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NOTES ON THE BIOLOGY AND IMMATURE STAGES OF A  
CRICKET PARASITE OF THE GENUS RHOPALOSOMA

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Introduction

For more than three-quarters of a century wasps of the genus *Rhopalosoma* Cresson, 1865, have attracted the interest of hymenopterists because characters of the adult have left doubt regarding family relationships. Although the family Rhopalosomatidae<sup>2</sup> was proposed for the genus in 1896, there remains uncertainty as to what other genera are to be included in the family.<sup>3</sup> Neither is it clear which of the related families is most closely allied to the Rhopalosomatidae. Biological studies of *Rhopalosoma* together with a critical examination of the immature stages may be helpful in clarifying these matters. Until now the only original published information concerning the biology and immature stages is that by Hood (1914). He collected a larva which was reared to maturity and identified as *R. poeyi* Cresson, which is currently referred to *R. nearcticum* Brues. Hood's account is brief and, while it is a good general indication of the biology, contains no detailed morphological descriptions. The recent capture of a larva of *Rhopalosoma* at Falls Church, Va., has given

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<sup>2</sup> Originally given as Rhopalosomidae by Ashmead (1896). An adult specimen of the genus has been illustrated by Westwood (1874, pl. 24, fig. 9). The species shown there is *Rhopalosoma aenigmaticum* (Westwood) of Hispaniola.

<sup>3</sup> Readers are referred to Brues and Melander (1932, p. 499), Brues (1943), and Krombein (1951).

impetus to the gathering of biological data, and the material at my disposal has also permitted morphological studies to be made on several of the immature stages.

I am much indebted to Dr. Henry K. Townes, of the North Carolina State College (in absentia), for lending specimens of *Rhopalosoma* and for supplying collecting records and giving helpful suggestions. My colleagues Dr. B. D. Burks, K. V. Krombein, and Dr. W. H. Anderson have also advised me generously. David G. Shappirio, of Harvard University, and Dr. T. H. Hubbell, of the University of Michigan, have kindly supplied data on parasitized crickets preserved at the University of Michigan Museum of Zoology.

### Biological observations

The larva found at Falls Church<sup>4</sup> was in the fourth instar, attached to the left side of an adult female of *Hapithus agitator* Uhler. While I was beating deciduous underbrush for psocids, on September 30, 1950, the cricket was knocked into a collecting umbrella. The left hind leg was held at an unnatural angle with the body and the cricket was rather inactive and easily picked up. Leaves and other organic material were added to the jar in which the insect was placed, but the cricket was not seen to feed. The next day it scarcely changed its position, though the antennae occasionally moved. Meanwhile, the ventral surface of the parasite remained securely attached to the cricket and no movement was noticed. At 7 p.m. on the evening of October 2 the larva was beginning to shed its skin, as shown by the appearance of the white integument of the fifth instar where the fourth instar skin had split lengthwise along the middle of the dorsum. The cricket had then lost its foothold and was dying on its side, though its antennae still moved.

By 8:30 p.m. the larva (which was entirely white except for traces of pale brown about the mandible) had left the dead cricket and had moved an inch or so away. The larva was placed in a pill box of soil where it gradually darkened to a creamy yellow color. On the day following the molt the larva made frequent twisting contractions as if trying to burrow. The head was directed downward most of the time and one silk strand coming from the mouth was noticed. The larva did not succeed in becoming completely covered with soil; during the next day it was relatively inactive, with the head uppermost

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<sup>4</sup> Generic identification of the parasite is primarily based on the very close agreement with the situation reported by Hood (1914). It may eventually be shown that more than one nominal form of *Rhopalosoma* inhabits the United States and that some specimens from the vicinity of Washington, D. C., are distinct from *R. nearcticum*, the type locality of which is Kissimmee, Fla.

and showing occasional movements of the mouth parts. By the morning of October 5, it was decidedly quiescent and evidently dying, and by noon it had died and so was preserved in alcohol (pl. 1). If several inches of fine sand had been provided instead of heavy garden loam, perhaps the insect would have entered the soil and successfully spun a cocoon.

The present larva was attached to the cricket on the membrane between the terga and sterna of abdominal segments 1 to 5. After the fifth instar had left, the cricket (pl. 1) bore three exuviae visible from above, representing the second, third, and fourth instars. In each the head was directed posteriorly and located farther posteriorly on the cricket than that of the previous instar. The strongest single point of larval attachment was apparently just anterior to the parasite's modified anus; there the attachment was quite secure. The larval body was noticeably curled, but the entire ventral surface was closely appressed to the cricket. The exuviae of larval instar 1 was situated transversely on the ventral surface of the cricket, in a groove just behind the left hind coxa. The head end of the skin was directed mesally on the cricket and extended almost to the sternal plate of the first abdominal segment, while the posterior end was beneath the ends of succeeding exuviae. Remnants of the eggshell occurred with the exuviae of the first instar. On the body of the cricket, in part beneath the cast skins and also directly adjacent to them and extending briefly onto the left tegmen (front wing), was an accumulation of dried mucus or similar material. This was scalelike in appearance and I first mistook it for exuviae. The larval head was not inserted through the cricket's body wall, nor was there any definite opening, but the membrane where the last feeding mandibles (fourth instar) were applied showed signs of having been pierced. The points of contact for the mandibles of the second and third instars were covered with the exuviae of later instars.

