pedicle, which bears at its end a small cup-like sucker. The mites walk easily about, and when doing so drag after them a few very long bristles, which are not attached to the abdomen, but to the tarsi of the posterior group of legs.

These mites are found invariably under scales that contain at least a few sound eggs, and never under old scales where there is only decaying animal matter. Shimer (1868) and Walsh (1868) also, noticed the predaceous habits of this mite in Illinois at

about the same time. Both of these men gave interesting accounts of their observations. In the fall of 1867 Shimer found that many of the eggs under the scales were damaged by this mite, and he described the shriveled, brown appearance of the egg shells left by the mites. As Shimer and Walsh noted, the mites begin to work at the caudal end of the scale, feeding on the eggs, and gradually pushing forward beneath the scale. As the work under the scale proceeds the sound eggs are devoured, and the brownish, shriveled remnants of the eggs are thrust behind by the mites. Late in the fall, and in the spring, if these mites are abundant, many a scale may be found with only the shriveled remains of the eggs deposited there the summer before.

Shimer evidently had a very favorable opportunity to watch the work of this mite. In his notes dated September 15, 1867, he says that one fourth of the eggs were then damaged, while on October 22 that same year, he found that nine-tenths of that year's scales had all of the eggs destroyed by the mites, while not over 1% of them contained all sound eggs.

Walsh (1868) gave an account in his characteristic language of the manner in which a mite that he observed worked among the eggs of the oyster-shell scale. From this account it is quite evident that the species in question was *Hemisarcoptes malus*.

Lignières (1893), whose careful work on this subject is the most valuable contribution that we have on the subject, has the following to say regarding the eggs that have been eaten by *Hemisarcoptes malus*.

\* \* \* ils sont plus ou moins bosselés; souvent ils sont complètement vidés, et les deux parois de l'œuf, plus ou moins recroquevillées, offrent une teinte jaunâtre.

The scale insects as well as the eggs are attacked by these mites, as Lignières observed. In one observation made at Ames the beak of one of these mites was actually extracted from the scale insect itself. This was done with a pin on the stage of a compound microscope. Apparently the mite was attached by the beak or mouth parts alone. In 1910 *Hemisarcoptes* was found several times beneath oyster-shell scales where the scale insects were present, but without eggs.

*Life History.* Lignières has already traced out the main details of the life history of *Hemisarcoptes malus*. Reference is here

made to his observations, together with some additional notes made in Iowa.

In France, Lignières found the eggs of *Hemisarcoptes* during practically the whole year. They were abundant beginning in April, reaching the maximum about the middle of May. Then there was a decrease until the latter part of July, following an increase, then again a decrease, reaching the minimum in November, December and January. In February and March there was a slight increase.

The Iowa notes show a similar condition here. Under some scales taken March 24, in Northern Iowa, the eggs and mites of this species were abundant when examined March 29. Again these mite eggs were found abundant under scales examined April 14 and May 4, having been taken at places in northern Iowa a few days previous to their examination. In each case the eggs were common and the mites quite active.

Again, later in the year, *Hemisarcoptes* eggs were abundant around Ames, this being noted August 19 (1910), and as late as October 3 (1911).

The eggs of this species we found to be deposited among the fresh eggs of the oyster-shell scale. They are a little less than half as long as the eggs of the scale insect, more shiny and less granular in appearance. They are white, broad oval, .10 mm. long, .07 mm. broad.

Lignières observed these eggs in his work in France, and he gave a description of them, together with some notes on their period of incubation. From five eggs which were deposited at one time or another in the spring, he found that about twenty days were required for them to hatch. We have but a single observation to add to this. One of the eggs that was obtained from among fresh oyster-shell scale eggs at Ames, August 19, hatched on August 31. This egg was found with two others and the female, so it probably had not been deposited long. It is possible that the egg stage is about twelve or fifteen days in midsummer, somewhat less than in the spring, although we have no exact data to show this.

The larvæ of this species are very similar to the adults, except that they are hexapod, not octopod, and are hardly as active.

