

HETEROSPILUS CEPHI ROHWER, A PARASITE OF THE EUROPEAN WHEAT SAWFLY, CEPHUS PYGMAEUS (L.)¹

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INTRODUCTION

*Heterospilus cephi*³ Rohwer is a major parasite of the European wheat sawfly, *Cephus pygmaeus* (Linnaeus). It was first reared from this host in 1924, by Donald T. Ries. In 1925, it was described by Rohwer,⁴ and the following year reference was made to it by Ries⁵ in a paper on the wheat-stem sawfly.

It is the purpose of this paper to present certain details of the morphology and life history of this parasite.

GEOGRAPHICAL DISTRIBUTION

Heterospilus cephi has been found throughout most of the western wheat areas of the State of New York, from Syracuse and the Finger Lakes westward to Lake Erie, and over a limited area in northern Pennsylvania, but has not yet been recovered south of Lycoming County, Pa. Figure 1 shows the districts of New York and Pennsylvania from which it has been recovered.

HOST

Under natural conditions *Heterospilus cephi* has been found to attack only the European wheat sawfly, *Cephus pygmaeus* (L.). However, when introduced into a large outdoor cage containing wheat-infested with the black grain-stem sawfly, *Trachelus tabidus* (Fab.), it parasitized this species freely and passed through its complete normal life cycle on this host without difficulty. This would indicate its ability to adapt itself to this host even though it does not already normally parasitize it. It is possible that the different geographical ranges of these two sawflies may account for the apparent failure of *H. cephi* to attack *T. tabidus*, as the latter has a distinctly more southern range of distribution than has *C. pygmaeus*.

RATE OF PARASITISM

In Table 1 are summarized the percentages of European wheat sawflies found parasitized by *Heterospilus cephi* during the years from 1924 to 1929 in the State of New York. The counties from which material was obtained included Cayuga, Chemung, Erie, Genesee,

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² The authors are indebted to Prof. C. R. Crosby, of Cornell University, for furnishing infested wheat stubble from various parts of New York State; to Dr. D. T. Ries for rearing much of the material during the first year of the investigations, and to Esther H. Hart, of the Bureau of Entomology, U. S. Department of Agriculture, for drawings of the adult.

³ Order Hymenoptera, superfamily Ichneumonoidea, family Braconidae.

⁴ ROHWER, S. A. FIVE BRACONID PARASITES OF THE GENUS HETEROSPILUS. Jour. Wash. Acad. Sci. 15: 177-182, illus. 1925.

⁵ RIES, D. T. A BIOLOGICAL STUDY OF CEPHUS PYGMAEUS (LINNAEUS), THE WHEAT-STEM SAWFLY. Jour. Agr. Research 32: 277-295, illus. 1926.

Livingston, Monroe, Niagara, Onondaga, Ontario, Orleans, Schuyler, Tompkins, Wayne, Wyoming, and Yates. The percentages of wheat stalks infested by the host are included in the table to show the relative abundance of host and parasite.

TABLE 1.—Percentages of *Cephus pygmaeus* parasitized by *Heterospilus cephi* in the State of New York from 1924 to 1929, inclusive

Year	Counties	Wheat stalks infested by <i>C. pygmaeus</i>		Host insects examined		Host insects parasitized by <i>H. cephi</i>	
		Number	Per cent	Number	Per cent		
1924.....	16	31	1,959	21			
1925.....	17	19	2,376	25			
1926.....	15	13	544	32			
1927.....	13	3	100	39			
1928.....	17	3	124	9			
1929.....	15	4	218	1			

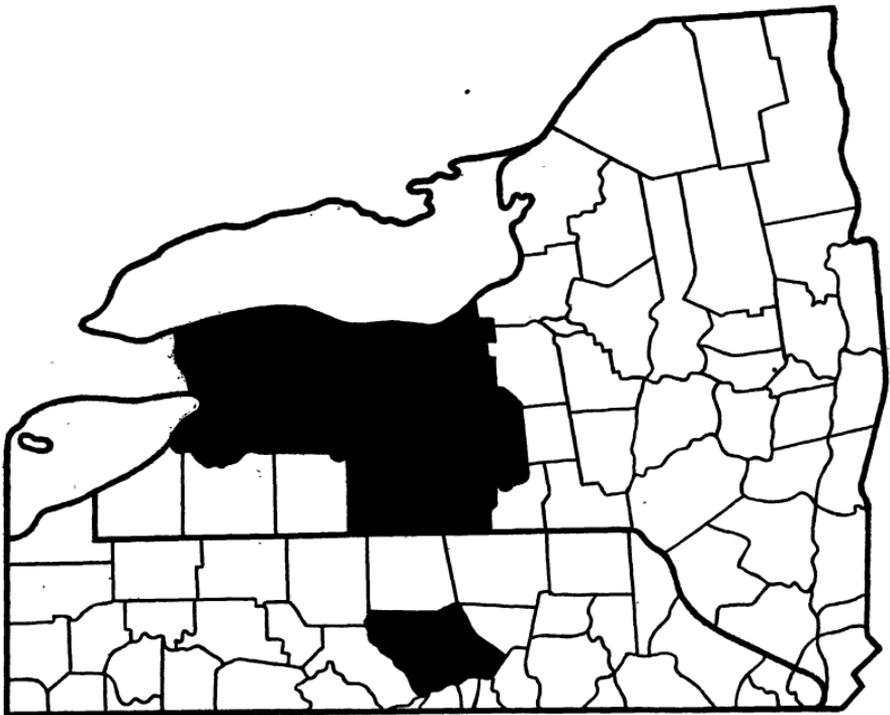


FIGURE 1.—Geographical distribution of *Heterospilus cephi*. Black area shows counties in New York and Pennsylvania where these parasites have been found