A second larva of *Rhopalosoma* in the U. S. National Museum was collected on a last instar male nymph of *Hapithus* sp. at Marietta, Ga., August 9, 1947. The larva is in the fifth instar, though it probably was captured in an earlier stage since the host cricket is also preserved. The exuviae which were attached to the left side of the cricket agree with those of the Falls Church specimen so far as has been noted.

The third larva of *Rhopalosoma* examined (fig. 9, *e, f*) was preserved in the fourth instar after having been collected on an adult female of *Hapithus agitator* at Fuguay, N. C., September 12, 1950, by Townes, Rabb, and Howden (North Carolina State College collection) (pl. 1). The head of the final feeding stage of the larva was on the cricket's fifth abdominal segment, with the mandibles applied to the membrane close to the spiracle and nearer the tergum than to the

sternum. A crust of a dried secretion was present, as in the case of the Falls Church larva. Though a crust may have been associated with the Marietta, Ga., material, none was seen. The eggshell and first larval exuviae of each of the three larvae occurred immediately behind the hind coxa of the cricket. Likewise, the hind leg of each cricket, adjacent to the parasite, was held outward as shown in the photographs.

A fourth larva examined is one of several which Dr. Townes has told me of finding on *Hapithus* and *Orocharis*. Of this particular larva he has written, "On September 12, 1950, I collected (at Fuguay, N. C.) a large *Orocharis* nymph with a one-third grown larva on it. I kept the cricket in a jar and its parasite prospered. On September 17 I found the remains of the demolished nymph in the jar and the *Rhopalosoma* larva, now creamy white with a large head and projecting mandibles, busily hitching itself along with its mandibles. It was very restless, so I put it in some damp sand. The larva promptly worked into the sand and came to rest in one corner of the jar, under the sand. Three days later it had completed an elongate, castaneous cocoon."

The cocoon was kept indoors by Dr. Townes, at a temperature in the neighborhood of 55° F. In late February he mailed it to me and suggested that dissection to determine whether pupation had occurred might be advisable. The parchmentlike cocoon was 14 millimeters long, about 5 millimeters in diameter, and rounded at the ends. The inner surface was a lighter chestnut color than the outside and scarcely any individual threads of silk were apparent except on the outside. When the cocoon was opened on February 23, the larva was doubled up in the middle of it with about one-fourth of the cocoon's length empty at each end. Pupation had not occurred, nor had there been any casting of larval skins or passing of fecal material, but the larva appeared perfectly healthy. After preservation it was 6 millimeters long. The mandibles bore no teeth.

The original observations of Hood (1914) were based on a larva taken at Plummer's Island, Md., October 6, 1912. The host, *Orocharis saltator* Uhler, was quite active when found, as it was said to be "scampering over the forest floor as rapidly as a large abdominal protuberance and a nearly functionless hind leg would permit." The anterior end of the parasite was at the host's eighth abdominal segment. This specimen grew rapidly, left the cricket three days after capture and entered the soil, emerging indoors as an adult about March 1, 1913. The information Hood gave concerning the exuviae and the quiescent state of the host just prior to the parasite's final visible molt agrees fully with my findings. The cocoon from which the adult emerged has recently been opened and the fifth instar exuviae

were relaxed and studied. The mandibles of the exuviae differ somewhat in shape from those of the Falls Church larva and they bear no teeth.

In the University of Michigan Museum of Zoology are at least 20 pinned cricket specimens bearing parasitic larvae presumed to be of one or more species of *Rhopalosoma*. I have not examined them, but detailed host data have been furnished me, together with the statement that the larvae vary considerably in size and that all are brown. The specimens were collected by Dr. T. H. Hubbell and several associated collectors and former students. The hosts, with the number of parasitized specimens, States where collected, and generalized dates of collection are as follows: *Hapithus agitator agitator* Uhler, seven specimens, southeastern Indiana, central Missouri, Mississippi, Tennessee, all collected in the last half of August; *H. agitator quadratus* Scudder, four specimens, Florida, late July to early September; *H. brevipennis* Saussure, four specimens, Florida, late July to mid-November; *Orocharis saltator* Uhler, four specimens, July 4 to July 29. The host associated with an additional larva from Florida is not recorded. These records represent the parasitism of this type occurring among several hundreds of *Hapithus* and *Orocharis* specimens.

The specimen of *Hapithus agitator* on which the Falls Church larva was parasitic was preserved in alcohol and later dissected to determine the condition of its internal organs. Scarcely any traces of food were in the digestive tract, none of recent ingestion. Reproductive organs were evidently intact, but there were no well-developed eggs or other signs of normal functioning of the organs.

The impression created was that the cricket had been weakened to a point where the drain on its vitality finally caused death, though there had been no mechanical destruction of organs.

