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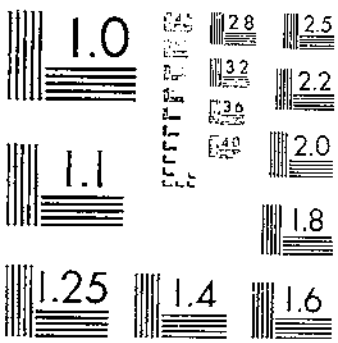

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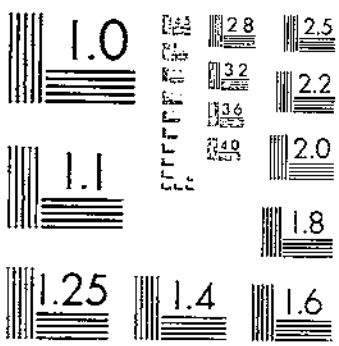

MICROCOPY RESOLUTION TEST CHART
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THE BIOLOGY OF CREMASTUS FLAVOORBITALIS (CAMERON), AN ICHNEUMONID PARASITE OF THE EUROPEAN CORN BORER

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INTRODUCTION

Cremastus flavoorbitalis (Cameron) is a larval parasite of the European corn borer (*Pyrausta nubilalis* Hbn.) in the Orient. It was first introduced into the United States in the winter of 1928–29 and was liberated during the summer of 1929 to aid in the biological control of the corn borer in this country. Recently imported stock has also been received at the Bureau of Entomology laboratory at Moorestown, N.J., and liberated in Pennsylvania as a parasite of the oriental fruit moth (*Grapholitha molesta* Busck).

C. flavoorbitalis is an ichneumonid parasite belonging to the subfamily Ophioninae. It was first described as *Tarytia flavo-orbitalis* by Cameron (*1*)[2] in 1907. In a recent paper by Cushman (*2*) it is shown that *flavoorbitalis* is the correct designation for this species and that the name *C. hymeniae*, first used by Viereck (*12*) and later by a number of other writers, is a synonym.

[1] The writers gratefully acknowledge their indebtedness to D. W. Jones, S. M. Dohanian, and A. M. Vance for their criticisms and helpful suggestions during the preparation of this bulletin, and to B. E. Hodgson and J. G. Pratt for the photographs.

[2] Italic numbers in parentheses refer to Literature Cited, p. 15.

The main purpose of this bulletin is to present descriptions of the immature stages of this insect, the results of studies of its biology, and information concerning the status of the species as a parasite of the European corn borer.

HOST RELATIONSHIPS

Under the name *Cremastus hymeniae*, *C. flavoorbitalis* is recorded by Viereck (*12*) as successfully reared from *Hymenia fascialis* Cram., the Hawaiian beet webworm, by H. O. Marsh in Honolulu.

Morley (*3, p. 506*) states that this insect is parasitic in India on *Euzophera perticella* Rag., *Antigastra catalaunalis* Dup., *Eucosma paragramma* Meyr., and *Chilo simplex* Butl.

The greatest number of hosts recorded for this parasite was compiled by Swezey (*6; 7, p. 13; 9*) in Hawaii. They are given below.

Phycitidae: *Genophantis iodora* Meyr. and *G. leahi* Sw.
Pyraustidae: *Omiodes blackburni* (Butl.), *O. accepta* (Butl.), *O. meyricki* Swezey, *O. monogona* Meyr., *O. musicola* Swezey, *O. localis* (Butl.), *Hymenia recurvalis* (Fab.), *Phlyctaenia stellata* (Butl.), *P. calcophanes* Meyr., *P. platyleuca* Meyr., *P. iocrosa* Meyr., *Phlyctaenia* sp., and *Chilo simplex* (Butl.).
Tortricidae: *Tortrix metallurgica* Walsm., *Epagoge infaustana* Walsm., *Capua santalata* Swezey, and *C. reynoldsiana* Swezey.
Eucosmidae: *Adenoneura falsifalcellum* Walsm., *Argyroploce illepida* (Butl.), *Crocidosema murcidellum* (Walsm.), *C. lantana* Busck, and *Bactra straminea* (Butl.).
Carposinidae: *Heterocrossa graminitrotor* Walsm.
Cosmopterygidae: *Batrachedra cuniculator* Busck and *Pyroderces rileyi* (Walsm.).
Tineidae: *Ereunetis minuscula* Walsm. and *E. flavistriata* Walsm.
Cygnodidae: *Petrochroa dimorpha* Busck.

Swezey (*8*) reports this insect as valuable in the control of the sugarcane leaf roller, *Omiodes accepta*, and the coconut leaf roller, *O. blackburni*.

Cushman (*2*) records that the national collection includes specimens of *C. flavoorbitalis* from Japan reared from *Pyrausta nubilalis* Hbn. and *Grapholitha molesta* Busck; from Hawaii from *Hymenia fascialis* Cramer and *H. recurvalis* Fab.; and from the Philippine Islands from *Crocidolomia binotalis* Zell.

The junior writer has bred this species under laboratory conditions from *Pyrausta nubilalis*, the European corn borer.

DESCRIPTIONS

ADULT

Cameron (*1, p. 589*) described the female of *Cremastus flavoorbitalis* in 1907 as *Tanylis flavo-orbitalis*. Morley (*3*) described both male and female of the species in 1913.

The following is a brief description of the adult, designed to distinguish it from other parasites of the European corn borer:

It has a slender, testaceous body with broad and rather abbreviated wings. The face is distinctly punctate, with the epistoma elevated and the clypeus distinctly discrete and apically margined.

Photographs of the adults are shown in plate 1, *A* and *B*.

