THE BIOLOGY OF THREE NORTH AMERICAN SPECIES OF
" MESOVELIA (HEMIPTERA-MESOVELIIDAE)

by

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INTRODUCTION

The purpose of this paper is to present what is known at the present time concerning the life histories and habits of the Mesoveliidae, particularly those of three species of the genus Mesovelia Muls. found in North America. Studies on our most common species, Mesovelia mulsanti bisignata Uhler, were carried out in Michigan and Kansas, while biological notes on the other two species were taken in the region of Douglas Lake, Michigan, their only known habitat. Isolated rearings and life history studies of all three species were made at Lawrence, Kansas. Not only had the biology of these forms been practically untouched, but an earlier investigator's results led me to expect a high mortality among the Mesovelia. It was with much determination as well as interest, therefore, that the writer observed and reared large numbers of these most interesting little bugs of the water.

The writer wishes to express his appreciation and gratitude to Dr. H. B. Hungerford, head of the Department of Entomology of the University of Kansas, for the opportunity of making this study as well as for his kindly help and criticism. The writer also wishes to acknowledge his indebtedness to Dr. Kathleen Doering for advice concerning

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HISTORICAL ACCOUNT AND SYSTEMATIC POSITION OF
MESOVELIIDAE FAMILY

An excellent abbreviated history of the family Mesoveliidae is given by Horvath (9) in the preface of his General Catalogue of the Hemiptera, Fascicle 2, "Mesoveliidae". The preface, which is a part of the Introduction to his Monograph published in 1915, reads as follows in idiomatic English:

" 'The Mesoveliids constitute a small family of Hemiptera-Heteroptera whose representatives live on the surface of stagnant waters or in a quiet stream. However, a species of New Guinea, the type of a new genus *Phrynovelia*, has not been found on the water, but under fallen leaves.

" 'The first species described in 1852 by Mulsant and Rey, *Mesovelis furcata*, was ascribed by the authors to the Amphibicorises near the genera *Velis* Latr. and *Microvelis* Westw. Dohrn (1859) united the genus *Mesovelis* Muls. and Rey with the genus *Hebrus* Curt. in the family of the Hebrids. Fieber (1861), Sahlberg (1875) and Uhler (1894) placed it in the family of the Veliids. Jakowleff who described (1874) the genus *Mesovelis* under the name of *Fieberia* as new, ascribed it to the Hebrids; G. C. Champion also followed his example later (1903). Since the Veliids, Hydrometrids and Gerrids, sometimes also the Hebrids, have been united as sub-families in one single family called first *Hydrodromica*, then *Hydrometridae* or *Gerridae*, the ma-

majority of authors have also placed the Mesoveliids in this family as a separate sub-family. But Puton (1879) justly pointed out that the genus Mesovelis will appear to have to constitute rather a separate family, on account of the numerous differences which it presents with the other Hydrometrids (Gerriids). Puton and the other Hemipterists forgot, however, that Douglas and Scott already established the family of the Mesoveliids in 1867. It is only in 1908 that A. Handlirsch cited, in his authoritative work on insect fossils, the Mesoveliids as a distinct family; it is only since then that they have been generally considered as a separate family.

" 'The systematic position of the family of Mesoveliids remained uncertain and doubtful for a rather long time. The general facial expression of these Insects and their habitat caused them to be placed in the Amphibicorises since the beginning, but their relations were not sufficiently elucidated and determined. Douglas and Scott (1867) united them with the Hebrids in the section of the Hebrina. Handlirsch (1908) represented them in his genealogical tree as receiving their origin from the branches of the Hydrometrids from which the Hebrids and the Aepophilids are perhaps also descendants. J. R. de la Torre-Bueno (1908) compared the Mesoveliids, because of a certain resemblance of the eggs, to the family of the Nabidids. My late friend O. M. Reuter who dedicated the last years of his laborious life

with as much zeal as success to phylogenetic and systematic studies of the Heteroptera, considered the Mesoveliids first (1910) as a phalanx of the superfamily Gerroideae, but in one of his last works (1912) he compared them to the Hebrids, in uniting these two families in one phalanx of the superfamily of the Reduviidae, neighbor of the phalanx Nabiformes.

" 'It seems to me, however, that Reuter in this case attributed too great an importance to the structure of the eggs, and that neither the Mesoveliids nor the Hebrids are in their right place in the superfamily of the Reduviidae. In my opinion it is necessary to carry them back to the superfamily of the Gerroideae. In examining these two families more attentively, one is not able to disregard their near relationships with the other three families of the Gerroideae. The presence of an orifice of the odoriferous gland on the metasternum, which is such a remarkable and exclusive character of adult Gerriids and Veliids, seems to me of the greatest importance in guiding us in the phylogeny of these Insects. The structure pretty nearly identical with the rostrum is also an indication of their affinity.' "

"The family of Mesoveliids is represented in all the zoogeographical regions of the globe and contains 2 genera and 14 species known at present."

REVIEW OF AMERICAN SPECIES OF GENUS MESOVELIA WITH KEY
TO MESOVELIA OF EASTERN AMERICA

The first American species of the genus Mesovelia Muls. discovered was Mesovelia mulsanti, which was described in 1879 by F. B. White from the Hemiptera collected in the Amazons by Prof. J. W. Trail (21). Uhler, in 1884, described Mesovelia bisignata from specimens of the United States (19). In 1898, Champion (7) placed Mesovelia bisignata Uhl. as a synonym of Mesovelia mulsanti White. Recently, Jaczewski (15) has made several sub-species out of Mesovelia mulsanti White, because of differences in the shape of the gonapophyses, and because each of the sub-species seems to have a more restricted area of distribution of its own. Accordingly, the same writer proposes to call Mesovelia mulsanti bisignata Uhler the North American subspecies; it was heretofore called Mesovelia bisignata Uhl. or Mesovelia mulsanti White by most North American authors. In 1894, Uhler (20) described Mesovelia amoena from the Island of Grenada. Then in 1924, Hungerford described two new American species of Mesovelia Muls.; namely, Mesovelia douglasensis (12) and Mesovelia cryptophila (13), both descriptions of which were based upon specimens from Douglas Lake, Michigan. Mesovelia bila, the fifth American species of the genus Mesovelia Muls., was described by Jaczewski (14) in 1928 from the South Brazilian State of Parana.

A survey of the literature concerning the biology of the members of the family Mesoveliidae shows that such information is somewhat limited and scattered. The biology of Mesovelia furcata Muls. and Rey, a European species of the genus Mesovelia Muls., is apparently confined to the following accounts: Scott (18), Butler (5), Lundblad (16), Bollweg (21), Gulde (8), Butler (6), and Poisson (17). Biological information on Mesovelia mulsanti bisignata Uhl. is restricted to studies made by Uhler (19), Bueno (3), Hungerford (10), Hungerford (11), and Bueno (4). Hungerford (10) worked out the life history of this species, and gives an excellent account of it in his paper entitled "The Life History of Mesovelia mulsanti White". Except for some biological notes on Mesovelia douglasensis Hung. by Hungerford (12), nothing has been done on the biology of the remaining species of the genus Mesovelia Muls.

The species of Eastern North America have been separated by Blatchley (1) as follows:

" a. Larger, length 3.6 -4mm.; hind margin of front and middle femora with a row of spines; beak reaching base of hind coxae; first genital of male with tufts of black setae on lower side. M. mulsanti.

aa. Smaller, not over 2.8 mm.; hind margin of front and middle femora without spines; first genital of male without setae.

b. Beak reaching first ventral.

c. Head brown with a narrow median pale line;

joint 1 of antennae not passing hind margin
of eye; general color mottled brown, shin-
ing. M. douglasensis.

cc. Head grayish with two narrow parallel dark
lines; joint 1 of antennae surpassing hind
margin of eye; general color olive-green,
thickly covered with a fine grayish
bloom. M. cryptophila.

bb. Beak reaching between middle coxae; head
yellow with two brown stripes.

