PLATYGASTER HIEMALIS FORBES, A PARASITE OF THE HESSIAN FLY[1]

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INTRODUCTION

One of the most widespread and effective natural enemies of the Hessian fly (*Phytophaga destructor* Say) in the United States is the serphoid parasite *Platygaster hiemalis* Forbes.[3] Although it has been recognized as an important parasite since 1841, when Herrick (*1*)[4] made some initial observations on what was evidently this insect, yet until recent years the species has been confused with at least one other serphoid parasite of the Hessian fly, and little has been known of its early stages and life history. It is, therefore, the purpose of this paper to present a general biological account of this parasite with records of its economic importance and seasonal history in the East.[5]

ECONOMIC IMPORTANCE

Platygaster hiemalis may be ranked first in importance as a parasitic enemy of the Hessian fly in the Middle Atlantic States. Its closest competitor is the serphoid parasite *Platygaster vernalis* (Myers) which attacks the spring generation of the fly. Estimates show that the latter parasite takes a toll of about 4 per cent fewer flies for the spring generation than does *P. hiemalis* for the fall generation. *P. hiemalis*, moreover, is the only parasite that attacks the fall generation to any appreciable extent, and is therefore of special value in helping to control this generation of the Hessian fly, which would otherwise develop practically unchecked by parasites.

Data obtained during the nine years from 1914 to 1922 show an annual parasitism of the fall generation of the Hessian fly of from 16 to 40 per cent with a yearly average of 28 per cent. Table I gives the percentage of parasitism and the number of hosts examined during the period. In obtaining these data, 48 different localities were visited, many of them during consecutive years. These places were widely distributed and ranged from Montoursville, Pa., on the north, to Staunton, Va., on the south.

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[3] Order Hymenoptera, superfamily Serphoidea.

[4] Reference is made by number (italic) to "Literature cited," p. 275.

[5] For the historical review and bibliography of this species reference should be made to an account of this parasite published by the writer (*2*) in 1922.

TABLE I.—*Percentage of Hessian flies killed by Platygaster hiemalis for each of the years from 1914 to 1922 and the number of hosts examined for each year*

Year	Percentage of hosts parasitized by P. hiemalis	Number of hosts examined	Year	Percentage of hosts parasitized by P. hiemalis	Number of hosts examined
1914	34	1,417	1920	32	2,207
1915	36	355	1921	19	944
1916	16	1,592	1922	17	3,617
1917	40	1,430			
1918	24	1,341	1914–1922	28	15,550
1919	35	2,647			

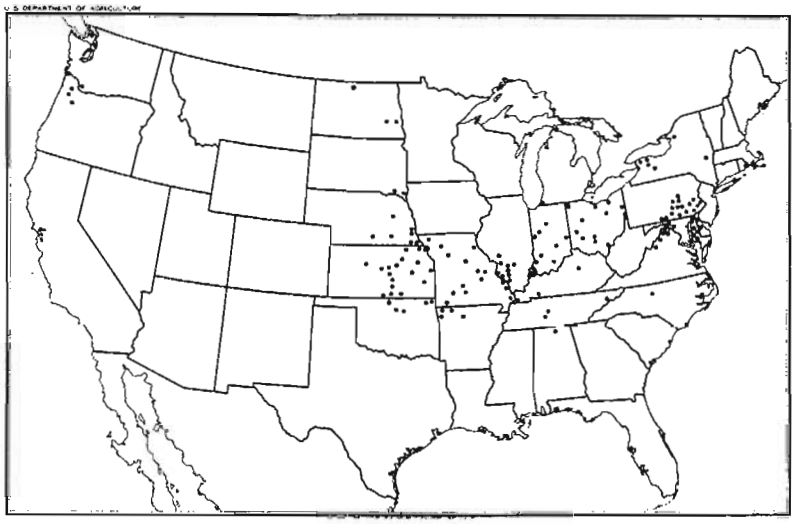

FIG. 1.—Geographical distribution of *Platygaster hiemalis*

GEOGRAPHICAL DISTRIBUTION

Platygaster hiemalis has been found in most wheat-growing regions where the Hessian fly occurs. On the Pacific coast it is present in Washington and Oregon, but C. M. Packard reports that none have been recovered in California. Several years ago it was introduced both into Washington (*12*) and California (*11*), but evidently it has failed to become established in the latter State. The accompanying map (fig. 1) shows the distribution in the United States of localities by counties where *P. hiemalis* has been recovered.[6]

THE EMBRYO

DESCRIPTION OF THE EGG

The egg (fig. 2, A) [7] is highly refractive, subellipsoidal, and slightly flattened along one side. Specimens examined before oviposition

[6] Many of the distribution records were secured through the courtesy of J. R. Horton, A. F. Satterthwait, C. N. Ainslie, and L. P. Rockwood.

[7] The letters used in referring to the figures are: *d*, Discoidal body; *em*, embryo; *g*, gonad; *go*, gorgerette; *ht*, host tissue; *m*, mid-intestine; *md*, mandible; *mo*, mouth; *os*, orifice of salivary glands; *ov*, ovary; *ovi*, oviduct; *p*, paranuclear mass; *pr*, proctodaeum; *s*, salivary glands; *sh*, sheath; *sp*, spermatheca; *spr*, spiracle; *styl*, stylet; *tr*, trophamnium; *v*, vagina.

