

Colorado Experiment Station

Bulletin 133

A Few Orchard Plant Lice

By

C. P. GILLETTE and E. P. TAYLOR

The Agricultural Experiment Station

OF THE

Colorado Agricultural College

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FORT COLLINS, COLORADO

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A FEW ORCHARD PLANT LICE

C. P. GILLETTE AND E. P. TAYLOR*

Among the worst insect enemies of the Colorado orchardist to-day are a few species of plant lice. The codling moth used to be our queen of orchard pests, but the apple growers have learned to successfully combat this insect by means of arsenical sprays.

The plant lice, or aphids, illustrated and discussed in these pages, are not the only ones that fruit growers have to contend with, but they are the species needing the closest attention at the present time in Colorado orchards, and when one has learned to combat these, he will be able to apply the proper remedies for the destruction of most other kinds that he is likely to come in contact with. It has been thought best to give a rather full account of the life habits of the lice here mentioned so that the fruit grower may better understand the methods of control.

The colored plates have been prepared at considerable expense that the reader may better recognize these pests. We believe the bulletin will help those who read it to understand that different plants have different species of lice infesting them, and that these lice often have very different life habits and require different means of control. The lice that infest any plant never appear spontaneously, but every louse, like every higher or larger animal, is the offspring of a parent of the same kind. Consequently all the lice that infest our plants were either native, living upon Colorado wild plants before white men came here, or they have been carried to our orchards upon nursery stock from other parts of the world.

GENERAL STRUCTURE AND HABITS OF THE PLANT LICE (*Aphididae*).

There are a large number of species belonging to the group of insects commonly designated as "aphids" or "plant lice," which have a remarkable similarity of structure and general habits. A knowledge of the more important structural characters of these

*The general direction of the studies here reported, the determination of species, all descriptions, and many of the field and insectary records were made by the writer of this note. The extensive field experiments with remedies upon the Western slope, as well as many life history and food plant notes, were made by Mr. E. P. Taylor, while acting as Field Entomologist for this station. A large portion of the life history and food plant notes, both in the field and in the insectary, have been by Mr. L. C. Bragg. The illustrations are all by the department artist, Miss M. A. Palmer, with the technical descriptions before her. Miss Palmer always draws from her own measurements of parts and when her measurements and mine do not tally, we reach a joint agreement before she proceeds. So I believe the drawings will be found, structurally, quite reliable.

The technical descriptions, with some additional notes upon life habits, have been sent to "Journal of Economic Entomology" for publication.—C.P. GILLETTE.

lice is necessary to enable one to distinguish the species from one another or to understand the descriptions. A knowledge of the general habits will be of great service in enabling one to decide what remedies to employ for the destruction of any of these lice when found infesting plants in general.

EXTERNAL STRUCTURE OF THE APHIDS.

The more important structural parts of an aphid are clearly shown in Fig. 1. The antennae upon the head are special organs of touch and probably smell also. By means of them the insect is able to find its food plants and its mates. The cornicles, standing out from the posterior part of the abdomen, are little tubes through

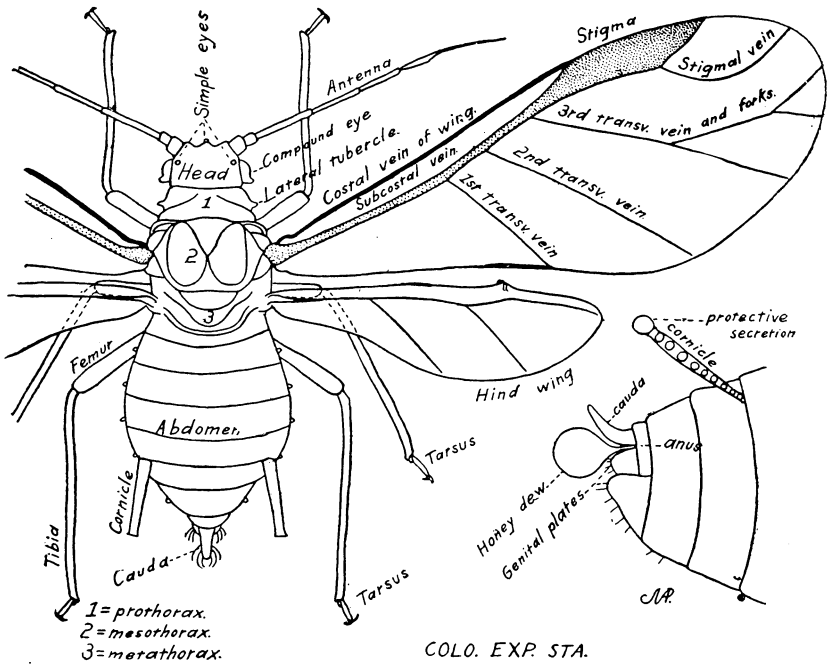


Figure 1. External Structure of an Aphid.—M. A. Palmer, artist.

which the louse expels a sticky material of various colors in different species, as green, yellow, red, black, white, etc. This secretion is probably for the purpose of defense against enemies, but these organs are never for the purpose of expelling the little clear drops of "honey dew" which are so eagerly sought after by ants and sometimes flies, bees and wasps, for food. The honey dew is expelled from the anal opening beneath the cauda, as shown in the smaller drawing, Figure I. The beak, through which the lice

suck the sap of plants, is beneath the head and does not show in the figure.