That Lignières fully appreciated the value of this important mite is shown by the following extract from his paper.

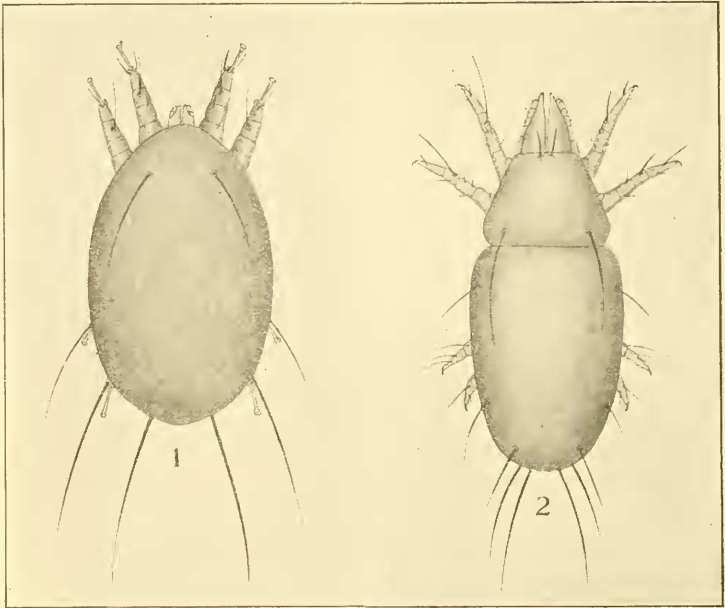


Fig. 1. 1, *Hemisarcotes malus* Shimer; 2, *Tydeus coccophagus* Ewing.

#### **Tydeus coccophagus** Ewing.

L'*Hemisarcotes coccisugus* est un Acarien parasite dans toute l'acceptation du mot. Il est le plus terrible ennemi des Kermes, qu'il tue pour nourrir.

Il est donc pour nous un auxiliaire extrêmement précieux.

This mite is next in importance as an enemy of the oyster-shell scale. It is a very small, white, active species, and is possibly one of several to which Walsh refers under the name of "Cannibal mites." The following quotation is from Walsh.

\* \* \* All cannibal mites that I am acquainted with, are, in the adult stage, exceedingly active, and run with astonishing rapidity for creatures of their minute size.

If one will raise up several of these scales during the month of July or later, he may notice a very minute, white, speck-like creature dart out from under one of them, and run rapidly about the twig or limb and disappear. Such is the behavior of the mite mentioned. The individuals are extremely hard to catch, but after much persistence we succeeded in getting several.



That this mite is predaceous upon the scale insect or its eggs, there is but little doubt. However, the case here is not so conclusive as it is with *Hemisarcoptes malus*, where we have time and again observed the mites attacking the scale insects and their eggs. The whole organization of the mouth-parts of this species (*Tydeus coccophagus*) is suited for predaceous habits, and the other members of the genus are known to be predaceous. These facts, together with the fact that we have found the mites under the scales and associated with the eggs and adult insects, makes out a strong case against them. However, these mites were frequently found under empty scales in June and July, where they probably were feeding upon the old decaying bits of eggs, etc., left from the past winter and spring. But as soon as the scale insects reached maturity, and began to deposit eggs, these mites were found in abundance under these sound scales. A different species of this genus is known to be an important enemy of scale insects in Florida. All the species of the genus so far as known are predaceous.

***Bdella cardinalis* Banks.**

Associated with the scales were frequently found very small nymphs of the genus *Bdella*. Although none of these were reared to maturity, their palpal characters, and the very common occurrence of *Bdella cardinalis* Banks under the bark of many kinds of trees around Ames would indicate that these nymphs belonged to that species. The Bdellidæ are predaceous in all their stages.

***Cyta brevipalpa* Ewing.**

This very small, bright red species was found several times under the scales. The species is known to have a wide distribution over the Mississippi Valley, where it is found on and under bark and in moss. It is a predaceous form, and doubtless feeds upon the eggs or the scale insects themselves, although it was not actually observed to do so. One observation made July 14, 1911, records the mite apparently feeding on old egg shells, etc., beneath an old scale.

