together." Evidently eggs are "deposited chiefly in the stems, less seldom in the midribs, and occasionally in the leaves." (3.) On mullein—"eggs being inserted in the petiole or leaf-stem and in the midrib."

From these notes it would appear that oviposition in the early spring takes place in volunteer plants, weeds, and developing fruit. Yet a further reference is found in the *Journal of Economic Entomology* for 1913 by Professor Haseman, of Missouri. He believed that the bug "does not deposit its eggs in the tissues of plants, as some maintain, not even in the soft stems of weeds." He claims that the ovipositor is not strong enough to drill into the tissues of plants. In Missouri, he claims, the bug "deposits its eggs in the fall of the year at least, only in the blossoms of flowers such as daisies, asters, and particularly 'mare's-tail' (*Erigeron canadensis*)." Professor Haseman has further determined that the life-cycle may be completed in about a month.

We may judge, therefore, that, although this insect is among the commonest in our entomological fauna, there still remains a doubt as to its oviposition period. There seems little doubt that eggs are laid, as stated and observed, in the fall and in the spring, and for the most part in weeds. While the actual points of oviposition remain in doubt, yet it would seem that weeds act as the host-plants in the fall and in the spring; consequently the net value of these records to the farmer and fruit-grower remains the same. Destroy weeds.

In the spring, in due course, the eggs hatch to nymphs or immature stages of the bug. Probably four or five moults are undergone before the mature adult is formed. The adult, of course, sucks its food, and it possesses a long beak fully one-third the length of its body, which is folded beneath it when not in use. The adults are very active, darting off immediately they are disturbed. The only hope of capturing them is in the very early morning in spring, when they are partially dormant. They may then be shaken off the plants.

As Mr. Brittain noted last year, the chief injury at present is in the effect of the attack on the terminal shoots, and especially noted in nurseries. Peaches, pears, and apples are attacked, and no doubt also a variety of other plants, by the bugs, which suck the juices from the buds, causing a cessation of growth, followed by a twiggy formation or by a complete check. It may be noticed that there is a certain difference in the growth of the various varieties of fruit-tree growing under like conditions. Pear-trees develop most rapidly in midsummer; apples a little later. Furthermore, conditions of growth vary in accordance with climatic arrangements for the year, and induced growth at periodic intervals may be forced under artificial or irrigated conditions. All such conditions have an important place in our orchards, when it is realized that a succulent condition of growth is a determining factor in reference to the spread of fire-blight in certain varieties by such insects as the tarnished plant-bug. Given a succulent growth, the presence of *L. pratensis*, and the blight organism, it will be noted that the attack will be more severe than on a growth hardening up or previous to sap activity with the same two agents present.

For control measures may be recommended the destruction of all weeds and the cleaning-up of fence corners in the orchard. The trapping by sticky shield or by beating in the early morning and the application of kerosene emulsion in dilute form to the leaves at the time when nymphs are present. Sprays of dilute nicotine extracts may also be used, applications in this form being applied about every ten days, especially under greenhouse conditions.

THE PART PLAYED BY INSECTS IN THE SPREAD OF PLANT-DISEASES.

By J. W. Eastham, Provincial Plant Pathologist, Vernon, B.C.

Plant-diseases are of two kinds. In the first place, we have the so-called physiological or non-parasitic ones, which are due to some irregularity or disturbance in the processes going on in the plant and induced by external conditions, such as deficiency or excess of certain chemical substances in the soil, too much water,

rapid change of temperature, etc. On the other hand, we have diseases directly due to a parasitic organism obtaining an entrance into the tissues of the plant, and growing there, bringing about malformation or death of the attacked parts. Obviously, insects can only be concerned in the spread of diseases of this type when an organism or "germ" can be conveyed from one plant to another. Disease-producing organism are of two kinds, fungi and bacteria. While both of these are for the most part microscopic, they are nevertheless very different in their relative size. A fungus often forms a "body" or mycelium of considerable extent, while bacteria are always exceedingly minute, and their destructive action depends upon their rapid multiplication, large masses of individuals being soon formed.