Each species of plant louse has its special food-plant or plants upon which it feeds. Some species are very restricted in food, having but one, or at most a very few closely allied plants, to live upon, while other species have a few preferred plants but also attack others in smaller numbers, and under certain conditions may adopt a very wide range of plants, especially in the spring, when nearly all growth is tender and succulent, and again in the fall after the preferred food plants may have ripened or have been killed by frosts.

Perhaps one of the most important things to be known, from an economic standpoint, is that very many plant lice have a regular alternation, or change, of food plants. Such lice usually migrate upon certain trees or other woody plants in the fall, upon which eggs are deposited to remain over winter and hatch in the spring to start the next year's broods. These spring forms, after going through one or more generations, acquire wings and go, either wholly or in part, to their summer food-plants, which are usually plants that will die down in the fall.

But it is a condition that we face. The lice are in our orchards. How can we recognize them? What are their habits? How can we prevent their injuries to the fruit crops? These are the questions we shall specially attempt to answer, for the fruit growers.

APPLE PLANT LICE

THE WOOLY APPLE APHIS

(*Schizoneura lanigera* Hausm.).

Plate I, Figs. 9, 10, 11, and Plate III, Figs. 3, 4.

If Colorado orchardists should vote their opinion as to what ought to be called the worst orchard pest in the state, it is very doubtful whether the codling moth, or the woolly aphis, would carry off the honors.

Most plant lice are leaf feeders, but this one confines its attacks to the tender bark, and it is not particular whether it is the bark of the trunk, limbs or roots, if it is only tender enough to enable the louse to insert its beak. When very abundant the lice sometimes attack the stems of the leaves and fruit.

PAST HISTORY.

No one seems to have determined with much certainty the native home of this insect. In fact, it may be said to be a louse without a country, as it is everywhere disowned. The earliest references to it that we have found dates back to 1787, when it was

reported upon apple trees in England. Harris, in his "Insect Injuries to Vegetation," states that the louse had been known in France several years earlier than this. In 1801 it was reported in Germany by Hausmann, who described it and gave it its scientific name. In 1810 it had become so abundant in Gloucestershire, England, that the farmers feared they would have to stop making apple cider, and it is still a serious pest there. In England it was early believed that this insect was first introduced upon nursery stock from America. Buckton, an English writer, in his "Monograph of British Aphidides," seems to believe that this louse is a native of America, and states that it has been known to occur upon the American crabapple;* but the first record we have of the occurrence of the woolly aphid in the United States is in Harris' "Insects Injurious to Vegetation," published in 1841, more than a half-century after it had become a recognized pest in Europe.

In England, before the real cause of the mouldy appearing trees had been discovered, this malady was called American blight. On account of the blood red stain, caused when this louse is crushed, the Germans have called it the blood-louse. But wherever this insect may have its native home, and whatever may have been its native food plants, we know that it now occurs in practically every apple-growing region on the globe and, as it is an insect of much economic importance in Colorado, we shall go rather fully into its habits, life history, and means of control.

THE LOUSE DESCRIBED.

Most orchardists will think a description unnecessary, and to them it would be were it not for the fact that there are many other woolly lice upon other plants that are frequently mistaken for the woolly aphid of the apple.

The name woolly aphid was given because of the white secretion occurring so abundantly upon the wingless lice, and, to some extent, upon the winged ones also. This is not a woolly covering in the sense that it grows like wool or hair. It is really a fatty or waxy secretion similar to the shellac, China wax, or beeswax of commerce. Small glands beneath the skin give off delicate white threads of this material through minute pores. This white secretion, when warmed, will melt like tallow. It is easily removed from the body, but in a short time the body will be covered again. It serves as a protection to the louse against storms, and, to some extent, no doubt, from its insect enemies.

*Buckton probably had in mind the statement made by Fitch in his first N. Y. report, p. 5, in which he says he has seen the winged form of the woolly aphid numerous in groves where he suggests that it had come from the shad-bush (*Amelanchier* sp.). It is altogether probable that Fitch mistook the winged form of *Pemphigus corrugatus* Sirt. for winged migrants of the woolly aphid of the apple.