During the four years 1924 to 1927, inclusive, parasitism steadily increased from 21 to 39 per cent. During the same interval the abundance of the host decreased from 31 to 3 per cent. In the next two years parasitism dropped to 9 per cent and then to 1 per cent. It is the belief of the writers that the amount of parasitism was too small to account for the rate of decrease in abundance of the host, although it was undoubtedly a contributing factor. Furthermore, as the life history of the host is quite different from that of the parasite, the factors causing its decrease would not necessarily affect the parasite directly. For this reason a gradual increase in the rate of parasitism could be expected to occur as long as host material was

available in sufficient quantity. The sharp decrease in parasitism observed in 1928 and 1929 can be accounted for by the scarcity of host material that prevailed during the period 1927 to 1929. Such a condition would so decrease the numbers of parasites in a field that their search for hosts would become increasingly difficult.

MORPHOLOGY

ADULT

Rohwer⁶ described the adult (fig. 2; fig 3, A) as follows:

Female.—Length, 2.25 mm. Length of ovipositor, 0.5 mm. Head behind the ocelli finely transversely striate; antenna 27-jointed, the joints poorly differentiated; pronotum not dentate laterally; scutum and prescutum rather coarsely

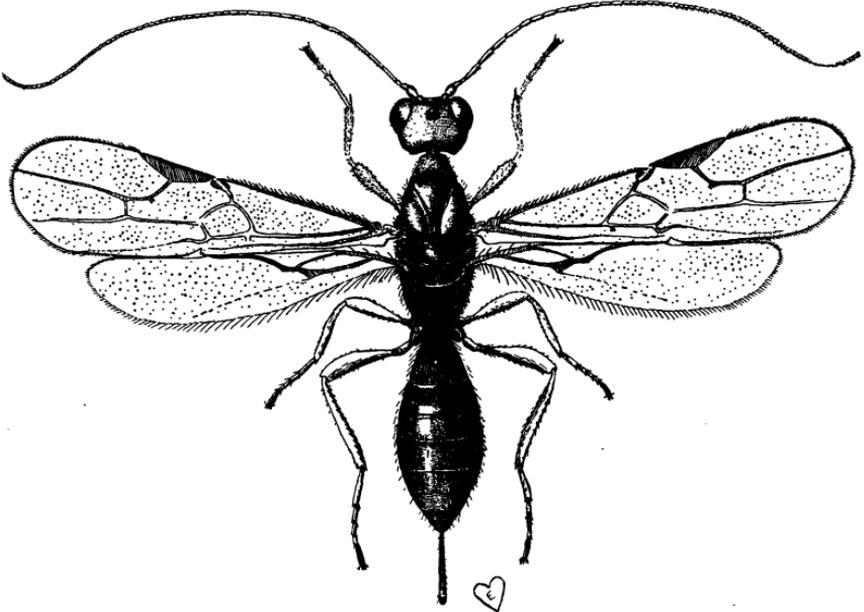


FIGURE 2.—*Heterospilus cephi*, adult female, very much enlarged

granular; notauli not foveolate, well defined; mesepisternum irregularly wrinkled dorsally with smooth, polished area ventrally; propodeum with the lateral-basal area finely granular, the lateral-dorsal carinae complete, with two diverging carinae dorsally which become obsolete laterally and posteriorly; the posterior face and dorsal surface between the diverging carinae irregularly wrinkled and with an indistinct median carina basally; first tergite sharply carinate laterally, longitudinally striate with the striae slightly irregular medianly; second tergite striato-granular; the base of the third and fourth tergites finely striate; ovipositor one-third as long as the abdomen; first intercubitus obsolescent; stigma angulate at the middle where the radius leaves it. Dark ferruginous; antennae, propodeum and first tergite piceous; wings hyaline, strongly iridescent; venation pale brown.

Male.—Length, 2.5 mm. Dorsal part of the head more feebly sculptured than the female; base of the fourth tergite feebly striate; the diverging carinae of the propodeum shorter than in the female and the median carina better defined; the posterior face of the propodeum more distinctly reticulate; antenna 31-jointed.

Type locality.—Ithaca, New York.

⁶ ROHWER, S. A. Op. cit., p. 178.

It is evident, from the average dimensions of the species, that the type specimen was an abnormally small individual.

The entire length of the ovipositor sheath (fig. 3, B) is 1 mm. The distal half of the sheath is normally exerted, and this portion is sparsely setose.

EGG

The egg (fig. 4, B) is elongate, kidney-shaped, somewhat curved, and tapers from a bluntly rounded cephalic pole to a rounded caudal pole about half as wide. The average dimensions of 10 eggs were 0.647 mm. long by 0.122 mm. wide at their greatest diameter.

Deviations in length showed a maximum of 0.706 mm. and a minimum of 0.590 mm.