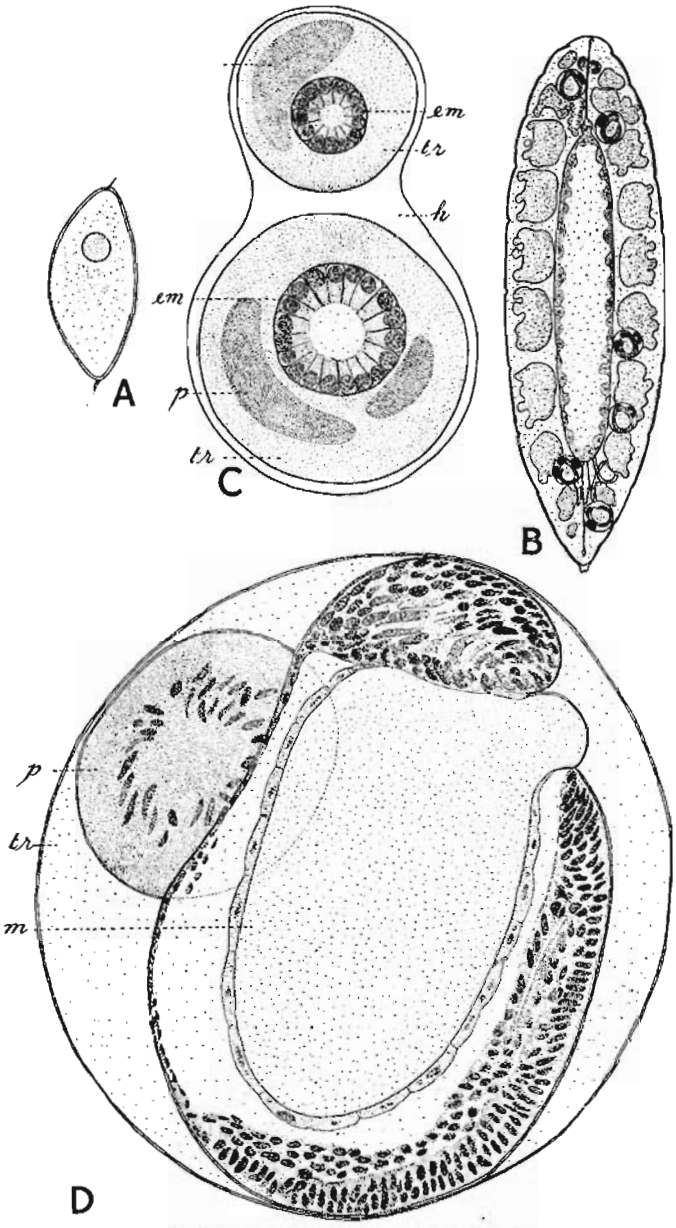

FIG. 2.—A, egg of *P. hiemalis* immediately after oviposition. × 1111. B, host larva containing six *P. hiemalis* embryos. × 18. C, section of embryos at blastula stage of development surrounded by trophamnium and host tissue, and showing paranuclear masses. × 402. D, embryo 18 weeks old surrounded by trophamnium and showing paranuclear mass. × 172.

showed one and sometimes two flagellum-like adherences at one end and one at the opposite extremity. Freshly deposited eggs measure approximately 0.02 mm. long by 0.01 mm. wide. The size and shape of the egg undergo no appreciable change upon oviposition.