Various details of the biology remain to be clarified, but the main outline seems evident. Upon hatching, the larva probably crawls part way from the eggshell and starts its development in a more or less transverse position. At the first molt the larva apparently shifts the anterior part of the body so that it extends longitudinally along the side of the cricket, though keeping the same place of anal attachment. The third and fourth instars each move the head posteriorly on the cricket at molting time. Sharp mandibles occur in the second, third, and fourth instars, and these apparently pierce the cricket's integument and permit fluids to be taken into the mouth. Definite mouth parts of the first instar have not been seen, but may occur. The fifth instar does not feed but is an inactive stage that leaves the host and spins a cocoon in the soil. Pupation is evidently delayed, perhaps until near emergence time of the adult.

Regarding habits of *Rhopalosoma* adults, Dr. Townes has furnished the following notes: "I have seen the adults on several occasions and usually was fortunate to catch them when seen. I should say that in the Upper and Lower Austral Zones of the Atlantic States they are widespread and not uncommon in the right habitat. This appears to be places of dense, shrubby vegetation where there is considerable humidity, as along stream bottoms and seashores, or, in other words, the same sorts of places where *Hapithus* and *Orocharis* abound. The adults may be flushed from the bushes. They fly up and alight again like an ophiomine ichneumonid. They may be distinguished from ophiomines in flight only by a slightly stockier appearance. At Long Beach, North Carolina, at twilight on July 9, 1949, I saw about 10 all together in normal flight, cruising in a rather slow but erratic manner just over the beach shrubbery, again like an ophiomine ichneumonid in its twilight flight. They were flying until no longer visible in the gathering dark. I could catch only two of these and they were both males."

The following collection dates accompanying specimens identified as *Rhopalosoma nearcticum* are available as an indication of when adults are active: Maryland: Mayo Beach, September 14, 1947, female (Townes); Berlin, July 19, 1932, female. North Carolina: Long Beach, July 9, 1949, two males (Townes); Wallace, August 2, 1949, female (Townes). South Carolina: Greenville, September 2, 1940, male (H. and M. Townes). Georgia: Stone Mountain, August 13, 1949, female (Fattig); Atlanta, August 11, 1946, female. Florida: About a dozen specimens, essentially all reported by Brues (1943), ranging from June 9 to August 13, but mostly collected in June and July.

In addition to the foregoing States, *nearcticum* has been recorded from Missouri and Kentucky by Krombein (1951).

The known hosts of *Rhopalosoma* in the United States are *Orocharis saltator* Uhler and *Hapithus agitator* Uhler. Judging from the records of parasitized crickets preserved in the University of Michigan Museum of Zoology, *Hapithus brevipennis* Saussure appears to be a host also. The distribution of *O. saltator*, as stated by Hebard (1931, p. 217), covers the entire southeastern United States, extending northward to southeastern Pennsylvania, Illinois, and Missouri, and undoubtedly to eastern Texas in the Southwest. In southern Florida a primarily West Indian species, *Orocharis gryllodes* (Pallas), occurs. *H. agitator* occurs as far northeast as Long Island, and otherwise is largely comparable to *O. saltator* in distribution (Blatchley, 1920, p. 740; Hebard, 1931, 1938; Rehn and Hebard, 1916, pp. 308-310). Two geographic subspecies are recognized, the southeastern one, *H. agitator quadratus* Scudder, living from the Atlantic Coast to Browns-

ville, Tex., and in the East apparently merging with typical *H. agitator* in central Georgia and along the "fall line" in North Carolina. *H. brevipennis* inhabits Florida, Georgia, and Louisiana, and doubtless other southeastern States. It may be that any of the crickets mentioned above are satisfactory hosts of *Rhopalosoma*. In southeastern Pennsylvania adults of both *Orocharis* and *Hapithus* begin to appear by early August, and in all of the more northern States the crickets pass the winter as eggs, and adults persist until frost time in the fall. Blatchley (1920) reported finding hibernating adults of *H. agitator* in Florida and suggested that they represented a fall generation. The subfamily Eneopterinae, to which *Hapithus* and *Orocharis* belong, is primarily tropical, and various genera are well represented in the Neotropical Region, from which Brues (1943) has recognized four species of *Rhopalosoma*.

### Morphological descriptions

*Mature larva (fifth instar from Falls Church, Va.)*.—General shape as in plate 1; strongly mandibulate; legs entirely absent; abdominal segments moderately well demarked, less so posteriorly, those beyond segment 8 not readily separated; two thoracic and eight abdominal pairs of spiracles.

Head in frontal view as in figure 8, *f*; occipital border broadly and evenly rounded (asymmetrical in the figure because it is bordered by uneven cervical folds); vertex and frons not individually demarked, the integument shiny, slightly irregular, not noticeably punctate; no frontal arms evident; paired conspicuous spots (*ey*), presumed to be vestigial eyes, just above base of clypeus; antenna reduced to sensory pit with traces of facetlike division, situated well to the side of frons, no apparent projecting sensilla; a presumed sensory area represented by about nine poorly defined, pigmented spots (*sa*), with tiny seta at lateral margin of group; frons and vertex with very sparse, short setae, grouped as illustrated; six strong clypeal setae; labrum conspicuously bilobed, each lobe with two major setae, lateral and anterior margins with microsetae, an irregular row of pits across each lobe, some bearing short setae; mandibles heavily sclerotized, apex prominent and narrowly rounded, basal third swollen laterally and with a single seta, biting margin thin, demarked from main mandibular structure by groove, and sharply but delicately toothed. (Left mandible with four well-spaced teeth along middle third of biting margin, followed by closely set group of four; right mandible with two teeth, others perhaps lost by breakage.) Maxilla with several medium-sized setae as illustrated, apex near tip of mandible sharply rounded and with asperities, maxillary palpus barrel shaped, galea

equally elongate but of smaller diameter; labium with palpi subequal to galeae, area of sericteries with two angular projections posterior to weakly sclerotized nonsegmented elongate appendages of uncertain homology; apparent opening of silk duct (sd) between bases of latter appendages.

