Observations on the Woolly Aphis of the Apple

Eriosoma lanigerum (Hausm)

By E. P. VENABLES,

Dominion Entomological Laboratory, Vernon, B. C.

OWING to the prevalence of the woolly aphis of the apple throughout the orchard sections of the Okanagan valley in British Columbia, the Dominion Entomological Branch undertook a special study of the insect in order that the control might be placed on a more satisfactory basis. The need for this study became increasingly important, owing to the conclusion arrived at by Mr. C. L. McLarty, Plant Pathologist at the Summerland Experimental Station, namely, that this aphis was closely associated with the spread of the perennial canker of the apple (**Gloeosporium perennans** Childs & Zeller), a serious disease which had recently made its appearance in some Okanagan orchards.

McLarty has secured good evidence that the spread of the disease, in individual cankers, is due to the feeding of the woolly apple aphis upon the tender healing tissue around the canker margin. From his experiments, exclusion of the aphis resulted in the healing of the cankers.

From a study of the literature, it was apparent that the investigation would be a complicated one. Points in the life cycle known to occur in one locality might not hold good in a different area.

In parts of Eastern Canada and the United States the migration of this aphis from elm to apple is an important factor in the life cycle, which is further complicated by the presence of the root form on apple, and also that feeding and colonization may take place upon thorn (Crataegus) and mountain ash (Sorbus.)

In British Columbia little detailed information exists regarding this aphis. It has been definitely shown in our studies that the elm plays no part in the life cycle, the root form occurs at Vancouver but is apparently absent in the interior, thorn and mountain ash are plentiful but are not attacked.

In order that the life history of the woolly apple aphis might be clearly understood, it was evident that it would be necessary to study, to some extent, the allied species of **Eriosoma** occurring in the district.

It was particularly important to ascertain which species adopted the elm as a winter host.

As a result of our studies at Vernon, B. C., in the Okanagan valley, the following species of the genus have been found and their winter and summer host plants determined.

Eriosoma ulmi Linnaeus. Summer host, roots of currant and gooseberry; winter host, elm.

Eriosoma americana Riley. Summer host, roots of June berry (**Amelanchier** spp.); winter host, elm.

Eriosoma lanigera Hausmann. Summer and winter host, apple.

Another species has been found upon elm in small numbers, but its identity is at present in doubt.

Life-History

That the life-history of the woolly aphis of the apple is a complicated problem is evident to any one who has studied the literature. Various forms of the insect have been described, and its migration to certain other hosts has been shown to be a normal procedure in parts of North America and elsewhere.

Our observations, commenced in 1928, were based on the assumption that the life-history would conform more or less closely to that in other parts of the continent.

We have found the winged form to be present only in the autumn at Vernon, Oyama and Kelowna. At Penticton, some 80 miles south of Vernon, two winged individuals were taken in a colony in early June, and this is the only indication that we have which suggests any migration by flight in early summer, although very careful watch was kept at all times. The winged females of the fall generation appeared in late August on caged trees, and by early September were extremely numerous, both in the cages and in the field. So far as our observations have gone, we have been unable to trace the migration of this aphis to any other plant. None have been taken on elm trees at any time, although a fair number of elms occur near some orchards. A point of great interest in connection with these alate individuals is that, although they contain embryonic young, both males and females, these are never produced. Careful tests with numbers of these potentially reproductive fall migrants failed to indicate that their progeny are deposited either on apple or elm. In the caged tree, they clustered by hundreds on the cotton walls and died. When the door was left open those upon the cotton flew off rapidly. None of the true sexual forms were found upon apple trees, although winged females were numerous upon them. That

thes sexual forms are deposited upon elm and, also, to some extent, on apple, has been clearly demonstrated in sections of the eastern United States, and is referred to as the normal procedure in the literature.

Davidson, in Science Progress No. 84, 1927, in dealing with the migration of the woolly aphis of the apple, quotes the observations of two investigators in Switzerland who have established the fact that in that country the alate females give birth to sexual forms which are inoperative and die without laying eggs, and that they have, in that country, apparently lost the habit of completing the bisexual cycle owing to the absence of the American elm in Europe, and even where this alternate host is found, sexual reproduction does not occur.

In France, Marchal, in 1919-1924, was able to trace the fall migrants from apple to elm where these alate females produced the sexual forms, which, however, were inoperative, so that there was no return from elm to apple in the spring.

Theobald, in England, states that the true sexual brood is extremely rare, and that it has occurred only twice in twelve years on an apple tree kept under observation.

From these facts it appears that in the woolly apple aphis we have an illustration of progressive suppression of sexual reproduction, possibly owing to the absence of the primary host, elm, in the early days when apple trees were first introduced.

In our experiments, the only way in which we were able to secure normal sexual forms from the winged migrants was by enclosing a number of them in a tightly corked vial. These females died in a short time and a few young would be found crawling on the glass. Placed in cylinders over apple twigs, the winged migrants refused to reproduce and no sexual forms were encountered upon apple. Caging individuals over elm gave no results; in fact, it looks as though the suppression of the sexual forms, as noted in the quotations above, is progressing to include the alate progenitors of these forms, and to render them also inoperative. It is hoped that more extended observations will be carried out in this connection.

Injuries

As stated before, one of the main reasons for this investigation was on account of the strong probability that the woolly aphis of the apple is the main cause of the spread of perennial canker. Whilst this point is acceded to by those who have studied the disease, there is no information as yet to show the exact status of the insect in this connection.

In order to gain information on the problem of twig and wood injury caused by the feeding of the aphis, generally referred to as "gall-

ing," we commenced a study of the galls themselves, and of the mouth parts of the aphids.