M. amoena."

THE BIOLOGY OF MESOVELIA MULSANTI BISIGNATA UHLER

Habitat.--Mesovelia mulsanti bisignata Uhl., the largest of the three species of Mesovelia Muls. considered in this paper, lives upon the floating shoreward vegetation of the waters of ponds, marshes, bogs, and other such bodies. Uhler (19) found members of this species on the leaves of Potamogeton; Bueno (1) on duckweed, matted hydrodictyon, and other algae floating on the surface of ponds; Hungerford (11) about old logs projecting from the water, about clumps of smartweed at the water's edge, on rafts of filamentous algae, and on the leaves and stems of such plants as water shamrock, procumbent upon the surface; while the writer has found them on Nymphaea and amidst thick growths of Chamaedaphne, as well as on some of the above named plants. Both winged and wingless forms occur in this species, but the latter ones far outnumber the winged forms.

Hibernation.--This species is thought by most writers to overwinter as an adult, but conclusive evidence is lacking. The writer made numerous trips to Lake View, a large standing body of water about 6 miles northwest of Lawrence, Kansas, in order to watch this species during the fall and winter months. It was exceedingly dry during the fall months and the water of this lake receded about 20 feet a month, thus making observations difficult. In October, hundreds of apterous forms were present along the lake

shore and also in the small inlets from the lake which contained an abundance of algae and larger aquatic plants. By the middle of the following month, however, their numbers had diminished; and the males and females were found in groups of from 10 to 30 under dead lily leaves which were partially hidden in the mud. Most of the bugs were found about two feet from the water's edge, and no doubt the cold weather caused them to be found lying flat against the leaf or on the mud. They were inactive and moved about only after being disturbed. A dead apterous male, found under a lily leaf on November 26, 1930, was the last specimen taken, the others disappearing mysteriously. I might say that the above observation was made after a series of hard freezes. Searches through several tubs-full of mud and debris which had been removed from the edge of the water and from a few feet back of the water margin, and which were examined in the laboratory, failed to reveal any hibernating adults.

Adults collected at Lake View in November were brought to the laboratory, where they soon became very active, fed voraciously, mated, and laid eggs within a few days. A housefly was tossed in a dish containing 20 adults, and within a few minutes all of them had their beaks in the fly. Some of the eggs laid by these adults hatched out in a couple of weeks, while others hatched intermittently throughout the months even up to May.

Some eggs of Mesovelgia mulsanti bisignata Uhl. laid in pieces of cattail leaf during the middle of August in

Michigan, were taken to Kansas, where they were placed in the laboratory and where a goodly number hatched out at intervals of about a week from that time on until the month of May. Another piece of cattail leaf containing eggs laid the same month was placed in refrigeration at 32° F. for about a month; i.e. from October 25 to November 25, and between the third and eight of December fifteen eggs hatched out. Thus, the eggs can withstand freezing temperature and might do so in their normal habitat.

On May 2, 1931, after the completion of the first draft of this paper, the writer decided to visit Lake View once more in an attempt to be present at the first appearance of hibernating adults. Much to his surprise, however, he found a large number of first instar nymphs, but no amount of searching revealed adults. These nymphs, then, would appear to come from over-wintering eggs and do not seem to be the progeny of over-wintering adults.

Mating.--Hungerford (11) gives the following account of mating in this species: " In mating the male mounts the female, clasps his fore legs around her mesothorax in front of her middle legs, rests his middle legs upon the water film or other supporting surface, and holds the hind legs poised in the air. The copulatory organ of the male is long and curves around the side of the tip of the female's body to come in contact with the genital opening. Contact lasts from a few seconds to one minute or longer. Upon

withdrawal the copulatory organ is seen to be a slender white tube of astonishing length". Copulation may take place on the water or on vegetation, and a number of pairs were observed mating in the bottles in which they were collected. It has been noted that the male used the hind legs to advantage in keeping his equilibrium, and that mating is terminated by vigorous kicking on the part of the female.

Preoviposition.--The preoviposition period seems to lie between 2 and 6 days. Hungerford (10) states that "mating occurs and oviposition begins about the third day", while most of my records show the preoviposition period to be about six days in length.

Oviposition and fecundity.--Butler (5), in 1893, called attention to the fact that Mesovelia furoata Muls. and Rey. mated several times and that the bodies of the females became greatly distended at the end of three weeks. Although the same writer failed to find out the method of oviposition, he noted that impregnation took place in the summer. Mesovelia mulsanti bisignata Uhl. protects its eggs by placing them in the tissues of certain plants by means of an ovipositor as is mentioned by Bueno and Hungerford (11). Hungerford (11) describes the method of oviposition as follows:

"The female frequently explores the stem with the tips of her beak and antennae if indifferent in the matter, but

if eager to oviposit, she mounts the stem without delay, raises the abdomen slightly, unsheathes the ovipositor and turns its tip down to the surface of the stem. At times the surface is tested out at several points -- again if the first point of contact is favorable, the tip is caused to quiver back and forth till it gains a footing, and then rocking the body slightly from side to side the entire drill is caused to rotate or twist back and forth on its axis, rapidly at times, or again more slowly as may suit the necessity of the work, until a hole is effected and the ovipositor is buried to its base. During the deeper drillings the longitudinal alternate thrusts of the drill parts are apparent. The first part of the operation at least involves much the same sort of motion as one employs in making a hole with a gimlet or awl. It takes but a moment in the spongy, water-soaked stem of a sedge to drive the instrument up to its base. Then, after a moment of apparent quiet, the ovipositor is lifted slightly and the egg is forced by a series of abdominal contractions down the ovipositor and into the cavity reamed out to receive it". He also points out that the male often remains on the back of the female as she is ovipositing, and that mating is attempted and often consummated between her labors.

In the laboratory, many females not only deposit eggs in plant tissue, but lay them on the surface of the plants and in the water. None of the eggs laid on the surface

ever hatched. The table below shows the number of eggs laid by 10 females from the time of maturity until their death. The mating dates recorded were the first ones observed, but the pairs probably mated within a few days after reaching maturity. One female laid 104 eggs in about one and one-half months, but most of the females laid a smaller number of eggs and died within a month's time.

Table (1)

Oviposition Record of Mesovelia mulsanti bisignata Uhl.

Expt.No.	Date of Maturity	Mated	Eggs laid	Number of eggs	Died
31-1	12/17/30	12/29/30	12/22/30	53	1/21/31
31-2	12/23/30	-	-	11	1/6/31
31-3	12/23/30	-	12/29/30	104	2/4/31
31-4	12/23/30	-	-	28	1/5/31
31-5	12/24/30	-	-	36	1/10/31
31-6	12/24/30	-	-	21	1/8/31
31-7	12/25/30	-	-	18	1/9/31
31-8	12/28/30	1/7/31	-	27	1/15/31
31-9	12/26/30	12/29/30	1/12/30	38	1/21/31
31-16	1/22/30	1/26/30	1/28/30	56	2/22/31

Incubation.--Hungerford (11) observed that the egg stage lasted from 7 to 9 days, and that the deep red eye spots are present 2 days before hatching. The writer found the above incubation period to be correct for some eggs -- and doubtless this is the normal case --, but the

period was much greater for most of the eggs kept under observation. For example, eggs laid in the laboratory during August and during the fall hatched out irregularly even until the following May.