***Anystis agilis* Banks.**

This very common and widely distributed species of Acarina appears to be an enemy to the oyster-shell scale only in the larval state. The adults are much too large to get under the edges of

the scale, hence they could not get at the mature insects or their eggs. The larvæ, however, were found under the scales, but were not observed feeding on the eggs or the insects. A larva found July 25 at Ames was beneath an old empty scale, probably feeding on egg shells.

*Eupalus* sp.

This, the last of the real enemies to be mentioned, is rare among the scales examined at Ames. The members of this genus have large raptorial palpi and are predaceous. Consequently this species is included in the list of predaceous mites.

MITES NOT ENEMIES FOUND WITH THE OYSTER-SHELL SCALE.

Three species of mites were found frequently among the oyster-shell scales on the limbs and twigs of various trees. One of these, *Monieziella entomophaga*, is a constant companion of the scales, while the other two are essentially bark or leaf species, and there is no symbiotic or definite relation between them and the scales. These mites are mentioned in the order of their importance.

*Monieziella entomophaga* Laboulbène.

*Identity.* This species has already been mentioned in connection with *Hemisarcoptes malus*, with which it has been confused. It is the species which Riley figures doubtfully as a form of the *Acarus? malus* of Shimer. Lignières, apparently misled by Riley's figures, calls it *Tyroglyphus (Acarus) malus* Shimer. The real identity of Lignières' mite was pointed out by Michael, who referred it to Laboulbène (1852).

In this country, Banks has described a species very closely related to *Monieziella entomophaga* under the name of *Monieziella angusta*. It may be that these two species are the same, for some of the specimens which we have examined show such variations as to strongly suggest the synonymy of the two.

This species is about the same size as *Hemisarcoptes malus*, and since the two are generally found together during the season, it is not to be wondered that earlier writers confused the two species. *Monieziella entomophaga* can be distinguished from *Hemisarcoptes malus*, however, by the marked constriction between the cephalothorax and the abdomen, by the absence of the tarsal appendages

with their sucker-like discs, and by the absence of the very long bristles which are dragged behind the abdomen in the case of the second named species.

*Habits.* This is the mite that was given much of the credit of causing havoc among the oyster-shell scales up to the time of Lignières' work. Lignières was the first to ascertain its true relationship to the scale insects and their eggs, which is that of a scavenger and not of a parasitic or predaceous enemy.

It seems probable, also, that Shimer (1868) observed this mite, from a short account of a species which he saw among oyster-shell scales. He says:

"The careful observer will not confound this *Acarus* (*malus* Shimer) with another yellowish-white mite-like insect, that I find here on the bark of the trees; this runs much more rapidly than my *Acarus*; its body is, in proportion to its size, much longer, as it appears under my exploring glass. \* \* \* I don't find it under any of this year's scales, therefore I do not believe that it is an egg-eater, like my *Acarus*; it may be a vegetable feeder, or possibly feeding on the decomposing matter of the scales of former years."

*Monieziella entomophaga* may be found among injured eggs of the oyster-shell scale at almost any time of the year. They are never found among fresh eggs of the scale insect, and only follow up the work of other mites.

This relationship was clearly seen by Lignières, as the following quotations from his article shows:

\* \* \* j'ai enfermé plusieurs de ces Acariens (après les avoir fait jeûner huit jours) dans des coques de Kermès remplies d'œufs; ces derniers sont restés intacts, tandis que tous les Tyroglyphes sont morts au bout d' un mois environ.

Quand, au contraire, je les enfermais avec des coques de Kermès maintenues un peu humides, ils vivaient facilement.

That this species does not feed upon the living scale insects, nor upon their sound eggs is, we think, fully established. Our observations, which quite agree with those of Lignières, may be summed up in the following paragraphs.

