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Life history and biology of the riffle bug *Rhagovelia obesa* Uhler (Heteroptera: Veliidae) in Southern Ontario

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The life history of *Rhagovelia obesa* (Heteroptera: Veliidae) was investigated using field collected and laboratory reared material. The nymphal instars and adults are described and figured. This is the first life-history study of *Rhagovelia* or its related genera *Tetraripis* and *Trochopus*. These genera together have almost a worldwide distribution and are characterized by a unique swimming plume beating under-water. Four nymphal instars occur instead of the usual five. The overwintering stage is the egg, another unusual feature for aquatic Hemiptera. The site(s) of egg laying have not been located. For the first time *Rhagovelia* has been raised in the laboratory from first instar to adult.

Introduction

The genus *Rhagovelia* is widely distributed in the world being absent only from Europe. Related genera include *Tetraripis*, confined to Asia and *Trochopus* a New World marine genus. These three genera are unique among the gymnocerate water bugs in their mode of swimming which is effected by a fan-shaped plume on the terminal segment of the second pair of legs beating below the water surface (Bueno 1907; Coker *et al.* 1936). Although over 100 species of *Rhagovelia* are known in the literature (Lundblad 1935; Bacon 1956), no previous study of their life history has been published and little barring casual observations is available on their biology.

In the present paper the life history of *Rhagovelia obesa* Uhler, a common veliid in running waters in Southern Ontario, has been studied. For the first time these insects have been reared in the laboratory from the first instar to the adult stage. There are only four larval stages. Although Caesarian eggs have been hatched in the laboratory, no viable eggs have been found in the laboratory nor have they been collected in the field. Evidence from laboratory and field studies have shown that contrary to previous surmises the overwintering state is the egg. Although the actual sites of egg laying have not been located, circumstantial evidence suggests the mud crevices on stream edges or the bottom of the stream. The observations on the biology made during the present studies are discussed with reference to previous work.

Materials and Methods

Rhagovelia obesa is a common veliid in North America, and is the only species of the genus in Southern Ontario

(Gould 1931; Bacon 1956; Brooks and Kelton 1967). It is numerous in streams and rivers and easily obtainable in large numbers throughout the summer.

The major portion of the material used in this study was collected at 3-day intervals in 1969 from two localities near Waterloo, Ontario: Sunfish Creek, a small stream near Sunfish Lake (Fig. 1A), and Laurel Creek near Erbsville. Some additional material was obtained from Wellington County, namely the Credit River near Orangeville, the Speed River near Fergus, and the Credit River near Rockwood. A few collections were also made from a small stream in Marsland Park, Waterloo.

The specimens were collected with a pond net (0.3* mesh) and were brought back to the laboratory either alive in a small quantity of water and transferred to artificial streams or they were preserved in 70% alcohol. Live specimens were reared in artificial streams (Fig. 1B). These streams were made of fiber glass with a plastic coating and were 10 cm wide and oval in shape measuring 92 × 60 cm. The water, obtained from a natural stream, contained microcrustaceans and small insect larvae. In addition fishfood (Tropical fishfood; fine grade: Hartz Mountain Products Corporation, New York) was sprinkled lightly three or four times a day on the water surface. The water was circulated by a series of rotating vanes and the specimens were separated from the vanes by fine mesh. The water temperature in the stream was maintained at 19°C and illumination with standard room illumination was provided for 8-10 h a day.

Since *Rhagovelia* was believed to overwinter in terrestrial vegetation, two types of traps were designed to capture individuals returning to the stream in spring. Nylon nets (mesh 0.2) were fitted to metal frames 15 × 90 cm (Fig. 1A). The nets were half submerged in water and the frames orientated with their long axis at an acute angle to the bank. Sticky boards were constructed with wood (20 × 90 cm and 2.5 cm thick) on which a sheet of polyethylene was stretched. The polyethylene sheet was sprayed with "Tanglefoot" (Tanglefoot Co. Michigan). These boards were placed to catch any insects crawling back to the stream.