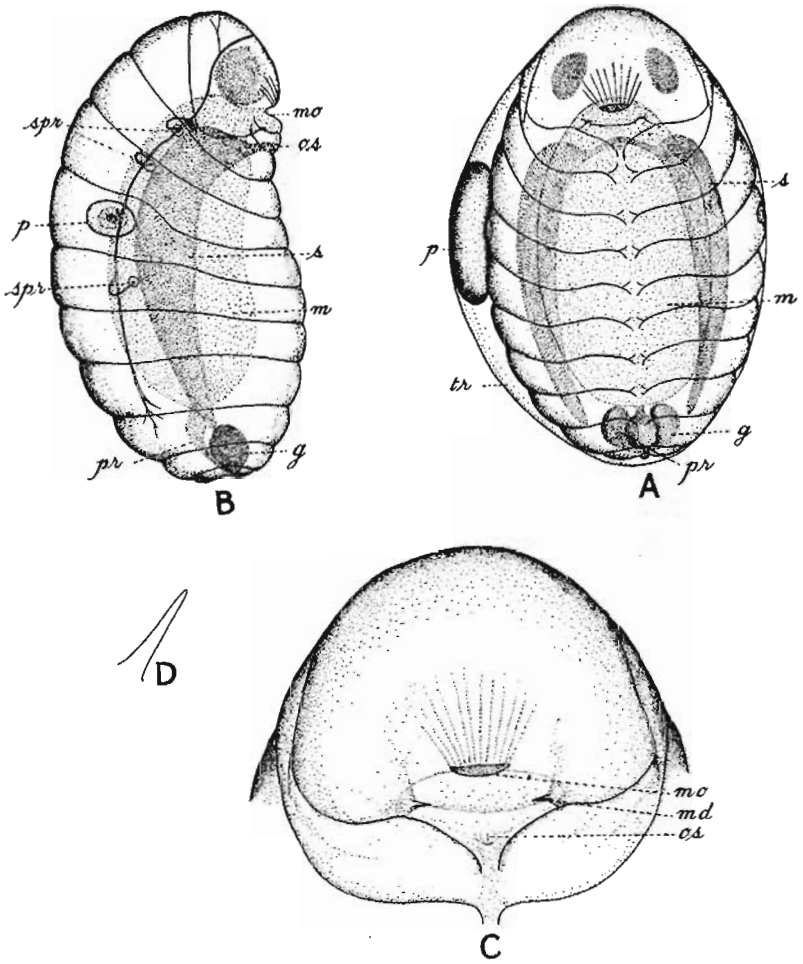

FIG. 3.—A, ventral aspect of *P. hiemalis* embryo nearly ready to break away as a free larva from the surrounding trophamnium. Observe presence of salivary glands, mid-intestine, and gonads. × 60½. B, lateral aspect of larva showing spiracles, discoidal body, salivary gland on one side, mid-intestine, gonad on one side, and proctodaeum. × 45. C, ventral aspect of head of larva showing mouth, mandibles, and orifice of salivary glands. × 97. D, mandible of larva. × 450

EMBRYONIC DEVELOPMENT

Development takes place both polyembryonically and monembryonically in the body cavity of the host (fig. 2, B). In its polyembryonic type of development two embryos are produced from a single egg (fig. 2, C). Shortly after growth commences large paranuclear masses are formed which function as nutritive bodies (fig. 2, C, *p*). The egg also becomes encysted with host tissue (fig. 2, C, *ht*), which serves as the source of supply for the necessary nutrition. Aborted

eggs are frequently found, and this is probably accounted for by the lack of sufficient encysting host tissue. Most of the young embryos separate one from the other at a very early stage of development, but occasionally they are held together by host tissue until quite far advanced in life.[8]

The winter and part of the spring and summer are usually passed in a resting stage (fig. 2, D), in which well-defined larval characteristics are present. Body segmentation is not yet apparent, but the body walls and stomach wall have formed, the buccal cavity has developed, and the proctodaeum is very distinct. More rarely the winter is passed in embryonic forms no further advanced than the blastula stage, and sometimes, on the other hand, in forms sufficiently far advanced to show body segmentation. Such digressions may be attributed to exceptional meteorological conditions or very early or very late oviposition. For instance, in eastern Pennsylvania, during the fall of 1922, emergence of both parasites and hosts was greatly retarded, and cold weather appeared before a majority of the parasites had developed beyond the blastula stage, with the result that most of the *hiemalis* in this region passed the winter in the blastula stage of development.

With the warm weather of summer growth is resumed; whereupon the body lengthens, the segments become distinct, and the trophamnium shrinks. (Fig. 3, A). When the larva is completely formed, it breaks away from the surrounding trophamnium and commences at once to feed.

THE LARVA

The fully developed larva (fig. 3, B) is about 1.4 mm. long by 0.6 mm. in diameter and has seven abdominal and three thoracic segments well defined by sutural lines. It is white, ovoid, bare of setae, with spiracles (fig.3, B, *spr*) present on the second and third thoracic segments, and second abdominal segment. In the first abdominal segment, instead of an external spiracle, there is a large discoidal body (fig. 3, B, *d*) under the cuticula at the terminus of the lateral tracheal branch of this segment. The mouth (fig. 3, C, *mo*) is a simple transverse orifice capable of being opened and closed by strong radiating muscles attached to the superior lip. The mandibles (fig. 3, C, *md*, D) are 0.03 mm. long, attenuated, and nearly straight, a very slight curve only being distinguishable along one plane under high magnification. Large tapering salivary glands (fig. 3, A, B, *s*) extend nearly the full length of the body on each side and unite in a single opening a short distance below the mouth. The mid-intestine (fig. 3, A, B, *m*) is sacklike, and when distended fills most of the contents of the larva. It comes in contact with the walls of the proctodaeum (fig. 3, A, B, *pr*), but no opening from the one into the other is discernible. The external orifice of the proctodaeum is present close to the ventral edge of the seventh abdominal segment. Gonads (fig. 3, A, B, *g*) are distinguishable on either side of the proctodaeum.

The larva increases somewhat in size as it feeds and the fat bodies develop, but apparently it undergoes no molt, and the mandibles

[8] For a more detailed account of the embryological development of *P. hiemalis* see "The Twinning and Monembryonic Development of *Platygaster hiemalis*, a Parasite of the Hessian Fly," by R. W. Leiby and C. C. Hill (*5*).

remain unchanged in size and shape throughout the period. During this stage all of the contents of the host are consumed except the outer integument and some of the interior of a chitinous nature.

THE COCOON

Before pupating each parasite larva forms an ovoid yellowish-brown cocoon made of a tough, elastic material. When all of the individuals within a single host have developed to this point, the host skin and puparium become completely filled out by the inclosed parasite cocoons (fig. 4, A).

THE PUPA

The pupa (fig. 4, B), which at first is white, gradually darkens until it is shiny black, with the exception of the integuments between the abdominal plates, which remain white. The scutellum is prominent. The wing pads extend caudad to about the middle of the abdomen, and the antennae reach to within a short distance of the extremity of the wing pads.

COMPARISON OF THE LARVAL FORMS OF PLATYGASTER HIEMALIS WITH THOSE OF OTHER SPECIES IN THE SAME GENUS

As a guide to the identification of the immature stages of this parasite, it is of interest to compare its larval stage with those of some of the other species of the genus Platygaster.

