BIOLOGY AND ECONOMIC IMPORTANCE OF ANASTATUS SEMIFLAVIDUS, A RECENTLY DESCRIBED EGG PARASITE OF HEMILEUCA OLIVIAE

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INTRODUCTION

Adults of the recently described egg parasite Anastatus semiflavidus Gahan were first reared from eggs of the New Mexico range caterpillar, Hemileuca oliviae Ckll., during the progress of experiments to determine methods for the economic control of that destructive pest.

These rearings were made by F. H. Gates from Hemileuca oliviae eggs collected in the vicinity of Koehler, N. Mex., during June, 1913. For several years prior to this date extensive egg collections in the same vicinity and throughout the infested area had failed to reveal the presence of any egg parasite of H. oliviae. It is assumed from the foregoing that, just before the period during which these negative collections were made, some severe and unusual climatic condition had reduced the numbers of the parasite to such an extent that its presence was not discovered at that time. Since its discovery in 1913 the parasite has appeared in increasing numbers each year until it now exerts a powerful influence in the natural control of its host.

DISTRIBUTION OF THE PARASITE

Egg collections made during the autumn of 1915 and the winter and spring of 1916 demonstrated that the parasite was widely distributed in that part of northeastern New Mexico which was heavily infested by the range caterpillar. Adults were reared from the following localities in that section: Maxwell, Brackett, Nolan, Las Vegas, Springer, Chico, Cimarron, Mora, Watrous, Miami, Colfax, Folsom, Wagon Mound, Vermejo, Koehler, Colmor, Taylor, Levy, Roy, Mills, and Clayton.

1 The observations detailed in this paper were made principally at the United States Range Caterpillar Camp near Koehler, N. Mex., and at the United States Entomological Laboratory, Maxwell, N. Mex., V. L. Wildermuth, F. H. Gates, W. F. Schlupp, and H. E. Smith assisted in securing the data herein presented.


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CLASSIFICATION AND DESCRIPTION

_Anastratus semiflavidus_ belongs to the hymenopterous superfamily Chalcidoidea, family Encyrtidae, and subfamily Eupelmidae. It was described as a new species by A. B. Gahan, of the Bureau of Entomology, from type specimens reared from _Hemileuca oliviae_ eggs by F. H. Gates at Koehler, N. Mex. Mr. Gahan's description of the adult follows.

ADULT

_Anastratus semiflavidus_, new species. **Female [Pl. 68, A].—**Length, 2.3 to 2.5 mm. Head strongly punctate; eyes elliptical; antennal pedicel about two-thirds the length of the first funicle joint; ring-joint transverse; first, second, and third funicle joints subequal, following joints shorter; mesoscutum with the median and lateral lobes alike faintly scaly-punctate and hairy; the median lobes more distinctly sculptured bordering the lateral margins; scutellum and axillae very finely and closely-punctured, the former precipitously posteriorly and the posterior face smooth; propodeum smooth; mesopleurae mostly smooth, but with the anterior portion above scaly-punctate; postmarginal vein twice as long as the stigmal, the marginal a little more than twice the postmarginal; abdomen faintly lineolate, about as long as the thorax. Scape reddish-yellow, flagellum black; head brassy-green; mesoscutum, punctate area on the mesopleurae, posterior face of the scutellum, propodeum, hind coxae, and underside of the thorax metallic blue-green; scutellum and axillae varying from wholly pale orange-yellow to dark brown, with only the bases yellowish; remainder of the thorax reddish yellow; legs yellowish within and along the margins, blackish or brownish outwardly, the femora often tinged with metallic; wings fuscous, the base hyaline to the beginning of the marginal vein and a broad hyaline transverse band before the stigmal vein; abdomen yellowish above except the three apical segments, which are darker and somewhat metallic; venter pale at base, brownish medially and metallic apically.

**Male [Pl. 68, B].—**Head strongly punctate; antennal scape compressed and expanded beneath, pedicel very short, flagellum tapering slightly from base to apex; first funicle joint about twice as long as wide; following joints successively shortening; club scarcely as long as the two last funicle joints combined; mesoscutum and scutellum alike scaly-punctate, mesopleurae mostly smooth; propodeum smooth; post-marginal vein nearly as long as the marginal and a little more than twice the length of the stigmal; abdomen reticulately lineolate. Color dark blue-green; antennae black, the expansion of scape pale; abdomen beyond the first segment brownish-black; all trochanters, a line above and the apices of front and middle femora, front tibiae outwardly for its whole length, basal third of middle and hind tibiae and the three basal joints of the middle and hind tarsi yellowish white; front tarsi and apical two joints of the other tarsi fuscous; remainder of the legs blue-green or blackish.