LARVA

FIRST INSTAR

The newly hatched larva (fig. 4, A) is circular in cross section and tapers toward each extremity, the head being broader and blunter than the caudal end. A typical larva measured 0.677 mm. in length by 0.176 mm. in width. Its general color is translucent whitish. There are 13 well-defined body segments, besides the head. Spiracles occur on the posterior part of the first thoracic segment and on the anterior part of the first eight abdominal segments. The entire body is almost entirely covered with minute spines, with the exception of the head and the median dorsal area.

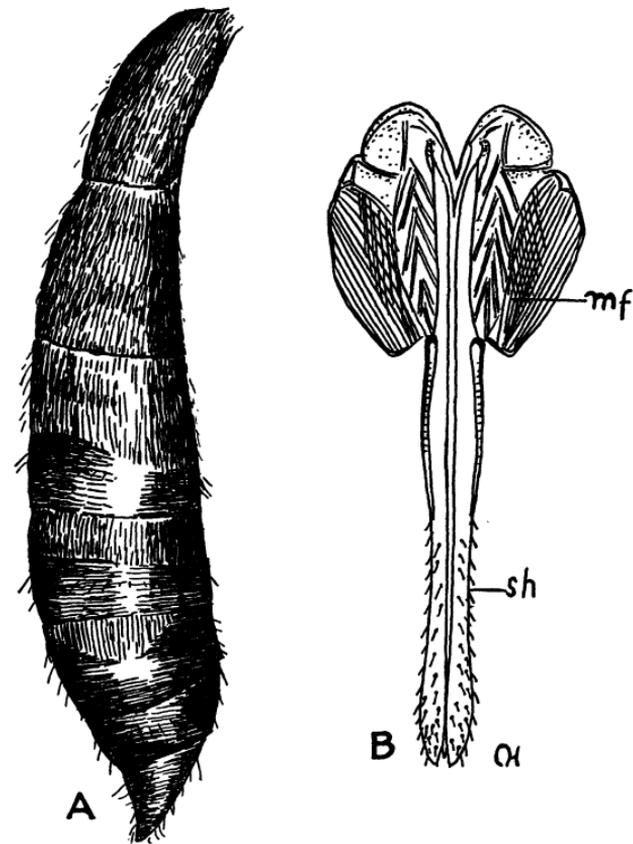


FIGURE 3.—*Heterospilus cephi*: A, Lateral aspect of abdomen of adult male, $\times 65$; B, ovipositor of female, showing muscle fibers (*mf*) and sheath (*sh*), $\times 75$

The head (fig. 4, E) has two conspicuous antennae 0.033 mm. in length. The length of the outer edge of the mandibles (fig. 4, D) is 0.0266 mm. From five to six teeth in comblike arrangement are along the inside edge. The labrum bears four setae, and two pairs of setae are present on each side of the mouth.

SECOND INSTAR

The second instar, in general respects, resembles the last. The body varies considerably in size according to the length of time the insect has been feeding. A minimum length of 0.90 mm. and a maxi-

mum of 2.20 mm. were found. The antennae on the head are smaller than in the first instar and measure 0.009 to 0.013 mm. in length. The mandibles (fig. 4, F) are each provided with six teeth in comblike arrangement similar to that found in the first and last instars, with a length along the outer edge of 0.037 mm.