EGG

The egg of *Cremastus flavoorbitalis* is elongate-ovoid or kidney-shaped, with both ends bluntly rounded. The chorion is smooth,

bearing no spines or external processes. It is pearly white. The average length is 0.513 mm, and the average width through the center of the egg is 0.167 mm (fig. 1). At the time of hatching the mature embryo is folded, jackknife fashion, within the chorion of the egg, i.e., the head and tail are bent forward on the remainder of the body within the shell.

The duration of the egg stage is 84 hours or 3½ days. (All statements concerning the duration of the various stages of this insect are based on observations made at a constant temperature of 80° F. and a constant relative humidity of 70 percent.)

LARVA

Three instars of the larva of *Cremastus flavoorbitalis* have been observed by the writers. Their descriptions follow.

FIRST INSTAR

The primary larva of *C. flavoorbitalis* is of the caudate or tailed type. It has a heavily sclerotized, testaceous head. The body is divided into 13 segments. The last abdominal segment is developed into a long, narrow, tapering tail. The body is creamy white and has no spines or hairs. The first instar lasts 5 days. During this period the body changes markedly in appearance and in size. The head, however, remains the same throughout these changes.

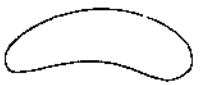


FIGURE 1.—Egg of *Cremastus flavoorbitalis*, ×50.

One day after hatching the larva has an average length, including the tail, of 1.3 mm and an average width at the widest part of the body of 0.15 mm. The length of the tail is approximately half the entire length of the body and presents a ruffled or uneven appearance. Each of the 12 remaining body segments has a double row of "scallops" running around the body in the middle of each segment (fig. 2, *A*). Apparently this structure permits the body to expand more readily.

The 2-day-old larva (fig. 2, *B*) measures 2.5 mm in length and 0.19 mm in width. The tail is still approximately half the entire length of the body. The remaining body segments are nearly smooth, having only vestiges of their ruffles.

At the time of molting into the second instar, 5 days after the hatching of the egg, the larva (fig. 2, *C*) averages 3.6 mm in length and 0.31 mm in diameter. The tail is now about one-third the entire length of the body. The body segments have become expanded to their maximum size, leaving no trace whatsoever of the scalloped appearance that was in evidence earlier.

In the first instar the larval head is testaceous, heavily sclerotized, somewhat thimble-shaped, and has on the dorsal surface two grooves originating at the posterior boundary of the head and running anteriorly about three-fourths of its length. A slight ridge on each side of the head extends posteriorly from the insertion of the mandibles. On the dorsal portion of the head between the grooves there are no spines or sensory hairs (fig. 3). Laterally (fig. 4) there are seven pairs of small spines on the head: One spine (*a*) at the anterior end of the head about one-half the distance between the mouth parts and the end of the dorsal groove; one spine (*c*)

slightly ventrad and slightly caudad of the anterior end of the dorsal groove; a group of three spines (*b*, *d*, *f*), which might be connected by a curve, midway between the mandible and the dorsal

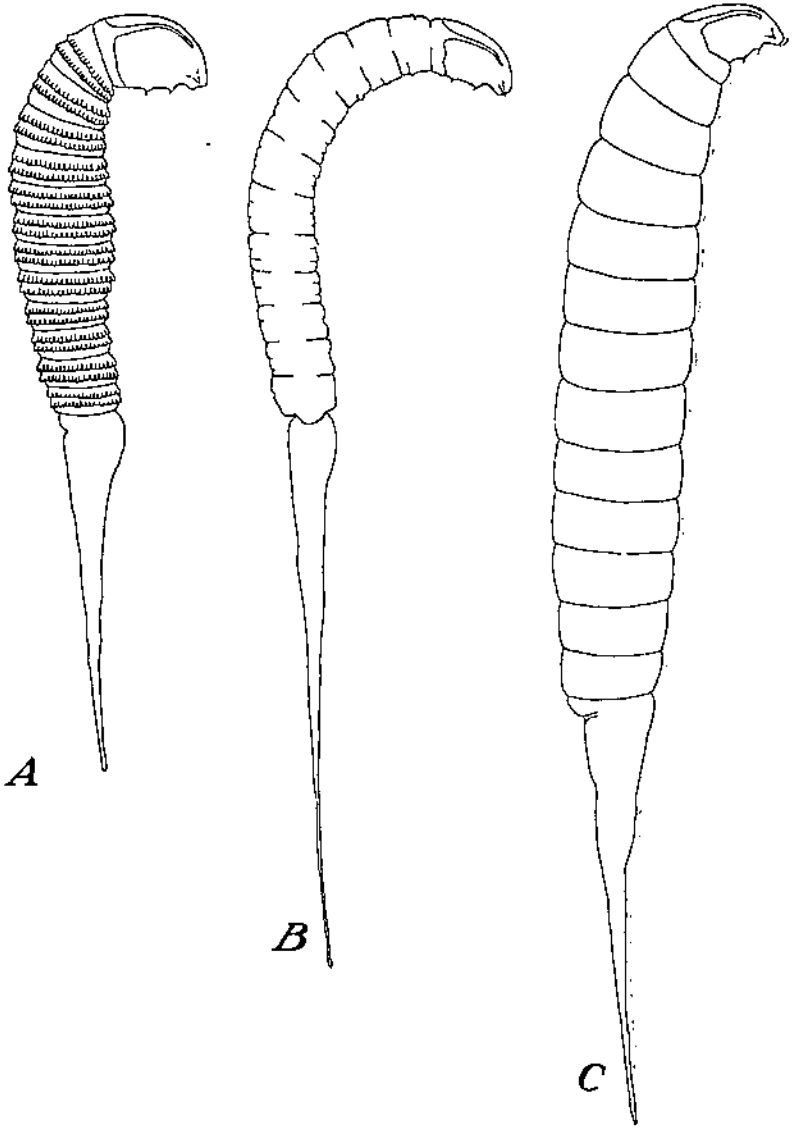


FIGURE 2.—First-instar larva of *Cremastus flavoorbitalis*: *A*, Larva 96 hours after oviposition, showing annular rings, ×75; *B*, larva 144 hours after oviposition, ×45; *C*, larva 240 hours after oviposition, ×30.