*All measurements, unless otherwise stated, in millimeters, throughout.

Field Observations

In the fall of 1968, when this work began, regular collections of *Rhagovelia obesa* were made in Sunfish Creek. Only adults were collected during the period mid September until late October. Many mating pairs were observed during this period and the adults disappeared from the stream at the end of October. A similar pattern was repeated for this period in 1969 and 1970. Though the overwintering habits of *Rhagovelia* were not known it has been suspected that the adults overwinter as is the case with other

aquatic gymnocerate bugs. No adults were found in the fall after their disappearance from the stream although intensive searching in the vicinity of the creek was carried out. To catch any individuals returning to the creek in spring the two types of traps mentioned earlier were set up. Six of each type were set up on both sides of the stream along a 50-meter stretch. A few *Gerris remigis* Say were captured in mid April but no *Rhagovelia obesa* was caught. Regular collecting in the stream with a fine-meshed net (0.3 mesh) was done at 3-day intervals and on June 8 the first specimen of a first instar nymph of

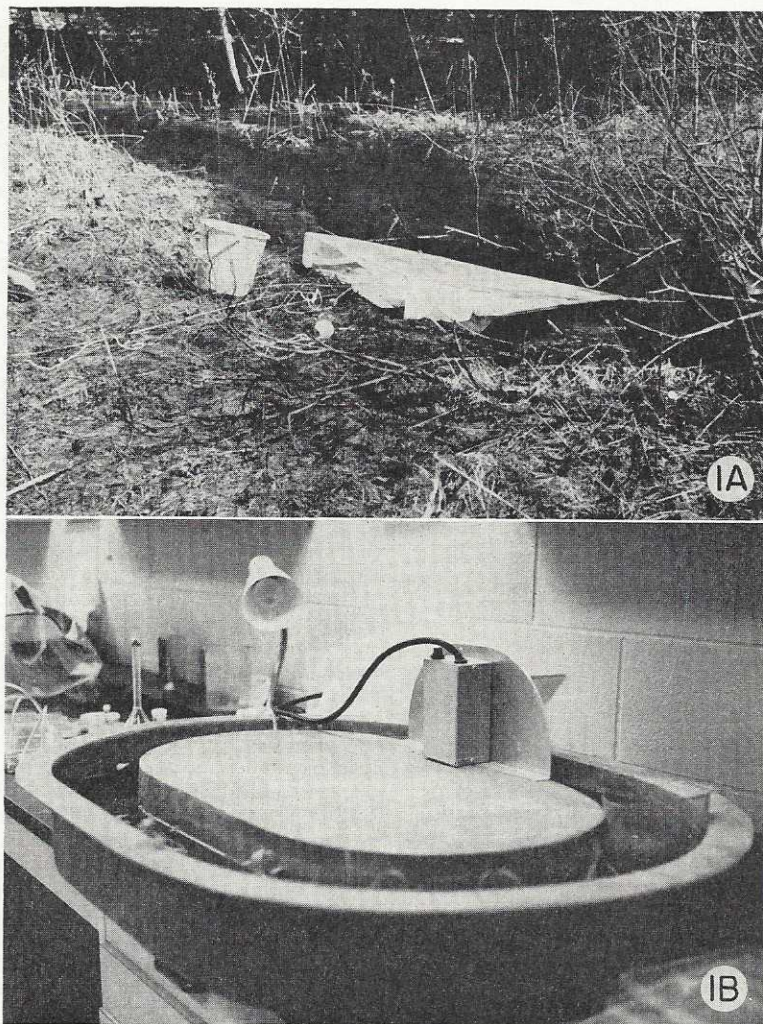


FIG. 1. A. Sunfish Creek showing trap set at stream edge in spring. B. Artificial stream used to rear *Rhagovelia*.