**Type-locality.**—Koehler, New Mexico.

**Host.**—_Hemileuca oliviae._

**Type.**—Cat. No. 18321, U. S. N. M.

LARVA

The freshly dissected larva (fig. 1) is dirty white in color with the body contents showing darker. When viewed dorsally, the general shape is elliptical, becoming slightly broader posteriorly. When viewed later-

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ally, the larva appears crescent-shaped and is slightly depressed dorso-ventrally. The head is partly retracted and not chitinized. The mandibles are small and almost invisible. The body segments, 13 in number, are well defined and slightly broader dorsally than ventrally. This causes a well-defined fold just above the pleural areas which becomes more pronounced posteriorly. A narrow ridge extends down the median line dorsally. The head and first two body segments are sparsely pubescent.

The average dimensions of the larva are: Length when extended, 2.5 mm.; width, 1.25 mm.; depth dorso-ventrally, 1 mm.

**PUPA**

The pupa (fig. 2) when first formed is creamy white in color and closely resembles the adult in shape. The appendages are folded close to the body, and the entire pupa is covered by a thin pupal skin. The sex differences are early apparent. The female pupa, when extended, averages 2.5 mm. in length, and the male pupa, 1.75 mm. Soon after formation, the eyes of both sexes turn pink and gradually the thorax and abdominal bands of the female become light brown in color, while in the male they become dark blue-green. Just before the emergence of the adult, the entire pupa assumes the characteristic color of its sex.

**LIFE HISTORY**

**EGG PERIOD**

All attempts to dissect the egg of *Anastatus semiflavidus* from its host or to ascertain the length of the incubation period have been unsuccessful.

The period of normal oviposition in the field begins when the *Hemileuca oliviae* eggs are first deposited, about the middle of September, and continues until the arrival of severe winter weather, which occurs in these comparatively high altitudes during late November or early December.

Judging from indications furnished by numerous dissections of host eggs from life-history cages and from eggs collected at various times in the field, it is probable that the parasite eggs which are deposited just before the beginning of cold weather hibernate in that stage, while the eggs which are deposited early in the season hatch and hibernate as
partly developed larvae within their host. This theory would account for the presence of the fully developed larvae that are frequently found within their host eggs early in the succeeding spring.

**LARVAL PERIOD**

Periodic dissections and emergence records of egg clusters that had been exposed to adults in confinement indicated extreme variations in the duration of the larval period for different individuals.

From a series of isolated host egg clusters that had been exposed to parasite adults in cages for two days during the last week of September, 1914, a few adults emerged early in May, 1915. The larval period of these individuals therefore was limited to about seven months, whereas some of the other eggs in these same egg clusters were found to contain full-grown dormant larvae nearly two years later—that is to say, in March, 1917.

Dissections of 1- and 2-year-old eggs collected in the field gave similar results and established the fact that on some occasions the insect remains in a dormant larval state for at least two years.

It will be apparent from the foregoing that any statement concerning the duration of the larval period must necessarily be in approximate terms.

**PUPAL PERIOD**

The pupal period is evidently very short, as in a long series of dissections of parasitized eggs, made at intervals of three or four days, it was observed that pupae were rarely found, although many of these eggs contained fully developed larvae and adults were emerging each day.

Pupae were dissected out of the host and placed in different types of cages in an attempt to ascertain the length of the pupal period, but none were reared through to the adult form.

**ADULT PERIOD**

In laboratory experiments the females remained alive for several weeks in Doten cages that were supplied with equal parts of honey and water as food. Under these same conditions the males remained alive but a few days after being placed in the cages.

Adults have been observed in the field from the early part of May until the first of December, the maximum emergence occurring during July and August. As the host eggs are not deposited until September, it is probable that the females live for long periods under field conditions, the length of their life depending upon the proximity of their host and upon the weather conditions.