groove; one spine (*h*) in a caudad-central position near the lateral ridge; and one spine (*k*) in a central-posterior position. The ventral surface (fig. 5) supports three pairs of small spines and one pair of large spines. One pair of spines (*e*) is situated on the

anterior portion caudad of the mouth parts and is separated by about the width of two mandibles. Another pair (*g*) is midway on the head and is separated by the width of one mandible. The third pair (*i*) is on the posterior part of the head and is separated by a distance twice as great as that between the preceding pair. The large spines (*j*) are situated immediately caudad of the third pair of small spines and are separated by the same distance. These large spines are set on tubercles.

First-instar larvae of *C. flavoorbitalis* possess distinctly defined mouth parts. The entire mouth-part structure is circular in shape (fig. 6, *A*). The labral region is semicircular and has within its borders several areas that are but thinly sclerotized. One large area within the labral region is located in a dorsal position. Laterad and slightly ventrad of this are two smaller areas within the labral structure. Supplmentary to these are eight minute similarly constructed areas. There are no spines or hairs. In the oral cavity there are two large spines. The maxillary and labial region consists of two pairs of triangular structures, their apices directed toward the center of the oral cavity. The mandibles are simple, strongly curved, and rather sharply pointed. The mandibular condyle is well developed (fig. 6, *B*).

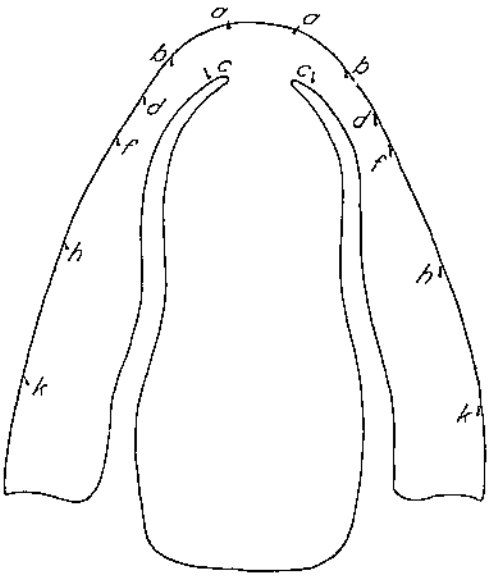


FIGURE 3.—Dorsal view of head of first-instar larva of *Cremastus flavoorbitalis*, showing placement of spines.

SECOND INSTAR

The larval period of the second instar lasts but 1 day. The parasite, however, is markedly different in appearance from what it was during the first instar. It measures on the average 3.8 mm in length and 0.7 mm in width. The head has become rounded and is very thinly sclerotized. The tail has been reduced to a very short robust process (fig. 7, *A*). The mandibles are very lightly sclerotized and are less strongly curved; they are nearly triangular and stout (fig. 7, *B*).

THIRD INSTAR

The mature or third-instar larva of *Cremastus flavoorbitalis* measures 8.2 mm in length and 2.05 mm in width and is dirty white. The body consists of 13 segments. The spiracles are situated on the first thoracic and the first eight abdominal segments. The wing buds are visible on the mesothoracic and metathoracic segments, and the leg buds are visible through the wall of the three thoracic seg-

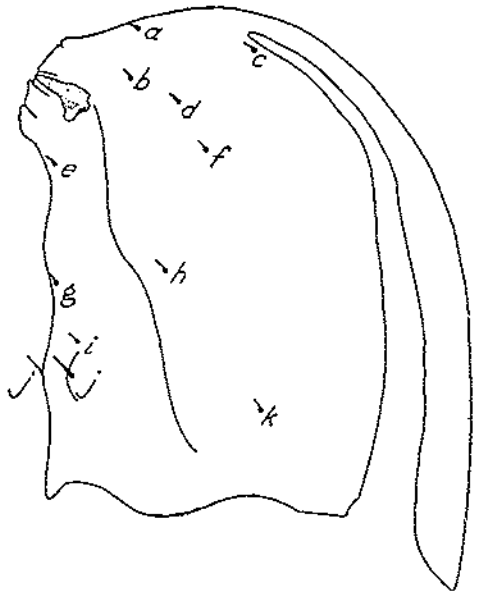


FIGURE 4.—Lateral view of head of first-instar larva of *Cremastus flavoorbitalis*, showing placement of spines.

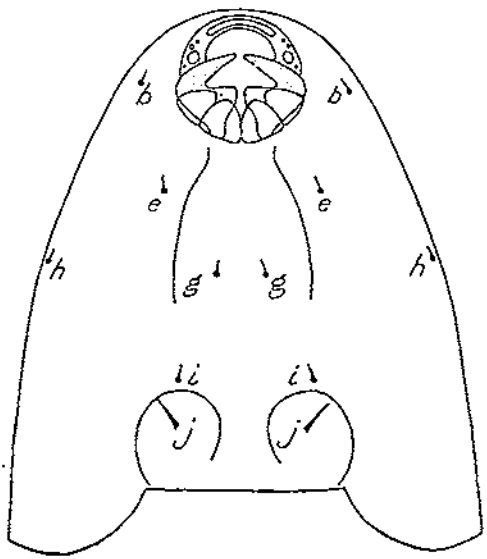


FIGURE 5.—Ventral view of head of first-instar larva of *Cremastus flavoorbitalis*, showing placement of spines.

ments. The cuticle is void of spines or other large processes, but is composed of many fine tubercles. The tail is still further reduced (fig. 7, *C*).