The body beneath the wool is of a rusty or purplish brown color in the fully grown lice, but the very young are much lighter colored. The winged lice are recognized in patches of the white secretion by their long, dusky wings. The thorax and head are black, or nearly so; the abdomen is a dark yellowish brown, and the legs, eyes and antennae are also black or blackish. The last lice in the fall, those that live over on the tree above ground (Fig. 11), are of a dark yellowish to dusky brown color, without the cottony secretion, and would not be recognized as the same insect at all by one not familiar with this stage in the life history of this insect.

LIFE HISTORY.

The life history of this pest of our apple orchards is most wonderful, some stages of which are still not well worked out. Upon the roots, the wingless lice may be found in all stages of development at any time of the year, reproduction and growth taking place more slowly or ceasing entirely in cold weather. Apparently the weather is never cold enough to kill the lice that are well beneath the surface of the ground. We have occasionally found winged lice beneath the surface of the ground when digging about the roots of trees, but we have never found the true males or females or eggs upon the roots. So the lice are always carried through the winter in large numbers upon the roots of the trees, and many of the small lice have often been seen in the spring and early summer migrating up the trunks of apple trees, some of which, undoubtedly, lived over winter upon the roots, or are the offspring of those that did. This does not mean that there is anything like a general migration of the root-lice upward in the spring, for we have no reason to think that such is the case. Neither do lice that are half-grown or more seem inclined to change their locations. Only the very young seem to travel about.*

Upon the trunks and branches of the trees we have, then, four possible sources of the lice in the spring; the little brown lice that descended mostly to the crowns of the trees in the fall to spend the winter; lice from the roots, whose ancestors lived upon the roots the previous summer; young lice of the last fall brood that were able to withstand the rigors of the winter upon the trunk and branches, and lice hatching from eggs that were deposited the previous fall by the sexual females.

From our observations, the most important of these sources is the first mentioned, and the least, if of any importance at all.

*Since writing the above, a letter from Mr. George P. Weldon, Field Entomologist, located at Delta, Colo., dated June 25, '08, says: "I notice only very small lice are trapped in Tanglefoot bands, indicating that the larger ones do not migrate at all."

the last one. Much careful observation has not rewarded us by the finding of a single sexual male or female or an egg of this louse out of doors upon an apple tree under normal conditions. Professor F. V. Theobald, of the South-Eastern Agricultural College, at Wye, England, in his "Report on Economic Zoology," 1907, says: "The egg stage takes place close to the base of the tree, always, however, above ground level. These ova remain frequently hidden in the crevices of the bark all the winter, and in spring they produce a larva which soon matures into the 'mother-queen' form, and which sets to work at a great rate to produce viviparous young." Whether Professor Theobald is reporting his observations or is reasoning from analogy we are unable to say. We know from the actual observations of the writers and by Mr. L. C. Bragg, that such a method of procedure is pursued by the elm woolly aphid, *Schizoneura americana*. The fall winged lice of this species that give birth to the sexual forms sometimes accumulate in thousands about the bases of elm trees to deposit the sexual forms, but we have been unable to discover such a habit for the woolly apple aphid. We are not averse to believing that it has such a habit, but we have not been able to discover it and do not feel sure that Prof. Theobald intended to announce that he had for this species.

During the winter of 1906-07, when the thermometer barely reached zero in the Grand Valley about Grand Junction, and only reached -9.3 degrees at Fort Collins, the lice lived over winter in large numbers upon the trunks and branches. As a result, in the Grand Valley especially, this louse was the most numerous the following spring and summer that we have ever known it in the state. Fortunately, the lady beetles (Plate II, Figs. 12, 13, 14, 15) aphid lions (Plate I, Fig. 15), and syrphus larvae, came through in good condition, too, so that by the first of August scarcely any of these lice could be found anywhere in Colorado above ground.

Last winter (1907-8) the temperature went several degrees lower, and at Fort Collins there were several nights when the temperature went below zero, yet quite a number of the little, dark, over-winter form of this louse lived through in old scars and beneath the dead bodies of the lice of the previous fall.

How many of those that migrate upward from the crowns of the trees in the spring are really from the roots, and how many are the over-winter form from the tops that went down in the fall, it is impossible to state with certainty. Tanglefoot bands put about the trees early in the spring caught large numbers of the ascending lice at the lower margin and apparently the greater proportion, early in the season, were the over-winter form.

If the lice have lived over in any great numbers, a man with a good hand glass (which every fruit grower should have) can easily detect the fresh white secretion appearing in the old scars.