Fungous diseases are not usually directly spread by insects, although the spores may be carried about and distributed to some extent by their agency. Usually a parasitic fungus produces quantities of spores which are most effectively distributed by wind and rain. To produce infection, however, these spores must have sufficient moisture to enable them to germinate, and the germ-tube so produced has either to dissolve its way through a very resistant membrane, the cuticle of a plant, or to grow along until it finds some natural opening like a stoma or a place where the cuticle has been broken. It is in this latter respect that insects may greatly favour infection. It is probable that the flea-beetle in this way aids the spread of the early blight of the potato and tomato due to *Macrosporium solani*. Perhaps the best instance, however, is the spread of the brown-rot (*Sclerotinia fructigena*) in plum and peach orchards in the East through the agency of the plum-curculio (*Conotrachelus nenuphar*). The punctures made by this insect result in an exudation of gum which affords an excellent situation for the development of the spores of the fungus, which, moreover, are often carried and introduced into the wounds by the insects. The control of the plum-curculio has hence been found to be essential in the control of brown-rot in the East.

In the case of bacteria we find that these organisms have usually no power of penetrating the cuticle of a plant. They are for the most part dependent for an entrance on natural openings or injuries, except when the tissues are exceedingly delicate and without cuticle, as in the nectaries of flowers, root-hairs, and perhaps the young growing tips of shoots. They also do not produce externally anything corresponding to the spores of a fungus, but live internally in the host-plant. Hence the role of insects as agents in the distribution of such disease is much more important.

A very good example is the wilt disease of Curcubita, which attacks cucumbers, muskmelons, pumpkins, or squashes. This is caused by *Bacillus tracheiphilus*, which develops in the sap-vessels of infected plants to such an extent that the vessels are completely plugged up for long distances. Later the walls of the vessels are destroyed and the conducting system broken down. As a consequence the whole of the plant above the infected vessels wilts and dies. So far as is known, natural infection can only take place through insects feeding on an infected plant, getting their mouth-parts smeared with bacteria and then biting into a healthy plant. The two insects mostly held responsible are the striped cucumber-beetles, *Diabrotica vittata* and *D. 12-punctata*. The chief gap in our knowledge of the life-history of the disease is with regard to the way in which the organism passes the winter. Probably the remains of attacked plants in some cases retain bacteria in a living condition over the winter, and the first infections of the season may be, so to speak, more or less accidental. I do not know that either this disease or its insect carriers are found in this Province, but the disease is known in Nebraska and Colorado, and the insects, I believe, have been found in Washington, so it is quite likely we shall ultimately have to deal with this disease.

A disease which comes nearer home to most of us, and in the distribution of which insects play an exceedingly important part, is the fire-blight of apple, pear, and quince. So far as we know, the first infections of the season are always produced by insect infection of the blossoms. The exudate from hold-over cankers

serves to contaminate the insects which come to feed on it, and if such an insect visits a blossom within a short time after, the honey-glands of the latter are likely to become infected. The nature of the insects visiting these running cankers affords scope for much further observation. Probably many kinds of flies may serve to carry the disease. Wasps have also been rather frequently recorded as visiting the cankers, but I am not sure that these insects are very common visitors of orchard blossoms. Chiefly on the strength of the observations of M. B. Waite, of the United States Department of Agriculture, the honey-bee has been put down as a carrier of the first infection, but I have been able to find very few other trustworthy observations of honey-bees visiting the cankers. We also know that many moths are strongly attracted by sticky, sweet substances, and that the "sugaring" method is a common one with entomologists for collecting night-flying Lepidoptera, and I think it is quite possible that these insects may play a part in disseminating fire-blight. There are, of course, rather grave practical difficulties in the way of securing proper data on these points. In the first place, it would be necessary to have running cankers under observation, both night and day, for some time. Such cankers would also have to be freely exposed, and in a region where fire-blight offers such difficulties in the way of its control an experiment of this kind would not be likely to be viewed with much favour by neighbouring orchardists. We should be very glad, however, to receive specimens of any insects which may happen to be found on running cankers about blossoming-time.

