New York Agricultural Experiment Station.

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THE CABBAGE MAGGOT AND ITS WORK.

SUMMARIZED BY
F. H. HALL
FROM BULLETIN BY
W. J. SCHOENE.

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Address all correspondence, not to individual members of the staff, but to the
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them.

*Absent on leave. †Connected with Grape Culture Investigations.
More than eighty years ago the cabbage maggot was described in Europe as a pest of cruciferous crops. It has been known in America nearly as long, but undoubtedly came from England or the Continent some time before, possibly as larvæ in turnips brought over for food on shipboard, but much more likely in the pupal form in sand used for ballast, which had been taken from places where cabbages, mustard or cruciferous weeds had grown.

In all northern latitudes where cabbage thrives, the maggot is one of the most serious pests of this crop and its relatives, cauliflower, radish, turnip, etc.; but it does little harm south of 45 degrees latitude in North America or 40 degrees in Europe. During certain seasons it is very destructive, while at other times it becomes so reduced in numbers by weather conditions and the work of its natural enemies that the damage it does is hardly noticeable.

As a cabbage pest in America, the insect affects the early crop in the field and the late crop in the seed bed. The mature insects, which are flies, feed on the nectar of flowers, the sweet exudations of plants or the juices of over-ripe fruit, but do no particular harm by their feeding. The eggs are laid, usually below ground, where the young larvæ can feed on those parts of the plants that lack the green coloring matter, or chlorophyll. Not many true maggots feed on living tissue, but those of this species rasp and tunnel and burrow in the roots and underground parts of the stems of cabbage, cauliflower, radishes, mustard and mustard-like weeds, so that the plants are stunted, deformed and killed. Another closely allied species works on the onion.

The work of this insect on cabbage plants in the seed bed was described in detail in Bulletins 301 and 334 of this Station, with experiments that proved screening the beds the best and most
economical method of preventing damage; and in Bulletin No. 382 the use of tar-paper pads was recommended, after very successful experimental trials, for the prevention of injury to early cabbage in the field. A future publication will discuss the work and control of the insect on radishes.

The present bulletin deals principally with points in the life history of the maggot, previously obscure or in dispute, to which study has been given for from three to five or more seasons.

Life history in brief.

The insect passes the winter in the pupal stage, mainly if not exclusively; the pupae change in the spring to flies, which begin to emerge about the time Windsor cherries blossom and may continue to appear for three or four weeks. They deposit eggs very promptly, and these hatch in from three to five days. The larvae feed about three weeks under ordinary conditions and then change to pupae, in which form they remain about two weeks, normally, after which the flies again appear. This succession is repeated once or twice during the season, occasionally more, so that the insect is usually three-brooded, but may be two-brooded, or, under very unfavorable conditions, one-brooded, while with exceptionally favorable weather, a partial fourth brood may be produced. Of course the pupae of the fall brood live longer than the normal two weeks, since they hibernate; and occasionally pupae of the earlier broods may undergo the same experience.

The egg and egg-laying.

The egg is about one twenty-fifth of an inch long and one-third as thick, is glistening white in color, but marked with irregular longitudinal furrows. It is usually placed just below the surface of the ground on the roots of cruciferous plants, the choice of location being apparently determined more by the succulence of the tissue than by the variety of plant. The female examines various locations with the tip of the extended ovipositor, and, under observation, none has ever deposited more than one egg in a place; but the presence of eggs in clusters indicates that frequently many more than one are laid at a time. How many eggs each female lays cannot be stated definitely, since none of the large number of caged females oviposited, though given apparently favorable conditions for doing so. It is probable, however, as inferred from the eggs present in dissected females, from the apparent condition of the ovaries, and from comparisons with other flies, that each female may lay from 50 to 200 eggs.

The eggs hatch normally in about three and a half days, but the time may be hastened half a day by favorable conditions or retarded even more by unfavorable ones. In experimental tests increase in temperature up to about 80° hastened development, but no eggs hatched when the temperature was 105° or 62 3/4°, nor when the eggs were kept in dry sand or exposed to light and air.
Plate I.—Injurious Work of Cabbage Maggot.
1, Different degrees of root injury; 2, damages to seed bed.
The larvae are whitish maggots, slightly larger than the eggs on emergence, and increasing in size through three stages until they are from one-tenth to three-tenths of an inch long and from one twenty-fifth to one-twelfth of an inch in diameter, roughly cylindrical in form, tapering slightly toward the head. The later stages are marked by tubercles on various parts of the body, whose arrangement and form serve to identify the insect in the larval stage, since it differs from the larvae of other flies only in such small points. The variation in size of the last-stage larvae and the resulting pupae is due to the fact that stress of circumstances, such as scarcity of food or unfavorable weather, causes the larvae to pupate when only one-third to one-half the size they might attain.

When changing to this quiescent stage, the pupa form, the skin of the larva hardens and contracts, forming a shell-like case, the whole looking much like some kind of a seed with irregular protuberances where the tubercles of the larva were. Within this puparium the pupa changes to the adult form. In this stage the greatest variation in length of the period of development occurs. Aside from the hibernation of the pupæ of the last brood, and probably of occasional individuals of earlier broods, which prolongs the pupal life for months, the normal two-week period may be varied to quite an extent by weather conditions. In tests on large numbers of pupæ kept where moisture and temperature could be varied within quite definite limits it was found that ordinary differences in the soil moisture, though quite wide, do not alter the length of the pupal period after development has begun; but that a marked deficiency of moisture, such as would cause a noticeable shrinkage of the insect within the puparium, would retard its development. High temperature, such as often occurs during the summer months in western New York, is unfavorable to normal growth of the pupa, as well as injurious to the larva, and seems to cause a retardation in development which may last until low temperature returns. It is undoubtedly this factor that does most to decrease the number of broods in certain seasons.