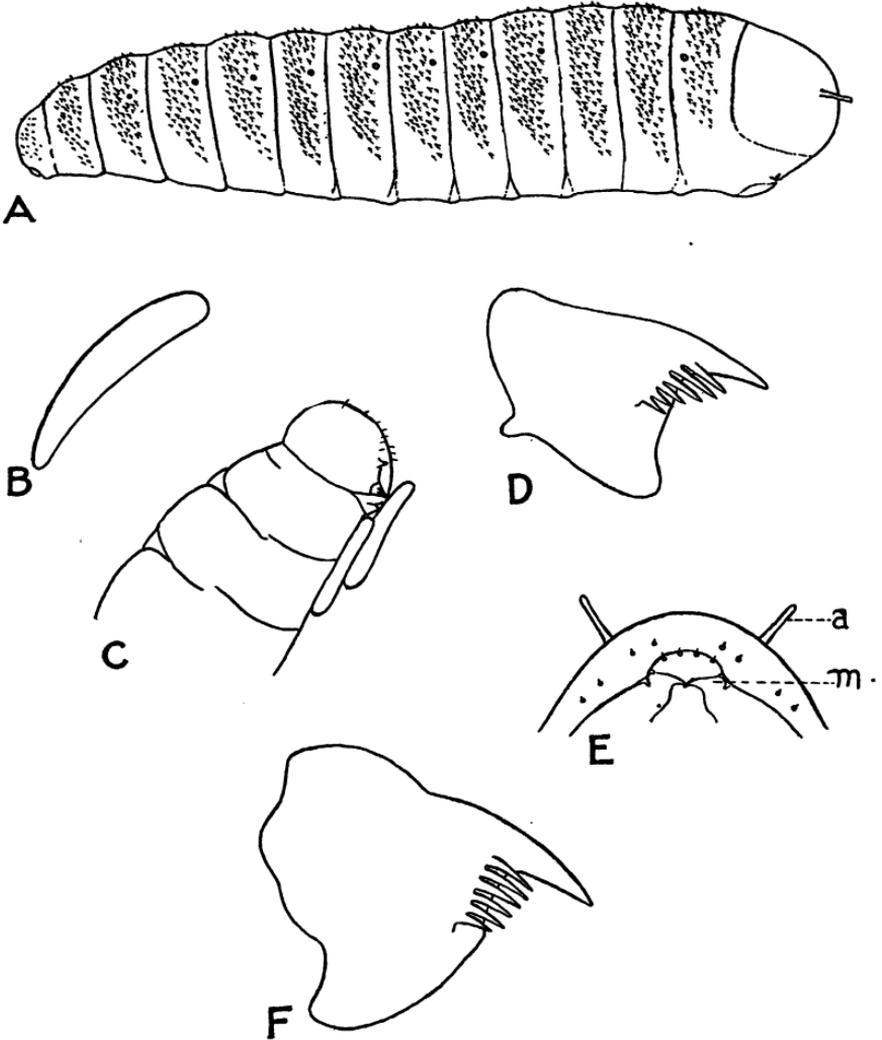


FIGURE 4.—*Heterospilus cephi*: A, Lateral aspect of first-instar larva, $\times 150$; B, egg, $\times 45$; C, eggs on host larva, much enlarged; D, mandible of first-instar larva, $\times 1,200$; E, head and mouth parts of first-instar larva, $\times 240$; a, antenna; m, mouth; F, mandible of second-instar larva, $\times 1,300$

LAST INSTAR

The mature larva (fig. 5, A, and fig. 7, A, B) is white and tapers bluntly toward each extremity. A typical larva which had been removed from its cocoon and measured while alive had a length of 2.9 mm. and a width of 1.8 mm. There are 13 segments, besides the head. Spiracles occur on the first thoracic segment and the first eight abdominal segments. Figure 5, B, shows that the surface of the body, with the exception of the head and caudal segment, is

thickly covered with short tegumentary spines. Setae, slightly larger than the spines, are sparsely distributed on all the segments of the body, including the head. Conical, fleshy antennae 0.0166 mm. long are present on either side of the head. (Fig. 6, D.) The sensorial structures of the mouth parts (fig. 6, D) include 3 pairs of sensory spines on the area of the labrum, 6 on that of the labium, and 2 on each of the maxillary areas. Small disks (fig. 6, B, D), representing modified palpi, are found, one on each maxillary area,

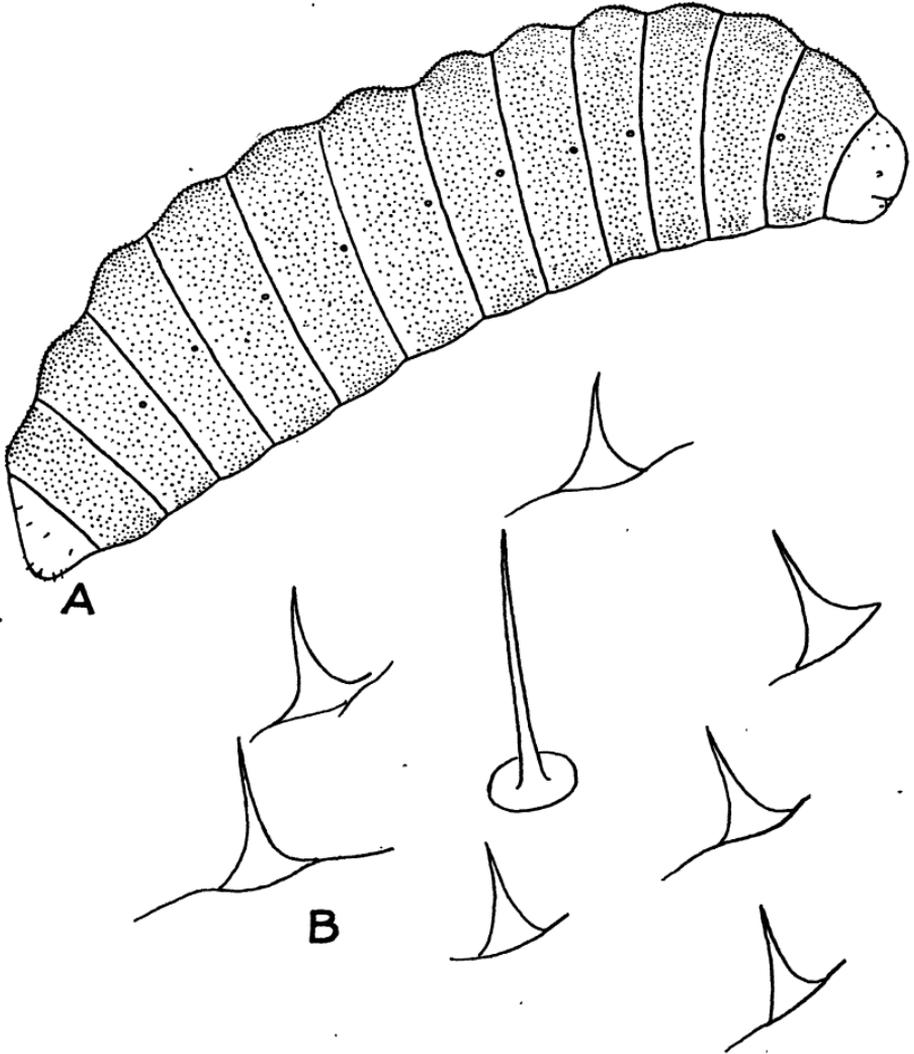


FIGURE 5.—*Heterospilus cephi*: A, Last-instar larva, $\times 40$; B, portion of epidermis of last-instar larva showing several spines and a single seta near the center, much enlarged

and one on each side of the labium. Similar structures found on the maxillary area of the mouth parts of *Eurytoma parva* were termed "vestigial maxillary palpi" by Phillips.⁷ Genieys⁸ also refers to vestigial maxillary palpi on *Habrobracon brevicornis* (Vipionidae). Four pairs of minute setae, arranged in a row, are present dorsad,

⁷ PHILLIPS, W. J. EURYTOMA PARVA (GIRAULT) PHILLIPS AND ITS BIOLOGY AS A PARASITE OF THE WHEAT JOINTWORM, HARMOLITA TRITICI (FITCH). Jour. Agr. Research 34: 743-758, illus. 1927.