Rhagovelia obesa was captured. Regular collections were carried out until late October. Mud from the sides of the stream and stones and mud from the bottom were examined for eggs during September and October, 1969 but no eggs were found. In spring 1970 attempts to hatch nymphs from similar material failed although collected from sites where numerous mating pairs had been observed in the fall of 1969. Surface water temperatures were taken for Sunfish Creek and Laurel Creek and are given in Fig. 2.

Laboratory Studies

At various times in September 1968, specimens of *Rhagovelia obesa* were collected from Sunfish Creek and kept in artificial streams in the laboratory. In all about 100 adults, including several mating pairs, were thus treated. They lived for varying periods of up to 3 weeks. At the end of October all were dead. The mud from the bottom of the streams was washed and sieved through 0.1 mesh and carefully examined for eggs. From about 1 kg of fine mud 56 eggs were collected of which 23 were intact. They mea-

sured* 1.5×0.6 . No evidence of embryogenesis could be seen under the light microscope ($\times 100$). Twenty eggs kept in the laboratory until the next spring showed no signs of development and, of the few which did not become moldy, none hatched.

In June 1969 over 100 first instar nymphs were collected from the field. About 40 of them were kept in artificial streams and to our surprise about 25% survived and completed their development to the adult stage. Since *Rhagovelia obesa* damages easily we did not handle nor examine the specimens in the laboratory and hence no record of the duration of each stadium is available. However, we have records of newly molted adults and the development in the laboratory from first instar to adult was about 46 days.

We kept mating pairs in individual aerated glass containers provided with apparently suitable ovipositing sites of various types (stones, gravel, mud, and macrophytes in different combinations). Twenty-six such experiments were carried out using one to five mating pairs in each. All the adults were dead in 3–6 days. We examined the substrates carefully but found no eggs.

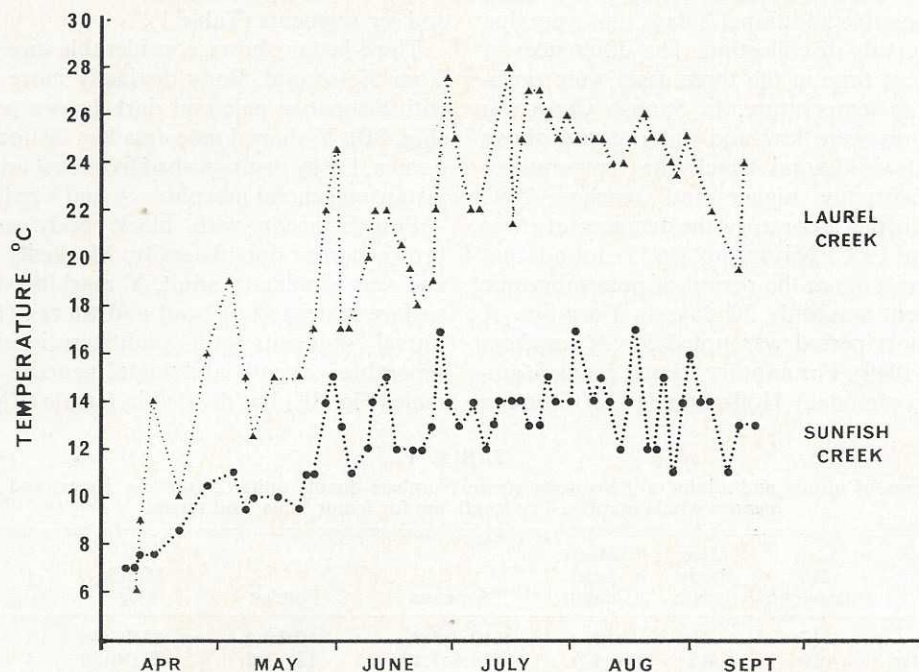


FIG. 2. Temperatures recorded in Sunfish Creek and Laurel Creek near Erbsville from April–September 1969.