Hatching.--Hatching has been observed by Hungerford (11), and he gives the following description:

"At hatching the young nymphs, still enclosed in their embryonic membrane, work their way up through the little circular openings of the stem. This is a remarkable feat, considering the size of the nymph and the size of the hole, but is aided materially by the peculiar backward pointed pegs on the thin embryonic membrane. When well out of the stem, this membrane is cast and the nymph takes its place upon the water".

Behavior of the newly hatched.--The newly hatched, which are light in color and have red eyes, are larger and more active than the other two species considered in this paper. They are so agile that it is often difficult to change the food and water in their containers without having them scamper up and out of the glass stender without warning. They are ready for a meal as soon as they straighten out the limbs and give them a thorough cleaning. Within a few hours, the little nymphs darken to amber and finally become green. When disturbed the nymphs draw the legs close to the body and remain motionless, thus becoming hard to detect from other particles in the

water.

Number of instars.--There are five nymphal instars as was noted by Hungerford (11). The duration of the several stadia is given in the Table of Rearings (p.24).

Molting.--Molting may take place upon floating material, on the sides of the stender near the water, or on the water itself. The process is not unlike that described for Mesovelgia douglasensis Hung. Most of the little bugs are able to free themselves from their old skins in 2 or 3 minutes, but it takes about 10 minutes for them to straighten out their legs and walk away. The greatest mortality occurs in the first and fifth instars because of the nymphs' inability to molt. The skin is either found split at their death, or else their regular molting period is overdue in comparison with that of other rearings. Mortality is shown in the Table of Rearings for the third, fourth, and fifth instars.

Longevity.--Adults collected in the field in both Michigan and Kansas, and those obtained by rearing, indicate the duration of life in this species is relatively short, because most of them died within a month's time.

Number of generations.--The following statement is given by Hungerford (10) in regard to this subject: "There is a succession of generations throughout the season, each cycle requiring about twenty-four days". The writer

has successfully reared consecutive generations in the laboratory, and the average time spent by 48 reared adults from the abandonment of the egg to maturity was 20 days. This number plus the normal incubation period would coincide with that given above for the length of the life cycle.

Food habits.--Butler (6), in his work on Mesovelia furcata Muls. & Rey., speaks of these bugs as being carnivorous in tastes. He gave them freshly killed insects and observed them sucking a Smythurus, a Crambus, a Chalcid, and a Hydrometra. The same writer was unable to say whether they catch their prey alive or use drowned or partially disabled specimens for food. Hungerford (10) believes that the little bugs are not dependent upon the terrestrial insects caught upon the surface film, but spear small Crustacea that are associated with algae and floating Typha near the surface of the water. In his isolated rearings, he found it inadvisable to offer spring-tails, as suggested by Butler, for food, and he used plant lice which were not nearly so active and gave better results.

The writer reared Mesovelia mulsanti bisignata Uhl. on houseflies and fruit flies, the latter of which, killed with heat, served as excellent food. The rostrum of these insects is very flexible, and while feeding it is bent into whatever position best enables the small bugs to reach

the soft parts of their prey. They grasp their prey with the fore-legs and suck the juices.

Behavior.--Uhler (19) in speaking of this species, states that "Nothing could be lighter than their motions over the surface, walking there without making impression or ripple, and moving with the celerity of a spider".

Mesovelia fureata Muls. & Rey was noted by Butler (6) to assume often a frog-like position, with its head in the air and the body sloping until the hinder extremity almost touches the leaf on which it is standing. This same response, with the hind legs being stretched straight back, occurs in Mesovelia mulsanti bisignata Uhl., especially when the surface of the water is disturbed. The adults usually rest on the sides of their containers, completely out of the water but facing it, ready to dart away upon the least disturbance.

These little surface bugs are noted for their cleanly habits, always busily cleaning themselves from hour to hour. The method of "cleaning up" is alike in the three species considered in this paper, and is similar to the following method described by Butler (5) for Mesovelia fureata Muls. & Rey:

" Each leg on either side rubs its neighbor on that side; the fore pair also clean one another in the manner with which the housefly has made us familiar. With the forelegs also the insect cleans its antennae and rostrum, drawing the antennae between the two tarsi, and then

running the latter down the rostrum, taking great care that the tip of that instrument is thoroughly cleaned. With the second and third pairs of legs they clean the back, by rubbing the tarsi over the surface". They walk about on the water moving the corresponding legs of the opposite sides alternately. Mesovelia hold on to life very tenaciously. Many specimens struggled two or three days to gain an upright position on the water, even after their legs were too weak to support the body, before succumbing.

Description of Stages

Egg.--The egg is described by Hungerford (11) as being "elongate-oval, with a curved neck terminating in a flat surface which marks the exposed end of the egg as it lies in situ in the stem of some plant". It is white when first laid, but within a few days it becomes watery transparent as the embryo begins to take form. The deep red eye spots and segmentation appear two days before hatching. The Table of Measurements of ten eggs of this species given below in millimeters show the average length to be .877 mm., the greatest diameter .268 mm., and the diameter of the exposed end of the egg to be .163 mm.

TABLE (2)

Measurements in Millimeters of the Eggs of

Mesovelia mulsanti bisignata Uhl.

Number	Length	Greatest diameter	Diameter of exposed circle
1	.816	.272	.153
2	.850	.272	.170
3	.850	.306	.170
4	.884	.272	.153
5	.901	.221	.153
6	.901	.289	.170
7	.935	.238	.170
8	.884	.289	.170
9	.850	.272	.153
10	.901	.255	.170
Average	.877	.268	.163
Minimum	.816	.221	.153
Maximum	.935	.306	.170

First instar.--The nymphs are white with red eyes when first hatched, darkening to amber and green as they age. Hungerford (11) mentions the following structural characteristics:

"The general form is stouter and more robust than that of the later stages. The body and limbs are clothed with hairs and bristles. The head and thorax bear a few stout bristles and the antennae bear on the first segment

several (usually three or four) stout bristles directed mesally and the terminal segment is thickly covered with fine hairs. The limbs, besides bearing many hairs, possess a number of black bristles arranged as follows: One stout bristle is prominent near the distal end on the anterior margin of the meso- and metathoracic femora. The metathoracic tibiae are beset with numerous irregularly arranged bristles, terminating with one larger than the others".

As was noted by the same writer, the four-segmented antennae are stout and as long as the body, the last segment usually being as long as the other three combined and slightly broader. The ocelli are absent. The stout limbs bear one-segmented tarsi and end in two claws. A dorsal gland pore is present on the median line of the dorsum of the fourth abdominal segment.

Later instars.--The later instars, which are green in color and rather slender, bear one black bristle on the anterior margin of the femur and two on the other femora. The structural characters remain constant until the adult stage is attained. Then, as was noted by Hungerford (11), the first antennal segment bears one black bristle instead of several, the tarsi are three-segmented, and the connexivium is broad and the sexual characteristics appear. A Table of Measurements of the various instars and of the adults is given below.

TABLE (3).

Measurements in Millimeters of Mesovelia mulsanti bisignata Uhler.