⁸ GENIEYS, P. HABROBRACON BREVICORNIS WESM. Ann. Ent. Soc. Amer. 18: 143-202, illus. 1925.

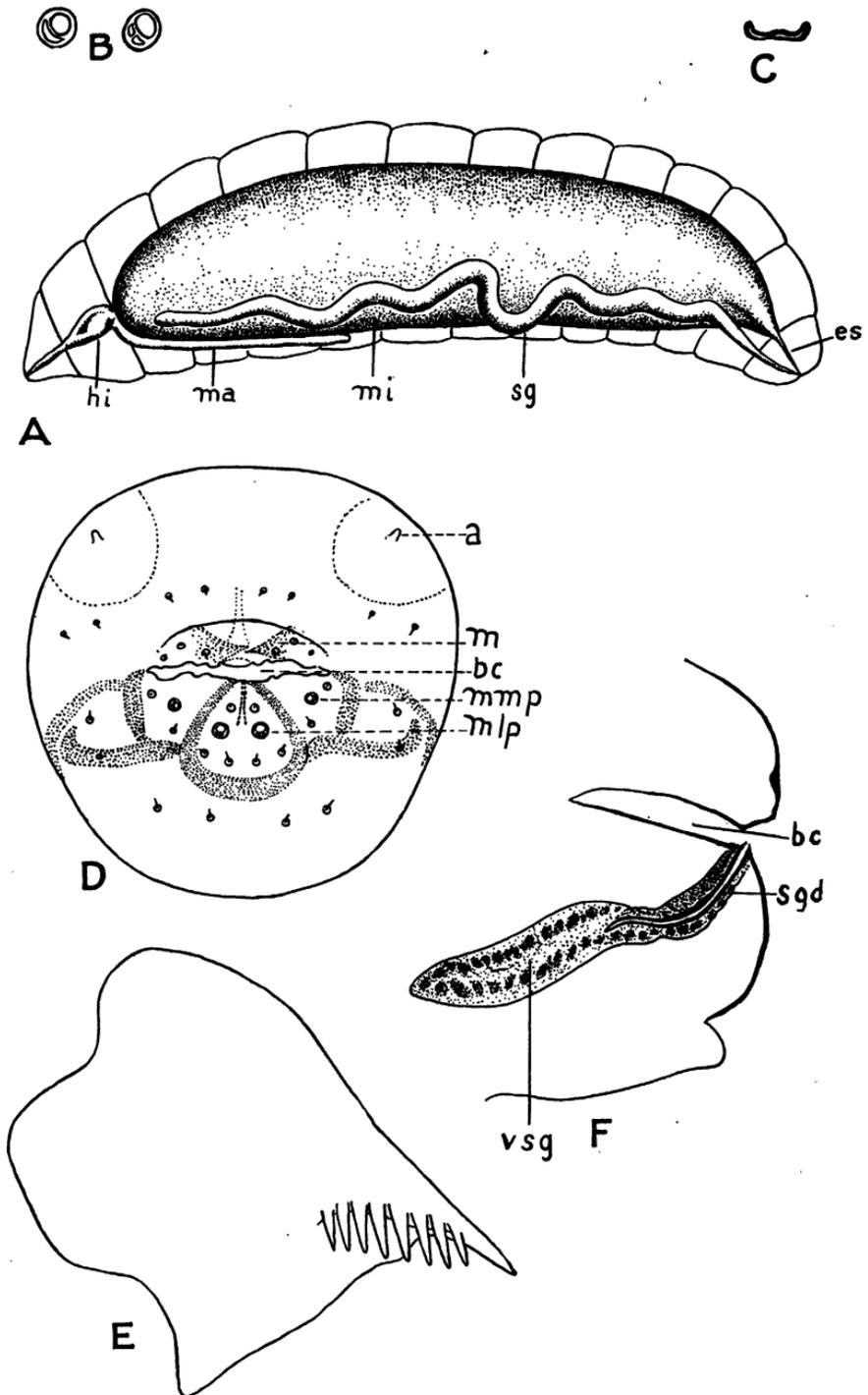


FIGURE 6.—*Heterospilus cephi*, mature larva: A, Lateral aspect of internal organs, esophagus (*es*), mid-gut (*mi*), hind-gut (*hi*), Malpighian tube (*ma*), silk glands (*sg*); B, modified palpi; C, cross section of silk-gland duct, made close to labium, $\times 265$; D, head and mouth parts, antenna (*a*), buccal cavity (*bc*), mandible (*m*), modified labial palpus (*mlp*), and modified maxillary palpus (*mmp*); E, mandible; F, sagittal section of head of larva which has spun its cocoon, showing silk-gland duct (*sgd*), buccal cavity (*bc*), and remains of silk gland (*vsg*) after reduction in size has taken place

and two pair ventrad to mouth parts. The mandibles (fig. 6, E) are heavily chitinized, triangular in outline, with a row of eight long, narrow teeth along the inner margin. The length of the outer margin of the mandible is 0.0533 mm. It is interesting to note the similarity of structure between the mandibles of this species and those of *H. brevicornis* as described by Genieys.