Adult females collected in September and October usually had eggs which appeared mature. The number of eggs in a single individual varied from one to nine. Some of these Caesarian eggs were kept in petri dishes lined with moist filter paper and others were kept in well aerated stream water in glass containers. Of about 15 eggs 1 hatched in 11 days. This newly hatched individual was identical with the earliest stage collected in the field.

Life History

In *Rhagovelia obesa* there are only four larval instars instead of the usual five in most other aquatic Hemiptera. Usinger (1956) states that all aquatic bugs except some species of *Microvelia* (Veliidae) have five larval instars. Hoffmann (1925) found that *Microvelia borealis* and *M. buenoi* have four larval instars and Frick (1949) found that some apterous specimens underwent four larval instars while most had five in *Microvelia capitata*.

The period of postembryonic development from field data was 48 days for Sunfish Creek and 41 days for Laurel Creek. In the laboratory this was 46 days for field collected first instars, giving a possible additional 2 days that were due to the intervals of collection. The differences in development time in the three cases were probably due to temperature. In Sunfish Creek the temperatures were low and did not rise above 17°C while in Laurel Creek the temperatures were consistently higher and reached 28°C (Fig. 2). In the laboratory the temperature was a constant 19°C. Miyamoto (1953) found that in *Microvelia diluta* the period of postembryonic development was only 20 days in Formosa. A similar short period was noted for *M. capitata* by Frick (1949). For another related genus *Mesovelia* (Mesoveliidae) Hoffmann (1932) found a

similar short period of development. Frick (1949) noted that for several species of *Microvelia* studied by earlier workers postembryonic development ranged from 15 to 49 days for one species but 22 to 23 days for four others.

Description of Stages

Some measurements of nymphs and adults are given in Table 1 and illustrations are given in Figs. 3 and 4.

Egg elongate with broadly rounded ends (Fig. 4I). Average size 1.5×0.66 . Surface of egg roughened. Under the scanning electron microscope a uniform, closely set distribution of cup shaped "areoles" was noted on the surface.

First instar oval in shape (Fig. 3A). Body covered with fine setae, dark brown with a pale border dorsolaterally and a Y-shaped marking dorsally. Antennae and legs robust. Midtarsal claws already well developed but tarsal segments not differentiated. Eyes of newly hatched instar bright red. All appendages pale brown.

Second instar very similar to the first in color pattern and general morphology. Body somewhat elongate. Difficult to distinguish from first instar except by measurements of the antennal and leg segments (Table 1).

Third-instar shows considerable size increase from the second. Body distinctly more elongate with distinctive pale and dark brown patterning (Fig. 3B). Y-shaped pale area less distinct on abdomen. Easily distinguished from first and second instars on general morphology and size (Table 1).

Fourth instar with black body and dark brown border dorsolaterally. Markedly elongate and very similar to adult. Y marking on dorsal surface restricted to head and thorax (Fig. 3C). Tarsal segments still undifferentiated. Sexes separable; seventh abdominal ventrite entire in male (Fig. 3E) but divided in female (Fig. 3F).

TABLE 1

Measurements of instars and adults of *Rhagovelia obesa*. Numbers denote units (20 units = 1 mm) and are to the nearest whole number. Leg length are for femur, tibia, and tarsus

Stage	No. measured	Mean body length	Mean head length	Antenna	Foreleg	Middle leg	Hind leg
First instar	17	36	13	10:4:5:9	10:10:4	17:12:24	12:16:8
Second instar	10	45	17	13:6:7:10	15: 3:5	23:16:29	15:21:10
Third instar	13	68	20	19:7:9:12	19:18:7	33:21:37	22:28:12
Fourth instar	22	97	24	24:12:13:15	27:26:9	45:30:48	33:38:17
Male	5	115	24	29:15:16:15	33:34:9	63:43:50	50:41:17
Female	6	126	26	30:14:15:15	35:36:9	62:43:51	48:47:19