Stage	Length of Beak	Width of Head Across Eyes	Antennae				Fore leg			Middle leg			Hind leg			Body		Measurement from tip of Femur to tip of Femur - (Hind Legs)
			1st seg.	2nd seg.	3rd seg.	4th seg.	Femur	Tibia	Tarsi	Femur	Tibia	Tarsi	Femur	Tibia	Tarsi	Length	Greatest Width	
1st instar	.374	.255	.153	.102	.136	.391	.238	.204	.136	.306	.340	.170	.425	.595	.204	.935	.357	1.173
2nd instar	.459	.323	.170	.136	.187	.408	.255	.272	.153	.374	.418	.204	.578	.748	.238	1.190	.459	1.343
3rd instar	.540	.396	.252	.180	.288	.504	.324	.360	.180	.504	.540	.252	.684	.972	.288	1.692	.576	1.764
4th instar	.720	.504	.360	.252	.396	.648	.396	.432	.216	.612	.720	.324	.936	1.332	.396	2.412	.756	2.304
5th instar	.828	.576	.396	.324	.504	.792	.576	.612	.288	.828	.900	.360	1.152	1.548	.468	2.880	1.008	2.880
5th [♂] instar	1.008	.576	.540	.360	.684	.828	.792	.720	.288	.936	1.080	.396	1.260	1.760	.468	2.950	.720	3.240
6th [♀] instar	1.188	.612	.576	.468	.720	.792	.828	.756	.324	1.152	1.188	.504	1.620	2.016	.648	3.456	1.224	4.032

Summary of Life History Studies

The accompanying table shows the results obtained from isolated rearings. As the table indicates, 48 specimens were reared from hatching to maturity. Of this number, 28 were males and 19 females, while one specimen escaped after having molted for the last time. In computing the average, minimum, and maximum duration of a given stage of development, only complete figures were used. That is, if a nymph died in the fourth stage, only the duration of the first three stages was taken into consideration. Following this line of procedure, it will be apparent that the averages were not secured for the same number of individuals in each column. For convenience, the number of individuals used in securing the averages is placed in parentheses beside the average length of each instar and the length of the entire nymphal development.

Mortality in the first two instars, which represents thirty specimens, is not shown in the table. Data for partial rearings are included in the table to show the rate of mortality and the relation of death to molting. Mortality was especially high in the first and last instars, largely due to the inability to molt.

The average duration of the first stadium for 71 specimens was 3.4 days (minimum 2, maximum 6 days); the average duration of the second stadium for 71 specimens

was 3.2 days (minimum 2, maximum 5 days); 61 nymphs spent an average of 3.5 days (minimum 2, maximum 5 days) in the third stadium; 59 nymphs spent an average of 4.4 days (minimum 3, maximum 6 days) in the fourth stadium; 47 nymphs spent an average of 5.4 days (minimum 3, maximum 9 days) in the fifth stadium.

The 48 specimens carried through from the abandonment of the egg to maturity required an average of 20.02 days (minimum 17, maximum 24 days) for their nymphal development. There seems to be no difference in the length of the developmental period of the sexes, and the amount of food does not effect the length of the life cycle nor the size of the bug.

TABLE (4)

Isolated Rearings of Mesovelia mulsanti bisignata Uhl.

Rearing number	First instar	Second instar	Third instar	Fourth instar	Fifth instar	Total days	Sex	Date of maturity
I 30-31	4	3	3	4	6	20	♂	12/17/30
I 30-32	4	3	3	4	5	19	♀	12/17/30
I 30-33	6	3	3d	-	-	-	-	-
I 30-35	3	3	2	4	5	17	♂	12/17/30
I 30-36	3	3	2	5	5	18	♂	12/18/30
I 30-37	3	3	1L	-	-	-	-	-
I 30-38	3	3	5	4	5	20	♀	12/23/30
I 30-41	3	4	3	5	5	20	♂	12/23/30
I 30-42	3	2	3	4	5	17	♂	12/20/30

I 30-43	3	3	3	4	4	17	♂	12/20/30
I 30-44	3	3	4	4	6	20	♂	12/23/30
I 30-46	3	3	2d	-	-	-	-	-
I 30-47	3	4	4	4	4	19	♀	12/23/30
I 30-48	4	3	4	4	4	19	♂	12/23/30
I 30-49	4	3	3	5	5	20	♂	12/24/30
I 30-50	4	2	4	4	4	18	♀	12/23/30
I 30-51	2	4	3	4	5	18	♀	12/23/30
I 30-52	2	4	3	4	5	18	♂	12/23/30
I 30-53	2	4	4	5	4	19	♂	12/24/30
I 30-54	3	3	4d	-	-	-	-	-
I 30-55	3	3	4	4	5	19	♂	12/24/30
I 30-56	3	3	3	4	7	20	♀	12/25/30
I 30-57	3	4	3	4	5	19	♀	12/24/30
I 30-58	3	4	4	3	4	18	♂	12/24/30
I 30-59	2	4	3	5	5L	19	-	12/25/30
I 30-63	3	3	5	3	4d	-	-	-
I 30-64	5	5	4	4	4	22	♀	12/28/30
I 30-66	4	2	4	4	4	18	♀	12/24/30
I 30-67	4	5	4	3	3	19	♀	12/26/30
I 30-70	5	5	2	4	4dm	-	-	-
I 30-73	3	4	3	5	4	19	♂	12/27/30
I 30-74	3	2	4d	-	-	-	-	-
I 30-75	3	3	3	5	4	18	♂	12/27/30
I 30-96	3	3	3	4	5	18	♂	1/19/31
I 30-101	2	3	3	4	5	17	♀	1/22/31
I 30-111	3	4	4	4	5dm	-	-	-

I 30-112	3	4	4	4	7dm	-	-	-
I 30-119	3	3	3	4	2k	-	-	-
I 30-121	3	3	3	4	7	20	♂	1/31/31
I 30-127	4	3	4	5	6	22	♂	2/3/31
I 30-129	3	3	4	5	7	22	♀	2/4/31
I 30-130	4	3	3	5	6dm	-	-	-
I 30-131	3	3	3	2k	-	-	-	-
I 30-132	3	2	3	5	5	18	♂	2/1/31
I 30-133	4	3	3	5	5	20	♂	2/3/31
I 30-135	4	3	4	6d	-	-	-	-
I 30-136	4	2	4	5	5d	-	-	-
I 30-137	4	2	4	6	7d	-	-	-
I 30-140	4	2	3	6	5	20	♂	2/5/31
I 30-141	3	3	4	5	8d	-	-	-
I 30-142	3	4	2d	-	-	-	-	-
I 30-143	4	3	2k	-	-	-	-	-
I 30-144	4	3	2d	-	-	-	-	-
I 30-145	4	2	3	5	5	19	♂	2/5/31
I 30-146	4	2	4	5	6	21	♂	2/7/31
I 30-150	4	4	5	5	9d	-	-	-
I 30-151	4	4	3	5	8	24	♀	2/13/31
I 30-152	3	4	4	4	9	24	♂	2/13/31
I 30-157	3	4	3	5	6d	-	-	-
I 30-161	5	3	3	5	8	24	♀	2/15/31
I 30-162	4	4	3	5	7	23	♀	2/14/31
I 30-164	5	3	3	5	7	23	♀	2/15/31
I 30-167	5	2	4	4	7	22	♀	2/17/31

I 30-168	4	3	4	5	6	22	♂	2/19/31
I 30-173	4	3	4	6	7	24	♀	2/22/31
I 30-177	3	3	5	5	5	21	♀	2/22/31
I 30-178	4	4	6d	-	-	-	-	-
I 30-196	4	4	4	4	6	22	♂	3/3/31
I 30-219	4	3	4	4	7	22	♂	3/20/31
I 30-227	4	3	1d	-	-	-	-	-
I 30-228	3	4	4	5	7	23	♂	4/5/31

Average 3.49(71) 3.21(71) 3.50(61) 4.47(59) 5.47(47) 20.(48)

Minimum 2 2 2 3 3 17 -

Maximum 6 5 5 6 9 24 -

♂ -male ♀ -female d-died dm-died molting k-killed for specimen

L-lost Proportion of sexes: Males 28, Females 19.

