LABORATORY STUDIES ON TETRASTICHUS XANTHOMELAENAE ROND. AND TETRASTICHUS SP., TWO HYMENOPTEROUS EGG PARASITES OF THE ELM LEAF BEETLE

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INTRODUCTION

Several attempts have been made to establish Tetrastichus xanthomelaenae Rond., an important egg parasite of the elm leaf beetle (Galerucella xanthomelaena (Schr.)), in the United States. The first shipments were made from France in 1908, and up to 1932 occasional attempts were made to establish this species in the New England States. In 1932 importations on a larger scale were undertaken, and parasitized eggs were received from both France and Austria. These shipments were made early in the season in order to give the parasites access, upon their liberation in the United States, to the greatest possible number of elm leaf beetle eggs. Emergence of parasites began soon after the parasitized eggs arrived at the Melrose Highlands laboratory.

After many of the parasites had emerged, it was discovered that two species of Tetrastichus were present. One was T. xanthomelaenae and the other an unidentified species. Separation of the living specimens of these two species was difficult and was not considered to be practical in view of the large quantity of material received. It seemed advisable to hold all material in the laboratory until the status of the new species could be determined.

The percentage of Tetrastichus sp. occurring in the imported material has been low. A sample of 600 adults from Oberpullendorf, Austria, contained 29 Tetrastichus sp., or 4.8 percent. In a sample of 500 adults from Hyères, France, there were 17 Tetrastichus sp., or only 3.4 percent.

Apparently Tetrastichus sp. has always been present in much smaller numbers than T. xanthomelaenae. Marchal made a number of observations on T. xanthomelaenae but did not encounter the new species in his work. In another paper, in which he described T. xanthomelaenae, Marchal mentioned another parasite reported as attacking eggs of Galerucella xanthomelaena, but the record of the exact host is questionable and the brief notes on the parasite indicate that it was not Tetrastichus sp.

1 Received for publication June 17, 1938; issued December, 1938.
2 This study was conducted at the Melrose Highlands, Mass., laboratory of the Bureau of Entomology and Plant Quarantine during 1932 and 1935. The writer is indebted to O. W. Collins, in charge of the laboratory previous to 1935, and to R. C. Brown, in charge during 1935, for making these investigations possible, and to P. B. Dowden for helpful advice.

Journal of Agricultural Research, Washington, D. C.

Vol. 57, No. 11
Dec. 1, 1938
Key No. K-297

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Parker 6 figured the egg, the first-instar larva, and the full-grown larva of *Tetrastichus* sp., but he reported it as *T. xanthomelaenae*. This is not surprising, for prior to 1932 only one species was known to attack the eggs of the elm leaf beetle.

EXPERIMENTS ON THE TWO PARASITES WHEN OCCURRING SEPARATELY AND WHEN IN COMPETITION

Experiments were undertaken to determine the status of each species of parasite when occurring separately, the effect that one would have upon the efficiency of the other when they were operating together, and whether either species acted as a secondary parasite upon the other species. For this purpose it was necessary to conduct several series simultaneously. In all the experiments the development was observed through daily dissections of a portion of the exposed material.

In the first series of experiments each species of parasite was reared separately from egg to adult on clusters of elm leaf beetle eggs collected from several localities in Massachusetts, and the life cycles and the principal habits of the two species were studied. *Tetrastichus xanthomelaenae* oviposited freely in the elm leaf beetle eggs, dissections showing that each egg contained from one to four eggs of the parasite. Only one individual, however, developed to maturity in a single host egg; the others succumbed in an early stage of development. The cause of the death of the excess young larvae where superparasitization occurred was not apparent. Adult males and females issued in about equal numbers from all the lots exposed. The average length of the developmental period from the time the eggs were laid until the adults issued was 16.9 days. The average life cycle of *Tetrastichus* sp. was found to be 17.5 days, or about 14 hours longer than that of *T. xanthomelaenae*. In other respects the development was the same in the two species.

In the second series of experiments several masses of elm leaf beetle eggs were exposed to a mixed lot of parasites containing equal numbers of mated females of each species. Dissections of a part of the material showed a high percentage of parasitization and considerable superparasitization. Frequently eggs and larvae of both species of parasites were found in the same host egg. Only one of the larvae developed to maturity, however. Sometimes it was one species and sometimes the other. Out of 200 dissected eggs that contained both species of larvae with only one larva living, there were 85 eggs in which the larvae of *Tetrastichus xanthomelaenae* remained alive and 115 in which the *Tetrastichus* sp. survived. The eggs that were allowed to develop to maturity produced 105 *T. xanthomelaenae* and 93 *Tetrastichus* sp. It is evident, therefore, that the chances of developing to maturity are about equal for the two species when they both attack at the same time.

In the third set of experiments egg masses were exposed first to one species of *Tetrastichus* and then to the other. Several egg masses were exposed to *T. xanthomelaenae* for 4 hours. This material was then divided into 10 lots, which were numbered from 1 to 10. Lot No. 1 was exposed to *Tetrastichus* sp. the day following exposure to

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T. xanthomelaenae, lot No. 2 the second day, and so on until the sixth day, when the parasites refused to oviposit in the parasitized eggs. Dissections of a number of samples showed that oviposition by Tetrastichus sp. in the parasitized eggs decreased after the second day and only a few of those offered on the fifth day were attacked. There were a few cases in which the Tetrastichus sp. survived where from 1 to 2 days intervened between the periods of attack. Where there was an interval of more than 2 days, T. xanthomelaenae survived in all cases observed.

