ASPARAGUS-BEETLE EGG PARASITE

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INTRODUCTION

On May 23, 1909, a minute chalcidid parasite was reported from Concord, Mass., by Messrs. C. W. Prescott and J. B. Norton, of the Bureau of Plant Industry, where, according to information received from Mr. Prescott, the insect was observed devouring the contents of the eggs of the asparagus beetle (*Crioceris asparagi* L.). Later, on June 2, Dr. H. T. Fernald found the same parasite at Amherst, Mass. The species was referred to the Bureau of Entomology and was determined by Mr. J. C. Crawford, of the United States National Museum, as being new to science, and was accordingly described as *Tetrastichus asparagi* Cwfd. (1).[1] In July of that year and later, in August, Dr. Fernald published short articles on this species. Since the asparagus beetles have never been carefully studied throughout their life history, the fact that the parasite had been recorded was overlooked. In an earlier article, however, published in 1869, Riley and Walsh (6) referred to a notice of the occurrence of a parasitic fly as follows:

> But in the year 1863, as we learn from Isaac Hicks, of Long Island, a deliverer appeared in the form of a small shining black parasitic fly, probably belonging either to the Chalcis or to the Proctotrupes family. Whether this fly lays its eggs in the eggs of the asparagus beetle or in the larva of that insect does not seem to be at present clearly ascertained; but if the accounts that we have received of it be correct it must do either one or the other. In the former case the larva that hatches out from the parasitic egg will consume the egg of the asparagus beetle and entirely prevent it from hatching; in the latter case it will destroy the larva before it has time to pass into the perfect state. The result in either event will be equally destructive to the bug and beneficial to the gardener.

Later, in 1882, Lintner (4) made notes on the same species, referring to the publication in the American Entomologist just quoted. Again in 1893 (5) he called attention to a parasite, stating that it was undescribed and that it might have disappeared before it could receive scientific attention, because nothing seemed to be known of it at that time.

From the descriptions given it seems almost certain that the parasite mentioned by Riley and Walsh and *Tetrastichus asparagi* Cwfd. are the same. If so, it is hard to explain why this insect, which was reported in considerable numbers in 1863, should have escaped further observation until 1909.

[1] Reference is made by number to "Literature cited," p. 312.

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So far as known by the writer, the life history of this parasite had not been studied, and as it appeared in considerable numbers during the season of 1912 near Riverhead, N. Y., where the writer was stationed, a study of its life history and habits was undertaken. During the fall of 1912 Mr. H. M. Russell, of the Bureau of Entomology, also stationed at Riverhead, and the writer published a short article (7) on this parasite, based principally on observations made during that season.

DESCRIPTION OF THE PARASITE

The adult (Pl. XLIX, fig. 1) of *T. asparagi* was described by Mr. Crawford as follows:

THE ADULT

Female.—Length 2 mm. Belongs to the group of *T. hylotomae* Ashm.; dark blue green; face finely reticulate and with scattered punctures; antennæ with one ring joint; joints 1–3 of flagellum almost equal, the first slightly longer and about as long as the pedicel; third flagellar joint hardly longer than wide and about as long as the first joint of club; mesothorax finely longitudinally rugulose, the median furrow failing anteriorly; middle lobe of mesonotum with a single indistinct row of punctures on each side; metathorax roughened, median and lateral carinæ strong; metathorax at median carina much longer than postscutellum; coxæ, trochanters, and femora, except apices, green, the rest of the legs reddish testaceous.

Amherst, Mass., reared from eggs of *Crioceris asparagi* by Dr. H. T. Fernald.

Type.—Cat. No. 12676, U. S. Nat. Mus.

This species is very closely related to *T. hylotomae*, but has shorter antennæ. In the female of *T. hylotomae* the third joint of the flagellum is twice as long as wide, and distinctly longer than the first joint of the club, the first joint of the flagellum is one and one-half times as long as the pedicel; the median furrow of mesonotum is distinct to the anterior margin.

The following descriptions of the egg, larva, and pupa of *Tetrastichus asparagi* are by the author.