The terminology used in this bulletin in relation to the nomenclature of the structures of the head follows that of Vance and Smith (*11*). The detailed description follows.

Head hemispherical, thinly sclerotized, generally creamy white in color, and covered with many short protuberances; antennal fossae large, lightly sclerotized; metopic suture present; frontal region not well differentiated into a labrum; bilobed near oral cavity; two labral sensillae present; four papillae on frontal region, two dorsolaterad of the sensillae, two on the lobes in the oral cavity; superior pleurostomal ramus short, lightly sclerotized and lightly pigmented, brown; genal region possessing six regularly arranged setae; hypostoma heavily sclerotized, deeply pigmented, brown, blunt at lateral end, narrow, becoming wider at junction of stipital sclerome and inferior pleurostomal ramus; inferior pleurostomal ramus short, narrow, becoming wider at juncture of hypostoma and stipital sclerome; stipital sclerome narrow, becoming wider at junction with hypostoma; maxillary sclerome curved, blunt, heavily sclerotized, brown, thick near inner end, suddenly becoming thin, connecting with hypostoma at lateral end; maxillary region possessing a palpus and two definitely arranged setae; silk duct opening U-shaped, lying directly ventrad of oral cavity; one pair of labial palpi and two pairs of setae present in labial region, which is surrounded by a thickened border; border heavily sclerotized in dorsal portion, becoming less so at ventral portion; three definitely arranged setae present on labiobase on each side of thickened border (fig. 8); mandible simple, sickle-shaped, bearing no spines or teeth (fig. 7, *D*).

The third larval instar is 2 days in duration.

COCOON

The cocoon of *Cremastus flavoorbitalis* is oblong oval in shape and on an average measures 8.85 mm in length and 3.34 mm in width. There is, however, a marked variation in the dimensions of cocoons, the range being from 7 to 10 mm in length and from 2.5 to 4 mm in width. The coloration of the cocoon is not constant, as it varies from tan to dark brown. In most cases there is a lighter narrow band about the middle. Some cocoons, however, are without this faint marking. The cocoon (pl. 1, *D*) is enveloped in a loose but finely woven silk sheath (pl. 1, *E*). The average length of the period spent in the cocoon is 10 days.

PREPUPA AND PUPA

Cremastus flavoorbitalis spends the first 3 days of its cocoon existence as a prepupa of the usual hymenopterous type.

At the time of molting, the pupa is nearly white, with the exception of the darkened eye spots. In the course of several days the pupa darkens, and a few days before eclosion it takes on the markings and general appearance of the adult insect. The male pupa is generally smaller than the female. The ovipositor of the female extends beyond the tip of the abdomen and lies flat against the dorsal surface.

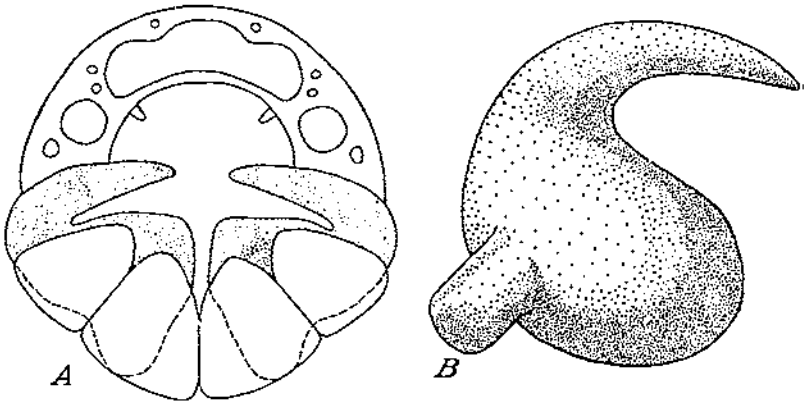


FIGURE 6.—*A*, Mouth-part structure of first-instar larva of *Cremastus flavoorbitalis*; *B*, mandible of first-instar larva.

BIOLOGY

HATCHING, GROWTH, AND DEVELOPMENT

While instances have been noted in which as many as five eggs of *C. flavoorbitalis* have been deposited in a single host, in no case has more than one larva of the parasite been known to develop beyond the first instar. The mechanics of this mortality of the supernumerary individuals is not known. However, in the case of these larvae, phagocytosis usually takes place immediately after they have hatched from the eggs. This condition was reported by Thompson and Parker (*10*) in connection with *Eulimeria crassifemur* (Thomson), another ichneumonid parasite of the European corn borer. It is

thought that in the case of *Aphidius* larvae (*5*) the first parasite to emerge from the egg emits a cytolytic enzyme that affects the younger larvae as well as the tissues of the host itself, thereby eliminating the extra individuals. Muesebeck and Parker (*4*, *p. 344*), in connection with *Hyposoter disparis* Viereck, a parasite of