1. The species was never found among eggs that were all fresh, nor attacking the live scale insects, but was found only in scales that contained old eggs, eggshells or dead scale insects undergoing decomposition.

2. The members of the family to which this species belongs are

known to be, almost without exception, feeders upon decaying animal tissue, and not upon live plant or animal tissue.

3. We have repeatedly observed the mites feeding upon old eggshells and dead scale insects.

4. Individuals of this species confined with fresh eggs of the oyster-shell scale in a small cell, crawled about over the eggs, but finally died, while the eggs remained as perfect and fresh as when first placed in the cell.

The eggs of *Monieziella entomophaga* were figured and described by Lignières. We met with them occasionally at Ames during the summer, finding them beneath empty scales. The egg is white, about one-third as long as the egg of the oyster-shell scale, and similar in shape.

*The Hypopus Stage.* In the case of a great many of the species of the family *Tyroglyphida*, the family to which *Monieziella entomophaga* belongs, there exists a very peculiar stage in the life history, immediately following the first nymphal stage. This stage is known as the *hypopus* stage, and the individuals then present as *hypopi*. The *hypopus* is entirely different from any of the other immature forms of the species and from all other mites. The body is more chitinized, frequently very much smaller; there is no mouth orifice; the legs are ill adapted for locomotion; and as a rule there are many suckers on the posterior ventral part of the body. This stage was primarily an adaptation for the migration of the species, this migration taking place by the *hypopi* attaching themselves to insects or other Arachnids. However, as was shown by Michael, this stage is vanishing in many species, in some of which the *hypopi* never emerge from the first nymphal skin, in others the *hypopi* never become even fully formed. The *hypopus* finally moults into an octopod nymph, which after a period of feeding, transforms into the adult.

In France Lignières discovered the hypopus stage of *Monieziella entomophaga*, but the present writers have failed to do so in this country, hence we quote from him as follows.

“Les huit exemplaires que je possède actuellement sont le résultat de recherches poursuivies pendant deux années; durant celles-ci, j'ai eu la bonne fortune de trouver deux fois la *Nymphe hypopiale* vivante dans l'intérieur même de la *nymphe-octopode normale*; à ce moment, cette dernière était inerte comme si elle allait effectuer une mue ordinaire; mais à l'intérieur de son corps, on distinguait une teinte un peu roussâtre dénotant la présence de l'hypope.”

**Tetranychus telarius** Linné.

This species is found frequently in any one of its stages among the scales on the bark of the trees, and for this reason might be thought to be preying upon the scale insects or their eggs. We noticed it commonly at Ames. This, however, is a plant feeder, as are all the members of the family *Tetranychidae*, and it is in no manner connected with the oyster-shell scale. As a rule these mites confine their attacks to the leaves of the trees, but especially during the dormant period, many of them take refuge upon or under the bark, where they may occasionally suck some nourishment from the bark.

**Oribata** sp.

Upon examining trees infested with the oyster-shell scale we frequently found nymphs of a species of Oribatidæ moving slowly over the surface of the bark, or sometimes inside old empty scales. As we did not succeed in rearing any of these nymphs to maturity, no specific determination could be made. They are more or less scavengers in habits, eating bits of decaying organic matter and frequently fungi. These mites are never predaceous or parasitic.

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## NOTE ON MYRMELEON IMMACULATUS DE GEER.

BY J. H. EMERTON.

Large numbers of larvæ of this ant-lion were found at Merry-meeting Park near Brunswick, Me., Aug. 24, 1911, in their pits in loose sand along the sides of foot paths. Several of these larvæ were kept alive, each in a separate bottle with enough sand to make a small pit and fed with spiders at irregular intervals sometimes of several weeks. They remained all winter in an ordinary living room without any special care. The first of November they ceased to make pits and no food was offered them until they began again in March when they took all spiders and insects of suitable size that were given them. On May 1 one of them made its cocoon on the top of the sand and came out adult June 2. The others followed and the last one made its cocoon June 2, coming out July 1. The insects are now in the collection of the Boston Society of Natural History.