INTERNAL ORGANS OF THE MATURE LARVA

The alimentary canal includes a slender esophagus extending into the anterior part of the first or prothoracic segment, a large mid-gut reaching from the prothoracic segment to the eighth abdominal segment, and a hind-gut (fig. 7, C, and fig. 6, A) with a pear-shaped

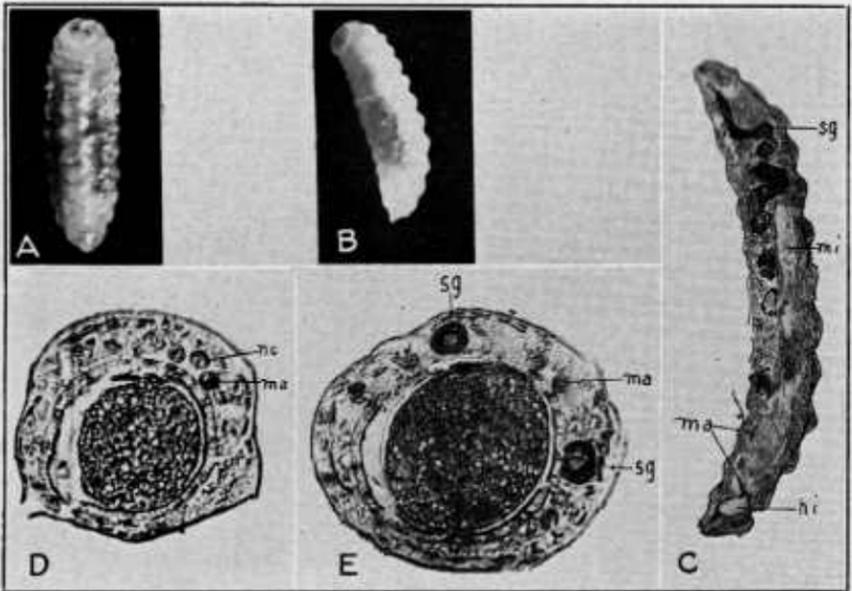


FIGURE 7.—*Heterospilus cephi*, mature larva: A, Ventral aspect; B, lateral aspect; C, sagittal section showing silk glands (*sg*), mid-gut (*mi*), hind-gut (*hi*), and parts of Malpighian tubes (*ma*), $\times 20$; D, cross section of eighth abdominal segment before cocoon has been spun, showing Malpighian tubes (*ma*), nerve cord (*nc*), and mid-gut (photomicrograph $\times 40$); E, cross section in region of sixth abdominal segment before cocoon has been spun, showing Malpighian tubes (*ma*), silk glands (*sg*), and mid-gut (photo-micrograph $\times 40$)

enlargement within the ninth abdominal segment and a slender conduit within the tenth. This terminates in a transverse anal opening.

The large intestine (fig. 7, D, E, and fig. 6, A), when filled with food, occupies most of the body cavity. It remains as a blind sac until after the cocoon has been spun, when an opening is made into the hind-gut. The meconium is then voided, and the stomach contracts to about one-third its previous size and appears as a slightly distended tube continuous with the esophagus and the hind-gut.

The two Malpighian tubes (fig. 7, D, E, and fig. 6, A) arise from the anterior end of the hind-gut. They curve slightly near their point of attachment and then extend as two straight rods along the ventral side of the mid-gut, one on each side of the ventral nerve cord, until they terminate within the fifth abdominal segment.

In number and appearance these tubes are similar to those found in the larva of the vipionid *Habrobracon brevicornis*,⁹ although in the latter they are considerably longer in proportion to the length of the body of the larva. They differ in number from those found on other hymenopterous larvae, the ichneumonid *Eulimneria crassifemur*¹⁰ having four Malpighian tubes instead of two, and the Chalcidoidea, according to citations by Parker,¹¹ having three tubes, one of which extends caudad.

The silk glands (fig. 7, C, D, E, and fig. 6, A) consist of two stout undulating tubes extending on each side of the body cavity from the buccal region into the eighth abdominal segment. They unite close to the buccal cavity to form a single very slender chitinous duct (fig. 6, C, F) which opens at the lip of the labium where minute teeth serve as a guide for the exuded silk. In cross section the lumen of the duct in the head is compressed and somewhat crescent shaped. (Fig. 6, C.) Before pupation takes place the silk glands become reduced in size, and it has been possible to find only a small amount of glandular structure left in the region of the head. (Fig. 6, F.)

The glands differ considerably from those in the braconid *Chelonus texanus* Cress. Unpublished observations made by the senior writer on the larva of this species show the occurrence of four lateral branches instead of two. The same is true for the vipionid *Habrobracon brevicornis*,¹² and for the ichneumonid *Eulimneria crassifemur*.¹³ On the other hand, according to Parker¹⁴ the Chalcidoidea have only a single lateral branch, one on each side of the stomach, as does *Heterospilus cephi*.