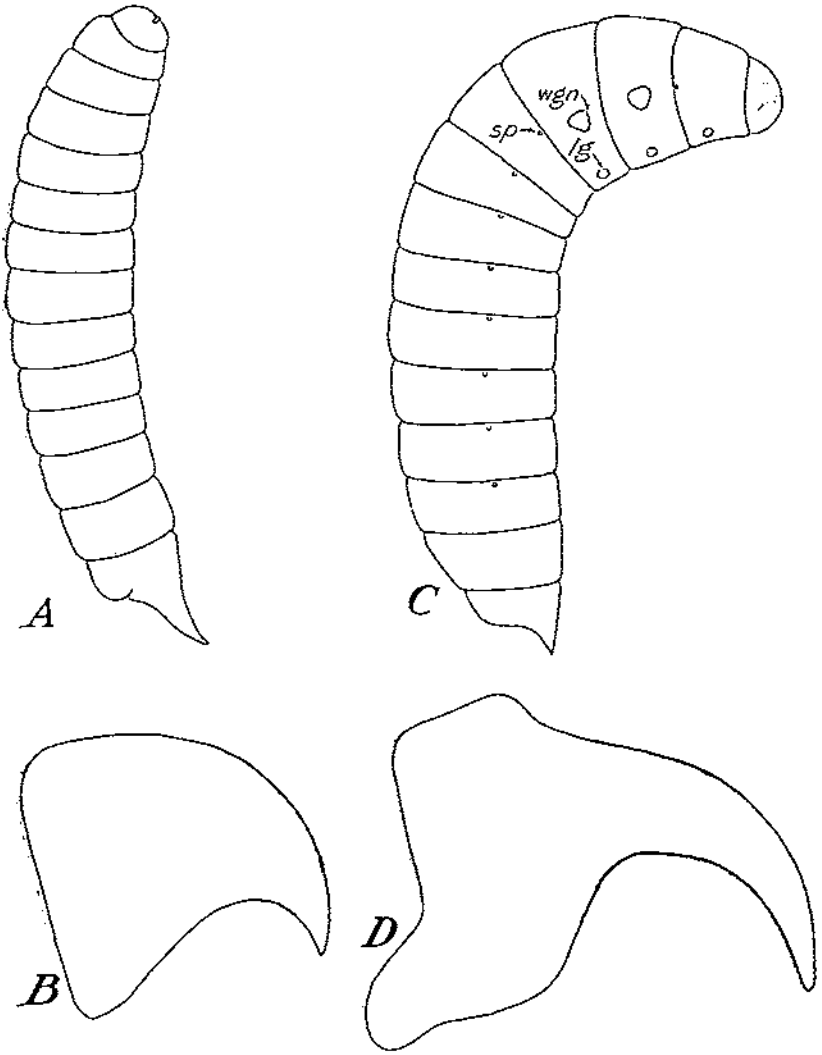


FIGURE 7.—Second- and third-instar larvae of *Cremastus flavorbitalis*: *A*, Second-instar larva, ×20; *B*, mandible of second-instar larva; *C*, third-instar larva, ×8; *lg*, leg bud; *wgn*, wing bud; *D*, mandible of third-instar larva.

the gypsy moth, suggest that the egg or larva dies apparently before encystment occurs because the medium in which the parasite finds itself is not altogether suited to its development.

The egg floats freely within the body cavity of the host and hatches after 3½ days. The presence of the larval parasite in the body of

A

B

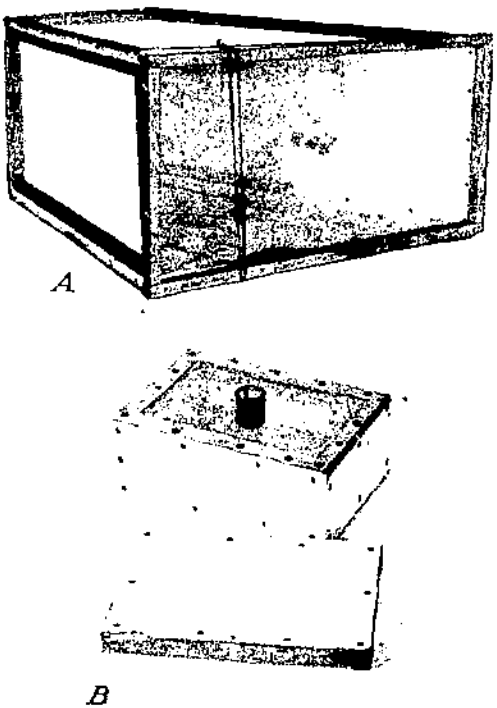
C

D

E

ADULTS, LARVA AND COCOONS OF CREMASTUS FLAVOORBITALIS

A, Adult male, ×5. B, Adult female, ×5. C, Third-instar larva of parasite after issuance from a larva of *Pyrausta nubilalis*, with remains of host, ×5. D, Cocoon, with silken sheath removed, showing exit hole of adult, ×5. E, Cocoon with attached head capsule of host larva, ×5.



CAGES USED IN EXPERIMENTS WITH CREMASTUS FLAVOORBITALIS.

A, Cage used for mating studies. *B*, Cage used for oviposition studies.

the host seemingly has no effect on the physical condition of the borer while the parasite is small. For 5 days the larva remains in this instar, changing in body form, as has been indicated elsewhere in this bulletin. The second instar lasts but 1 day. One day after the parasite has molted into the third instar, the host larva spins a loose web, attaching itself to any convenient surface, and reclines in a characteristic hammocklike position and remains quiescent. It then begins to darken at both ends, and this blackening steadily progresses toward the center of the larva. When the host has become completely darkened, usually 2 days after the molt of the parasite into the third instar, the *Cremastus* larva makes its first appearance on the outside,