Compared with *Platygaster vernalis*, reared from the same species of host insect, the writer (*3*) has noted a radical difference. *Vernalis* passes through a primary larval stage somewhat resembling a cyclopean form, but in *hiemalis* no larval stage of this sort occurs either in its embryological or larval development. A closer resemblance is found, however, in the final larval stages, although there are still some marked differences. In *vernalis*, maxillae are present and the mandibles are distinctly curved; in *hiemalis* there are no maxillae and the mandibles are nearly straight. Moreover, there are eight segments apparent in the abdomen of *vernalis* and but seven in *hiemalis*.

The same comparisons apply to (*Polygnotus*) *Platygaster minutus* Lindemann, which has been reared from the Hessian fly in Europe and studied by Marchal (*6*), except that Marchal does not mention the presence of maxillae in *minutus*, and finds nine abdominal segments instead of eight.[9]

Two other Platygaster parasites differ radically from *P. hiemalis* in their larval stages: *Platygaster lineatus* Kieffer, a parasite of *Diplosis pyrivora* Riley, and *Platygaster marchali* Kieffer, reared from *Perrisia ulmariae* Br. According to Marchal both have primary larval stages resembling cyclopean forms, thus affording at once a marked distinction in larval development from that of *hiemalis*.

[9] Both *Platygaster vernalis* (Myers) and the parasite studied by Marchal under the name of *Polygnotus minutus* (Lindemann) occur in the same species of host (*Phytophaga destructor*), and very closely resemble each other in all phases of their development; and as Myers (*8*) has pointed out, both may prove to be *Platygaster zosine* Walker.

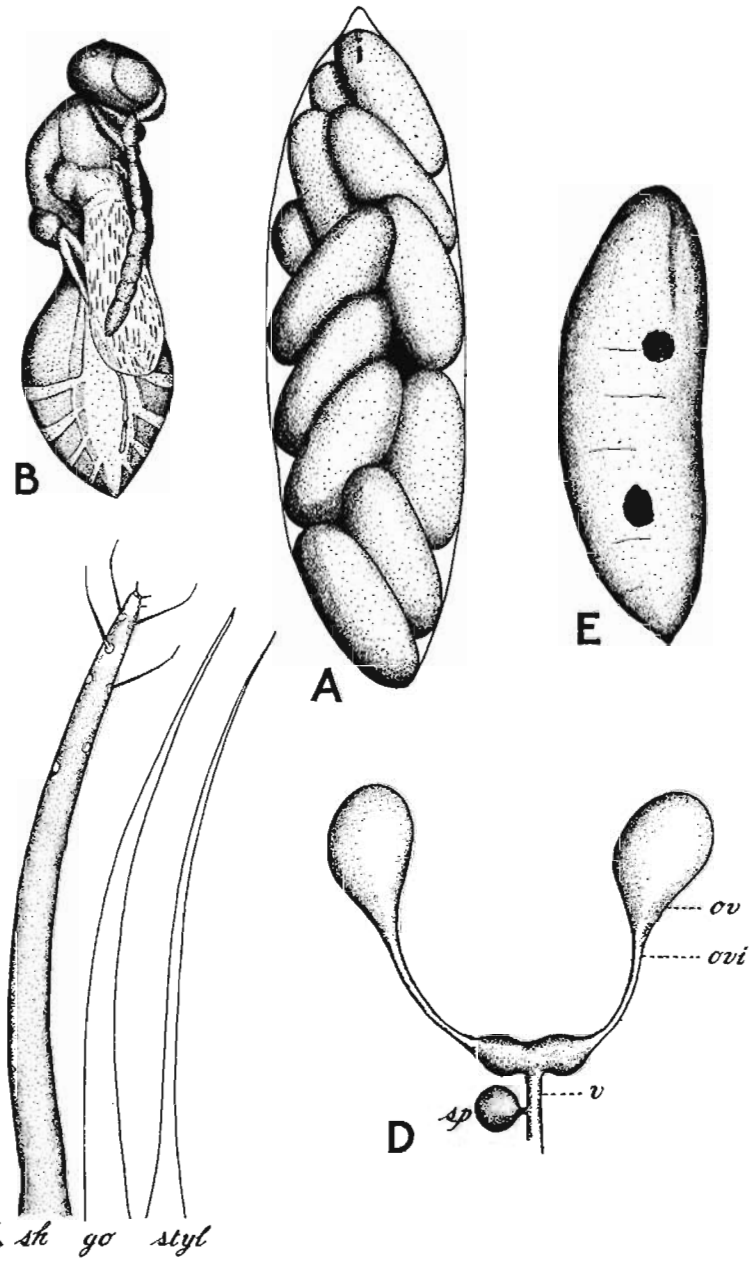

FIG. 4.—A, cocoons of *P. hiemalis* in host puparium. The host puparium is indicated by outline. × 19½. B, pupa. × 43½. C, ovipositor, showing sheath, gorgerette, and stylet. × 572. D, female reproductive system. × 123. E, host puparium, showing exit holes made by adult of *P. hiemalis*. × 14

Compared with *Platygaster herrickii* Packard, another parasite of the Hessian fly, the same outstanding difference is observed in so far as a true cyclopean form is found in this parasite.[10]

Platygaster ornatus Kieffer reared from *Perrisia ulmariae* Br. and depicted by Marchal (*7*) bears, however, a marked resemblance in larval form to *hiemalis*. It shows no distinct secondary larval stage, and the larva is very similar in structure to that of *hiemalis*. *Ornatus*, however, shows traces of maxillae which are lacking in *hiemalis*.