THE EGG

The egg (Pl. XLIX, fig. 2) is reniform in shape, with one end more slender than the other, about 0.24 mm. long and 0.08 mm. wide, semitransparent, and is of a milky color, with a granular appearance within. While the eggs may be laid singly, in a number of cases they were found side by side in pairs (Pl. XLIX, fig. 3).

THE LARVA

The mature larva (Pl. XLIX, fig. 4) is from 2 to 2.5 mm. long and about 1 mm. wide. It is white, with the alimentary canal appearing greenish; ovate; widest near the head, which is contracted and bent under the body. The surface is smooth and devoid of hairs. There are no legs, and the larva seems incapable of motion, except to move the end of the abdomen when disturbed.

THE PUPA

The pupa (Pl. XLIX, fig. 5) is from 2 to 2.5 mm. long and from 1 to 1.2 mm. wide. It is yellowish white; convex dorsally, with the head somewhat bent under and inconspicuous wing pads folded along the side (Pl. XLIX, fig. 6). The antennæ and legs are folded under ventrally. The head, thorax, and abdomen are distinctly differentiated from one another; the abdomen tapers posteriorly.

DISTRIBUTION OF THE PARASITE

This insect has been recorded from Amherst and Concord, Mass., by Dr. H. T. Fernald; by Mr. D. E. Fink, of the Bureau of Entomology, from Ithaca, N. Y.; and the writer has observed it in considerable numbers on Long Island. During June and July, 1911, specimens of this insect were liberated at Jessup, Riverdale, and Rives, Md., but at the present time it has not been retaken in these places. In all probability, however, it is present in many localities in the northeastern part of the United States, other than those mentioned.

OCCURRENCE ON LONG ISLAND

On June 10, 1912, the author first observed this parasite at Aquebogue, Long Island, while examining an asparagus field. Large numbers of this insect, together with the asparagus beetle (*Crioceris asparagi*) and its eggs, were found on check rows of asparagus which had been left in the field to attract the beetles from the main crop. At times as many as six or seven parasites were to be seen on a single stalk. These check rows had not been set aside as a trap for the beetles until a short time before, and as a consequence the asparagus was not over a foot high and had not branched out. As a result, the beetle eggs were confined to a limited area, and it was fairly easy to follow the actions of the parasites.

FEEDING OF PARASITES

This insect is an energetic feeder on its host's eggs and is evidently as useful in checking the host in this way as by its parasitic development, if not more so.

When a careful examination of the beetle eggs on stalks of asparagus was made, many were found that had collapsed and withered, and it was quite evident that they would never hatch. On some asparagus stalks the only viable eggs appeared to be those recently deposited. The cause of this collapsed condition of the eggs was soon apparent. A female adult parasite under observation approached an egg, and, after carefully examining it with her antennæ, climbed upon it, inserted her ovipositor, and worked it up and down with a pumping motion. This motion was continued for varying lengths of time, from a few seconds to three or four minutes, after which she withdrew the ovipositor, backed down from the egg, and, applying her mouthparts to the puncture, sucked up the egg contents.

She usually fed from the egg until the shell collapsed. At times it was necessary for her to manipulate the ovipositor in the egg four or five times before the contents were sufficiently loosened to permit their extraction. This feeding of the parasite was so extensive that of 2,097 eggs counted on 28 stalks of asparagus, 1,495, or 71.29 per cent, had been destroyed.

LABORATORY EXPERIMENTS

Several of the adult parasites, captured and confined with the eggs of the asparagus beetle in the laboratory, were noted shortly afterward, ovipositing and feeding on the beetle eggs. A few days later all eggs of *Crioceris asparagi* which had not been eaten by the parasites had hatched. At the time this could not be accounted for, since this insect had previously been considered an egg parasite and many of the eggs which hatched were known to have been subjects of oviposition. None of the young beetle larvæ that hatched from these eggs were carried through to maturity. The cause of their death appeared to be a lack of proper food.