THE BIOLOGY OF MESOVELIA CRYPTOPHILA HUNGERFORD

Habitat.--The abode of Mesovelia cryptophila Hung. is similar to that of Mesovelia douglasensis Hung.; that is, it is amongst the thick growths of Chamaedaphne. The only known bog in which this species is found, Nichol's Bog, is located in an upland pasture in the Douglas Lake region, a few miles from the Biological Station of the University of Michigan. As is stated by Hungerford (13), large piles of sawdust occupy one end of the bog, an open pasture borders one side, while the other end and side are fringed with growths of Chamaedaphne. He found the bugs in the thickest growths of Chamaedaphne, back a short distance from the watermargin. Since the summer of 1930 was very dry in Michigan, the water of this bog was low. For that reason, the writer was able to walk on and collect from the large clumps of Chamaedaphne, from the driest part of the bog to the inner growths that were partially submerged. The bugs which the writer collected, all wingless specimens, were taken from these growths along the open water margin or from a distance of a few feet back from the edge of the open water; and were secured only by a vigorous sweeping with a heavy aquatic insect net.

Hibernation.--Practically no data are at hand on the hibernation of this species. Adults were last taken July 19 and no attempt was made to collect more until the latter part of September, when a couple days of collecting

was fruitless. Eggs laid in July appeared to be in good condition the following April, although only one has hatched since September 24. Some of the eggs have been frozen for a month and appear to be perfectly normal. In the following species, Mesovelgia douglasensis Hungerford, a large number of the eggs hatched after the above exposure.

Mating.--More data are desired regarding this point. The adults have been observed mating in vials containing dry celu, in which they were conveyed from the field to the laboratory. In the laboratory, they mate freely throughout the day and for several minutes or more at a time. As is true of the other species, the female is little concerned during copulation and either walks about the container or feeds.

Preoviposition.---Since no males happened to be reared at the time the females became adults, the latter could not be mated. Female I 30-27 became an adult on October 10 and laid one egg in the piece of cattail leaf provided on the 16th, and two or more eggs each day until her death. Female I 30-19 reached maturity on October 7 and laid one egg in the tissue on October 14, while a number of eggs were found on top of the leaf. The other two females laid eggs nine days after they had become adults, so the preoviposition period may vary from six to nine days.

Oviposition and fecundity.--The method of oviposition is the same as that given under the preceding species. A number of the females were timed while ovipositing, and it generally took from three to five minutes for each deposition. One female inserted and kept her ovipositor in a cattail leaf for twenty-two minutes, swaying her body and working hard to deposit an egg. For some reason or another, she could not get the egg down her ovipositor, so she pulled the instrument out of the tissue of the plant and laid the egg on the surface of the leaf. A large number of eggs are found thus on the leaf surface. As in the case of Mesovelia mulsanti bisignata Uhl., the males of Mesovelia cryptophila Hung. try to mate with the females while they are busily engaged in oviposition, and some are successful in effecting a connection between her labors.

The females, with few exceptions, laid one or more eggs per day throughout their lives after reaching maturity. As is shown in the table below, one female laid 75 eggs during her lifetime, and the average number of eggs for the four females is 55. Evidently this species is not parthenogenic, for none of the eggs had hatched by April.

TABLE (5)

Oviposition Record of Mesovelia cryptophila Hung.

Expt. No.	Date of maturity	Eggs laid	Number of eggs	Died
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I 30-19	10/7/30	10/14/30	48	11/4/30
I 30-20	10/7/30	10/16/30	75	11/27/30
I 30-25	10/12/30	10/21/30	49	11/12/30
I 30-27	10/10/30	10/16/30	48	11/6/30

Incubation.--No definite data are at hand on incubation. The females reared came from eggs laid July 24 and 25 and which hatched between the 21st and 25th of September. The lone male that was reared hatched out on March 14 from one of the eggs that was laid on July 27.

Hatching.--Hatching was not observed, but the method is probably the same as that given for the preceding species. The red eye spots of an egg were observed at three o'clock on September 17, and the writer hoped to see the egg hatch. His vigil was not rewarded, however, for the egg hatched during the noon hour of the following day.

Behavior of the newly hatched.--The newly hatched, which are light in color and have red eyes, are very active. They wander about in the small stenders, crawling up and down the glass sides as if attempting to escape. They spend the remainder of their time feeding or sitting on a Chamaedaphne leaf cleaning beak, antennae, and legs. They are greedy little fellows and within four hours after hatching can suck up the juice of an aphid much larger than themselves.

Number of instars.--There are four nymphal instars. The duration of the several instars is indicated in the Table of Rearings (p.38).

Molting.--Molting is not unlike that of the other species, and may occur on the vegetation or on the sides of the stender. The large mortality in the first instars is probably due to the inability to molt, because most of them died eight or nine days after hatching. Occasionally, a nymph will molt but will die soon after apparently of exhaustion.

Longevity.--Both sexes lived well over a month at Michigan, after which time it became necessary to discontinue the observations. An adult female reared in Kansas lived 51 days and in that time deposited 75 eggs.

Number of generations.--Since Mesovelia cryptophila Hung. spends only about 17 days from hatching to adulthood, it is likely that there is a succession of generations throughout the summer.

Food habits.--The nymphs and adults are predaceous and no doubt live on the same food as do the preceding species. In the laboratory, they were reared on adult houseflies and fruit flies. Aphids were used first, but they proved unsatisfactory. The little nymphs would become literally gummed up in the honey dew of the aphid, and the writer lost many good rearings before he discon-

tinued using aphids for food. These nymphs do not require much food. Only a third of an adult housefly was given to each one every other day, and the reared adults were all normal in size.

Behavior.--In their native habitat these bugs are so well concealed that observations of their behavior are quite impossible. Agile as they are, they lend themselves to laboratory study. The adults, as well as the nymphs, spend many hours of the day resting on the sides of the containers "cleaning up". Egg shells are often found in the containers, and it is supposed that the adults suck their own eggs, although the latter fact has not been observed in this particular species.

Description of Stages

Egg.--The general shape of the egg is not unlike that of Mesovelia mulsanti bisignata Uhl., but it is smaller in size. It is an elongate oval with a curved neck ending in a small flat surface on top, which is the exposed end of the egg visible as one looks down on a stem containing eggs. The variation in the size of the eggs is indicated in the table below. The average length is .824 mm., the greatest diameter .222 mm., and the diameter of the exposed circle or end of egg is .141 mm. The color of the egg when first laid is white or clouded, some eggs having a yellowish cast near the tip. The red eye spots and segmentation are present a day before

hatching.

TABLE (6)

Measurements in Millimeters of the Eggs of
Mesovelis cryptophila Hung.

Number	Length	Greatest diameter	Diameter of exposed circle
1	.853	.221	.136
2	.850	.187	.136
3	.782	.204	.136
4	.816	.221	.153
5	.816	.238	.153
6	.850	.238	.136
7	.850	.238	.153
8	.799	.238	.136
9	.799	.221	.136
10	.850	.221	.136
Average	.824	.222	.141
Minimum	.782	.187	.136
Maximum	.850	.238	.153

First instar.--Day old nymphs are reddish-brown in color, but within a day or two the head, thorax, and dorsum of abdomen become greenish-brown, while the remainder of the abdomen is orange colored. The legs are pale or smoky colored, while the eyes are red. The body and limbs are covered with hairs and bristles, the distribution of which is about the same as that of the above species. The

size of the insect during this stage is given in the Table of Measurements.