COCOON

The cocoon (fig. 8, C) is cylindrical, slightly ovoid, and about 5 mm. long by 1.5 mm. wide. It is whitish and usually somewhat sprinkled with pale brown, finely granulated frass. The exit hole of the parasite is roughly oval, with a ragged edge, and is about 1.0 mm. long by 0.9 mm. wide.

The cocoons are found within the hollow center of the wheat culm where the host has been feeding and may occur almost anywhere along the stem except in the extreme base and terminal portions. Sometimes they are found in groups at different places in the stem. When more than one are present, they are usually placed end to end, with a thin partition of woven silk and frass between them.

PREPUPA

The prepupa (fig. 8, A) is white, more nearly cylindrical than the larva, and has a noticeable constriction in the region of the third thoracic and first abdominal segments. A typical prepupa measured 3.1 mm. long by 0.8 mm. wide. The eyes of the developing adult are faintly visible under the integument of the first thoracic segment.

⁹ GENIEYS, P. Op. cit.

¹⁰ THOMPSON, W. R., AND PARKER, H. L. THE MORPHOLOGY AND BIOLOGY OF EULIMNERIA CRASSIFEMUR, AN IMPORTANT PARASITE OF THE EUROPEAN CORN BORER. Jour. Agr. Research 40: 321-345, illus. 1930.

¹¹ PARKER, H. L. RECHERCHES SUR LES FORMES POST-EMBRYONNAIRES DES CHALCIDIENS. Ann. Soc. Ent. France 93: 261-379, illus.

¹² GENIEYS, P. Op. cit.

¹³ THOMPSON, W. R., AND PARKER, H. L. Op. cit.

¹⁴ PARKER, H. L. Op. cit.

PUPA

The newly formed pupa (fig. 8, B) is nearly white, but the eyes turn dark in the course of a few days and the general coloration of the adult is assumed before eclosion takes place. Measurements of 10 pupae of each sex gave for the female an average length of 4.36 mm., with a maximum of 4.8 mm. and a minimum of 3.9 mm.; and for the male an average of 3.69 mm., with a maximum of 4.4 mm. and a minimum of 2.3 mm. The ovipositor in the female extends beyond the tip of the abdomen, and the antennae extend down each side of the body beyond the

abdomen and nearly to the extremity of the ovipositor. The antennae are shorter in immature pupae, extending, in the male, just beyond the tip of the abdomen. The wing pads of both sexes reach to about the base of the second abdominal segment.

LIFE HISTORY AND HABITS

SYNOPSIS

The incubation period lasts only a few days, and the early development of this parasite from the time of oviposition to the formation of the cocoon requires about three weeks. At least 10 months are then spent as a fully developed larva within the cocoon, before further transformation takes place. Three instars were observed in the larva. Pupation

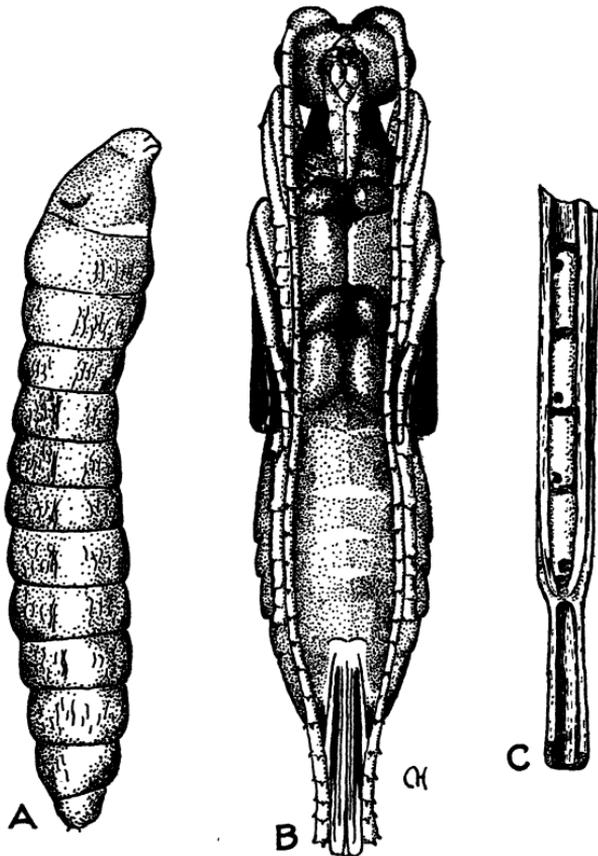


FIGURE 8.—*Heterospilus cephi*: A, prepupal stage; B, ventral aspect of pupa; C, wheat stem containing cocoons showing exit holes

occurs with the advent of warm spring weather, and the prepupal and pupal periods combined occupy about one month. The adults live two or three weeks after emergence. The complete life cycle takes an entire year.

SEX RATIO

From 644 adults reared from European wheat sawfly material, collected from various parts of New York, 47 per cent were females and 53 per cent males. In the majority of cases both sexes developed on the same host.

LONGEVITY OF ADULT

In order to estimate the longevity of the adult two large vials were selected, 23 males placed in one and 19 females in the other. The air content was kept humid by the daily addition of a few drops of water, and the vials were kept tightly stoppered to prevent their drying out. The results gave for the males an average length of life of 10 days, with a maximum of 16 and a minimum of 2 days; for the females, an average of 9 days, with a maximum of 12 and a minimum of 6 days.