A question sometimes asked is whether the blight bacillus can live through the winter season in the hive or nest of the bee. If so, it is conceivable that bees might become contaminated with the germs and carry the infection to the flowers during their honey-collecting trips in the spring. So far as the honey is concerned, there would seem to be very little danger. Nectar, it is true, affords a medium suitable to the rapid multiplication of the blight bacillus, but the nectar of a flower is different in composition from the stored honey. Such examinations as have been made of comb-honey have shown it to be almost uniformly sterile.

It is at the same time worthy of note that germs of a rather remarkable nature can be isolated from the intestine of the honey-bee. Dr. Franklin White states that he has thus isolated the colon bacillus and that of hog-cholera. Whether the fire-blight bacillus could exist for any length of time in the intestinal tract of the bee or not, I do not know for certain, and I do not know of any work on this phase of the subject. I should think, however, it would be very unlikely. In the first place, the germ is not a spore-former, and has therefore only very limited powers of resistance to unfavourable conditions; and, secondly, being adapted for plant-parasitism, the conditions of temperature, oxygen supply, etc., in the intestines would probably be very unsuitable. The same objections would probably apply in a less degree to the possibility of the germs wintering over elsewhere in the hive.

Once the disease has been introduced into the first blossoms, there is no doubt that subsequent blossom-infection results from bees visiting such infected blossoms, becoming smeared with the germs and then leaving them behind in the healthy flowers visited. The number of flowers which may be infected in this way after one visit to an infected flower is probably very large, although I have no data. Surprise is often expressed that so many blossoms on a tree should show the blight almost simultaneously. Considering, however, the method by which it is spread, a very few contaminated insects would be sufficient to explain this.

It is sometimes stated that blossoms may show the effect of blight before they have opened. In this connection it is to be noted that there is liability of confusion between the effects of blight and of certain insects—e.g., tarnished plant-bug. On the other hand, it is quite possible that some small insects may visit cankers and afterwards creep into unopened blossom-buds. More observation is required in this connection.

A question of practical importance is whether there is any relation between the number of bees kept and the prevalence of blight. In some parts of the

Okanagan the part played by bees in distributing the disease has so seized upon the minds of the growers that any person setting up an apiary is regarded with considerable disfavour by the rest of the community. Now, I do not know that any one has ever noticed a correlation between the number of bees kept and the prevalence of blight. From what has been previously said, it will also be seen that a very few bees may be as effective in spreading the disease as a large number. However, if many bees are kept and there is a scarcity of flowers in early spring, it is possible they might be more attracted to running cankers and thus produce more primary blossom-infection. On the other hand, proper setting of the fruit is largely dependent on bees, and in the districts mentioned there are some indications of defective pollination. On the whole, it would be much better policy to make every possible effort to clean out hold-over cankers rather than place bee-keeping under a ban, as in any case it will not be possible to control or exterminate wild bees.

In the spread of the disease later in the season several insects are implicated, the tarnished plant-bug, aphides, and leaf-hoppers being probably the worst offenders in this part of the country. In Ontario the bark beetle (*Scolytus rugulosus*) has been shown to be a very potent agent in disseminating fire-blight in the pear. If a pear-tree is suffering from attacks of both blight and bark-beetles, there is great danger of the beetles leaving such a tree and boring into healthy adjacent trees, and thus communicating blight, which is often "body-blight" and rapidly fatal to the tree.

D. H. Jones records a case where a pear-tree infected with body-blight was cut down but not removed. The beetles migrated from this tree into two rows of young pear-trees adjoining, with the result that 60 per cent. of these became attacked, a beetle being found in every blight area. This beetle has not, I believe, been yet discovered in British Columbia, but beetles of similar habits occur and such infections may be considered possible.

The extent of the danger resulting from leaving the blight-cuttings under the tree instead of at once removing and burning them is a matter of practical importance. While the danger may not usually be great, it may become considerable under certain conditions. I have seen fresh cuttings of blight-infected twigs lying on the ground and swarms of ants running over and amongst them and then up the trees. Aphides were present on the twigs of the trees, and ants are very prone to mingle with aphides on account of the honey-dew they excrete. If fresh exudate had been present on the blight-cutting, we should have had all conditions present for reinfection of the trees. At the time the weather was hot and dry and moist exudate was not observed, thus reducing the chances of infection under the circumstances to a minimum.