On the first day that the parasites were observed in the field, Mr. Russell collected nearly mature larvæ of the asparagus beetle from volunteer asparagus plants in a field which had been planted to asparagus at some prior date. The larvæ were taken to the laboratory and placed in rearing cages that they might form their cells. A few days later, while the cocoons were being examined, six small whitish larvæ were found in one cocoon. Some of these larvæ at a later date pupated, but died before the adult stage was reached, so there was no certainty that these were the larvæ of *T. asparagi.*

About July 10 the writer collected asparagus-beetle larvæ from a field in which parasites had been previously noted in abundance and, bringing them into the laboratory, supplied them with food and confined them in vials without earth.

Upon examining the vials on July 24 it was seen that five beetles had emerged and in one vial there were three small pupæ. In another vial was a small whitish larva similar to those which Mr. Russell had previously taken from a beetle cell.

The three pupæ were placed in a separate vial, and on July 30 and 31 they emerged as adults, which were later identified by Mr. Crawford as *T. asparagi.*

On June 20 the writer dissected the egg of *T. asparagi* from the asparagus-beetle egg, and the peculiar life history of this parasite was at length established.

For nearly two weeks after the parasites were first observed in the field they were to be found in considerable numbers, after which they suddenly disappeared; by June 24 none could be found. During the latter part of July they again made their appearance in the field but were much harder to locate, since the entire asparagus field by this time had been allowed to grow, and, in consequence, the parasites were scattered over a much larger area than before.

On August 5 the first parasites of a second generation were captured in the field and brought into the laboratory. They were confined in large vials and each day were given a fresh supply of beetle eggs, which were treated as noted before. On hatching, the beetle larvæ were removed to

another vial and supplied daily with fresh food. At maturity they went into the soil in the bottom of the vial, and in due time either adult beetles or the parasites issued from the soil.

METHODS USED FOR REARING THE PARASITES IN CONFINEMENT

The adults of the parasite *T. asparagi* were captured in the field and confined in the laboratory in vials, measuring 100 mm. in length and 28 mm. in diameter. The ends of the vials were covered with cheesecloth, as better results were obtained when this was used than when the vials were stopped with cotton plugs. Each day a supply of fresh asparagus-beetle eggs was collected in the field, brought into the laboratory, and a certain number placed in a vial with each parasite. The eggs remained with the parasites for 24 hours, when they were removed, the number parasitized and the number eaten by each parasite being recorded and the twigs bearing the eggs placed in moist sand, so that the eggs might hatch.

As soon as the young beetle larvæ hatched, they were confined in vials about one-third full of moist earth, and supplied with fresh food each day. As soon as the beetle larvæ were full grown, they were allowed to go into the soil in the vial and pupate. In several cases the pupal cells were formed near the glass, and it was possible to observe the naked parasitic larvæ in the cell after they had completely consumed their host.

LENGTH OF LIFE OF ADULTS IN CONFINEMENT

Tables I, II, and III show the length of life of adults collected in the field and those reared in the laboratory, and the number of eggs parasitized and eaten by each parasite.

TABLE I.—*Length of life of the parasite Tetrastichus asparagi, reared at the Riverhead, N. Y., laboratory in 1912*

Date of emergence.	Date of death.	Number of eggs parasitized.	Number of eggs eaten.	Length of life.[a]	Average number of eggs parasitized daily.	Average number of eggs eaten daily.
				Days.		
Sept. 3	Sept. 9	18	26	[b]6	3	4.33
3	9	16	30	6	2.66	5
3	9	14	32	6	2.33	5.33
3	10	11	25	7	1.57	3.57
3	8	15	20	[c]5	3	4
3	10	11	22	7	1.57	3.14
12	17	0	0	5	.....	.....
12	17	0	0	5	.....	.....
12	18	10	10	6	1.66	1.66
12	22	19	27	10	1.99	2.7
12	18	0	1	6	.....	.....
12	Oct. 7	40	61	[d]25	1.81	2.77

[a] The average length of life was 7.83 days: the maximum, 25 days.
[b] All died on Sept. 9, when they were left from morning until afternoon without any eggs in the vial.
[c] This parasite was accidentally killed.
[d] During the last 3 days no asparagus-beetle eggs could be obtained.