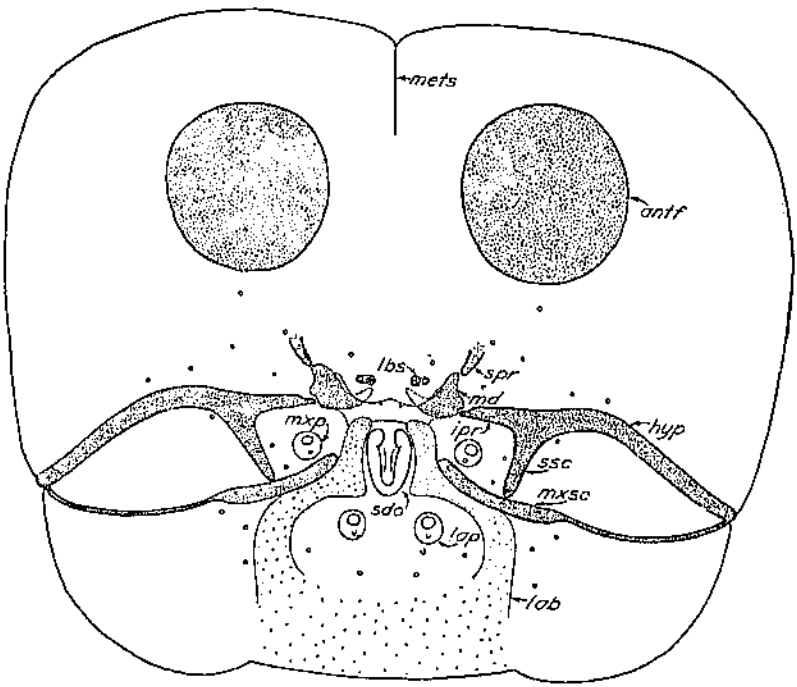


FIGURE 8.—Head structure of third-instar larva of *Cremastus flavoorbitalis*: *antf*, antennal fossa; *hyp*, hypostoma; *ipr*, inferior pleurostomal ramus; *lab*, labiobase; *lap*, labial palp; *lbs*, labral sensillae; *md*, mandible; *mets*, metopic suture; *mxp*, maxillary palp; *mxsc*, maxillary sclerome; *sdo*, silk duct opening; *spr*, superior pleurostomal ramus; *ssc*, stipital sclerome.

emerging through a hole in the middle of the host. There is no external feeding.

European corn-borer larvae parasitized by *Cremastus flavoorbitalis* are usually smaller than the nonparasitized larvae, at least a few days prior to the issuance of the parasite larva from the host. Head measurements of larvae after the parasite had left the body would seem to indicate that the host larvae were in the fourth instar. This is probably incorrect. In the case of larvae parasitized by *Chelonus annulipes* it was found that the head capsules were distinctly smaller than those of nonparasitized larvae of the same instar. It is possible to assume, then, that the host larvae are in the fifth instar at the time that the parasites issue from the hosts.

The larva immediately upon issuance (pl. 1, *C*) begins to spin a cocoon, cementing it to any nearby surface. The head capsule and the dried-up body of the host larva (pl. 1, *E*) are usually attached by a few loose threads. When the operation of cocoon spinning is completed, the parasite is in the prepupal stage and stays as such for 3 days; then it expels the larval meconium and molts into a typical white hymenopterous pupa. The pupa gradually develops and darkens for 7 days, at which time the adult sheds the pupal skin, chews an irregular hole at one end of the cocoon (pl. 1, *D*), and emerges.

At Kobe, Japan, C. A. Clark [3] found that in the laboratory the life cycle was about 26 days in July and August.

Adults were kept in wooden cages, each cage containing a piece of lump sugar, fastened to a glass slide by means of a drop of melted beeswax. (The cages when not in use were kept in a cool cellar and covered with moist burlap.)

The maximum recorded longevity of *Cremastus* adults under laboratory conditions was 66 days. The average longevity was 38.78 days.

HABITS OF THE ADULT

The adult of *Cremastus flavoorbitalis* is quite positively responsive to light, is very active, and exhibits a restless temperament. When several adults are placed in a cage, especially if it is small, their activities in trying to escape are very pronounced. In several instances in mating studies, adults were introduced into a specially prepared cellophane cage, but their efforts to beat their way through the sides of the structure were so frantic that the use of these cages had to be abandoned. When first introduced into cloth-covered cages, although noticeably irritable, they calm down in a few minutes and content themselves with incessant ramblings over the end of the cage nearest the light. At temperatures below 70° F. they are quiescent and do not become active until the temperature rises above that point.

The adults will feed on sweetened water, honey, or invert sugar, such as glucose.

MATING

In the rearing of *Cremastus flavoorbitalis* in the laboratory, the problem of mating in captivity was the most difficult one encountered. Many attempts were made to overcome this so that it might be possible to rear this parasite in large numbers.

Matings were secured in abundance on only one occasion, on July 2, 1931. At that time 75 males and 65 females were introduced into a cloth mating cage. This cage (pl. 2, *A*) is 9 inches in height, 18 inches in width at the open end, and 18 inches in length, tapering toward the front or closed end, which is 9 by 9 inches. The open back is equipped with a 9- by 18-inch celluloid-covered frame, which is held in place by elastic bands.

The cage was placed on a table in a third-story room, so that the small end was facing a closed window and no direct sunlight shone

[3] C. A. Clark, assistant entomologist, Bureau of Entomology, United States Department of Agriculture, was in charge of European corn borer parasite investigations in the Orient from the fall of 1930 to the spring of 1932.

on the cage. The temperature inside the cage was 74° to 76° F. On the outside it was 82° F. This cage was dampened, and sand was placed in the bottom of it, before the parasite adults, which were 2 days old, were introduced. Almost immediately after admission to the cage, the parasites began to show some attraction for each other, although this had not been observed before. When the cage had become nearly dry, one mating occurred. The sides of the cage were again moistened with a sprayer and a stream of air allowed to enter the rear of the cage in such a way that the insects received only a part of the effect of the breeze. This aeration was continued for 5 minutes and then stopped. For 5 or 10 minutes thereafter matings occurred in such rapid succession that it was extremely difficult to remove the mated females.

Experiments were made to discover whether foods other than sugar, different temperatures, different lights, or different times of day had any effect on the mating of *C. flavoorbitalis*, but only occasional matings occurred.