**DURATION OF LIFE CYCLE**

From a series of 49 cages started in September and October, 1914, a total of 383 adults were reared. These adults required a maximum of
449 days and a minimum of 226 days to complete their life cycle, the average being 380 days. (See Tables I and II for a record of two of these cages.) From a series of cages started in October, 1915, a total of 40 adults were reared. These adults required a maximum of 346 days and a minimum of 238 days to complete their life cycle, the average being 266 days. From a series of stock cages started the last week in September, 1914, adults were reared from the first week in the following May until March, 1917, a minimum of 7 months and a maximum of 30 months. It is evident that this prolonged life cycle was not due to the artificial cage conditions because adults emerged from 1- and 2-year-old eggs collected in the field.

**Table I.—Duration of life cycle, proportion of sexes, and progeny of one female *Anastatus semiflavidus***

<table>
<thead>
<tr>
<th>Cage No.</th>
<th>Date egg was exposed</th>
<th>Date adult parasite emerged</th>
<th>Total number of days</th>
<th>Number and sex of adults</th>
<th>Result of dissecting eggs still intact on May 20, 1916</th>
</tr>
</thead>
<tbody>
<tr>
<td>817 (1)</td>
<td>1915.</td>
<td>Sept. 17</td>
<td>1915.</td>
<td>15</td>
<td>One living larva.</td>
</tr>
<tr>
<td></td>
<td>Sept. 22</td>
<td>370</td>
<td>2♂, 1♀</td>
<td></td>
<td>Two dead larvae.</td>
</tr>
<tr>
<td></td>
<td>Oct. 26</td>
<td>378</td>
<td>1♀</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dec. 4</td>
<td>404</td>
<td>2♀</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dec. 10</td>
<td>443</td>
<td>1♀</td>
<td></td>
<td></td>
</tr>
<tr>
<td>817 (2)</td>
<td>18</td>
<td>Sept. 22</td>
<td>369</td>
<td>1♂, 2♀</td>
<td>One living larva.</td>
</tr>
<tr>
<td></td>
<td>Oct. 22</td>
<td>397</td>
<td>1♀</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Dec. 10</td>
<td>449</td>
<td>1♀</td>
<td></td>
<td></td>
</tr>
<tr>
<td>817 (3)</td>
<td>20</td>
<td>Sept. 3</td>
<td>344</td>
<td>1♀</td>
<td>One living larva.</td>
</tr>
<tr>
<td></td>
<td>Oct. 19</td>
<td>390</td>
<td>1♀</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nov. 16</td>
<td>418</td>
<td>1♀</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>422</td>
<td>1♀</td>
<td></td>
<td></td>
</tr>
<tr>
<td>817 (4)</td>
<td>25</td>
<td>May 17</td>
<td>233</td>
<td>3♀</td>
<td>One living larva.</td>
</tr>
<tr>
<td></td>
<td>Sept. 22</td>
<td>360</td>
<td>3♀</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oct. 2</td>
<td>377</td>
<td>1♀</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>373</td>
<td>1♀</td>
<td></td>
<td></td>
</tr>
<tr>
<td>817 (5)</td>
<td>27</td>
<td>Sept. 22</td>
<td>358</td>
<td>2♂</td>
<td>One dead larva.</td>
</tr>
<tr>
<td></td>
<td>Oct. 2</td>
<td>364</td>
<td>2♀</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>369</td>
<td>1♀</td>
<td></td>
<td></td>
</tr>
<tr>
<td>817 (6)</td>
<td>20</td>
<td>Oct. 22</td>
<td>360</td>
<td>3♀</td>
<td>One living larva.</td>
</tr>
<tr>
<td></td>
<td>Oct. 2</td>
<td>371</td>
<td>1♀</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>4</td>
<td>373</td>
<td>1♀</td>
<td></td>
<td></td>
</tr>
<tr>
<td>817 (7)</td>
<td>25</td>
<td>Sept. 22</td>
<td>358</td>
<td>2♂</td>
<td>One dead larva.</td>
</tr>
<tr>
<td></td>
<td>Oct. 26</td>
<td>362</td>
<td>2♀</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>20</td>
<td>366</td>
<td>2♀</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oct. 25</td>
<td>392</td>
<td>1♀</td>
<td></td>
<td></td>
</tr>
<tr>
<td>817 (8)</td>
<td>Oct. 1</td>
<td>Sept. 7</td>
<td>342</td>
<td>1♂</td>
<td></td>
</tr>
</tbody>
</table>

Average number of days in life cycle= 372.4.
Maximum number of days in life cycle= 446.
Minimum number of days in life cycle= 233.
Proportion of sexes= 12 males and 17 females.
Total progeny of one female= 54 individuals.
Many experiments were carried on to determine whether this parasite would reproduce in mature eggs. No reproduction was secured in any of these experiments.