Later instars.--The second and later instars are yellowish with red eyes and pale limbs just after molting, but color up in a few hours, the head, thorax, and abdomen becoming quite green. As in the preceding species, one black bristle is present on the anterior margin of the fore femur and two are present on the other femora. The stout spines on the rear margins of the front and middle femora of Mesovelia mulsanti bisignata Uhl. are lacking or minute in this species. The adults always have two, and sometimes three, bristles on the first segment of the antennae instead of one as is true of Mesovelia mulsanti bisignata Uhl. The tarsi are three segmented and the connexivium is broad. The size of the various instars is given in the Table of Measurements for this species.

TABLE (7).

Table of Measurements in Millimeters of Mesovelia cryptophila Hung.

Stage	Length of Beak	Width of Head A- cross Eyes	Antennae				Fore leg			Middle leg			Hind leg			Body		Measure- ment from tip of femur to tip of femur (Hind Legs.)
			1st seg.	2nd seg.	3rd seg.	4th seg.	Femur	Tibia	Tarsi	Femur	Tibia	Tarsi	Femur	Tibia	Tarsi	Length	Greatest Width	
1st instar	.375	----	.136	.102	.153	.442	.204	.221	.119	.255	.289	.136	.374	.493	.187	.833	.272	.952
2nd instar	.425	----	.187	.153	.238	.544	.255	.272	.153	.340	.374	.187	.510	.663	.221	1.088	.306	1.241
3rd instar	.612	----	.252	.180	.324	.612	.324	.360	.180	.396	.504	.252	.612	.864	.288	1.332	.504	1.620
4th instar	.792	----	.360	.252	.504	.684	.432	.504	.252	.540	.720	.324	.792	1.224	.596	1.728	.648	2.160
6th ♀ instar	1.008	.534	.396	.324	.720	.792	.612	.612	.252	.756	.864	.360	.972	1.476	.468	2.664	.972	2.808
6th ♂ instar	.972	.432	.360	.288	.720	.792	.612	.576	.252	.684	.792	.360	.972	1.404	.468	2.088	.540	2.412

Summary of Life History Studies

The following table shows the data obtained in the rearing experiments. By reference to the table we see that five specimens were reared from the moment of hatching to maturity. Eighteen other life histories were attempted, but the little nymphs died without molting. The same method of computing the average, minimum, and maximum duration of a given instar, or of total nymphal development, is used as in the previous species.

The average duration of the first stadium for 7 specimens was 3.5 days (minimum 2, maximum 7 days); the average duration of the second stadium for 6 specimens was 3.6 days (minimum 2, maximum 5 days); the average duration of the third stadium was 4.2 (minimum 3, maximum 6 days); the average duration of the fourth stadium was 5.8 (minimum 5, maximum 7 days). In the third and fourth stadia, the averages were secured from five nymphs.

The five specimens reared from hatching to maturity required an average of 17.6 days (minimum 16, maximum 21 days) for their nymphal development. Thus, the life cycle of this species is shorter than that of the other two. It is also interesting to note that Mesovelgia cryptophila Hung. has only 4 nymphal stages, an unusual number for most semi-aquatic Hemiptera.

TABLE (8)

Isolated Rearings of Mesovelia cryptophila Hung.

Rearing number	First instar	Second instar	Third instar	Fourth instar	Total days	Sex	Date of maturity
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I 30-6	2dm	-	-	-	-	-	-
I 30-18	3	1d	-	-	-	-	-
I 30-19	2	5	4	5	16	♀	10/7/30
I 30-20	2	4	4	6	16	♀	10/7/30
I 30-25	7	3	4	5	19	♀	10/12/30
I 30-27	3	4	3	6	16	♀	10/10/30
I 30-28	5	2	2d	-	-	-	-
I 30-229	4	4	6	7	21	♂	4/4/31

Average	3.57(7)	3.66(6)	4.20(5)	5.80(5)	17.60(5)	-
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Minimum	2	2	3	5	16	-
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Maximum	7	5	6	7	21	-
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♂ -male ♀ -female d-died dm-died molting

THE BIOLOGY OF MESOVIELIA DOUGLASENSIS HUNGERFORD

Habitat.--This small species is found beneath the dense growths of Chamaedaphne about the margins of some bogponds near the Biological Station of the University of Michigan. Since they are only found in such sheltered places, it is necessary for one to push the Chamaedaphne below the surface of the water and to sweep it hard and thoroughly with a strong aquatic insect net in order to capture the desired specimens. At Livingston's Bog, the writer attempted to collect them from a small rubber duck boat, dipping a net under the outlying growths of Chamaedaphne, but this did not prove successful. Undoubtedly they reside for the most part in dark and inaccessible places near the shore. It is even difficult to distinguish the bugs from the leaves, twigs, and other debris collected in the net, for they are not very active and match their surroundings perfectly. Six females and two males were taken, however, in a few hours time on the morning of August 15 by sweeping from the shore. No winged forms have been collected or reared. Heretofore, this species has only been taken from Bryant's Bog (12), and I am glad to record it from a larger bog commonly known as Livingston's Bog.

Hibernation.--Very little data are at hand regarding this point. Four males and four females were collected at Bryant's Bog on August 29, two days before the writer

departed for Kansas. A laboratory experiment conducted there would tend to show the possibility of Mesovelina douglasensis Hung. overwintering in the egg stage. On October 25, a number of petri dishes containing eggs deposited in pieces of cattail leaf were covered with water and placed in refrigeration at 32°F. These containers were not precooled, and in due time the pieces of cattail leaf and surrounding water became frozen. They were left in this condition until November 25, when they were removed and placed in the laboratory at about 74°F. An examination of the eggs showed that they were in good condition. They had been laid in July and August, and after the above exposure, the number which had hatched out by December 14 was greater than the number which had hatched out of those eggs kept at about 74°F. This experiment shows that the eggs can withstand cold temperatures, and apparently could do so in nature. It is interesting to note that some eggs laid the 19th of August hatched out on April 5.

Mating.--The tiny male seeks the much larger female and suddenly makes a quick jump, grasping the abdomen or the thorax with his legs. He then quickly slides backwards on the abdomen of the female to effect a connection. Hungerford (12) observed that the male is supported very curiously above the female by the genital clasp alone--all of the legs poised in mid-air. The same writer found that they remained in copula for thirty

minutes and longer.

Although the male is usually supported by the genital clasp alone and has the legs drawn close to the body, if the female becomes excited or tries to ward him off, he uses one of the hind legs to keep his balance. When copulation is about to terminate, the pair rock back and forth very rapidly, after which the female kicks the male off by means of her hind legs.

The females may terminate a connection by any one of three methods or by a combination of these methods, but usually one is sufficient. First, she may shake her abdomen very rapidly sidewise and cause the male to lose his hold. Secondly, she may push him off by means of one of her hind legs. In this case, the female makes her first push in the region of the male's prothoracic legs, the second at the base of his second pair of legs, and the third near the base of the metathoracic legs. Each successive push is stronger, and the last one usually finds the male on his back actively trying to gain an upright position. Thirdly, she kicks the male off using her hind legs simultaneously. The male cannot avoid this, for he is very small and poised in the air without much support. The female often guards herself against the advances of a male by the use of her right hind leg. This is such an effective weapon that the male will not molest her if the leg is outstretched.