All the lice appearing upon the trees or roots during spring and summer are viviparous females. That is, they are lice that give birth to living young without the intervention of males. Probably these lice live about three weeks after becoming mature, during which time they will give birth to from 75 to 125 young. These young require about ten days to mature and, like the parent, give birth to their quota of young and die. This process continues generation after generation, all the lice being wingless and viviparous until about the first week in September, when in some of the colonies, winged viviparous females will begin to appear in small numbers. They soon leave the colonies and take wing, and to the present time we have entirely failed to determine what becomes of them. When inclosed by cheesecloth so they cannot escape, they persist in crawling about over the walls of their cage and never return to the tree. Before dying, they give birth to the true male and female lice, but this is either done upon the walls of the cage or upon the inclosed trees. They act like a fall migrant of a louse having an alternate food plant and possessed of an instinct to desert the old one. It is possible that the bad behavior of the lice has been due to the artificial conditions under which they have been studied. We believe Professor Alwood was the first to observe and describe the true male and female of this louse,* and his observations also were confined to the laboratory.

The winged viviparous females appearing in the fall give birth to from six to twelve young, about half of which are males and half females. These egg-laying females are yellowish brown in color and are about half as large as the common adult apterous females. The male is rather light yellow in color and is considerably smaller than the female, and neither grow after being born, having no mouth parts with which to take food. The female develops one large yellow egg that is fully two-thirds as long as her own body. The female is also wingless. Ten winged females were dissected and from them were obtained males and females, as follows:

* Bull. 102, Virginia Experiment Station, p. 139, and Spec. Bull. (C. P. C. No. 45), p. 12, of the same station, 1904.

MALE AND FEMALE BIRTH RECORD OF WINGED MIGRANTS

	MALES	FEMALES		MALES	FEMALES
Louse ----1	4	5	Louse --- 9	2	4
" ----2	5	5	" ---10	4	5
" ----3	3	5	" ---11	3	6
" ----4	3	5	" ---12	4	5
" ----5	3	4	" ---13	4	5
" ----6	4	1	" ---14	3	4
" ----7	5	2	" ---15	4	5
" ----8	3	2	" ---16	4	3

In a state of nature these remarkable instincts and life habits were not developed without a very deep-seated cause. One purpose seems to be to enable the aphid to get away from its mortal foes and continue its existence. The lady beetles* and other predaceous enemies are likely to become so numerous late in the season as to exterminate the colonies of woolly aphid, but if such a thing should happen, the eggs deposited by the true females will start a number of new isolated colonies another spring away from the old haunts of the enemies, and in this manner greatly increase the probability of the continuation of the species. Probably another equally important consideration is the increase of food supply through the dissemination of the species.

When cold nights come on, about as winter apples are being picked, many of the young lice (Fig. 11) do not locate, take on a dusky to dark greenish color, do not grow or secrete any cotton or shed their skins, and seem to be developed for the special purpose of withstanding the winter's cold to start another round of woolly aphid life the next spring.

If a tree top is badly infested, these specialized young will crawl down the trunk in countless thousands in the fall. We have often seen them abundant enough to very perceptibly darken the trunk of the tree and the earth for some inches about the crown. Great numbers crawl into crevices in the earth, about the crowns of the trees, and others get into every possible hiding place beneath loose bark, in cavities of rotten limbs, in old scars and other places that will afford a little winter protection.

Apparently, all the lice in our Colorado climate that insert their beaks and begin taking nourishment in the fall are killed when severe freezing weather comes on. By far the greater num-

*We have found *Hippodamia convergens* to be by far the most abundant lady beetle attacking this louse. *Coccinella transversalis*, *C. transversoguttata*, and *C. monticola* we have also found feeding upon them to some extent.

ber of the over-winter lice perish, but a few find sufficient protection to enable them to withstand the cold and they start new colonies in the spring. Our tanglefoot bands have caught large numbers of these lice upon the lower half in the spring, and enormous numbers in the upper half in the fall.

PARTS OF TREE MOST ATTACKED.

A great deal of digging about the trees in orchards of the Western slope proved that very little harm is done to roots that are more than 10 inches below the surface of the soil, and more than three feet from the crown of the tree. If water sprouts are allowed to grow up about a tree, they are almost sure to be very lousy, especially just at the ground.

Succulent and rapidly-growing parts, especially grafts, are very susceptible to attack.

Of all the varieties grown in Colorado, the Missouri Pippin seems to be worst infested, and Northern Spy is practically exempt. We have yet to find a single tree of this latter variety much infested. In a few instances slight infestation has been found in pears.

Loose, porous soils seem more favorable for the development of this louse upon the roots than are the heavier and more compact soils.

INJURIES.