The resemblance of the larva of *hiemalis* and *Platygaster dryomyiae* Silvestri depicted by Silvestri (*10*) and found as a parasite of *Dryomyia lichtensteinii* Fr. Löw is yet more marked. The position and appearance of various essential parts of the anatomy are very similar. In *dryomyiae* traces of maxillae seem to be lacking, as in the case of *hiemalis*. One mark of distinction is in the discoidal body on the first abdominal segment, which appears to be more prominent in *dryomyiae*.

DESCRIPTION OF ADULT[11]

(Fig. 5, A, B, C, D, E, and fig. 4, C)

Female.—Length 0.8 mm. to 1.3 mm.; black and shining; head about twice as broad as long; vertex posteriorly finely regulose; face shining, with very faint aciculations running obliquely downward from a faint median elevation; lateral ocelli equidistant from eye and median ocellus; mandibles fusco-testaceous; antennae 10-jointed, fusco-piceous; flagel twice as long as the scape; scape pale testaceous at base; pedicel as long as the first two flagellar joints, thicker than the second joint; first flagellar joint small, slightly longer than thick, pale testaceous basally; second longer and slightly larger than the third; flagellar joints five, six, seven, and eight each with a pale spur near apex (under compound microscope); club five-jointed, joints except last slightly longer than wide, the last one-half longer than the preceding; pronotum shining, villose, and faintly aciculated; mesonotum shining, villose, and faintly aciculated, slightly elevated medially on the posterior margin; notauli faintly indicated, terminating posteriorly in aciculated, pilose foveae; scutellum highly elevated, convex, distinctly broader than long, immargined laterally; mesopleurae smooth, polished, and bare; propodeum with two median carinae, pilose except in sulcus; metapleurae clothed with dense, silvery pile; anterior coxae fuscous, median and posterior fusco-piceous; anterior trochanters fusco-testaceous, median and posterior fuscous; femora, fuscous, except apex of anterior which are fusco-testaceous; tibiae fuscous except anterior and base of median of posterior, which are fusco-testaceous; tarsi fulvous, anterior lighter than median and posterior; all apical tarsal joints fuscous; wings hyaline, pubescent, about twice as long as the abdomen; petiole dorsally coarsely aciculated; second segment occupying about two-thirds of the dorsal abdominal surface, smooth and polished, with two foveae at base; area between and about these foveae aciculated; remaining abdominal segments each with a row of hairs; ovipositor curved and attenuated, with a few setae at apex.

Male.—Essentially the same as female, but may be distinguished by the second flagellar joint of the antenna, which is thickened and curved, as long as pedicel; spurs on flagellar joints five, six, seven, and eight absent; club six-jointed.

[10] Kulagin (*4*) described two platygasters as having cyclopean forms, but the author fails to find in the account sufficient justification for their determination as platygasters. Furthermore, the cyclopean form depicted by Kulagin as *Platygaster herrickii* not only was taken from a host from which *herrickii* adults have never been reared, but also compares very unfavorably with similar stages which the author has on hand, reared under controlled conditions from *herrickii* adults by the late W. R. McConnell.

[11] Redescribed for this paper by P. R. Myers.