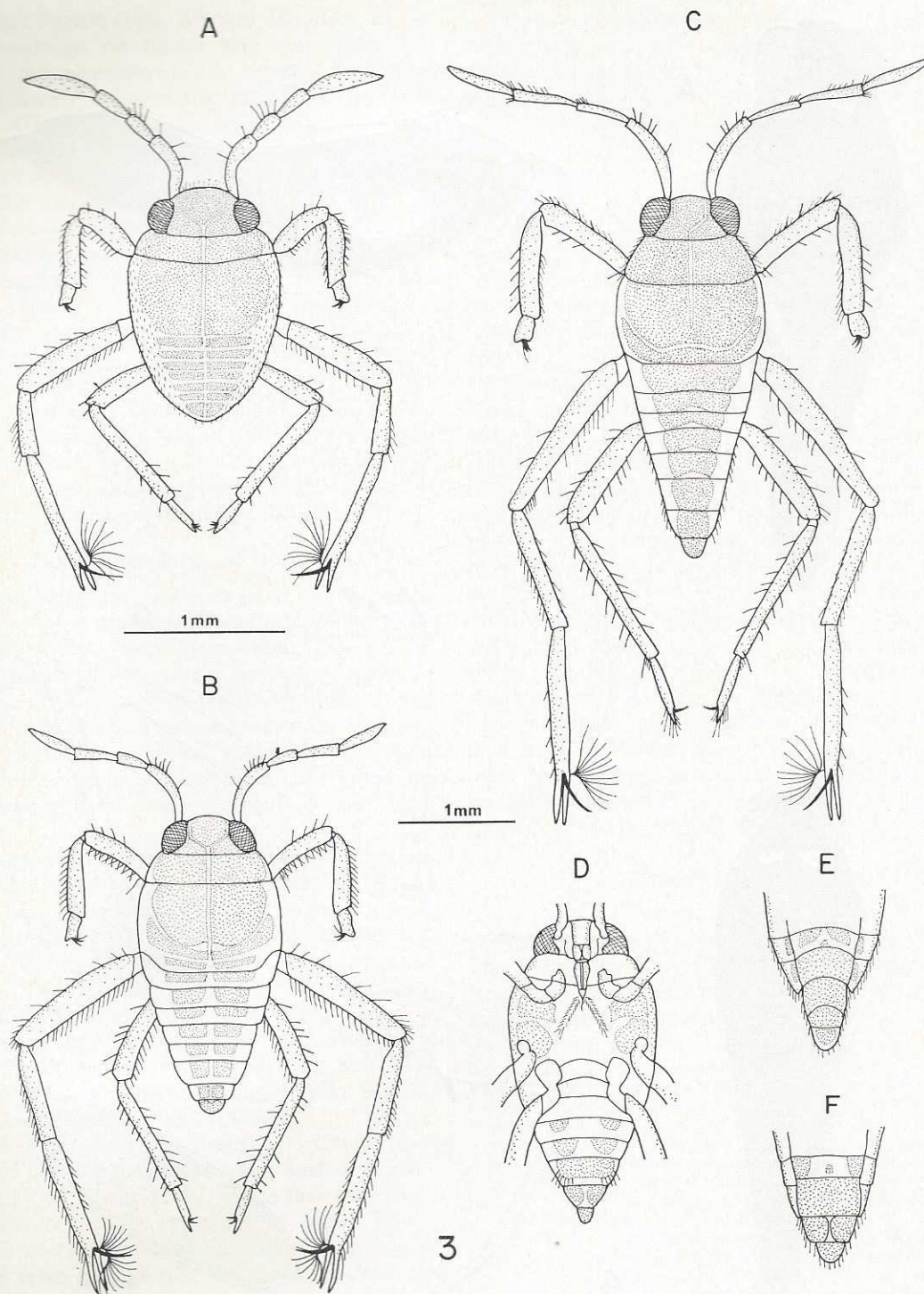


FIG. 3. First instar nymph, dorsal view. B. Third instar nymph, dorsal view. C. Fourth instar nymph, dorsal view. D. Fourth instar nymph, ventral view. E. Fourth instar nymph, male apical abdominal segments in ventral view. F. Fourth instar nymph, female apical abdominal segments in ventral view.