The injury to branches and twigs of apple by the aphis takes the form of nodular swellings or galls at the point of feeding. These galls may be one-half inch to two or three inches in length, depending on the severity of the infestation. After a time the bark splits and an overgrowth of the surrounding tissues commences as a result of the tree attempting to heal the wound. This offers an ideal situation for the colony of aphids. When settling down in pruning wounds the aphids congregate at the edge of the cut and attack the newly formed tissue, causing a somewhat similar condition to that on the twigs, large warty growths and nodules appearing beneath the colonies. In the case of twig galls, it will be found, if they are cut through horizontally, that the wood is, in all cases, blackened and dead, and that the pith itself is frequently severely injured. The attempt by the tree to heal this area results in large callus growths around the colony of aphids.

The question as to why a few individuals of the woolly aphis can cause such peculiar gall formation on apple twigs, while an infinitely greater number of the green apple aphis produce no such result, is of interest, and led us to make a series of comparative measurements of the feeding setae of the two species. As a result of this it was found that the setae of the woolly aphis are approximately one-third longer than are those of the green apple aphis **(Aphis mali.)** Comparison with the setae of **E. americana,** the leaf form from elm, showed the same condition to exist. From these observations it would appear that the formation of twig galls may be partly due to the fact that the woolly aphis is able to penetrate through the cambium and reach the xylem or wood beyond. The data supporting these points is based upon measurements of the feeding setae of numerous individuals. Microscopical preparations of wood sections made with the microtome, and stained with Flemming's triple stain, have clearly demonstrated the path followed by the setae, and also that the cambium is the point at which feeding takes place. Cases have also been noted where setae paths occurred in the xylem or wood by way of the medullary rays. The question of gall formation is of great interest, and the foregoing points are offered as being suggestive and of possible value in connection with our work on the transmission of perennial canker.

The cause underlying gall formation by various insects has been the subject of critical enquiry by several workers. B. W. Wells, in the American Journal of Botany, Volume 7, 1920, in a careful examination of data on the subject, mentions that Rosen's contention that continuous sucking at one point for a period of 15 days is the initial cause of gall formation, cannot be conceded in view of the fact that numerous

hemipterous insects produce no galling, although they may remain fixed at one point for long period, as is the case with scale insects, and many aphids. Wells' summary of the findings of Prillieux, Rosen, Petri and others goes to show that a true interpretation of the nature of gall formation is lacking, and that the statement that some specific stimulus is injected by the insect into the plants has not been proved, although, as he remarks, the very minute quantity injected would make its detection difficult.

The galls produced by the woolly aphis on the roots of apple are of a different character to those found on the aerial portions of the tree, being more globular in outline and often occurring in clusters.

Natural Enemies

The caged tree at Vernon has been an excellent demonstration of the part played by the various insect enemies of the woolly aphis, the cage serving to shut off these natural enemies and allowing the infestation to develop unchecked.

This tree was about eight feet in height, and was, at the time of caging, carefully examined for signs of infestation. No aphids were found either upon the limbs or trunk, and the tree was considered "clean." The cage was constructed of heavy cotton, and was apparently insect proof.

Two weeks after caging, a small colony of the wolly aphis of the apple, consisting of eight or ten individuals, was found to have developed in a knot hole near the ground, and the presence of this colony rendered artificial infestation unnecessary.

By the month of July this colony had developed to such an extent that the whole of the young wood and older twigs were coated with masses of wool, and by August the whole tree was very heavily infested.

In our experience, syrphid flies are one of the main factors in the control of the woolly aphis under natural conditions. Syrphids became very numerous during August and September, by which time the woolly aphis reaches its maximum in the interior of British Columbia.

We have succeeded in rearing three species of syrphids which appear to be of importance in controlling the woolly aphis, one of these being new to science, namely, **Syrphus venablesi** Curran, **Syrphus opinator** O. S., and **Syrphus meadii** Jones. From our observations, these three species occur in numbers and are of major importance.

Lacewing larvae appear to prefer to feed upon the green aphis on the twigs, and find the woolly colonies difficult to deal with, although

scattered migrating individuals are picked up. It is interesting to note that syrphid eggs are generally laid in close proximity to colonies of woolly aphids, and are frequently buried beneath the wool before they hatch, owing to the increase in the size of the colony subsequent to the laying of the eggs, whereas the lace wing flies lay their eggs on the leaves infested with the green aphis and are seldom found deposited near colonies of woolly aphids.

Coccinellids, or lady-bird beetles, are apparently more at home feeding on green aphids owing to the difficulty of dealing with the woolly masses, but they undoubtedly pick up many exposed individuals which are wandering about on the limbs.

We have discovered no sign of any hymenopterous parasites attacking the woolly aphis of the apple in the Okanagan. In eastern Canada and the United States one of the most important checks is exercised by a minute Chalcid fly, **Aphelinus mali** DeGeer, which develops within the bodies of the insects and produces several generations in a season. We have, during the past season, for various reasons, brought in colonies of aphids from eastern Canada and have found the **Aphelinus** to be quite numerous amongst them. The advisability of importing this parasite is being considered.

In New Zealand and Australia the woolly aphis of the apple is a pest of a very serious nature and the governments of those countries have, through their entomological officers, imported the **Aphelinus** with most remarkable success. An interesting point regarding this parasite in New Zealand is the fact that it existed in the islands prior to its introduction from America, but was attacking aphids other than the woolly aphis. The imported parasites, however, at once commenced to destroy this aphis and are doing excellent work.

The foregoing remarks are offered merely as the outcome of a season's work, and much remains to be done to develop certain phases of the problem.