The extreme variation in the duration of the life cycle, as shown in Tables I and II, is important in that it would allow the parasite to survive any unfavorable weather conditions for an extended period.

**Table II.—Duration of life cycle, proportion of sexes, and progeny of one female *Anasutus semiflavus***

<table>
<thead>
<tr>
<th>Cage No.</th>
<th>Date egg was exposed</th>
<th>Date adult parasite emerged</th>
<th>Total number of days</th>
<th>Number and sex of adults</th>
<th>Result of dissecting eggs still intact on May 20, 1916</th>
</tr>
</thead>
<tbody>
<tr>
<td>818 (1)</td>
<td>Sept. 18</td>
<td>1914. July 24</td>
<td>309</td>
<td>1♀</td>
<td>Three dead larvae.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Aug. 24</td>
<td>316</td>
<td>1♂</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Dec. 7</td>
<td>445</td>
<td>1♂</td>
<td></td>
</tr>
<tr>
<td>818 (2)</td>
<td></td>
<td>Sept. 22</td>
<td>367</td>
<td>2♂</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>20</td>
<td>369</td>
<td>1♀</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Oct. 8</td>
<td>371</td>
<td>1♀</td>
<td></td>
</tr>
<tr>
<td>818 (3)</td>
<td>22</td>
<td></td>
<td></td>
<td></td>
<td>No parasitism.</td>
</tr>
<tr>
<td>818 (4)</td>
<td>Sept. 22</td>
<td>25</td>
<td>362</td>
<td>1♂, 2♀</td>
<td>One dead larva.</td>
</tr>
<tr>
<td></td>
<td>Dec. 9</td>
<td></td>
<td>364</td>
<td>1♂</td>
<td>One dead male.</td>
</tr>
<tr>
<td>818 (5)</td>
<td>Oct. 17</td>
<td>27</td>
<td>385</td>
<td>1♂</td>
<td>One dead female.</td>
</tr>
<tr>
<td></td>
<td>26</td>
<td></td>
<td>394</td>
<td>1♀</td>
<td></td>
</tr>
<tr>
<td>818 (6)</td>
<td>Oct. 10</td>
<td>29</td>
<td>361</td>
<td>1♂, 1♀</td>
<td>One living larva.</td>
</tr>
<tr>
<td></td>
<td>22</td>
<td></td>
<td>362</td>
<td>1♂</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oct. 8</td>
<td></td>
<td>370</td>
<td>1♂</td>
<td></td>
</tr>
<tr>
<td></td>
<td>22</td>
<td></td>
<td>388</td>
<td>1♂</td>
<td></td>
</tr>
<tr>
<td>818 (7)</td>
<td>Oct. 1</td>
<td></td>
<td>364</td>
<td>1♂, 1♀</td>
<td>One dead larva.</td>
</tr>
<tr>
<td></td>
<td>12</td>
<td></td>
<td>370</td>
<td>1♂</td>
<td></td>
</tr>
<tr>
<td></td>
<td>21</td>
<td></td>
<td>385</td>
<td>2♂, 1♀</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nov. 7</td>
<td></td>
<td>402</td>
<td>1♂</td>
<td></td>
</tr>
<tr>
<td>818 (8)</td>
<td>May 17</td>
<td>3</td>
<td>226</td>
<td>1♀</td>
<td>Four dead larvae.</td>
</tr>
<tr>
<td></td>
<td>Sept. 3</td>
<td></td>
<td>335</td>
<td>1♂</td>
<td>One dead pupa.</td>
</tr>
<tr>
<td></td>
<td>22</td>
<td></td>
<td>354</td>
<td>3♀</td>
<td>Two dead females.</td>
</tr>
<tr>
<td></td>
<td>25</td>
<td></td>
<td>357</td>
<td>1♀</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Nov. 7</td>
<td></td>
<td>400</td>
<td>1♂</td>
<td></td>
</tr>
<tr>
<td>818 (9)</td>
<td>Sept. 28</td>
<td>5</td>
<td>358</td>
<td>1♂</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Oct. 25</td>
<td></td>
<td>385</td>
<td>1♂</td>
<td></td>
</tr>
</tbody>
</table>