The woolly aphid belongs to a gall-producing group of plant lice. Their punctures in the bark have an irritating or poisoning effect, which results in an increased flow of sap, which is to the advantage of the louse, and at the same time it causes an abnormal growth of the part. Very small rootlets may have lumpy galls of considerable size (Plate III, Fig. 4), and larger roots may have an aggregation of these swellings involving a large portion of the root surface. As a result of these attacks, the roots often die and rot and sometimes the condition is so bad that a tree may be pushed or blown over because of the number of roots that have died near the crown of the tree. When the lice attack the tender bark about a scar, upon trunk or limb, the new growth is made more or less gnarly, but the effect is not so pronounced as upon the roots. The lice also attack the tender bark of the small limbs, and particularly where rapid growth is taking place, so that grafts and water sprouts are usually worse infested than other portions of the tree. Upon these rapidly growing parts the lumpy growths often become very numerous. The galls are usually smooth but often crack open, and especially is this true in cases of severe infestation.

If this louse is very abundant, either upon roots or limbs, the result is an unthrifty tree, bearing small and poorly colored fruit. Even if the fruit is worth picking it will be more or less smeared with the excretions of the lice, and the pickers may have their clothing almost completely colored with the red juices of the crushed lice.

Probably the injuries to the tree are greatest from the root attack, but the direct losses to the orchardist are doubtless greatest from the injuries to branches and fruit.

PREVENTION.

Prevention is usually much better than any remedy, but we are seldom aroused into action until we are hurt, and money spent on preventive measures is likely to be considered money thrown away. The greatest care should be exercised to avoid setting young trees with woolly aphis already upon them. Such trees have a severe handicap from the first. To avoid this handicap purchase trees, so far as possible, from nurseries that send out clean stock and then insist on your nursery stock being thoroughly inspected by a competent person and, if infected, either reject it or insist upon thorough disinfection.

One way to prevent the root injuries of this louse is to plant only such apple trees as are grown upon Northern Spy roots.

If nursery stock is received with the roots "puddled," covered with mud, insist upon the mud being thoroughly washed off so as to expose the roots for inspection. This is one way nurserymen have of covering up the woolly aphis on the roots.

As we find that the lice seldom are found upon roots more than ten inches from the surface of the ground, this is a strong hint that the soil for a successful apple orchard should be deep, and that planting, cultivation, and irrigation should be so managed as to make the trees deep rooted. Set the trees rather deep, irrigate thoroughly but not often, and cultivate deeply, from the first, between the rows.

Finally, during the last half of August, before the winged lice appear, thoroughly spray for the purpose of cleaning up the lice upon the tree tops, so that the winged migrating form cannot spread about to distribute the species to other trees.

NATURAL ENEMIES.

Notwithstanding the fact that this louse is heavily covered with a protective waxy secretion, it is freely preyed upon by lady beetles (*Coccinellidae*), Syrphus flies, and Chrysopa larvae, commonly called aphis-lions or lace-wing flies. The orchardist will often notice that certain limbs or trees that were badly infested early in July may be nearly or quite freed from the lice by the

middle of August. We had an excellent illustration of what the predaceous insects can do in this way last year. Probably this insect never was so abundant in the orchards of the state as they were last year, from their first appearance in the spring until about the middle of July. About that time the enemies had become so abundant that a noticeable decrease soon became apparent and by the 10th of August it was almost impossible to find a living louse above ground. Upon the roots there was no noticeable change in the infestation. The enemies then left the trees, and the few lice that were overlooked, with a few others that migrated upward from the roots, soon began to increase in numbers, so that by the last of September the trees were showing a light infestation again. Apparently this is all easily explained. The winter of 1906-7 was very open and mild, so that plant lice of all kinds lived through unusually well and were very abundant early in the spring. As a result, there was a very abundant food supply for their enemies, which also increased with great rapidity, so that by the first of August they began to get the upper hand of the lice, and to prevent their own starvation, almost completely ate the latter from every exposed place. In the Grand Valley the greater portion of this benefit was done by the lace-winged fly (Plate I, Fig. 15), while upon the Eastern slope the lady-bettles (Plate II, Figs. 12, 13, 14, 15) were the chief benefactors, with the lace-winged flies and the *Syrphus* flies as efficient helpers in the good work. Specimens of a small black parasitic fly* were taken by Mr. L. C. Bragg, ovipositing in this louse at Fort Collins, August 20, 1908.

REMEDIES ABOVE GROUND.

Wherever this louse can be reached by sprays, it may be destroyed, like any other plant louse, but one important precaution is necessary, the spray must be applied with sufficient force to wet through or remove the woolly covering. This louse is then more easily killed than is the green apple aphid, which curls the leaves for protection.

There are several spray materials that may be used with success. In fact, any spray that is generally successful when used for the destruction of plant lice may be considered useful for the destruction of this insect.

KEROSENE EMULSION.