The mating preliminaries are very brief and mating itself lasts from 1 to 5 minutes. During mating a pair may be greatly disturbed without the act being interrupted.

D. W. Jones, of the Arlington, Mass., laboratory, states that *Cremastus flavoorbitalis* sometimes mates very readily immediately after the cover of the liberation can has been removed and the insects have flown out into the open. This experience suggested that perhaps the insects would mate if they were not confined to a small place, but observations of specimens in the emergence cages, which have a screen area of approximately 32 square feet, indicated that apparently this had no bearing on the problem. What the determining factor is that controls the mating instinct in this particular parasite is problematical.

OVIPOSITION

The cage (pl. 2, *B*) used in this study of oviposition consists of a wooden framework 2 by 4 by 5½ inches, covered with cloth on the sides. The top is of celluloid and contains a hole in the center, which is closed with a stopper. The bottom, which is detachable, consists of a 4- by 5½-inch wooden frame on which either cloth or celluloid has been tacked. The celluloid-covered bottom is considered more satisfactory because the borers do not make holes in it as readily as they do in cloth. This whole equipment is held together by means of elastic bands.

The cage was prepared for use by placing a thin layer (one-eighth inch) of finely diced peas on the detached bottom of the cage. It was then fastened together with the bands, care being taken that the peas remained in their original position. Ten-day-old incubator-reared host larvae were then inserted through the opening in the top of the cage and the stopper was replaced. This whole equipment was placed in the incubator (regulated for 80° F. and 70 percent relative humidity) overnight to allow the borers to become webbed up in the peas. It is possible to prevent the wandering of the larvae from the pea stratum on the bottom by placing the cage in a glass-bottomed cabinet so that the light reaching the cage comes through the bottom only.

The following morning the cage was removed and five mated *Ormastus* females were introduced into it through the entrance hole in the top. At this time the host larvae were in the fourth instar. The cage was then placed on a table near a window or on a window sill in such a way that the light reached the inside of the cage through the bottom.

Almost immediately upon their entrance to the cage the parasite females begin to crawl about the webbed-up peas and dry frass, intensely interested in what lies beneath. During this meandering they continually beat the peas with their antennae and prod here and there with their ovipositors. An ovipositing female has been observed to prod a webbed-up, frass-covered pea, from which the borer had escaped, just as readily as one that contained a borer, whereas a free-crawling borer rarely incited her curiosity. However, a few cases have been noted in which oviposition apparently has taken place in free-crawling larvae. When the parasite locates a corn-borer larva in its webbing she stabs it but once with her ovipositor. All of the ovipositions noted were made in the thorax of the host larva immediately behind the head capsule. After accomplishing oviposition the parasite walks away, continually beating and prodding in search of another victim. The attacked borer thrashes its head back and forth, apparently in a vain effort to rid itself of the parasite egg.

Oviposition experiments were tried on the fall webworm (*Hyphantria cunea* Drury), the pitch-pine webworm (*Tetralopha robustella* Zell.), and several undetermined webworms and borers, with no success.

SEX PROPORTIONS

The proportion of sexes in *C. flavoorbitalis* in samples of material sent from the Orient for parasite liberations in this country, covering a period of 2 years, is 62.1 percent females and 37.9 percent males. On the other hand, in material bred in the laboratory the percentages are about reversed, there being 68.5 percent males and only 31.5 percent females. The latter figures are based on material that was reared from apparently mated females. It is thought that this situation might arise through the difficulty in mating the parasite in captivity, since unfertilized females produce males only.

SEASONAL HISTORY

This parasite was shipped from the Orient to the Arlington, Mass., corn-borer laboratory during the winter as well-developed first-instar larvae within the mature corn-borer host larvae. These shipments reached this country under refrigeration in the ship's vegetable storage room, where the temperature range was 35° to 40° F. During the remainder of the winter they were stored in an underground cellar, where the temperature range was 32° to 45°, later gradually rising to nearly 55°, when the use of ice became necessary to keep the temperature below this point. The relative humidity in this cellar was kept above 90 percent.

On March 7, 1932, a sample lot was taken from refrigeration to determine the development of the species in the United States at Arlington, Mass. Dissections were made biweekly until the first of June, after which time they were made every other day. All dissections made before July 1 showed the parasite larvae to be in the

first instar. In July, however, all stages of development (first-, second-, and third-instar larvae, cocoons, and adults) were found in the material, showing that the stages beyond the first larval instar are so short in overwintering *Cremastus* that it would be possible to find all stages in the field at one time after they had started to develop.

It is not definitely known how many generations occur or when hibernation begins. C. A. Clark says:

> Winter is usually passed as immature larvae inside the overwintering corn-borer larvae, but apparently a small number pass the winter in the cocoon stage. Examination of a number of cocoons collected in the field in the Kokubu section in February 1932 proved that not all of the individuals of this species were in the host larvae. Most of the cocoons were empty, the adults probably having emerged in the late fall months, but a few live *flavoorbitalis* larvae were found, as well as one live pupa (February 18, 1932). The first spring cocoons were found on May 3 in Miyakonojo section in 1931 and by the middle of May cocoons became numerous in the fields here. In Kumamoto section a full spring generation of the parasite has been passed on *nubilalis* larvae by the end of June. Hyperparasites * * * somewhat reduce its effectiveness * * *. The parasite is usually recovered in numbers from overwintering borers in millet and from first summer-generation borers on hemp on Kyushu Island. It seems to be most important in the spring, but other species (*Macrocentrus gifuensis* Ashm. and *Ceromasia lepida* Meig.) apparently take its place later in the summer.[4]

DISTRIBUTION

Cremastus flavoorbitalis is widely dispersed in the Orient. It is known to occur in Banjo in the northern part of the peninsula of Chosen; in Kumamoto, Oita, Miyazaki, Kokubu, and Kagoshima, on the island of Kyushu; in Tokushima on Shikoku Island; at Chiba, Tochigi, Utsunomiya, and Hiroshima, on the largest island of Japan, Honshu.