While these wide variations in heat and moisture have a general effect upon the pupæ, there seems to be a decided difference between individuals, so that a few pupæ when subjected to high temperatures mature more quickly than under normal conditions, while others, as indicated, "aestivate," or become dormant through some of the summer months, just as others hibernate through the winter months. It would seem that Nature insures the survival of enough individuals to continue the species, no matter how severe the weather conditions may be.

The pupæ are usually to be found from two to three inches below the surface of the soil, and within about the same distance or perhaps a little more from the roots of the plants on which they have been
feeding. They may occasionally be found in small numbers in hiding places upon the stumps of the cabbage left in the field after the heads have been removed, as the succulent buds and sprouts arising from such stumps appear to be a favorite feeding place for larvae of the late fall brood. Removal and destruction of such cabbage refuse, and reduction of the number of mustard-like weeds in cabbage-growing districts will undoubtedly aid materially in reducing the numbers of the pest.

Adult. Though the pupae usually lie only a short distance below the surface of the soil, the adults can penetrate many inches of earth. In plowing tests, turning the soil either six or nine inches deep did not interfere seriously with the emergence of the flies, either by reducing their numbers or greatly delaying the time of appearance. In pots, larger percentages of flies emerged when the pupae were buried 10 or 12 inches in lightly compacted clay loam than when covered with only 2 or 4 inches of the soil.

The male fly is dark in color, with gray markings, thickly covered with fine hairs or bristles. The position of the tufts of bristles is an identification mark for the species. The female is lighter in color than the male, less bristly, as a whole, and lacking the particular tuft of bristles on one of the pairs of legs which serves to identify the male.

Enemies. Hot, dry weather in late summer and early fall is, without doubt, the greatest factor in diminishing the numbers of the cabbage maggot; but certain insects play a very prominent part in checking it. Among these are small beetles of the genus Aleochara, of which the immature forms of at least one species are probably parasitic in the larvae, while the mature beetles feed upon that and other stages. The life history of other beetles of this group is not well known, but several species of them were either bred from cabbage-maggot larvae or found in such close connection with the pest in some of its stages as to justify the conclusion that they attack it. In England twenty-five per cent. of the pupae of the cabbage maggot examined by one investigator were found to be infested by beetles of this group.

Another enemy of the maggots is a minute wasp-like insect which lays its eggs on or in the host, so that the young of the parasite feeds upon and destroys the pupae. On a screened cabbage-bed near Geneva, nearly one-fourth as many adults of this parasite were collected as of the maggot flies.

A mite also attacks the eggs and has been known to destroy large numbers of them; in one instance three of the mites destroyed twenty-eight eggs of the maggot fly in a single day. This mite is numerous in the cabbage fields about Geneva, and while exact data regarding its work were not secured, it must have been very active as an egg-destroyer, since as many as 200 maggot-fly eggs a day were known
to have been deposited about the cabbage plants; yet this mite and other enemies of the insect so reduced the numbers that very little injury was done to the cabbages.

To control the cabbage maggot about early cabbage the most effective means tested has been the use of small hexagonal pads or collars of single-ply tarpaper. These are cut with a slit from the edge to the center and shorter slits about the center so that they can be placed about the plants shortly after they are set, fitted about the stem, and pressed close to the ground. The flies then cannot reach the roots by crawling down the stem or along the surface of the soil. These pads can either be purchased at a small price, or made at home by cutting from the roll of tar paper with a simple tool. Applying them is a simple, rapid and inexpensive process, and the protection afforded is so good that the use of the pads is very profitable in seasons when the maggots are abundant. Injection of carbolic-acid emulsion about the roots of the plants has often been recommended, but in tests made at the Station the emulsion in strength great enough to destroy the maggots was also injurious to the cabbage plants.

For many years in certain cabbage-growing sections of New York it has been almost impossible to secure, in open seed beds of reasonable size, enough plants to set the cabbage fields planned; while purchase and shipment of the plants from outside the State is expensive. In early tests by private growers, screening the beds with cheesecloth did not prove very effective; since it was not then realized how carefully the protection must be arranged to exclude the insects.

Station tests, however, proved that a well-adjusted screen would not only exclude the maggot flies, but also shut out the flea beetles that are nearly as injurious, and would give larger, earlier and better plants through the effect of the screening on moisture and other conditions in the bed.

The practice is now very general over large parts of the cabbage-growing areas of the State and there regarded as indispensable. The cost is less than the amount spent for extra seed under the old conditions and the protection can easily be made perfect. Level soil should be selected for the beds, as free as possible from weeds and free from cabbage diseases. It should be thoroughly prepared and well fertilized before laying out the bed and putting up the screening, since further cultivation is not possible. Boards six, eight or ten inches wide may be used, united by tight joints at the ends and pressed firmly upon or into the soil so that no insects may enter at the ends or below the boards. Any low spots in the ground beneath the boards should be filled and the dirt banked slightly along the bottom of them.

Cheesecloth of 20 to 30 threads to the inch is stretched tightly over the bed, before the plants appear and attached to the boards
so no insects can enter along the edges. If the bed is large the cloth must be kept from sagging, which is best done by galvanized iron wires 4 or 5 feet apart lengthwise the bed supported by flat-topped stakes to which the wires are attached by staples, galvanized to lessen danger of rusting. The cheesecloth should be removed ten days or so before the plants are to be set, so that they may harden. If examination of the earth about the plants shows that eggs of the maggot flies are being laid, the plants should be set at once, shaking off the eggs with the soil.