THE INTRODUCTION AND PROPAGATION OF DIGONICHAETA SETIPENNIS FALL., A PARASITE OF THE EUROPEAN EARWIG.

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Biological control is one of the newer tools of the economic entomologist for use in combating insect pests. Several outstanding instances of its successful application for the control of important economic insects are well known. This paper deals with the control of the European earwig (**Forficula auricularia** L.) by the use of the parasitic fly (**Digonichaeta setipennis** Fall.)

The Earwig

The European earwig was accidentally introduced into Washington and Oregon about 1909 and within a few years had gained a foothold in Seattle, Washington and Portland, Oregon. Various types of poisoned baits, traps, and other means of extermination have been devised and hundreds of thousands of dollars spent in attempting to eradicate or even control the earwig through compulsory and voluntary baiting and other means. The Bureau of Entomology and Plant Quarantine of the United States Department of Agriculture has developed a poisoned bait that gives better results than any previously used and will effectively reduce the earwig population in the baited area for any given season.

But, even with the methods of control at hand, the earwig has continued to spread from the original areas infested and now it may be found not only in the city but in the country and it is even infesting the woods. It is now gaining a foothold in eastern Oregon, eastern Washington and in western Idaho, and has recently been reported in Denver, Colorado.

The depredations of the earwig are far-reaching and affect small home flower and vegetable gardens as well as the large commercial plantings. Because of its nocturnal habits and ability to conceal itself so well during the day, its existence is often unknown and something else is blamed for the damage it does.

Earwigs not only destroy plants but destroy their usefulness. The beauty and charm of a flower or the delicacy of a fresh vegetable often have to vie with the repulsiveness of the earwigs they harbor. Cut flowers and earwigs have come to be associated to such an extent that the sale of flowers has fallen off. These losses are indirect and to check such infestations by baiting would be difficult.

All these factors make imperative some means of control that is not dependent upon regular concerted human attention. Biological control fulfills this need. Once an insect parasite is successfully established, it takes its toll of the host unceasingly, without effort on the part of man, and almost unnoticed.

Although parasites had previously been introduced into Oregon, it was not until the fall of 1931 that parasites were received at the Federal Laboratory at Puyallup, Washington. During the fall of 1931 about 121,000 earwigs were collected in Italy, England and France by agents of the Division of Foreign Parasite Introduction having headquarters at its laboratory in France, and shipped to Puyallup, Washington. From this importation of earwigs, about 2,800 specimens of the more important parasite, **Digonichaeta setipennis,** were obtained. These served as a start for the propagation of the parasite at the laboratory. Losses at first were heavy and parasitisation under artificial conditions slow, but as the needs and habits of the fly became better understood and better technique was worked out, production increased rapidly.

Method of Parasitization

Briefly, the method of parasitization now used is as follows: The parasites overwinter as puparia, brown in color and much like a grain of wheat in size and shape. Early in May the flies, mostly males at first, start emerging from these puparia and are put into mating cages for a few days. After mating, the females are transferred to oviposition cages for two or three weeks while they develop their eggs, after which they become quite active and anxious to find earwigs. They are then given proper light and heat and eggs are obtained by inserting into the cage with them a small cloth-covered wood block or cage containing a few live earwigs. The flies detect the presence of their host by odor and at once start ovipositing on the cloth above the earwigs. Each egg contains a fully developed larva or maggot about one-sixty-fourth of an inch in length inclosed in a thin skin or chorion which splits within a few seconds after being laid and releases the larva. This maggot has no eyes and locates its host by odor, alternately standing on its tail and waving its head about in an effort to pick up the odor, then dropping down and crawling for a short distance. When it detects the presence of the earwig its actions become more rapid.

When the cloth block contains a number of eggs and larvae, it is removed from the cage and earwigs whose activity has been reduced by ether are then individually hand-parasitized by picking each earwig up with a pair of forceps and holding it within reach of the active larva. The larva immediately clings to the earwig and crawls very rapidly until it comes to the soft membrane at the base of the legs or wings, about the

neck, or even between the segments of the abdomen, where it starts burrowing in at once. About 2,000 earwigs per person per day can be parasitized in this manner. If a greater number of parasitized earwigs is desired, at a sacrifice of the assurance that each earwig will have one parasite, then the number of larvae on the block is estimated and about the same number of anaesthetized earwigs spread over the larvae, covered with a glass dish and shaken lightly to aid distribution. By this method, twelve to fifteen thousand earwigs may be parasitized per day.