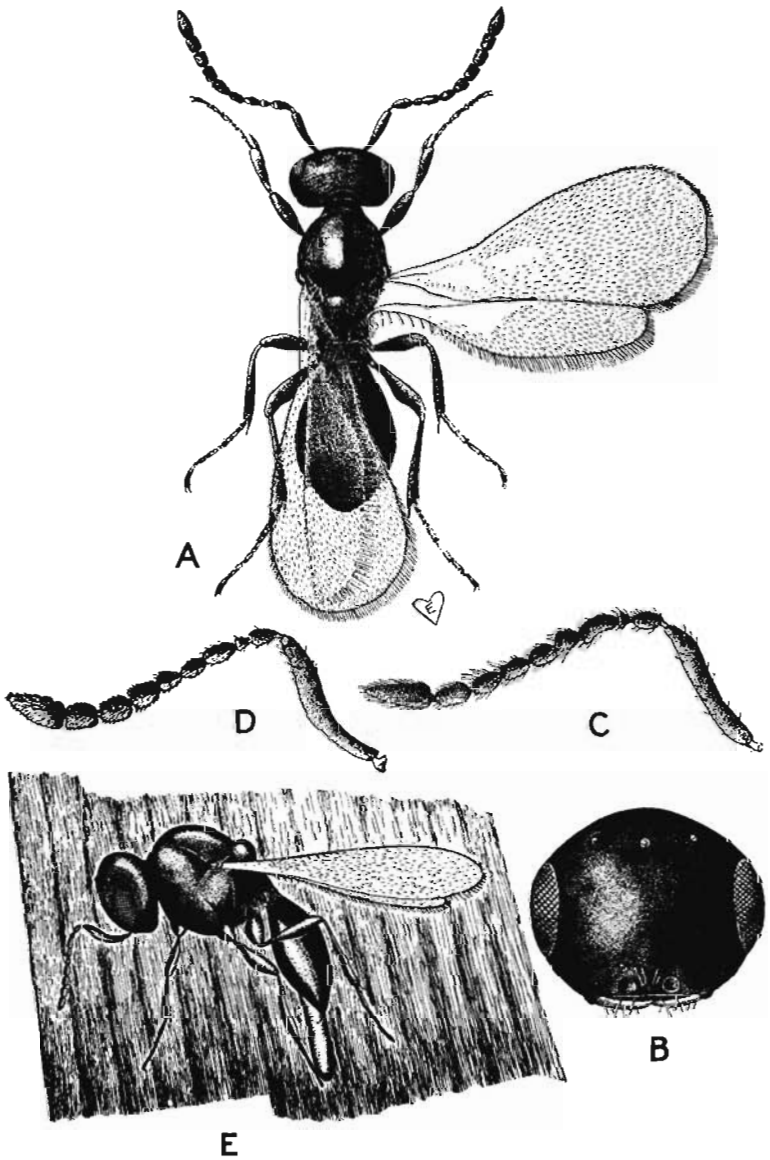

FIG. 5.—A, adult female; B, frontal view of head of adult; C, antenna of male; D, antenna of female; E, female ovipositing into Hessian fly egg on wheat leaf. All greatly enlarged

FEMALE REPRODUCTIVE SYSTEM

(Fig. 4, D)

The ovaries are ovoid, and sometimes, when distended with eggs, considerably elongated. The oviducts are slender and usually slightly longer than the ovaries and open into a two-lobed pouch at the base of the vagina. The spermatheca is spherical and is connected by a small neck close to the base of the vagina.

CERTAIN HABITS AND REACTIONS

The adults are very active and fly readily. When greatly disturbed they feign death. They will lap up water and the juices of a wheat leaf which has been bruised or broken, and will nip at the short pubescence on the wheat leaf. They show no tendency, however, to feed in any way on the host. They are positively phototrophic.

C. N. Ainslie, in unpublished notes on the nocturnal habits of some adults of this species which he had in confinement, made the following observations:

> As darkness came on they betook themselves to the shelter afforded by the groove on the wheat blade and there spent the night, hunched together in a compact fashion, the antennae folded down and the legs bunched. A strong electric light flashed on them at short range and held steadily near them failed to disturb them in the slightest. They were evidently fast asleep.

At the time of eclosion they bite a round or irregularly shaped exit hole through the cocoon and puparium (fig. 4, E). A few such holes in the host puparium usually suffice to permit all the adults within the host to escape.

LENGTH OF LIFE OF ADULT

In order to secure data on the duration of the adult stage, 120 females and 66 males were distributed into three lots and subjected to different conditions. Lot 1 included 28 females and 14 males placed without nourishment in small vials plugged with cotton and exposed to the air in the laboratory in a dry condition. Lot 2 contained 58 females and 34 males in small vials plugged with cotton, the plugged ends of which were inserted in a plaster block kept constantly saturated with water. The cotton absorbed sufficient moisture from the plaster block to supply water for ingestion. Lot 3 consisted of 34 females and 18 males kept in a saturated atmosphere in the same manner as lot 2, but provided with sugar solution for nourishment. The results are summarized in Table II. It will be seen that the greatest length of life was 18 days and 19 hours; that in each lot the average length of life of the female exceeded that of the male; and that the parasites left in a saturated atmosphere with sugar solution for nourishment had the longest average length of life, which amounted to 11 days 2 hours. The entire experiment was conducted under ordinary laboratory temperature which varied from 51° to 78° F., with an average temperature of 66° F.

TABLE II.—*Length of life of Platygaster hiemalis adults*

[Lot 1 was kept in a dry atmosphere with no nourishment accessible; lot 2 in a saturated atmosphere with water accessible for ingestion; and lot 3 in a saturated atmosphere with sugar solution for nourishment]

Lot No.	Female			Male			Total average longevity
	Number used	Longevity		Number used	Longevity		
		Maximum	Average		Maximum	Average	
		Days Hours	*Days Hours*		*Days Hours*	*Days Hours*	*Days Hours*
1	28	3 20	2 11	14	3 20	2 4	2 8
2	58	8 17	4 22	34	7 20	3 16	4 11
3	34	18 19	11 21	18	17 17	9 15	11 2

PARTHENOGENESIS

Various stages of *Platygaster hiemalis* were reared by the author under controlled conditions from unfertilized females, giving positive evidence of the ability of this species to develop parthenogenetically. It has also been observed from sectioned material that an impregnated female will deposit both fertilized and unfertilized eggs at a single oviposition.

SEX RATIO

From 8,476 adult *Platygaster hiemalis* reared in confinement from Hessian fly puparia collected in the field, 66 per cent were females and 34 per cent males. In a majority of cases both sexes developed in the same host, which may be accounted for by the occurrence of both fertilized and unfertilized eggs.

In this connection it is interesting to note that the percentage of females is considerably lower than Patterson (*9*) found for *Platygaster feltii* Fouts. In the latter species the percentage of females amounted to about 86, as compared with 66 in *P. hiemalis*. In the case of *P. vernalis*, however, the author (*3*) found that the percentage of males somewhat exceeded that of the females, the number of females being a little less than 49 per cent.