Anterior spiracle on posterior third of prothorax; second spiracle barely anterior to groove separating meso- and metathorax; abdominal spiracles on segments 1 to 8, slightly more dorsad than thoracic ones, situated near anterior margin of the respective segments; each spiracle unspecialized so far as visible under 72-power magnification, consisting of circular disk with central aperture (internal structures not studied); no setae on thorax or abdomen apparent; no apparent specializations for crawling or clinging; vestigial anus transverse, at posterior margin of segment 10.

COLORATION: General color creamy yellow, darker on head (conspicuous black areas on body shown in photograph are necrotic spots developed at time of death). Vertex, frons, and clypeus yellowish; eye spots, sensory areas, antennae, and pits at bases of setae pale brownish; a darkened area anterior to sensory area; a somewhat darkened indefinite band across base of clypeus connecting bases of mandibles; labrum colorless, except for brown setae and pits; mandibles marked as illustrated with rich, dark brown; maxillary and labial palpi and galeae dark brown; labium white, elongate appendages in area of sericteries tinged with yellowish; spiracles yellowish; no special pigmented areas about nonfunctional anus or elsewhere on thorax and abdomen.

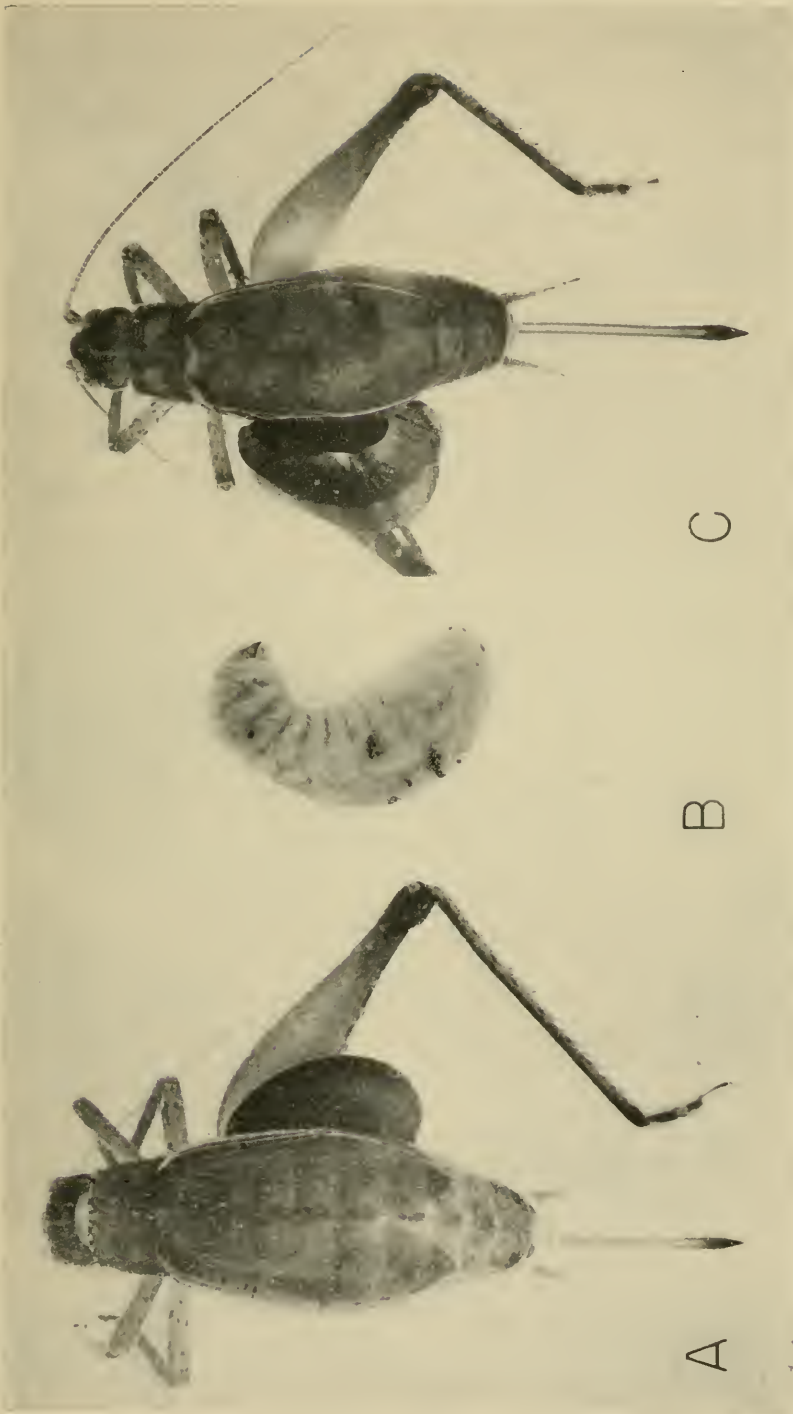
Measurements (in millimeters): Length 8 (would actually be slightly longer if body not curved); greatest width of body 3.2; greatest width of head capsule 1.3.