TABLE II.—*Length of life of adult Tetrastichus asparagi at the Riverhead, N. Y., laboratory in 1912*

Date of capture.	Date of death.	Number of eggs parasitized.	Number of eggs eaten.	Length of life.[a]	Average number of eggs parasitized daily.	Average number of eggs eaten daily.
				Days.		
Aug. 5	Aug. 11	0	7	[b]6	0	3.5
5	12	9	11	[c]7	3	3.66
7	11	13	22	4	3.25	5.5
7	14	22	44	7	3.14	6.28
8	19	41	50	11	3.72	4.54
8	19	17	51	11	1.54	[d]4.63
12	14	0	6	2	0	3
12	17	16	28	5	3.2	5.6
12	26	7	37	14	.5	[d]2.64
17	21	0	9	4	0	2.25

[a] The average length of life was 7.1 days; the maximum, 14 days.
[b] Records for the last 2 days only.
[c] Records for the last 3 days only.
[d] Several eggs hatched in the parasite vials.

TABLE III.—*Life cycle of Tetrastichus asparagi at the Riverhead, N. Y., laboratory in 1912*

Date of oviposition.	Date of emergence.	Number emerged.	Length of stages.	Remarks.
			Days.	
Aug. 6	Aug. 30	6	24	Was removed from the soil.
6	30	6	24	
8	30	[a]1	.....	
8	Sept. 2	5	25	
8	3	6	26	
9	2	7	24	
9	5	5	27	
11	5	4	25	
11	6	6	26	
6	6	2	31	
6	7	2	.....	Dead adults taken from top of the soil.
9	7	5	29	
6	11	[b]7	.....	The seven adults were dead in the soil.
15	12	6	28	
15	15	6	31	
15	16	[c]2	.....	Were taken from dirt near top of vial.
17	16	7	30	
6	21	.....	.....	Four larvæ and nine dead adults taken from soil in vial.
8	25	.....	.....	Four larvæ dug out of soil in vial.
Sept. 5	Oct. 11	7	36	Second generation.

[a] Pupa. [b] Adults. [c] Dead.

SEXES

During the time that this parasite has been under observation only females have been found, both among the adults collected in the field and among those reared in the laboratory, and reproduction has been parthenogenetic, so far as has been observed. Of two generations that have been reared in the laboratory, no males have appeared.

Parasites which were separated as soon as they emerged, and confined with asparagus-beetle eggs, immediately commenced feeding and ovipositing and another generation was reared from the parasitized eggs. In one case where six parasites emerged in one vial and were immediately separated, each being given beetle eggs, five of the six were observed to feed on an egg within 15 minutes after they were placed with the eggs, while the other one was observed to oviposit first. From this it would seem that, as a rule, the parasite after emerging feeds on a few eggs before beginning to oviposit. These five adults were observed to oviposit later in the day.

NUMBER OF GENERATIONS

Apparently this insect produces three generations a year on Long Island, for it was very abundant early in June, when it disappeared, to be found again in July, after which time two generations were reared in the laboratory. However, indications are that the third generation, in the fall, is only a partial one.

In one case three beetle eggs were found to be parasitized on August 9, and on August 11 the beetle larvæ hatched and were given food. On August 17 they went into the ground to pupate, and on September 7 five adult parasites emerged. On January 3, 1913, when the soil in the vial was taken out and examined, it was found that one of the two cells which were still in the ground held five dead adult parasites. In the other cell there were five parasitic pupæ. These pupæ, being confined in a warm room, immediately began to change and on January 8 emerged as adults. In another case, from beetle larvæ hatched on August 11 from eggs that had been confined with one parasite, 10 parasites emerged on September 5 and 6. As no more issued from this vial, the soil in it was taken out and examined February 3, 1913. In one cell were found five parasitic larvæ. These larvæ pupated February 7 and on February 17 were emerging as adults. From these facts it would appear that the last generation was but a partial one. The fact that in the laboratory experiments representatives of the third generation emerged in one vial only, whereas on examining the soil in some of the vials during January a number of parasitic larvæ were found, would indicate that the third generation might be the exception instead of the rule.

HIBERNATION

During the latter part of January and the first of February the soil in several vials was examined in order that the stage in which this insect passed the winter might be ascertained. Seven cells containing parasites were found, in six of which they were in the larval stage, while in the seventh they had passed to the pupal stage. This would indicate that the insect hibernates as a full-grown larva in the cell of its host in the ground.