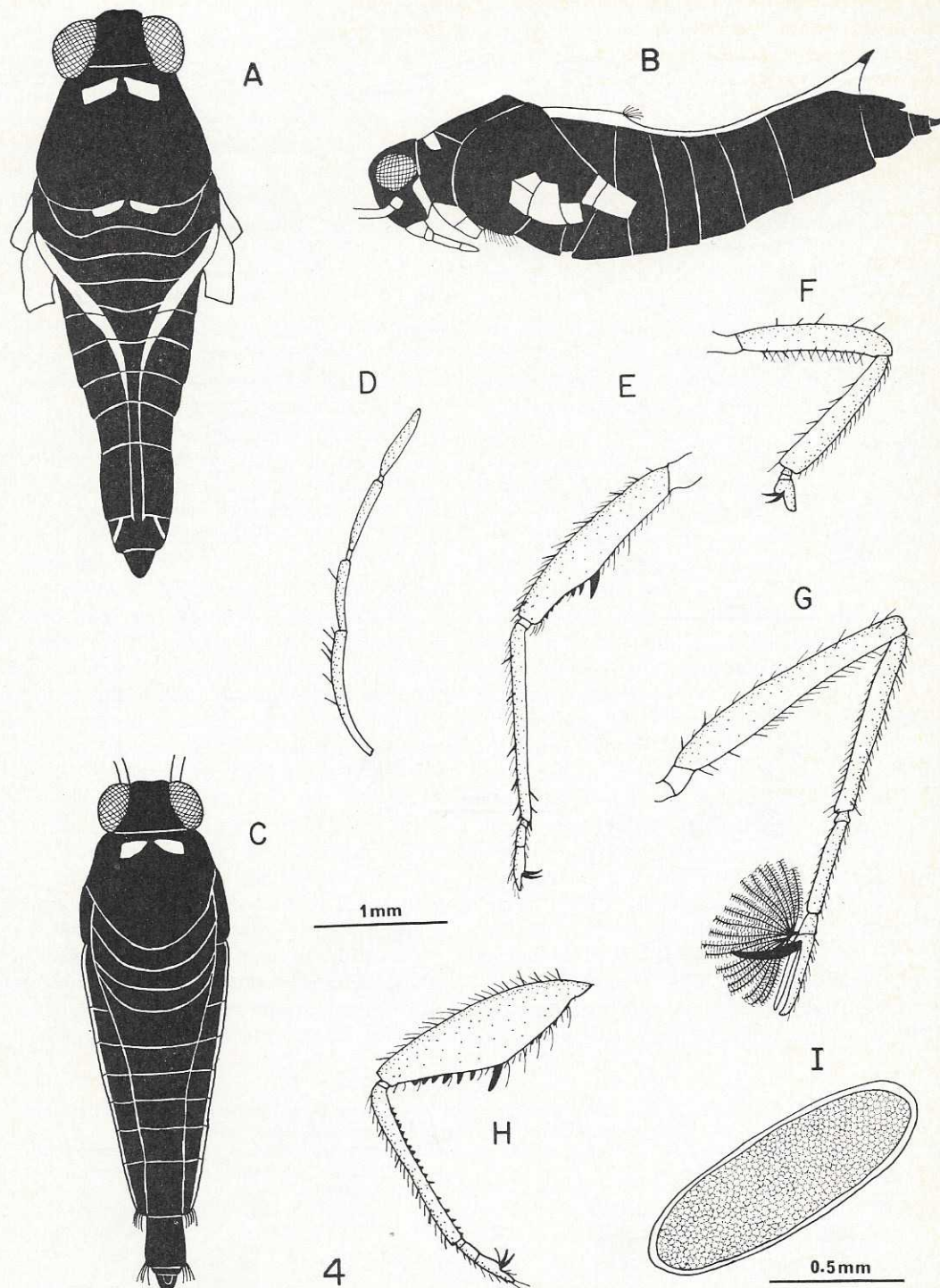


FIG. 4. A. Adult female, dorsal view. B. Adult female, lateral view. C. Adult male, dorsal view. D. Male antenna. E. Female hind leg. F. Female fore leg. G. Female middle leg. H. Male hind leg. I. Egg.

Adult female (Figs. 4A and 4B) black except for markings on thorax and connexiva. The latter are characteristically curved (Fig. 4A). Tarsi clearly differentiated into three segments (Fig. 4E-G). Easily distinguished from males by the upturned posterior end (Fig. 4B) and the narrow femur (Fig. 4E).

Adult male slightly smaller than female. Black ground color with one pair of white markings on the thorax and white connexiva. Front femur expanded and armed with spines, tubercles, and hairs. Tibia armed with a row of small teeth on inner margin (Fig. 4H).

All instars have a V-shaped series of black hair on the thoracic sternum (Fig. 3D). The swimming plume and tarsal claws on the middle legs are prominent in all instars. There is a gradual darkening of the body from the first instar to the adult stage with differentiation of the tarsal segments occurring in the adult.

Notes on Biology and Discussion

Rhagovelia and *Tetraripis* have been reported from running waters (Bueno 1907; Gould 1931; Lundblad 1933; and Bacon 1956). *Trochopus* is a marine genus occurring in bays along the coast (Bacon 1956; Cobben 1960). We have found *Rhagovelia obesa* in running waters in Southern Ontario but in addition numerous specimens were observed in September in Lake Opeongo, Algonquin Park, both in the bays and open water.

Rhagovelia obesa is commonly found in groups varying from 5 to 100. Both nymphs and adults have been observed to swarm in this way usually close to the banks of streams. When disturbed, such swarms tend to disperse, but reassociate later. Such swarming behavior is more pronounced in the nymphal stages.

Mating in *Rhagovelia obesa* was observed in July by Bueno (1907) in New York State. We found *Rhagovelia obesa* mating only in September and October in Sunfish Creek.