COMMENTS: Fifth instar from Marietta, Ga., more robust than larva from Falls Church, Va.; setae on frons and vertex smaller, scarcely noticeable; teeth on mandibles lacking. Measurements (in millimeters): Body length 8.5; greatest width 4; greatest width of head capsule 1.6.

*Penultimate stage larva (fourth instar from Fuguy, N. C.).*—General appearance typically hymenopteriform (fig. 9, *e, f*); head capsule and mouth parts not so highly developed as in fifth instar; legless; 10 pairs of spiracles; modified anus apparently specialized as a hold-fast organ.

Head capsule (fig. 8, *e*) rather masklike in contrast with that of fifth instar, integument very rough and irregularly rugose, a conspicuous transverse ridge (epistoma) dorsad of labrum; two pairs of blunt protuberances on upper part of face, the median pair (mt) broad and





A, *Hapithus agitator* Uhler, with attached fourth instar of *Rhopalosoma* before its removal, Fuguay, N. C.; B, Fifth instar of *Rhopalosoma* from cricket in figure C.; C, *Hapithus agitator* Uhler, with exuviae of *Rhopalosoma*, Falls Church, Va.



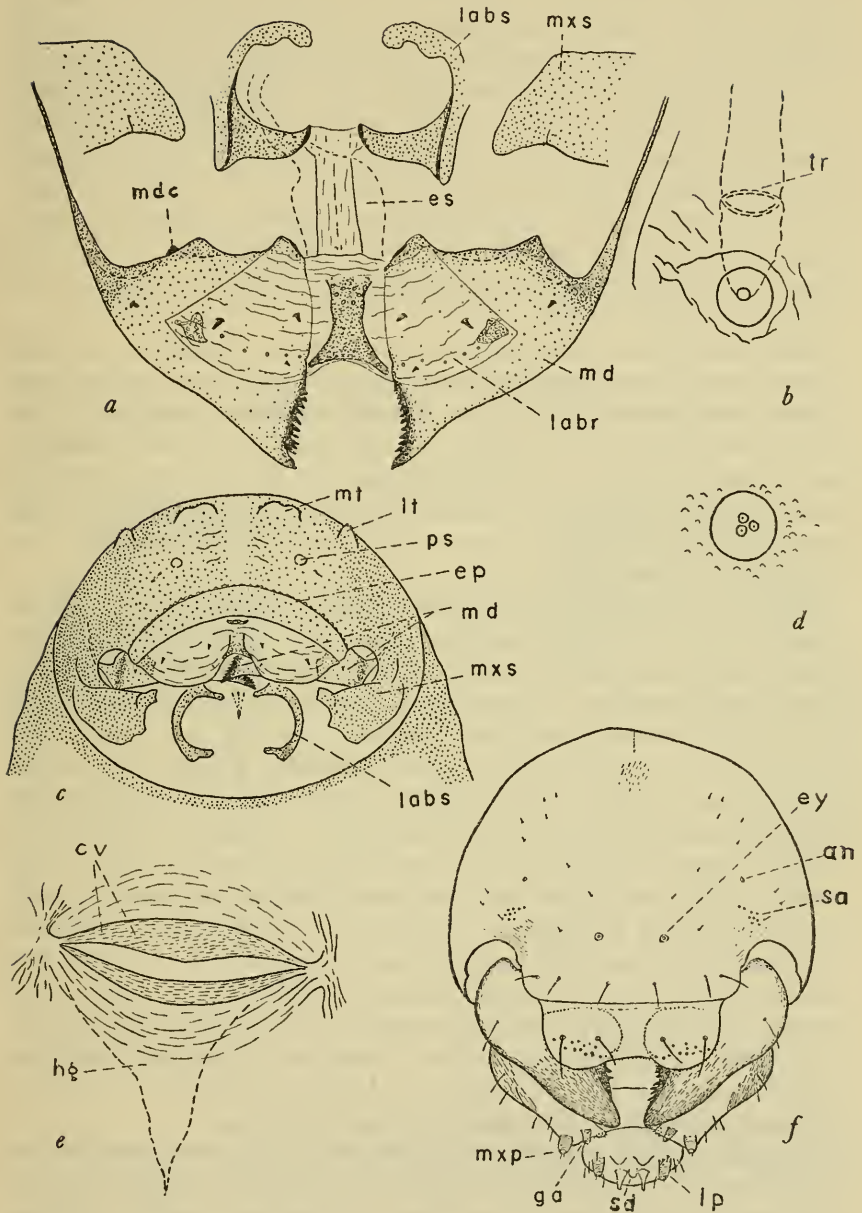


FIGURE 8.—The genus *Rhopalosoma* Cresson, 1865: a, Mouthparts of fourth instar exuviae; b, external view of sixth abdominal spiracle of fourth instar exuviae; c, front view of head, fourth instar alcoholic specimen; d, antenna of fourth instar exuviae; e, anal region, fourth instar exuviae; f, front view of head, fifth instar alcoholic specimen; (c made from Fuguay, N. C., specimen, all others from Falls Church, Va., material).