NUMBER OF PARASITES EMERGING FROM SINGLE HOST LARVA

In dissecting eggs of the host, from 1 to 5 eggs of the parasite were found, and in the rearing experiments undertaken in the laboratory from 1 to 10 larvæ of the parasite have been found in a single beetle cell. However, the usual number of parasites that issued from one host larva was from 5 to 7. In two cases only were more than 7 parasites found in a single host and in 1 of these 10 and in the other 9 were found. There was one case where only 1 parasite was found in the host, but as mites had destroyed several cells in this vial and were also in this cell, it seems strongly probable that they had destroyed some of the parasites in this particular cell.

ONLY HOST

The asparagus-beetle egg parasite has been observed attacking only the eggs of the common asparagus beetle (*Crioceris asparagi*). In the laboratory it has been confined with the eggs and young larvæ of the potato beetle, and with the eggs of the elm leaf beetle, but it paid no attention to them.

PUPATION AND THE PUPAL PERIOD

The pupa when first formed is yellowish white throughout. Shortly the eyes become reddish and the mandibles darken. In from two to three days the eyes are bright red and the ocelli are also visible and are of the same color. Next, the head and thorax begin to turn black and this continues on through the abdomen, until just before emergence the whole pupa appears black.

Parasitic larvæ which were seen in a cell on August 20 emerged as adults on August 30. Another brood first seen on August 26 on September 7 emerged as adults.

In a vial in which parasite larvæ were seen on August 20, adult parasites emerged August 30.

Parasitic larvæ which were taken from the soil on January 25, 1913, and kept in a warm room pupated on January 30 and the adults emerged on February 8.

Another lot of larvæ taken from the soil on February 3 pupated on February 7 and emerged as adults on February 17. According to these data, the pupal period lasts from 7 to 11 days.

OVIPOSITION

The process of oviposition is in some respects different from that of feeding. The parasite crawls slowly over the plant with the antennæ held down in front of the face and kept in constant vibration. When a beetle egg is encountered it is carefully examined with the antennæ and, if satisfactory, the parasite crawls upon it and inserts the ovipositor. The ovipositor remains in the egg for a few minutes, without the pul-

sations of the abdomen noticed when the parasite feeds on an egg. It is then withdrawn, and the parasite leaves the egg. In one or two instances it appeared that the parasite after ovipositing in an egg returned to it and repeated the act of oviposition.

In another case a parasite observed in the act of oviposition was approached by a second individual which, climbing up on the opposite side of the egg, began to work the ovipositer up and down in the egg in preparation for feeding. Each was aware of the other's presence, but paid no observable attention to the other.

Table IV gives the time required for oviposition and feeding for a few individuals.

TABLE IV.—*Length of oviposition and of feeding of Tetrastichus asparagi at the Riverhead, N. Y., laboratory in 1912*

Length of oviposition.						Length of feeding.		
Parasite No.	Minutes.	Seconds.	Parasite No.	Minutes.	Seconds.	Parasite No.	Minutes.	Seconds.
1	.....	33	12	1	[a]42	1	23	30
2	2	5	13	2	15	2	8	30
3	3	25	14	3	32	3	11	35
4	2	15	15	2	25	4	9	27
5	1	.....	16	3	30	5	9	.....
6	2	30	17	4	43	6	6	.....
7	.....	40	18	.....	25			
8	.....	[a]55	19	4	.....			
9	2	[a]25	20	4	12			
10	1	10	21	3	10			
11	.....	[a]36	22	3	.....			

[a] Same eggs.

EVIDENCE OF PARASITISM

By means of a hand lens the beetle eggs which had been parasitized were readily distinguishable. Where the ovipositor punctured the egg, a small circular area appeared which projected slightly from the rest of the eggshell and which had a shiny appearance, caused by the small amount of the contents of the egg which had oozed from the puncture.

Beetle larvæ hatching from parasitized eggs appeared normal and continued to feed and grow until maturity. When matured, they went into the ground and prepared their cells for pupation, but here their activities stopped, and in a few days the cell was occupied by the parasitic larvæ, all that remained of the beetle larva being the empty skin.