By the time the earwigs have recovered from the anaesthetic (ether) the parasites have usually completed their entrance. They do not go entirely in at this time, but stop with the hind end protruding slightly, leaving their spiracles exposed to the air. In the early stages the parasites feed only on the body fluid of their hosts, consequently the earwigs eat and digest their food in a normal manner. When almost full grown, the larvae detach themselves and float free inside the earwigs while feeding for a short time on the internal organs, then emerge as white maggots about one-fourth inch in length. They then burrow a short distance into the soil to shorten and harden into puparia, thus completing the life cycle. The earwigs live for only a few days after the maggots come out, and eat no food. Parasitized female earwigs never produce eggs.

Habits of the Fly

In the laboratory 15 percent of these first-generation puparia emerge in July and August as second-generation flies and about 5 percent of the puparia from these flies produce a third generation. Each fly lays from 300 to 500 eggs. The potential increase of the fly in a year is about 400 times as great as that of the earwig. That is, 10 female earwigs are capable of producing 600 offspring in a year while 10 female flies can produce about 242,000 in a year.

From what is known of the habits of the fly and of others in the same family of parasitic flies it is very unlikely that it will ever become troublesome in the house, even when it becomes abundant in nature. The adult fly feeds sparingly upon the nectar of certain flowers and is not attracted to cooking or other domestic odors.

In nature the adult females, when ready to lay, seek the haunts of the host and lay their eggs as close as possible to the hiding place of the earwigs so that the little maggots can get to them or will find them as they come out at night for food. The flies may be seen late in the afternoon running about over the bark of a tree, sticking their heads into every small crevice, or crawling into larger ones and dropping an egg or two where ever they pick up the earwig scent. The larvae, after hatching, can live for about 36 hours without the host.

Liberations

In the spring of 1934, about one-third of the puparia which had been reared the year before and overwintered at the laboratory were sent to the State of California to be propagated there. From the remainder, about 29,000 earwigs were hand parasitized from first generation flies and about 53,000 from the second-generation during the summer. From this stock, two experimental colonies of parasitized earwigs were liberated in the fall and a colony of puparia in the winter. In 1935, about 80,000 earwigs were parasitized from first-generation flies and 15,000 from the second generation. Fourteen additional liberations were made, all consisting of mated females that had been held at the laboratory until ready to oviposit. The parasites have now been liberated at Bellingham, Everett, Vashon Island, Puyallup, the laboratory, Roy, Castle Rock, Kalama, Amboy, Cathlamet, Naselle, South Bend, Hoquiam, Yakima, Walla Walla, and Pullman, Washington and Moscow, Idaho. These experimental colonies are for the purpose of determining the ability of the parasite to become established, its rate of distribution, and its effect upon the earwig.

Recoveries

In order to determine the presence of the parasite in the field, earwig hiding blocks or traps are put out at each colony at the point of liberation and at various points surrounding it. Each earwig trap has a parasite trap attached to the lower end to catch larvae as they issue from the earwigs and drop down to pupate. The presence of puparia then, in a trap indicates that the parasites have spread to that place. If percentage of parasitization is desired, the earwigs are collected from the traps and kept at the laboratory until their parasites have issued.

At this writing (November, 1935) either collections of earwigs or examinations of traps, or both, have been made at 9 colonies and parasites have been recovered from 6: Puyallup, the laboratory, Vashon Island, Roy, Everett, and Yakima. Seven puparia were found at one time in a trap on Vashon Island that had only 23 earwigs in it at the time of examination and six in a trap at Puyallup with 45 earwigs in it. In Puyallup the parasites were found to have spread at least two blocks to the north, within a year after liberation.

Conclusion

When parasites are transported from their native home into a new environment, reared and liberated in lesser numbers than occur in nature, they have many adverse factors with which to contend and it is

usually several years before they have become sufficiently abundant to be found. Often they are not recovered for many years and frequently they do not take hold at all. In view of this it is very gratifying that so many recoveries have been made of this earwig parasite within a year from the time of its liberation. Its successful establishment seems certain.

Summary

The European earwig (**Forficula auricularia** L.) has become an important economic pest and because of its wide distribution and large list of food plants, it is difficult to control by artificial means. Biological control is the logical means to hold this pest in check. **Digonichaeta setipennis** Fall., a parasite of the earwig in Europe, was imported in the fall of 1931 and from this stock, rearing methods as described have been worked out and large numbers propagated. Experimental liberations have been made and the parasite has been recovered within a year afterward. The results are encouraging for this parasite.