irregularly rounded, lateral pair (lt) narrow and evenly rounded; antennal socket (an, fig. 9, *e*) circular, minute, traces of sensilla scarcely visible under 72-power magnification; labrum membranous except mesally and at lateral extremities, strongly bilobed, each lobe bearing two small setae about equidistant from center and a minute seta near anteromesal margin; exposed apical fourth of overlapping mandibles triangular, the apex sharply acute, about seven sharp teeth; approximate basal third of each mandible exposed near end of epistoma, bearing a single, minute seta; a long tapering apodeme extending dorso-laterally within head capsule; maxillary sclerome (mxs) anterior to base of mandible, shaped as illustrated; labial sclerome (labs) an irregular, incomplete circle.

Abdomen with 10 apparent segments; spiracles located as in fifth instar; entire dorsal area glabrous; venter of prothorax and cervical region bearing minute asperities; dorsal and lateral integument appearing as if covered with closely appressed scales (see later description of exuviae); eight abdominal segments with ventral, transverse groups of small platelets; hold-fast organ at posterior margin of segment 10, transverse, weakly crescent-shaped, with short membranous flap extending posteriorly.

**COLORATION:** General color dark blackish-brown; ventral region (unstippled areas on fig. 9, *e, f*) unpigmented; a white middorsal line (where split occurs at subsequent molt) extending entire length of body; head considerably darker than thorax or abdomen; region of frons lighter colored than main epicranial region, two darker pigmented spots (ps) anterior to median tubercles, a wide longitudinal white stripe on frons, interrupted on anterior portion of vertex and resumed as narrow line on occiput; labrum unpigmented except at lateral extremities, on a slender transverse basal median sclerite, and mesally at the junction of the lobes; mandibles and scleromes of maxillae and labium pigmented with brown as illustrated. Abdomen with paired unpigmented spots dorsad of spiracles 3 to 8, and in a similar position on abdominal segment 9 (which bears no spiracle); transversely grouped platelets of ventral surface pale brown, also closing sclerites of hold-fast organ and immediately adjacent membrane.

**MEASUREMENTS** (in millimeters): Length of body 5.7; greatest width of body 2.2; greatest width of head capsule 1.4.

**COMMENTS:** Slide-mounted preparations of the cast skin of the fourth instar from Falls Church, Va., permitted structures to be observed in much greater magnification than was possible with the preserved alcoholic larva from Fuguay, N. C. While no significant differences in these individual fourth stage larvae apparently occur, it is important that the features illustrated and described be attributed to the correct specimens.