In the experiments in which the order of attack by the parasites was reversed, the results were similar in that the species attacking first survived in much the greater numbers. Neither species, therefore, acted as a secondary parasite on the other.

CHARACTERS FOR SEPARATING THE EARLY STAGES AND ADULTS OF TETRASTICHUS XANTHOMELAENAE AND TETRASTICHUS SP.

Eggs and early-instar larvae of these two species of Tetrastichus may be readily separated, but no distinguishing characters have been found for separating the later instars or the pupae.

**EGG**

The egg of Tetrastichus xanthomelaenae (fig. 1, D) measures 0.23 mm in length and 0.075 mm at its greatest width. It is almost circular in cross section and slightly curved in shape. It is white and has a smooth surface. From the cephalic end, which is bluntly rounded, the egg thickens slightly for a short distance and then gradually tapers to a round caudal end.

The egg of Tetrastichus sp. (fig. 1, B) measures 0.22 mm in length and 0.06 mm at its greatest width. It is almost circular in cross section and slightly curved in shape. It is white and has a smooth, glistening surface. The cephalic end has a protuberance resembling a petiole. From this petiolar region the egg thickens abruptly to its greatest diameter, from which it tapers gradually to a blunt caudal end.
LARVA

The first-instar larva of *Tetrastichus xanthomelaenae* (fig. 1, C), shortly after emerging from the egg, is 0.32 mm in length and 0.09 mm at its greatest width. The head is long and shaped like a thimble, but it is shorter and thicker than the head of *Tetrastichus* sp. There are 3 thoracic and 10 abdominal segments. The last segment is short and has a complete row of caudal hairs or spines, which are heavier than those on the other segments. On the posterior margins of each of the other segments there is a row of spines of about equal length extending across the dorsum and almost to the lateral margins. The young larva is hyaline, the midintestine being visible through the body walls.

The first-instar larva of *Tetrastichus* sp. (fig. 1, A), shortly after emerging from the egg, measures 0.37 mm in length and 0.09 mm at its greatest diameter. It is cylindrical in form, with diameter decreasing towards the posterior extremity. It has a long, thimble-shaped head and 3 thoracic and 10 abdominal segments. The last abdominal segment is terminated by two long, slightly curved hooks placed side by side. All segments except the last have rows of spines completely encircling the larva. The larva is hyaline.

ADULT

The characters for separating the adults of these two species of parasites, as described by B. D. Burks, of the Illinois Natural History Survey, are as follows:

*Tetrastichus xanthomelaenae* (Rond.)—Thorax dark metallic blue-green, abdomen entirely black, with faint metallic luster; pedicel of antenna globose in both sexes; flagellum of the males bearing short setae; none longer than the third funicle segment; submarginal vein of forewing with one dorsal bristle.

*Tetrastichus* sp. “Y”—Thorax shining black, abdomen dark brown and yellow at base; pedicel of antenna slender, elongate, slightly enlarged at apex in both sexes; flagellum of male bearing long setae; those borne by the second funicle segment longer than the entire funicle; submarginal vein of forewing with two dorsal bristles.

LIBERATIONS AND RECOVERIES

Prior to 1932 from 2,000 to 2,500 adults of *Tetrastichus xanthomelaenae* had been liberated at various localities in New England and New Jersey. A large number of these were reared in the laboratory at Melrose Highlands, Mass. From 1932 to 1935, inclusive, 35,234 adults were imported and liberated in the United States, as follows: Massachusetts, 8,445; Connecticut, 4,000; New Hampshire, 600; New York, 1,000; New Jersey, 2,484; District of Columbia, 3,950; Virginia, 2,750; Ohio, 5,000; and California, 7,005.

Several collections of elm leaf beetle eggs in Massachusetts and one in New Jersey have shown that the parasites reproduce in the field the same season in which they are liberated, but none have been recovered the following season. In 1933 collections of 449 egg masses from the sites of the 1932 liberations and in 1934 collections of 689 egg masses from the 1932–33 liberation points failed to produce a single parasite.

7 Private communication.
SUMMARY

In the course of attempts to establish the elm leaf beetle parasite *Tetrastichus xanthomelaenae* Rond. in the United States, another, unidentified, species of *Tetrastichus* was discovered in the imported material. A study of the two species was therefore undertaken in the laboratory to observe their development and parasitic habits, both when each species occurred separately and when the two were in competition. The characters distinguishing the two species were also determined.

The development was found to be similar in the two species, except that the life cycle of *Tetrastichus* sp. was slightly longer than that of *T. xanthomelaenae*. When superparasitism or multiple parasitism occurred, all but one larva in each host egg died in the early instars. Where the host was attacked by both species, the one attacking first had the better chance of surviving. Both species are therefore primary parasites.

The eggs and young larvae of the two parasites have definite characters by which they can be readily separated, but no distinguishing characters were found for the later instars or the pupae.

In all importations the percentages of adult *Tetrastichus* sp. emerging from the beetle eggs were low, never exceeding 5 percent.