Cremastus flavoorbitalis is of most importance in Kumamoto, Kokubu, and Miyakonojo sections, but is also found in considerable numbers in Utsunomiya and Hiroshima sections, where it is of some value as a *nubilalis* parasite. It seems to be of particular importance as a parasite in Kumamoto section, where parasitization of over 30 percent has been recorded, though the average parasitization is considerably lower than this.

It has been recorded (*3*) in India from Pusa, Chapra, and Katihar, Bengal; Deesa and Surat, Bombay; Quilon and Travancore, Madras; Trincomali and Peradeniya, Ceylon; and Bhamo, Burma. Specimens were also taken on shipboard 4 miles off Tuticorin and 10 miles off Coconada, Madras coast.

There are specimens in the national collection (*2*) from Japan, Hawaii, and the Philippines, and in the Baker collection from Singapore.

This species was probably introduced into Hawaii, as it was unknown there until 1910 (*7*). It appeared first in the lowlands but has now spread to the mountains and all over the island of Oahu.

This parasite has been liberated in the United States and Canada. The names of the places, the seasons of liberation, and the number of parasites released, are given below.

Massachusetts: Arlington, 1930, 2; 1932, 15; total, 17. Saugus, 1929, 220; 1930, 371; 1931, 18; total, 609. Bridgewater, 1931, 1,660; 1932, 1,488; total, 3,148. Swansea, 1932, 1,668. Medford, 1932, 593. Peabody, 1932, 705.

[4] From Clark's unpublished report on corn-borer work in the Orient.

Rhode Island: East Providence, 1929, 116; 1930, 16; total, 132. Portsmouth, 1932, 522; 1933, 360; total, 882.
Connecticut: East Lyme, 1929, 25; 1930, 93; 1931, 203; 1932, 315; total, 636.
Ohio: Jerusalem Township (Lucas County), 1932, 2,321; Damascus Township (Henry County), 1932, 2,824.
New York: Glenville, 1930, 276; Jamesport, 1933, 141; Eastport, 1933, 92.
Ontario, Canada: Belleville, 1932, 1,371; 1933, 160; total, 1,531.
Total by States and Provinces: Massachusetts, 6,740; Ohio, 5,145; Rhode Island, 1,014; Connecticut, 636; New York, 509; Ontario, 1,531. Grand total, 15,575.

In 1931, 141 *Cremastus flavoorbitalis* were sent from Japan to Guam but probably were not liberated.

The first recovery of this species in the United States was made at Saugus, Mass., in 1929. It was also taken at Providence, R.I., the same year. In 1931 the species was taken at Bridgewater, Mass. In 1932 it was recovered in Lucas County, Ohio, and in fair numbers in the greater Boston area, showing successful initial establishment.

SUMMARY

Cremastus flavoorbitalis (Cameron) is an oriental ichneumonid parasite of the European corn borer. In Hawaii it has a large number of hosts and is instrumental in the control of the coconut leaf roller and the sugarcane leaf roller.

The adult is a yellowish wasplike insect about one-third of an inch in length. The egg is pearly white, elongate-ovoid, and bears no spines or external processes. The duration of the egg stage is 3½ days. The first larval instar lasts 5 days. The primary larva has a long tail. One day after hatching the larva presents a ruffled or "scalloped" appearance, two rows of scallops to every segment. One day later this ruffle has nearly disappeared, and on the fifth day it has disappeared entirely, and the body has become robust. The head of the first-instar larva is thimble-shaped and bears several well-defined spines and setae. The mouth parts are well developed. The second larval instar lasts but a day. The tail has been reduced in length to become a very short process. The head is rounded and thinly sclerotized. The mandibles are triangular and lightly sclerotized. The mature larva has 13 body segments. Spiracles are found on the first thoracic and first 8 abdominal segments. The tail is still further reduced. The head and mouth parts are well differentiated. Mandibles are simple and sickle-shaped. This instar lasts 2 days. The cocoon is usually grayish tan with a lighter band about the middle. It is enveloped in a finely woven silk sheath. The time spent in the cocoon is 10 days. During the first 3 days of this period the insect is a prepupa. The newly formed pupa is nearly white.

The egg is laid in the body of the host larva and floats freely within its walls. While as many as five eggs may be deposited, only one develops beyond the first stage. One day after the parasite molts to the third instar the host larva spins a loose web, attaches itself to a convenient surface in a characteristic hammocklike fashion, and commences to turn dark from the ends toward the middle. The *Cremastus* larva makes its appearance through a hole in the middle portion of the host during the late fifth instar of the host. The parasite larva immediately begins to spin its cocoon.

After shedding its pupal skin, the adult emerges through an irregular hole at one end of the cocoon. The adult is positively phototropic, very active, and very restless. Adults fed on sweetened water, honey, or glucose. The maximum recorded longevity is 66 days. The insect does not mate readily in captivity. Females oviposit readily in spun-up corn-borer larvae of the fourth or early fifth instar. Ordinarily they do not deposit eggs in free-crawling borers.

Parasites reach this country in the winter as well developed first-instar larvae within the overwintering borers. Under natural conditions they emerge as adults during the first part of July at Arlington, Mass.

Cremastus flavoorbitalis is widely dispersed in the Orient. It is found quite generally in the Hawaiian Islands. It has been liberated in sections of Massachusetts, Rhode Island, Connecticut, New York, Ohio, and Ontario, and has been recovered from the greater Boston area in Massachusetts, from Providence, R.I., and from Lucas County, Ohio.

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