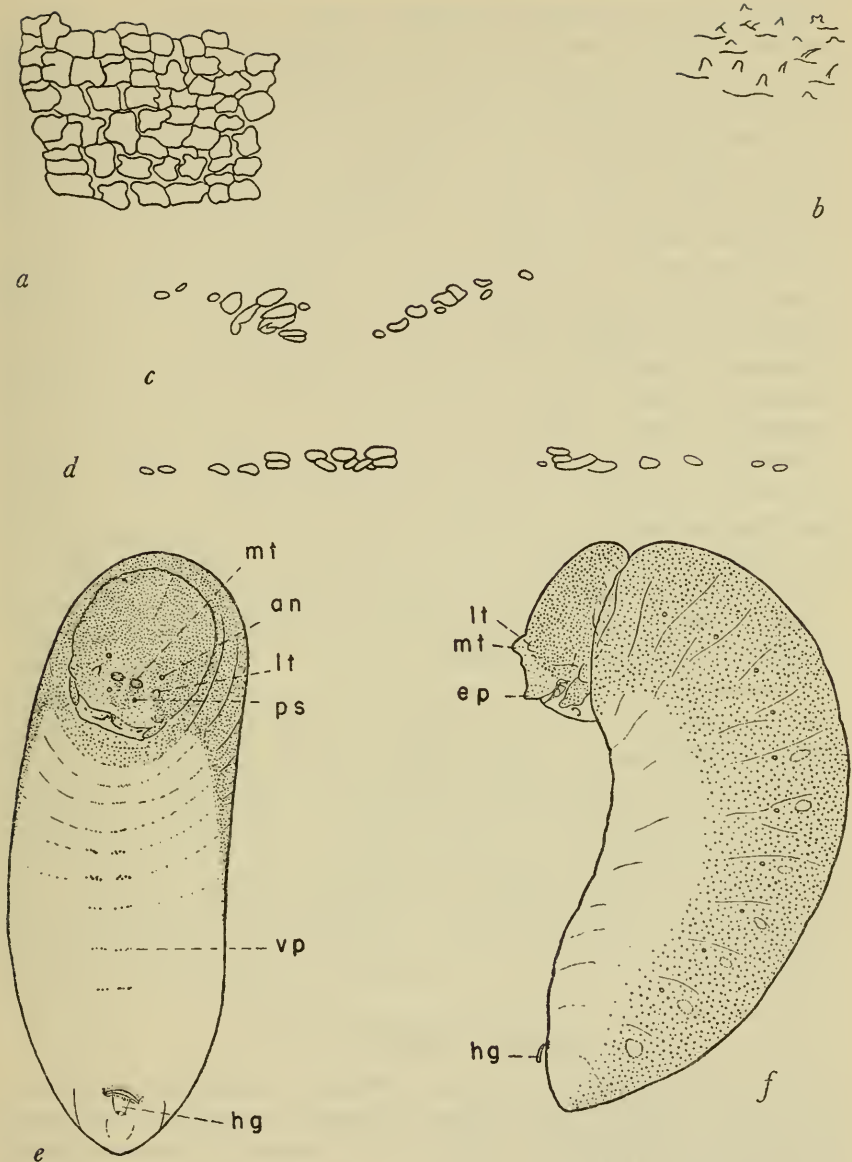


FIGURE 9.—The genus *Rhopalosoma* Cresson, 1865: *a*, Section from lateral area of thorax, showing closely grouped platelet structure, fourth instar exuviae; *b*, integumental asperities on ventral surface of prothorax, fourth instar exuviae; *c*, *d*, specialized platelets on ventral surface of fourth and fifth abdominal segments, respectively, fourth instar exuviae; *e*, *f*, ventral and lateral views, respectively, of fourth instar alcoholic specimen; (*e*, *f*, from Fuguay, N. C., specimen, others from Falls Church, Va., material).

an—antenna  
 cv—closing valves  
 ep—epistoma  
 es—esophagus  
 cy—eye  
 ga—galea  
 hg—hind gut

labs—labial sclerome  
 labr—labrum  
 lp—labial palpus  
 lt—lateral tubercle  
 md—mandible  
 mdc—mandibular condyle  
 mt—median tubercle

m xp—maxillary palpus  
 mxs—maxillary sclerome  
 ps—pigment spots  
 sa—sensory area  
 sd—opening of silk gland  
 or sericteries  
 tr—tracheal ring  
 vp—ventral platelets

Exuviae split lengthwise on dorsum, from epistoma to tenth abdominal segment; presumed antenna consisting of circular socket (fig. 8, *d*) with three tiny unpigmented circles in center, each bearing a central spot of pigment; mouth parts (fig. 8, *a*) with mandibles the most characteristic and best preserved of the parts; mandible thin, much flattened, biting margin with large apical tooth and about 10 acute smaller teeth in a single row along apical third, an emargination a little posterior to the teeth, portion of margin overlaid by labrum scarcely pigmented, a well-sclerotized and pigmented region at base of mesal margin; posterior margins of mandible with a prominent black ventral condyle, a small seta near base of long lateral apodeme (presumed mesal apodeme for muscle attachment missing in available material); labrum largely membranous, with irregular transverse wrinkles, a constricted pigmented sclerite mesally, about five subapical minute pits arranged transversely on each lateral half; a poorly defined, somewhat striated organ leading posteriorly to labial sclerome from base of labrum, dorsad of remnants of apparent esophagus (*es*); labial and maxillary scleromes showing somewhat different shape in flattened aspect than in natural position on alcoholic larva.

Integument of most of thorax and abdomen smooth, microscopically marked into platelets of different shapes on various areas of the body, averaging transversely elongate ventrally, irregularly quadrate (fig. 9, *a*) dorsally on thorax and anterior half of abdomen; ventral region of neck and prothorax bearing minute asperities of varied character (fig. 9, *b*), some setiform, others in form of sharp rugosities; less developed asperities on ventral surface of abdomen; specialized platelets on venter of abdominal segments 1 to 8 (poorly developed on 1 to 3 and 8, well developed on 4 to 7), of irregular grouping on 4 and 5 (fig. 9, *c*), others transverse (fig. 9, *d*). Spiracles each surrounded by narrow irregular area of membrane, the external portion a circular flattened disk with small central opening; trachea tapering to spiracular opening, with internal ring (*tr*, fig. 8, *b*) which may function as closing apparatus. Modified anus (fig. 8, *e*) with well-sclerotized and pigmented closing valves (*cv*), integument at lateral extremities wrinkled, that posterior and anterior to valves moderately pigmented, a short section of membrane on internal surface an apparent remnant of hind gut (*hg*).

Exuviae of the first three instars are very closely appressed to each other along the posterior half of their abdominal sterna, so much so that they can scarcely be separated without injury to the specimens. The closest attachment appears to be a little anterior to the modified anal opening (hold-fast organ). The platelets comprising the microstructure of the integument on the lateral and dorsal surfaces of

thorax and abdomen, which in the fourth instar vary from tightly grouped on the side of the thorax (fig. 9, *a*) to narrowly separated on the abdomen, are much less closely grouped in the third and second instars, while they are so distant and reduced in size in the first instar as to resemble very widely spaced spiculelike spots of pigment. Mandibles of the third and second instars roughly resemble those of the fourth, and bear sharp teeth, there being at least six to eight in the third and apparently fewer in the second. The epicranium of the first instar has about two pairs of rather large areas of darker pigment, but no mouth parts have been observed, though they may have escaped detection. There are 10 pairs of spiracles in the third and second instars, with the pre-spiracular tracheal ring poorly defined. Only six pairs of spiracles have been found on the exuviae of the first instar, and the posterior one is poorly developed. Each of the three early instars is brown, darker on the head. The venter is pale in the third and second instars. Approximate lengths of the exuviae of the Falls Church, Va., larva are as follows (in millimeters): Fourth 6.5; third 3.6; second 2.3; first 1.2. Those of the Marietta, Ga., larva are almost identical, but the Fuguay, N. C., larva is larger, the three exuviae measuring as follows: Third 4.4; second 2.6; first 1.3.