During copulation the female is little concerned,

often walking about the container or feeding upon a fly while so engaged. Mating may take place any time of the day, but seems to be at its height in the middle of the morning. Some pairs even mated in the vial in which they were being transferred from the field to the laboratory. On August 31, between nine o'clock and eleven o'clock in the morning, I observed ten different pairs in copulation for 25, 17, 18, 3, 26, 28, 5, 14, 17, and 21 minutes respectively. The average length of time for the ten is, then, slightly over 17 minutes. The male usually effects a connection with the female from the left side, but exceptions have been noted in one or two cases. Rather curiously, two females supplied with a large number of males mated at least once a day for 23 consecutive days.

Preoviposition.---A female which became adult on January 16 was placed with a male that emerged as an adult four days before. They mated on January 20 and twice the next day, but had probably mated a day or two before. A piece of decayed cattail leaf was placed in the stender, and on January 25 a number of eggs were deposited by the female in the plant tissue. Another pair isolated January 6, mated for twelve minutes three days later, and the female laid three eggs on January 13. From these figures and other records at hand, the length of the preoviposition period seems to lie between 7 and 9 days.

Oviposition and fecundity.--Oviposition in the laboratory was observed with the aid of a binocular. The process is practically the same as described in the fine account given by Hungerford (11) concerning Mesovelis mulsanti bisignata Uhl. Some females timed while depositing eggs were found to require from ten to twelve minutes to deposit a single egg. When the female gets her ovipositor sunk even with the host tissue, she rests for a minute or more, and then the ovipositor becomes distended and the egg slips through. A droplet of fluid appears on the ovipositor after the deposition of each egg.

It is usually possible to detect the presence of a Mesovelis egg by the exposed circle on the host plant in which the eggs were laid, but sometimes this is impossible. In certain light colored cattail leaves, eggs are not visible externally, although upon dissection a dozen or more may be found in the plant tissue, particularly near the sharp edges of the leaf. As a rule, however, Mesovelis douglasensis Hung. lacerates the tissue in ovipositing more than do the other two species, and the eggs are readily detected.

Some females not only deposit eggs in plant tissue, but lay them in the water and on the surface of the cattail leaf. One female laid 14 eggs side by side on the surface of a cattail leaf, starting with one egg and laying one or two every day up to 14. They were arranged in an imperfect circle and afforded an excellent opportunity

to note the variation in size of the eggs of a single female. None of the eggs I found deposited on the surface of plants hatched, and the contents of a number of them were sucked up by the adults. As the chart below indicates, one female deposited the surprisingly large number of 191 eggs in a little over two months time. The mating dates given in the chart for the females were the first ones observed, but in most cases the bugs had probably mated several times before the date recorded. Only a few females lived and deposited eggs for a period longer than that of two months.

TABLE (9)

Oviposition Record of Mesovelia douglasensis Hung.

Expt. No.	Date of maturity	Mated	Eggs laid	Number of eggs	Died
31-10	1/12/31	1/20/31	1/15/31	46	3/5/31
31-11	1/3/31	1/17/31	1/11/31	83	2/11/31
31-12	12/31/30	1/8/31	1/10/31	196	4/12/31
31-13	1/8/31	3/1/31	1/10/31	191	5/15/31
31-14	1/6/31	1/9/31	1/13/31	55	4/12/31
31-15	1/16/31	1/20/31	1/25/31	68	3/20/31
31-17	1/26/31	-	2/5/31	43	3/13/31

Incubation.--Eggs laid in the laboratory January 25 required only 12 days to hatch. This is apparently the length of the normal incubation period. The embryo does not completely fill the egg until shortly before hatch-

ing, and its white color forms a contrast against the transparency of the egg shell.

Many eggs laid August 17 and during the following month, however, hatched out one and two at a time in April. I noticed on February 11 the deep red eye spots of a Mesovelgia douglasensis Hung. egg that was deposited September 1. Segmentation was plainly visible four days later and it hatched out sometime during the morning of February 17.

Hatching.--Since there was no peak in the hatching period, the little fellows emerging one at a time intermittently, no data on hatching was secured. The hatching is presumed to be similar to that related for Mesovelgia mulsanti bisignata Uhl., however. The newly hatched nymphs are light colored with prominent red eyes, but a few hours exposure causes them to darken materially.

Behavior of the newly hatched.--The little nymphs are quite active soon after hatching, and skate or walk about their container as if exploring their homes. They are not nearly so active and restless as Mesovelgia mulsanti bisignata Uhl., however, and seldom try to escape by scampering up the sides of the stender. They feed within a few hours after hatching. If disturbed or placed in deep water, they draw their legs up close to the body, remain very quiet, and can hardly be distinguished from a piece of cattail leaf or other debris. This procedure no doubt

serves them well in nature, for the nymphs are even hard to detect in laboratory containers. Like the other two species, Mesovelia douglasensis Hung. incessantly "cleans up" from the time it hatches until it dies.

Number of instars.--There are five nymphal instars. The duration of the several stadia is indicated in the Table of Rearings.

Molting.--Molting takes place on the vegetation provided, on the sides of stenders adjoining the water level, or on the water itself. Most of the nymphs, however, molt on the sides of the stender. The skin splits along the median line of the head and thorax, and the antennae and beak emerge about the same time. The nymphs molt by successive forward lunges, the head slumping down after each effort until the skin is cast. The wrinkles in the body wall are straightened out by the circulation of the body fluids, which are visible as soon as the body of the bug is free from the old skin. The hind legs, which are stretched straight back during molting, are moved a great deal during the process. When the bug is free except for one of its hind legs, it often uses the prothoracic and metathoracic legs of the same side to free itself, while if one hind leg is already free it serves to steady the body.

The actual molting time, which requires only a few minutes, varies with different specimens. Some molt

easily, "clean-up" a little, and feed immediately, while others have difficulty in freeing the legs, particularly the hind ones. Sometimes they can be saved with a little help, but without this aid the nymph dies of exhaustion. Mortality is great in the first instar and occurs chiefly when the bug has passed its regular molting time. Death usually occurs before the skin has split. Some idea of the mortality due to inability to molt in the later instars may be noted in the Table of Rearings.

Longevity.--Four males and four females collected at Bryant's Bog, Douglas Lake, Michigan, on August 29 were placed in a food container supplied with sphagnum moss and taken to Kansas. The bugs seemed none the worse for their long journey, and the females deposited many eggs during the next month. Between the 4th and 11th of October, however, they had all succumbed. The average span of life of the reared ovipositing females is about two months, while that of the males is slightly longer.

Number of generations.--There is apparently a succession of generations throughout the season, since the nymphal development requires approximately twenty-five days.

Food habits.--These little bugs are predaceous, and probably live on the same fare in nature as Mesovelia mulsanti bisignata Uhl. In the laboratory, they were

reared on adult houseflies and fruit flies. The latter proved to be the better food, because their bodies can be pierced easily and because the water does not become so polluted as when houseflies are used. If a number of adults are kept in the same container, they will feed on their dead comrades or kill and feed on one that is about to die. A number of adults lived very well in an aquarium, the water of which contained Chara and an abundant supply of entomostracans.

Behavior.--In nature these bugs are hidden amongst the Chamaedaphne just as Mesovelis cryptophila Hung. and it is impossible to observe them. Nevertheless, they can be observed readily in the laboratory as they go about their everyday work. This little species cleans itself without cessation as does the former species and in the same manner. The males spend the greater part of the day resting or walking about on the cattail leaf, while the female rarely frequents it unless it is for oviposition. Much of their time is spent on the sides of the stender, either out of the water or near the surface of the water, but always facing it and ready to descend when disturbed.