OVIPOSITION

Platygaster hiemalis oviposits in the eggs of the Hessian fly (fig. 5, E). The host eggs are cylindrical, and from 0.4 to 0.5 mm. long, and usually are found scattered over the upper surface of the leaves of the wheat plants.

When searching for Hessian fly eggs the parasite keeps her antennae vibrating rapidly against the surface of the leaf on which she is crawling, and swings her head slightly from side to side in order apparently to cover more area with her antennae. As soon as she identifies an egg she halts and with an increased rapidity of motion of her antennae, concentrates on the spot. Sometimes she seems to lose track of the egg for a moment, but when this happens she usually turns in small circles until she finds it again. When the egg is located she strokes it rapidly for a second or two with both antennae, and if satisfied with this preliminary examination, quickly draws up her abdomen so that the tip of the ovipositor touches the surface of the egg. At the same time she swings her body at right angles to its long axis and places the tarsi of the middle legs just beyond the ends of the egg. Thus poised, and with antennae held motionless in a downward position, she hurriedly slides the tip of her ovipositor from one end of the egg to the other as if to make sure of its position and character. If all is well she brings her ovipositor to a halt at about the middle of the egg and commences to insert it. In no case did the author see more than a small fraction of the length of the ovipositor inserted. The entire process from the time the parasite first locates the egg until the ovipositor is withdrawn requires about 45 seconds.

It is evident from the manner in which the female uses her antennae and ovipositor in the process of finding the host egg and ovipositing, that tactile reactions take place to a large extent. The author, however, has frequently observed the females of this species stop and

examine with their antennae the place on a wheat leaf from which a host egg had been removed, and even attempt to oviposit on such a spot. This appears to be a very evident case of chemotropism, and undoubtedly reaction of this kind plays an important rôle in the location of the host egg.

This species also shows a marked ability to recognize eggs in which it has once oviposited, and when retracing its course over a number of host eggs avoids piercing a majority of those previously attacked. In one instance a female, crawling over a leaf which bore 42 eggs, oviposited in 24 of them in fairly regular order on the first trip. On the return trip, however, two that had not previously been pierced were attacked, and only one that had been visited previously was pierced a second time, although she brushed them all with her antennae. In another case, 9 out of 11 eggs were pierced on a first visit, and on a second inspection of the same eggs only the two that had not been attacked before were selected. A. L. Ford, in unpublished bureau notes, recorded similar observations on 5 different females of this species. He noticed that on a return trip over an egg-strewn leaf they carefully examined all the eggs with their antennae, but only oviposited in those which had been overlooked on the first trip; and only after all the eggs had been punctured did he observe them pierce a host egg more than once. He also mentioned the fact that one female did not seem able to recognize the occurrence of oviposition by another female. C. N. Ainslie observed similar behavior in two females of this species which he had in confinement. He said:

> The two Polygnoti in the tube worked steadily for hours, attacking the eggs on the wheat blades, inspecting every egg they approached. Never, as near as I could judge, was the same egg attacked more than once, even under these abnormal conditions.

The number of eggs laid at a single oviposition varies from 1 to 8. From the examination of 81 hosts pierced by *Platygaster hiemalis* while held under observation under a binocular microscope, the author found an average of 4.22 eggs laid per deposition. This figure is conservative, owing to the difficulty in always recovering all the eggs laid.

PROLIFERATION

It has been shown by Leiby and Hill (*5*) that, in addition to the twinning and monembryonic development of this parasite in certain of the earlier stages, the parasites sometimes become aborted and pseudoforms are developed. In order, therefore, to calculate the effects of twinning and abortion in the proliferation of this insect, special observations were made. Facts justify the assumption that host eggs are seldom oviposited into more than once. Many hosts were collected from divers localities and records kept of the number of *Platygaster hiemalis* embryos found in each. Since it has been shown that the phenomena of twinning and abortion in embryo development occur very early in the growth of the parasite, the embryos observed at the time of examination had passed beyond the twinning stage. The abortion period likewise was past and the early cases of aborted eggs were not included in the records. Thus the figures obtained represent with considerable accuracy the number of developing embryos resulting from an average oviposition. Hosts

to the number of 2,220 were collected and dissected and an average of 7 embryos per host was found. Thus 7 healthy embryos may be assumed to develop from a single oviposition. The average number of adults, however, that succeed in emerging from a host was found to be 6.31 (*2*). This is slightly less than the number of embryos which develop, and shows a mortality of about 0.69 per host between the period from embryo to adult. In consideration of the fact that an average of 4.22 eggs are laid per deposition, it results that adults develop at the rate of 1.5 per egg.

Some latitude should be allowed for individual variation. The number of adults to emerge from a host was found to range from 1 to 16, and as many as 23 fully formed *hiemalis* cocoons have been found in a single host carcass.

The greatest total number of ovipositions made under the author's observation by an individual *Platygaster hiemalis* in confinement amounted to 160. These were all deposited in the course of 24 hours and there is no reason to believe that if sufficient host material had been available there would not have been many more laid. C. N. Ainslie reported observing one female of this species oviposit uninterruptedly on four successive days. At the rate of 4.22 eggs per oviposition there must have been a total of slightly over 675 eggs laid in the course of 160 ovipositions, which would have produced under normal conditions more than 1,000 adults.