When properly made, a good kerosene emulsion has no superior, as a spray for the destruction of the woolly aphid, so far as we have been able to determine, and it penetrates the woolly covering better than most insecticides. When used in the usual strength of 1-15 (7 per cent.) oil we have always found it to be suffi-

**Aphelinus mali* (Hald.), determined for us by Dr. L. O. Howard.

ciently strong. A preparation of 1-20 (5 per cent.) oil is usually successful if thoroughly applied and makes a spray of very moderate cost. Directions for the preparation of kerosene emulsion are given near the end of the bulletin. The trouble, if any, will be in obtaining a good emulsion from which the oil will not separate and collect upon the surface. To be successful use a moderately coarse and forceful spray. While we are inclined to consider a good kerosene emulsion the most efficient of all the insecticides we have used against the woolly aphis, we are aware that most orchardists have had so much trouble making it that they prefer to use something more easily prepared, even at a somewhat increased expense. Such men as B. A. Smith, F. C. Jaquette, Joseph Cornetto, E. M. Cheedle, W. K. Haines, and others in the Grand Valley, have used the emulsion with the best of results.

SCALECIDE AND OTHER MISCIBLE OILS.

There are upon the market a number of so-called miscible, or soluble, oils which, when put into water, break up into very fine particles and form a milky white emulsion. These, like kerosene emulsion, make a very good and efficient spray for lice if they do not separate to form a film of pure oil on top. The only preparation of this kind that we have used at all extensively is Scalecide. When used as strong as 3 to 4 per cent. oil we have found it very effectual. Apparently the soluble oils have to be used with more care than kerosene emulsion on account of their liability to injure foliage when too strong.

SOAPS.

In our experiments for several years past some of the standard whale-oil or tree soaps have given very satisfactory results, but, for some reason, the orchardists have not seemed to be as successful with the soaps they have used. We have used chiefly the brands sold as Good's Whale-oil soap, and Bowker's Tree-Soap, and 1 pound to 8 gallons of water has usually been sufficiently strong. The warmer these soaps can be when applied, the better. We believe the soaps can be purchased so as to be among the cheapest of spray materials, and if anyone has been using a brand that has given him success, we see no reason why he should make a change. Mr. A. L. Roberts, of Paonia, reported to us last year that he completely cleaned the woolly and green apple lice out of his orchard by thoroughly spraying with 13 pounds of whale-oil soap and 1 gallon of Black Leaf to each tank of 220 gallons of water.

"BLACK LEAF."

The Kentucky Tobacco Product Company, of Louisville, Kentucky, manufactures a tobacco extract which they sell under the

above trade name and which has become very popular among the orchardists of Delta County as a spray for all plant lice in their orchards. Purchased in car load lots, it is one of the cheapest, and most easily prepared, of all spray materials used, and has given remarkable satisfaction, and in our experiments it has given splendid results. Aside from the fact that it does not penetrate the woolly covering of the lice quite so readily as the kerosene emulsion, we are inclined to place it about on a par with that insecticide in its killing effects. When this, or any other spray, is used, special care must be taken to throw the spray from all directions and under high pressure, 140 to 180 pounds, if possible, to get best results. The manufacturers write us that they take great pains to put out a uniform product of Black Leaf so far as the nicotine content is concerned, and that this is the only ingredient that it contains that has any special insecticidal value. This being the case, if the manufacturers keep up the present standard of quality in this dip, we predict that it will come into very general use for the destruction of all aphids upon out-of-door plants.

While the orchardists have been using Black Leaf, in most cases, in the proportion of 1 gallon to 65 gallons of water, we have found in our experiments, where we know that thorough treatments have been made, that 1 gallon to 75 gallons of the watery mixture is very uniformly successful in killing all the lice, and 1 to 100 (a 1 per cent. mixture) seldom fails to give excellent results.

It is a good plan for the orchardist to treat a few trees with varying strengths of his mixture a day or two before taking up his spraying in an extensive way, and note carefully the results. In this way he may save many dollars, either from using the insecticide in strengths that are unnecessarily strong, or by throwing away a large amount of time and material in the application of a spray that is too weak to give satisfactory results.

TOBACCO DECOCTIONS.

Some may prefer to make their own tobacco sprays, either by using tobacco stems, tobacco dust, or whole-leaf tobacco. While fruit growers do not report very uniform results from their own tobacco preparations, our experience has been different. When we have steeped tobacco stems, or tobacco dust, in water in the proportion of 1 pound to two gallons, or the whole-leaf tobacco in the proportion of a pound to four gallons of water, we have been very uniformly successful in getting a decoction that would kill the lice. See directions for preparing tobacco decoction near the end of this bulletin.

Mr. W. S. Coburn, President of the Colorado State Board of

Horticulture, tells us that he has had excellent success by using tobacco of his own raising in the proportion of 1 pound to 6 gallons of water after steeping for a full hour and then applying warm.

LIME-SULFUR SPRAYS.

Lime-sulfur sprays used during the summer, when the lice have a wooly covering, have not proven satisfactory in our experience. For early spring spraying, see below.