Average number of days in life cycle= 266.7.
Maximum number of days in life cycle= 445.
Minimum number of days in life cycle= 246.
Proportion of sexes= 30 males and 29 females.
Total progeny of one female= 60 individuals.
CAGE REARING METHODS

The cages used in experiments with *Anastatus semiflavidaus* adults were of a modified Doten type. This cage consisted of two round 30 by 100 mm. glass vials, of the same diameter and shape, cut off squarely at the open ends. A small patch of beeswax was melted on the inside of one vial, at a point equidistant from each end, to serve as a support for the food of the Hymenoptera. This food consisted of equal parts of honey and water and was applied as a small drop in a depression made in the beeswax. This vial was known as the food tube. The other vial was known as the home tube and was left in its original condition.

The Hymenoptera were introduced into the home tube, and the open ends of the two vials were placed together. A strip of heavy wrapping paper, 2 inches wide and 10 inches long, was then bandaged tightly around the abutting edges and secured by snapping a heavy rubber band around each vial at the edge of the paper bandage.

When it became necessary to change the food tube for replenishment or cleaning, a duplicate food tube was prepared to replace the original. Before this change could be affected, however, it was necessary to entice the Hymenoptera into the other, or home tube. This was accomplished by holding the home tube with its closed end toward the light and inclined slightly upward. A smart tap on the bottom of the food tube would usually drive any insects into the home tube that refused to crawl out. When all the Hymenoptera in the cage had moved into the home tube, the rubber band holding the original food tube was removed. The other rubber band on the home tube held the paper bandage in position while the newly prepared food tube was quickly inserted and its rubber band replaced.

In life-history experiments it became necessary to introduce egg clusters of the host into these cages. Under these circumstances, the Hymenoptera were enticed into the food tube, after which the home tube was removed, the host egg cluster quickly inserted, and the home tube returned to its original position.

The glass sides of this cage made it possible to follow easily the activities of the insects under observation, and its mobility allowed it to be placed upon the binocular stage for microscopic examination of its contents.

The labels and other necessary data were written on the paper bandage holding the two vials together.

The cage was prevented from rolling and smearing the honey solution over the interior by placing it in a shallow pasteboard box with loose cotton.

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Adults of *Anastatus semiflavidus* were kept alive for long periods in this type of cage, provided proper care was exercised in its maintenance. The honey solution was kept fresh, a new supply being prepared every few days, as experience demonstrated that a rancid or moldy condition of the food caused the death of the Hymenoptera. The interior of the cage was kept strictly clean and free from all particles of dirt or other foreign matter that would entangle the insects.

The direct rays of the sun proved fatal to the confined insects, so it was necessary to keep the cages in a shaded location.

**HABITS**

**FERTILIZATION**

The union of the sexes and the fertilization of the female take place in the manner common to most chalcids soon after the adults emerge and last but a few seconds.

When this species was first reared from *Hemileuca oliviae* eggs, it was thought that the male and female *Anastatus semiflavidus* were separate species. Each sex was accordingly exposed to eggs of *H. oliviae* in separate cages for the purpose of securing life-history records. Under these conditions, the species proved parthenogenetic, as all the progeny of the unmated female *A. semiflavidus* were males.

**OVIPOSITION**

The process of oviposition was often observed in life-history cages. In one instance, a female of *Anastatus semiflavidus* was introduced into a glass vial cage containing a *Hemileuca oliviae* egg cluster known to have been deposited 2 days previously. This female had been confined in a stock cage containing many adults of both sexes and had probably been fertilized. It had not previously been exposed to any eggs of its host. Immediately upon being introduced into the cage, the female began examining the egg cluster, running over the surface of the eggs and feeling them with her antennae. After 2 or 3 minutes she apparently selected an egg that suited her purpose and began making preparations to oviposit. V. L. Wildermuth then took this female under observation and through the binocular microscope observed the details of the process of oviposition. He states that in the two instances under his observation the female drilled a hole in the shell of the egg with her ovipositor in 15 and 20 minutes, respectively, after which an egg was apparently deposited in each instance. Mr. Wildermuth then directed the writer to observe the details of oviposition and to describe the same. After a short interval this cage was again examined by the writer, and soon the female was observed making preparations to oviposit.