POTENTIAL PROGENITIVENESS

In order to ascertain the full egg-laying capacity of *Platygaster hiemalis*, the ova contained in the ovaries of 10 individuals were dissected out and counted. (In this species the ova found in the adult stage are fully developed in size at the time of eclosion.) The results showed a maximum number of ova per individual of 6,336, a minimum of 1,675, and an average of 3,322. More eggs were sometimes found in one ovary than in the other of the same individual; the largest number found in any single ovary amounted to 3,671.[12] Assuming, therefore, that adults would develop at the rate of 1.5 per egg as figured above, the progeny from an average female, if she oviposited to her full capacity, would come to 4,983 adults. Deducting from this figure the 34 per cent which will develop into males, we have left a total of 3,289 females with the capacity of producing 20,819 adults [3,289 × 4.22 (eggs per ♀) × 1.5 (adults per egg)] for the following generation.

SEASONAL HISTORY

Throughout most of the eastern wheat-growing region of the United States *Platygaster hiemalis* has but one generation a year. The adults emerge in the fall, during the egg-laying period of the Hessian fly. They at once oviposit in the eggs of their host, and the embryos develop until cold weather sets in, causing them to remain dormant in this stage until the advent of warm weather late in the

[12] In counting these eggs a very high degree of accuracy was made possible by spreading the eggs from one ovary at a time over an ocular micrometer disc ruled into 1 mm. squares. In 1909 C. N. Ainslie dissected out both ovaries from a female of this species, broke them in water under a cover glass, and counted them through a high-power microscope. Two hours were spent in making an accurate count and the total number found came to about 3,600. The record, however, was never published. It will be observed that this count is very close to the average number of eggs found by the author.

spring. Although individuals sometimes pass the winter as very young embryos or as embryos considerably advanced in growth, the vast majority reach and remain at a certain point of development (fig. 2, D) characteristic of the hibernating stage of this species. This stage of growth has become so adapted to the habit of dormancy that such embryos are frequently encountered through the summer months. Most of them develop into free-living larvae during June and July. The contents of the host is then consumed and cocoons are formed. By the end of August most of the larvae have pupated and transformed into adults within their cocoons, where they remain until weather conditions are suitable for emergence and egg laying. Stray adults are occasionally found much earlier in the year, a fact which would indicate that precocious development sometimes takes place. In the spring-wheat region of northern New York the seasonal history of *P. hiemalis* is greatly modified and we find many adults emerging in the spring, which enables them to take advantage of the principal egg-laying period of their host in this region. Similar modifications in the seasonal history may occur in other parts of the United States where climatic conditions vary from those in the East. Figure 6

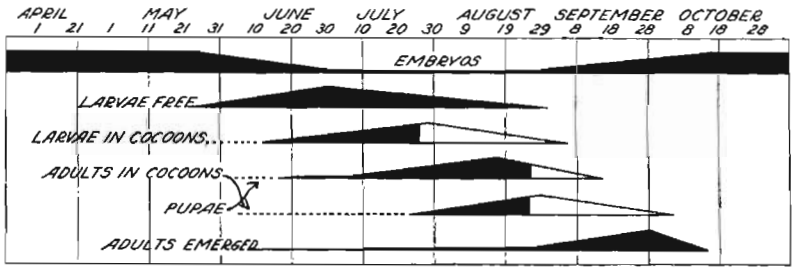

FIG. 6.—Diagram illustrating the seasonal history of *Platygaster hiemalis* in the vicinity of Carlisle, Pa. Dark areas show periods of occurrence and relative abundance of the various stages of life history as found by field observations. Light areas and dotted lines indicate probable occurrence of such stages

shows the average seasonal growth of the various stages of this parasite, based on data obtained in the vicinity of Carlisle, Pa., during the years 1918 to 1923, inclusive.

SUMMARY

Platygaster hiemalis is one of the most widespread and effective parasites of the Hessian fly in the United States. In the eastern wheat-growing regions it kills annually from 16 to 40 per cent of the fall generation of the fly, with an average yearly toll of 28 per cent.

The eggs are about 0.02 mm. long, subellipsoidal, and highly refractive. They develop polyembryonically by twinning, monembryonically, and some become aborted. The resulting yield in adults is a 50 per cent increase over the number of eggs deposited; and an average of 6 adults emerge from each host.

The larva is about 1 mm. long, and is white, ovoid, and bare of setae. During the larval stage the parasite consumes the contents of the host. Before succumbing to attack, however, the host usually succeeds in forming a darkened puparium.

Before pupating the parasitic larvae form ovoid, yellowish-brown cocoons. These are found packed closely within the cuticula of the host larva inside the host puparium.

The adult, which is about 1 mm. long and shiny black, is very active, flies readily, and is positively phototrophic. The female is able to reproduce parthenogenetically, and impregnated females usually deposit both fertilized and unfertilized eggs at a single oviposition. Approximately 66 per cent of the adults are females. The female deposits her eggs in the eggs of the host, and lays from 1 to 8 eggs at each oviposition. She seldom oviposits more than once in the same host. The ovaries of an average female contain 3,322 eggs.

Throughout most of the East *Platygaster hiemalis* passes the winter and early spring in the embryonic stage. During June and July it develops into free-living larvae, and by the end of August most of these have pupated and transformed into adults, ready to emerge from their cocoons during the oviposition period of the Hessian fly in the fall of the year.

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