Chloroleum, potash lye, and strong lime washes have also been tried without marked beneficial results.

LATE WINTER OR EARLY SPRING APPLICATIONS.

So far, the remedies mentioned have been for summer treatments, when the bodies of the lice are more or less covered with the waxy secretion. We believe the best time to get results in the treatment of this louse is late in the winter or early in spring before the buds open. This is not because the lice get protection from the opening buds, but because by the time the buds have opened, the lice have their bodies more or less covered by the waxy secretions that protect them to some extent from the effects of the insecticides.

Orchards in the Grand Valley treated early in the spring of 1907 for the destruction of the eggs of the green apple aphid were partially freed from the wooly aphid also.

We have no doubt but what kerosene emulsion, the soluble oil sprays, the tobacco sprays and the whale-oil soaps, could be used successfully as early spring sprays for the destruction of the overwinter lice upon the tree top, though we have not tested them in that way. As they are not as successful for the destruction of the eggs of the green apple aphid, and as the orchardist is likely to want to destroy both of these lice at the same time, if possible, it is probable that the lime-sulfur sprays will become most popular for early spring applications.

To get best results on the wooly aphid the spring application should be made fully a week or ten days before the apple buds begin to open at all, and the trunk and crown of the tree should be thoroughly drenched. Then, as a final act for best results, put tanglefoot bands about the trunks of the trees so that the lice at the roots cannot migrate to the top. For the application of these bands, see next paragraph.

TANGLEFOOT BANDS.

In the experiments upon the Western slope in particular, large numbers of Tanglefoot bands have been used. This material is put out by the O. & W. Thum Co., Grand Rapids, Michigan, and is

similar to the sticky material put upon the Tanglefoot Fly-paper. When at all abundant upon the trees, the newly-born lice are much inclined to travel about, and it is often astonishing to see the number of lice that will be captured in these bands. On the 7th of June, 1907, it was estimated that bands that had been on since the preceding fall had as many as 100,000 lice each in many cases. The bands remain fresh for several months and may be quickly freshened by rubbing a paddle over them, when they become filled with insects and dirt.

Mr. Weldon, field entomologist, reports these bands doing harm to trees, where they have been on for more than a year. The Tanglefoot was placed directly upon the bark, but it would be safer to put a band of stout paper around the trunk and then put the Tanglefoot upon that. To make certain that no lice should pass under the band, a light band of the cheapest cotton batting under the paper would be advisable. This band, in connection with the spring spraying mentioned above, we believe to be the surest method of freeing the tree tops of woolly aphid.

MOUNDING AND CULTIVATING.

The woolly aphid is not a burrowing insect in any true sense of the word. The lice that come down the trees get into the ground by way of the cracks or other openings in the soil that are large enough to allow them to enter. The lice that sometimes infest distant roots do not get to them by crawling there all the way from the crown of the tree, but they get down to them directly from the surface above. So far as possible, the descending overwinter lice congregate about the crown of the tree where they are able to get below the surface in the large cracks between the trunk and the earth. The migration, both to and from the roots, can be somewhat, often very largely, prevented by cultivating the surface of the soil and by stirring and compacting and even slightly mounding the earth about the crown of the tree and by re-stirring this earth when it becomes compacted after a rain or an irrigation.

TRIMMING.

When the lice become very abundant upon water sprouts and suckers, something can be done to lessen the number by thoroughly cutting out these growths, and a thorough thinning of the top so that plenty of sunlight can enter, has been noticed to lessen the number of lice which find the most congenial locations for their development in dense shade and upon the north side of the limbs, at least in sunny Colorado.

TREATMENT BELOW GROUND.

The treatment below ground is all aimed at the lice that are

within three feet of the crown of the tree and within one foot of the surface. It should also be remembered that the same substances that will kill the lice above ground will also kill them below, if they can only be put in contact with the lice. The orchardist should be cautious, also, not to accumulate in the soil, about the crowns of his trees, substances that are likely, either presently or after years of repetition, to do his trees an injury.

EXPERIMENTS IN GRAND VALLEY.

For many years tobacco, in the form of dry dust, stems or leaves, has been considered the best known remedy for this louse. Soapy solutions have also been thought of some value. In Bulletin 23 of the Georgia Experiment Station (1907), Professor R. I. Smith, reports far better success with kerosene emulsions than with tobacco or soaps for the destruction of the apple woolly aphis upon roots.