Through the binocular microscope, it was seen that the female was poised over the selected egg, the legs being strongly braced against the sides of the adjoining eggs, and most of the pressure being exerted
through the posterior pair of legs. The ovipositor protruded a short distance (fig. 3), and the abdomen moved slowly up and down, forcing the ovipositor into the shell of the egg. Occasionally the movement was from side to side, and there were short intervals of rest.

After 21 minutes, the opening in the egg appeared to be completed and a small drop of brownish liquid appeared at the point where the ovipositor was inserted in the egg. It is impossible to state whether this liquid exuded from the female or came from the egg. When this operation of drilling an opening in the egg was complete, the female turned around and examined the puncture. She appeared to be sipping the liquid around the opening in the eggshell or possibly feeding on the contents of the egg. The female soon resumed her original position and inserted the ovipositor into the egg, nearly full length. The ovipositor was then partly withdrawn and thrust again into the egg. This operation was repeated 9 or 10 times. Finally the ovipositor was thrust in full length, the female crouched low over the egg, the abdomen, meanwhile, was drawn sharply forward, and oviposition apparently took place. The female remained quiet, except for a slight movement of the abdomen, in this act of oviposition for 2 or 3 minutes. The ovipositor was then withdrawn, and the female turned around and manipulated the mandibles and antennae in the small drop of liquid which remained over the opening in the egg. This liquid soon hardened and formed a transparent, light brown, waxy substance which apparently sealed the oviposition puncture. After completing oviposition in this egg, the female resumed her examination of the remaining eggs in the cluster and was observed to oviposit several times during the remainder of the day.

INTERNAL APPEARANCE OF PARASITIZED EGG

For a long period after oviposition the internal appearance of a parasitized egg does not differ from the normal, the contents consisting of a reddish brown liquid. The only change apparent, until the parasite larva becomes visible, is a slight thickening of the liquid contents. In the course of its development, the larva consumes these liquid contents and finally occupies about two-thirds of the egg-cavity. Only one larva develops in each egg.

EXTERNAL APPEARANCE OF PARASITIZED EGG

Superficially the external appearance of a parasitized egg does not differ from the normal, there being no change in its color or shape. Microscopic
examination, however, reveals the presence of the sealed ovi-
position puncture, and this is the only external indication by which a
parasitized egg may be recognized. The parasite can not be discerned,
even during its advanced stages, through the opaque, thick-walled shell
of the egg. This appearance is in marked contrast to that of eggs of
the gypsy moth (Porthetria dispar L.) which have been parasitized by
Anastatus bijasciatus Fonsc. The parasite larva of this closely allied
species is plainly visible through the shell of its host egg.

_Hemileuca oliviae_ larvae frequently hatch from eggs bearing oviposition
punctures of the parasite. This is probably due to the fact that these
particular eggs were not successfully parasitized.

**Appearance of Host Eggs from Which Adults Have Emerged**

The adult, upon emerging from the pupa, finds itself completely inclosed
within the walls of the host egg. It gnaws a small but easily distin-
guishable hole through this wall and makes its escape.

The host eggs from which _Anastatus semiflavidus_ adults have issued
may be readily recognized by the presence of this exit hole. It is much
smaller than the hole made by the hatching of the host larvae. (Pl. 68, C.)

**Method of Larval Development**

The larva of _Anastatus semiflavidus_ prevents the formation of the
embryonic larva of its host and feeds exclusively upon the liquid contents
of the host egg. This method of larval development is characteristic
of the true egg parasites.

**Dormant Period of Full-Grown Larva**

After the larva has become full-grown, the development of the pupal
stage depends largely upon the external climatic conditions to which
the egg is subjected. In northern New Mexico, these climatic conditions
refer especially to humidity and must be considered in this special sense.
The degree of humidity as affecting the development of parasite larva in
this semiarid climate depends largely upon whether the eggs are situated
on high or low ground, or upon the distance from areas of surface water.