Rhagovelia swims by means of a tuft of hairs spread fanwise under the water surface (Coker et al. 1936). Bueno (1907) states that they swim underwater readily especially at night. Bacon (1956) noted that individuals swimming underwater were near death. We found underwater swimming occasionally in the laboratory but the individuals seemed ill at ease. It is, however, possible that under natural conditions under-

water swimming does occur. Sattler (1957) found mating pairs of *Gerris najas* swimming underwater to lay their eggs. Certainly Gerridae which are large are less adapted for underwater swimming than *Rhagovelia*.

According to Bacon (1956) *Rhagovelia* feeds on small insects and crustaceans trapped at the surface of the water, and on larger insects under laboratory conditions. We have found no record in the literature of the feeding habits of *Rhagovelia* under field conditions. We also supplied nymphs and adults finely ground "tropical fish food" containing pulverized insects, fish meal, and milk solids. The *Rhagovelia* became very active when this material was sprinkled on the water surface, but no actual feeding was observed.

Bacon (1956) obtained first instar nymphs from eggs laid by females confined in the laboratory, but states that no means was found to keep the instars alive in the laboratory. We have succeeded in keeping both instars and adults of *Rhagovelia* alive in artificial streams. Hence experimentation with these insects is now possible.

The sites of egg laying have not been located so far. Mating pairs were found frequenting shallow edges but if eggs are laid near the water's edge in fall the abrasive effects of ice-breakup must have an adverse effect on the eggs. On the other hand if eggs are laid under water as in gerrids (Sattler 1957) the chances of their survival would be greater.

Acknowledgments

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