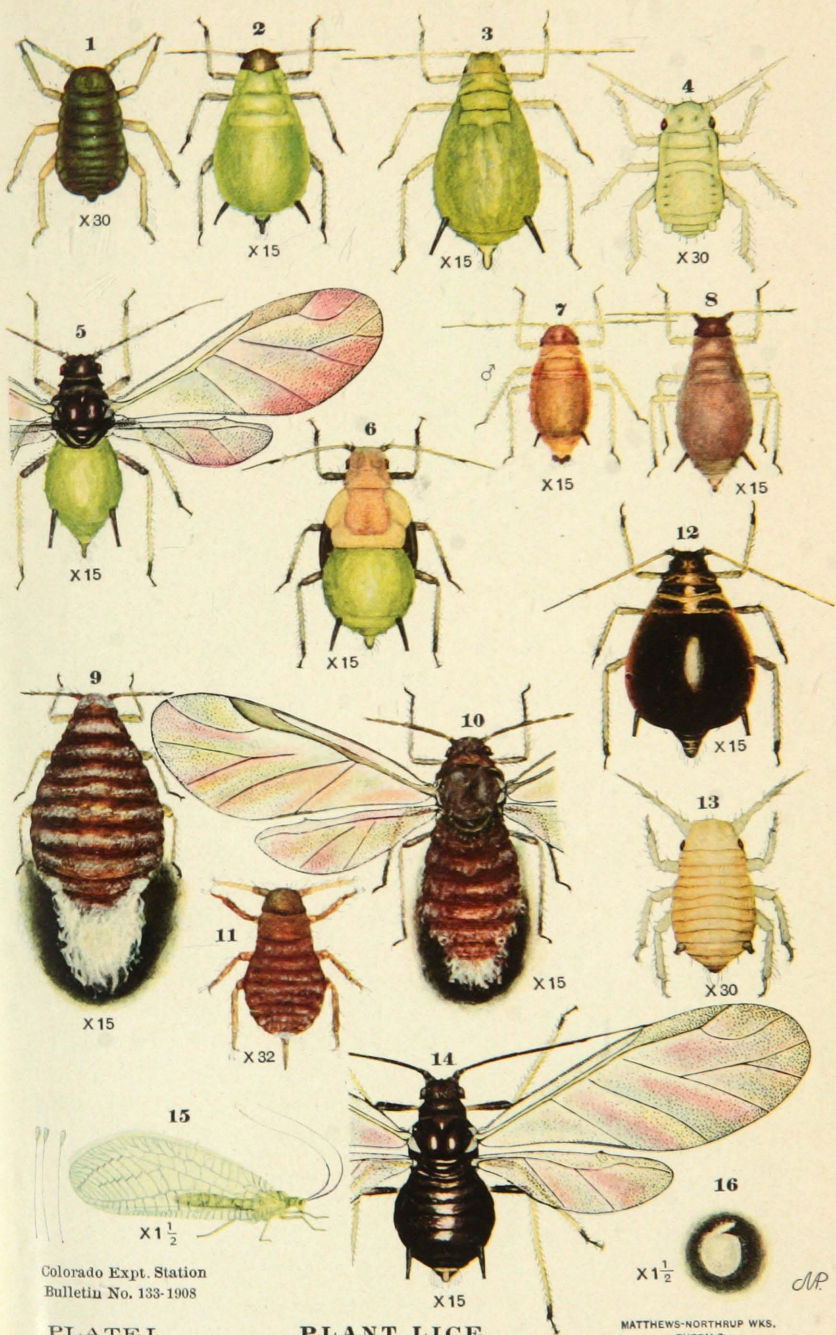
A rather extensive series of experiments for the purpose of testing substances that seemed to offer some promise of good results were carried through in irrigated orchards of the Grand Valley in Colorado, a summary of which is given in the table on the following page.

The authors are under special obligations to the men who kindly offered their trees for the experiments and in other ways aided in carrying on the work.

THE APPLICATIONS AND THEIR RESULTS

The experiments were begun in the fall of 1906 and the winter following. The materials used upon the roots were kerosene emulsion, Scalecide, Chloroleum, Black Leaf Dip, tobacco dust, tobacco dust decoction, tobacco stems, tobacco stem decoction, quick lime, lime-sulfur mixture, Rex lime-sulfur, Adams' lime-sulfur, whale-oil soap, and carbon bisulfide, as shown in the table. Other tests were also made upon the roots which are not scheduled.

Before making the applications, the earth was removed over the main roots to a depth of about 6 inches, and for a distance of about 2 feet upon all sides, of each tree. One man on an average would expose the roots of about 100 trees a day. Into these dirt basins, which varied some in depth and diameter, with the size and depth of the roots of the trees, the liquids were forcefully sprayed so as to well drench the exposed portions. Both the treated trees and the checks were given a rating of 1 to 4 as to degree of infestation, so as to be able to make fair comparisons in determining results. The liquid applications were then forcefully sprayed upon the roots in these basins until two or three gallons had been applied, and when the liquid had nearly or quite soaked into the



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PLATE I

PLANT LICE

MATTHEWS-NORTHROP WKS.
 BUFFALO

M.P.