In another experiment the adults were kept in a humid atmosphere in individual vials. Six individuals of each sex were observed, and the results gave for the males an average length of life of 13 days, with a maximum of 18 and a minimum of 10 days; and for the females, an average of 12½ days, with a maximum of 15 and a minimum of 7 days.

In the vials in which a number of the parasites were confined together in a relatively small area, the mutual interference of the parasites in moving about may have caused more constant activity and thereby accounted for the shorter length of life than occurred when a separate vial was used for each adult. Food was not furnished in either of these experiments.

OVIPOSITION

The female usually alights rather high upon the wheat culm and then crawls up and down the stalk until a favorable place for oviposition is found, whereupon she inserts her long ovipositor through the wheat stalk until it comes in contact with the host larva.

There is evidence that from one to six eggs, and possibly more, may be laid on a host at a time. Several hosts were found bearing 1 egg each, two with 2 eggs each, one with 4 eggs, and one with 6. Where more than one egg was found, the uniform arrangement indicated that the eggs were laid at the same time by a single parasite.

Of 8 hosts examined, 5 bore eggs on the head, 1 on the underside of the thorax, 1 on the side of the fourth abdominal segment, and 1 on the anal extremity.

It is evident that the female stings the host, probably just previous to depositing the eggs, as all hosts found with eggs or larvae on their bodies are in a torpid condition and able to react only slightly to outside stimulus.

The position of the host at the time of oviposition has, in the cases observed, been in the upper part of the wheat stalk.

HABITS OF THE LARVA

The host remains in a comatose condition from the time the eggs are laid on it until death. The larva crawls freely over the body of its victim and feeds through the epidermis. Most of the host contents are finally ingested, and the head capsule together with some of the dark and shrivelled epidermis of the body is all that remains of the host after the parasite has finished feeding. Three distinct instars have been observed.

PREPUPAL DEVELOPMENT

With the warm days of spring, the larva begins its transformation into a pupa. The length of the prepupal period of eight individuals observed under experimental conditions ranged from 8 to 16 days, with an average of 10.62 days. The 2-hour mean temperature of the atmosphere outside the cage during the experiment was 64° F.

PUPAL DEVELOPMENT

The pupal period lasts from 19 to 22 days, according to two experiments made to determine its length.

In the first, which was conducted in the spring of 1926, six male and six female pupae were used. The results show, for the females, an average of 19.17 days, with a maximum of 21 and a minimum of 17 days; for the males, an average of 18 days, with a maximum of 20 and a minimum of 15 days.

In the second experiment, conducted during the spring of 1927, 6 males and 10 females were used, and thermographic records were kept of the atmosphere surrounding the containers. The mean temperature based on readings made every two hours during this experiment was 64° F. Although the days were warm, the nights were quite cool, which accounted for the rather low mean temperature. The results showed for the females an average of 22.3 days, with a maximum of 26 and a minimum of 20 days; for the males, an average of 20.5 days, with a maximum of 23 and a minimum of 17 days.

The parasitic larvae were removed from their cocoons and confined in individual, small, shell vials, the moisture content of which was kept close to the saturation point. Close daily observations were kept of their time of pupation up to eclosion.

In both experiments the pupal period was from one to two days shorter for the male than for the female. This fact helps to account for the earlier appearance of the males. Males were also observed to emerge several days earlier than females from wheat stalks stored in the laboratory rooms.

NUMBER OF PARASITES PER HOST

From an examination of 747 wheat stems it was found that from 1 to 10 cocoons occurred in a single stem, the average number being 3 per stem. As only in rare instances does more than a single host occur in a wheat stem, three is a close estimate of the average number of these parasites capable of developing on a single host. The 10 individuals found in a stem may have developed from more than one host.

SEASONAL HISTORY

There is one generation of the parasite a year, which is coincident with the single generation of the host. The adults emerge somewhat later than do the adults of the host and may be found in the fields in the last part of June and throughout most of July. The feeding period of the individual parasite is about three weeks, at the end of which time the parasite spins its cocoon and remains quiescent, in the mature larval stage, within its silken case until the following spring, when pupation occurs.

SUMMARY

Heterospilus cephi is a major parasite of the European wheat sawfly, *Cephus pygmaeus* (L.).

So far as is known at present, its geographical distribution covers most of the western wheat-growing area of the State of New York and a limited area in northern Pennsylvania.

The percentage of parasitism increased from 21 per cent in 1924 to 39 per cent in 1927, with a coincident decrease in abundance of the

host from 31 to 3 per cent. In 1928 there was a sharp decrease in parasitism to 9 per cent, and in 1929 to 1 per cent.

There is one generation a year. Oviposition occurs during the last part of June and in early July while the host larvae are feeding within the wheat stems. The period of incubation and feeding occupies about three weeks; about 10 months are then spent in the mature larval stage within the silken cocoon. With the advent of warm days in the spring, pupation takes place, and about a month is spent in the prepupal and pupal stages. The length of life of the adult is from 1 to 2 weeks.

The female inserts her ovipositor into the wheat culm and lays from one to six eggs on the surface of the host larva feeding inside the stem. The parasitic larva remains on the surface of the host larva and feeds through the epidermis of the host. It passes through three distinct instars, and spins a whitish silken cocoon within the hollow of the wheat stem. An average of three parasites were found to mature on a single host. The sex ratio showed 47 per cent of the adults to be females.