IMPORTANCE OF THIS PARASITE

The asparagus-beetle egg parasite is of considerable importance, as it not only attacks the host during its parasitic development but is also beneficial in destroying its host's eggs through feeding; in fact, it ap-

pears to be of greater value as an egg destroyer than as a parasite developing within the host.

Mr. C. W. Prescott, of Concord, Mass., recently wrote that on May 23, 1909, he had noticed the parasite in the field feeding on the host eggs, and that on the day of writing he had attempted to find "slugs" or larvæ, but could find neither slug nor egg except those absolutely dry, in a field of 5 acres.

During the season of 1912, the field of asparagus at Aquebogue, N. Y., where this insect was found, received no treatment for the beetles, yet these were so scarce that no damage resulted. Previous to this, according to the owner, the field had been sprayed each year to prevent serious injury.

Without doubt this parasite was to a large degree responsible for the scarcity of the asparagus beetles. Certain other factors may have assisted, but there is little doubt that the parasites were the most important factors in preventing damage.

SUMMARY

Previous to the time that *Tetrastichus asparagi* was believed to be an egg parasite, its life history had never been worked out. As the parasite had been observed ovipositing in the host egg, it was supposed that it developed in the egg. During the investigation of the life history it was discovered that this insect presented one of those peculiar instances where oviposition in the host's eggs and retarded development of the parasite permitted the host to develop. In this case the following takes place:

The parasite deposits her eggs in the egg of the asparagus beetle; the beetle egg hatches; its larva feeds to maturity and entering the soil forms a pupal cell, but does not pupate. The parasites have by this time totally consumed the larva and emerge from it into the cell the larva has constructed, where they pupate and later emerge as adults.

Since the parasitic larva passes the winter in the soil in the pupal cell of its host, it would appear that the parasite might easily be transported from one place to another in the soil which might surround a shipment of asparagus roots.

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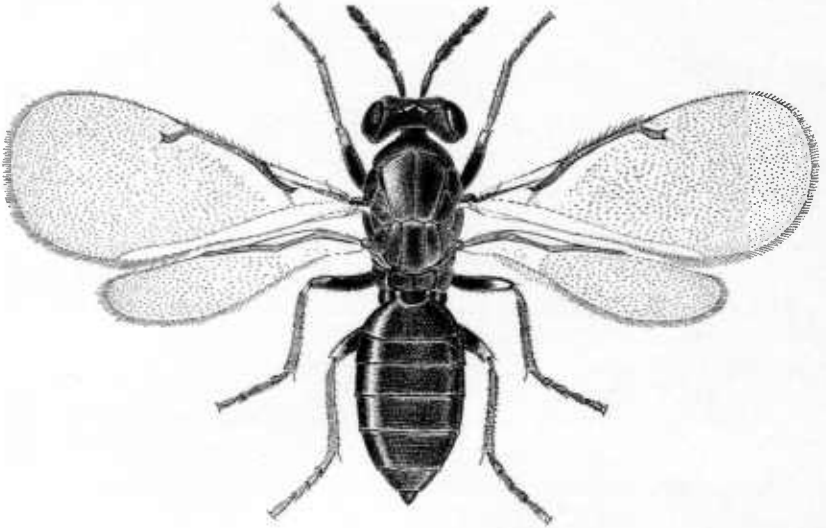
PLATE XLIX

Tetrastichus asparagi:

Fig. 1.—Female adult. Highly enlarged. Original.
Fig. 2.—Egg, laid singly. Highly enlarged. Original.
Fig. 3.—Eggs, laid in pairs. Highly enlarged. Original.
Fig. 4.—Larva. Highly enlarged. Original.
Fig. 5.—Pupa, ventral view. Enlarged. Original.
Fig. 6.—Pupa, side view showing inconspicuous wing pads. Enlarged. Original.



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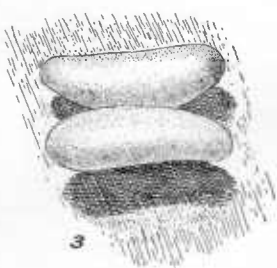

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