Eggs apparently are broadly elongate-oval; fragments are about 1.4 millimeters long.

A basic paper on the larval head of parasitic Hymenoptera is that of Vance and Smith (1933). Among the more specialized papers, those of G. C. Wheeler (1943) and Beirne (1941) have aided me most while studying the anatomy of fifth- and fourth-instar heads, respectively, of *Rhopalosoma*. The book by Clausen (1940) is a valuable aid toward understanding the biology and morphology of related families, and it should be consulted for references to the important work of J. C. Bridwell, F. A. Fenton, R. C. L. Perkins, F. X. Williams, F. van Emden, and others.

### Summary and discussion

Among the biological data additional to those brought out by Hood (1914) is the fact that *Hapithus agitator* is an acceptable host for *Rhopalosoma* in the eastern United States. The effect of the parasite on the internal organs of the host, unfortunately based on only one dissected cricket, has been described. Details concerning the position of the parasite egg and various larval stages have been given. Notes on adult habits, essentially lacking previously, make it clear that in parts of the Southeast specimens of *Rhopalosoma* are not nearly so scarce as has been supposed. Like many another rarity in collections, these insects can doubtless be taken in numbers by those familiar with

their appearance, time of occurrence, and favored habitats. It is noteworthy that on a single day, September 12, 1950, Dr. Townes and his associates found two larvae, one on *Hapithus*, the other on *Orocharis*. Specimens belonging to the University of Michigan show that on three other occasions, once in Indiana and twice in Florida, a collector has found two instances of parasitism in a single day.

There remain many unanswered questions concerning the biology of the species of *Rhopalosoma*, some of which may require controlled cage studies. Stages earlier than the fourth instar are still known from exuviae and fragments of eggshell, and first instar specimens are especially desirable for morphological study.

More study material, including specimens from northern and southern States, may show that more than one form of *Rhopalosoma* occurs in the United States. Adults of *nearcticum* were distinguished from their Neotropical congeners by Brues (1943) on rather minor morphological features, and differences correlated with geographic distribution might be better represented in larvae than adults. Of the four fifth-instar specimens examined, the ones from Georgia and North Carolina and the exuviae of Hood's Maryland specimen lack teeth on the mandibles, while the larva from Virginia apparently has a full complement of teeth on the left mandible but only a few basal ones on the right mandible. It is not known whether occasional breakage of teeth occurs while the larvae are burrowing in soil prior to cocoon formation. Some breakage of the teeth of the Virginia larva may have resulted from my manipulation of the mandibles with needles before I realized the existence of teeth. The three fifth-stage larvae have been measured for maximum head width and length of mandibles. The ratio of head width to length of mandible is 1.68, 1.86, and 2.0 for the larvae from Virginia, North Carolina, and Georgia, respectively.

Brief examination of a few examples of other families has suggested certain characters which deserve careful attention in subsequent work of a comparative nature. A chrysidid larva (*Chrysis*) has the second thoracic spiracle located behind the groove separating meso- and metathorax, while the corresponding spiracle of *Rhopalosoma* is slightly in front of the groove. Unlike the condition in *Rhopalosoma*, the second spiracle of a tiphiid larva (*Cosila*) is smaller than adjacent ones. This tiphiid larva has two maxillary appendages, and there are two prominent angular projections on the labium in the area of the sericteries. As more details of rhopalosomatid life histories become available, comparisons with the situation in the Tiphiidae, such as has been discussed by Clausen, King, and Teranishi (1927), will perhaps be instructive.

A larva of one of the Larridae (*Larra analis* Fabricius, which attacks mole crickets) has the head proportionately smaller than



*Rhopalosoma*, but as in the latter the maxilla and labium have two pairs of appendages each. A conspicuous difference is that the mandible of *Larra* has a single preapical tooth in the incisor area, and basally on a lower lever there are two heavy molar teeth, or "prosthecae." The mesal pair of elongate labial appendages of *Rhopalosoma* has apparent homologues in this larrid.

The mouth parts of those few larvae of Bethyridae and Dryinidae that I have seen are much reduced or otherwise specialized. Illustrations of dryinid larvae on the bodies of leafhoppers, such as those of Haupt (1916), show that the parasite larva sometimes remains associated with its exuviae in a manner suggestive of *Rhopalosoma*. The genus *Harpagocryptus* Perkins, based on a species that Perkins (1908) described from Queensland, is of interest in this connection because the larva was said to form "a sac on the sides of the abdomen of small crickets (Trigonidiidae)." Although originally referred by Perkins to the Dryinidae, Bischoff (1927, p. 407) called *Harpagocryptus* a bethyrid, and Reid (1939) suggested that it may be a psammocharid. As with *Rhopalosoma*, a knowledge of the immature stages of *Harpagocryptus* might prove of great value when adequate comparative studies eventually are possible.

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