If the parasitized egg, containing a full-grown larva, happens to be
subjected to a long period of drought, pupation may be delayed and a
dormant larval period of indefinite duration produced until such a time
as both humidity and temperature are favorable for further development.

When these favorable conditions occur, the full-grown dormant larva
changes to a pupa without regard to the length of time spent in the
larval stage.

**Short Length of Pupal Period**

The duration of the pupal period is very short, as noted by numerous
dissections. From this fact it is assumed that the insect must be less
resistant to adverse weather conditions as a pupa than as a dormant larva or as an adult, and it would appear that the pupal period is made as short as possible in order to hurry the insect through the most vulnerable period of its existence. The few pupae dissected from parasitized eggs have invariably been found during periods of heavy adult emergence.

NUMBER OF INDIVIDUALS PRODUCED BY EACH FEMALE

In cage experiments, two females under observation produced 60 and 54 individuals, respectively (Tables I and II). These figures may be considered as being below the average, because under natural conditions each female probably produces a greater number of progeny than when confined in cages.

JUMPING HABIT OF ADULTS

Although equipped with wings, the adults of both sexes appear to lack the power of sustained flight. Locomotion seems to be accomplished largely by means of jumping or running. Adults that were observed in the field running around on the ground in the vicinity of host egg clusters disappeared with startling rapidity when an attempt was made to collect them, their movements, when approached, resembling those of the haliticine flea-beetles. This ability to jump made the species very difficult to handle in the laboratory cages, and many adults were lost during the process of feeding or when they were being transferred from one cage to another.

The males are much more active than the females.

RELATIVE PROPORTION OF SEXES

From a quantity of Hemileuca oliviae eggs collected in the field a total of 393 adults issued. Of this number 158 were males and 235 were females. From two series of life-history cages a total of 423 adults issued. Of this number 175 were males and 248 were females. These figures would seem to indicate that both sexes were well represented but that the females were slightly more abundant than the males. (Tables I and II.)

POSITIVELY PHOTOTROPIC HABIT OF ADULTS

The adults of Anastatus semiflavidosus are positively phototropic. This characteristic was used to advantage in rearing the adults from eggs collected in the field and in handling the species in life-history cages.

HOSTS OTHER THAN HEMILEUCA OLIVIAE

Adults of Anastatus semiflavidosus were reared from eggs of Hemileuca nevadensis Stretch, collected from willow along the banks of the Red River in New Mexico. Laboratory experiments also demonstrated that
adults of *A. semiflaviceps*, emerging from *H. oliviae* eggs, would breed in eggs of *H. nevadensis*.

The eggs of this closely allied species are not very numerous in the region infested by *Hemileuca oliviae* and, therefore, do not form a very important host for *Anastatus semiflaviceps*. If for any reason, however, *H. oliviae* should become greatly reduced in numbers, the eggs of *H. nevadensis* would serve as a valuable host in perpetuating *A. semiflaviceps*. From many indications, it is probable that such a condition of affairs has existed in the past. A study of the life history of *H. nevadensis* demonstrated that its life cycle and that of *H. oliviae* correlate very closely.

An attempt was made to rear *Anastatus semiflaviceps* from the eggs of *Malacosoma fragilis* Stretch, collected from scrub oak along the foothills, and to secure parasitism of these eggs in confinement, but only negative results were obtained.

**ECONOMIC IMPORTANCE OF THE PARASITE**

It has been very noticeable that this highly beneficial insect has been increasing rapidly in numbers since the spring of 1913 when the species was first discovered. This increase has been especially marked in areas of heavy *Hemileuca oliviae* infestation.

In the collections of *Hemileuca oliviae* eggs made from different localities during the autumn of 1915 and the winter and spring of 1916 the percentage of parasitism varied from 75 to only a trace. The species was found to be present in every locality from which *H. oliviae* eggs were collected with the exception of two isolated areas far to the south of the main area of infestation, in which only a very few egg clusters were found.

At the present time *Anastatus semiflaviceps* appears to be one of the most efficient natural enemies contributing to the control of *Hemileuca oliviae*. 
PLATE 68

*Anastatus semiavudus:*

A.—Adult female, dorsal view.
B.—Adult male, dorsal view.
C.—Exit holes of adults from egg clusters of *Hemileuca oliviae.*