As was mentioned under oviposition, the females often lay eggs on the surface of the cattail leaf in company with a number of empty egg shells. The writer had the good fortune to observe the causal factor in the production of the egg shells as he watched a female depositing eggs in late August. She deposited a number of eggs on

the surface of the cattail leaf and then took her beak and explored one of these eggs from end to end. Finally, after examining the egg thoroughly, she inserted her beak in the bulb-end of the egg and sucked out the contents. Naturally the egg collapsed and became just a flat transparent empty egg shell. No doubt only a few eggs laid on the surface escape this procedure.

This species has the habit of floating when it is met by an influx of water or if its container is turned on end. The front legs are kept forward, the middle ones horizontal, while the hind legs are stretched straight back. But this "frog-like" position does not keep the insect from readily drawing its legs into a normal position and skating away from approaching danger.

Description of Stages

Egg.--The general shape of the egg is like that of the other two species, and is best shown in the drawing. Hungerford (12) gives the following description: "The egg is elongate oval, with a curved neck terminating in a flat surface which marks the exposed end of the egg as it lies in situ in the plant stem. It measures .75 mm. in length and .2 mm. in width and is a little plumper than the egg of M. mulsanti. The curved neck is larger proportionately." In the table showing the measurements of eggs of this species, it may be noted that the average length of the egg is .75 mm., the average greatest diameter .22 mm.,

while the average diameter of the exposed circle is .13mm. The egg is white when first laid, but within a few days it becomes watery transparent and the embryo begins to take form. The deep red eye spots are evident 6 days before hatching, and segmentation in the embryo is visible two days before the nymph emerges.

TABLE (10)

Measurements in Millimeters of the Eggs of
Mesovelia douglasensis Kung.

Number	Length	Greatest diameter	Diameter of exposed circle
1	.765	.221	.136
2	.731	.187	.119
3	.799	.204	.136
4	.799	.221	.136
5	.799	.221	.136
6	.697	.238	.119
7	.748	.221	.136
8	.799	.255	.119
9	.714	.255	.153
10	.731	.187	.136
Average	.758	.221	.132
Minimum	.697	.187	.119
Maximum	.799	.255	.153

First instar.--When first hatched the nymph is white with red eyes, but as it ages the antennae, legs,

thorax, and the dorsum of the abdomen become greenish-brown. The remainder of the abdomen varies from yellow to orange in color. The size of this instar is given in the Table of Measurements. It is much smaller than the first instar of either Mesovelia mulsanti bisignata Uhl. or Mesovelia cryptophila Hung. and can be readily distinguished from them by its size. As in the other two species, the body and limbs of Mesovelia douglasensis Hung. are covered with hairs and bristles. Two or three stout bristles are present on the first segment of the antennae, while the other three segments are covered with short hairs, those of the terminal segment being very fine. The antennae are four segmented and stout, while the legs are stout and have one segmented tarsi.

Later instars.--The color of the head and thorax of the remaining instars may vary from light green through brown, and the abdomen from light yellow to orange with tints of red and brown. The eyes are red and the antennae and limbs are smoky colored. The color variation in the instars of this species is so great that color is not reliable enough to be used for the differentiation of the various instars. The abdomen of some of the fourth instar nymphs becomes very "blocky" in form, but this does not seem to indicate a sexual difference, for both males and females have been reared from "blocky" forms. The three pairs of setiferous dots located on the head are brown un-

til the bug becomes adult, after which they are black. The dorsum of the fourth abdominal segment bears the repellent gland pore.

As in the other two species, there appears one black bristle on the anterior margin of the fore femur and two on the other femora. The adults of Mesovelia douglasensis Hung., however, retain the two or three stout bristles on the first segment of the antennae that prevail in the earlier instars, instead of undergoing a reduction as is the case of Mesovelia mulsanti bisignata Uhl. The stout spines on the rear margin of the first and middle femora of Mesovelia mulsanti bisignata Uhl. are lacking or minute in this species, as was noted by Hungerford (12). The limbs, which are very slender, have three segmented tarsi. Upon becoming adult the connexivum and other sexual characteristics appear. A Table of Measurements of the various instars and of the adults is appended.

TABLE (11)

Measurements in Millimeters of Mesovelia douglasensis Hung.

Stage	Length of Beak	Width of Head Across Eyes	Antennae				Fore leg			Middle leg			Hind leg			Body		Measurement from tip of femur to tip of femur. (Hind Legs.)
			1st seg.	2nd seg.	3rd seg.	4th seg.	Femur	Tibia	Tarsi	Femur	Tibia	Tarsi	Femur	Tibia	Tarsi	Length	Greatest Width	
1st instar	.306	.255	.102	.085	.136	.374	.153	.187	.102	.204	.221	.102	.255	.374	.119	.867	.289	.799
2nd instar	.424	.289	.153	.119	.204	.442	.204	.238	.136	.255	.289	.136	.357	.476	.153	1.071	.391	.952
3rd instar	.476	.340	.187	.136	.238	.476	.238	.272	.136	.289	.340	.153	.425	.578	.170	1.224	.510	1.088
4th instar	.612	.396	.216	.180	.396	.576	.324	.360	.180	.396	.468	.216	.576	.792	.252	1.620	.684	1.476
5th instar	.756	.468	.324	.216	.468	.720	.396	.468	.216	.504	.612	.252	.648	1.008	.324	1.908	.720	1.872
6th ♂ instar	.864	.504	.324	.288	.540	.792	.540	.540	.288	.612	.684	.288	.864	1.152	.396	2.304	.720	2.268
6th ♀ instar	.864	.540	.324	.288	.540	.720	.540	.540	.252	.648	.720	.288	.900	1.224	.396	2.484	1.152	2.340

Summary of Life History Studies

The accompanying table shows the data obtained in the rearing experiments. A glance at the table will indicate that 62 specimens were reared from hatching to maturity, 32 of which were males and the remaining 30 females. The method of computing the average, minimum, and maximum duration of a given instar, or of total nymphal development, is the same as explained under Mesovelia mulsanti bisignata Uhl.

The mortality in the first two instars is not shown in the table, but it includes 16 specimens. Data are shown for partial rearings from the third instar on as well as for completed rearings in order to show the mortality rate, the relation of death to molting, etc. The first and fifth instars appear to be the most crucial times in the lives of these insects.

By referring to the table, we see that 87 nymphs spent an average of 4.3 (minimum 2, maximum 7) days in the first stadium; 87 nymphs spent 4. (minimum 1, maximum 7) days in the second stadium; 79 nymphs spent 4.4 (minimum 3, maximum 7) days in the third stadium; the average duration of the fourth stadium for 76 specimens was 5.4 (minimum 3, maximum 9) days; the average duration of the fifth stadium for 61 specimens was 7.1 (minimum 5, maximum 10) days.

The 62 specimens reared to maturity required an average of 24.9 days (minimum 19, maximum 37) for their nymphal

development. There appears to be little difference in the length of the developmental period of males and females. An attempt was made to rear a number of specimens in a constant-temperature chamber, which was kept at 80° F. The result was that most of the nymphs died before molting for the first time, while one isolated February 14 died as a fifth instar, having spent 17 days in that stage. This specimen spent 3, 5, 4, and 8 days respectively in the first four stages. Thus, the nymphal development of Mesovelia douglasensis Hung. is slowed down at a temperature of 80° F., whereas it seems to continue regularly at 74° F.

TABLE (12)

Isolated Rearings of Mesovelia douglasensis Hung.

Rearing number	First instar	Second instar	Third instar	Fourth instar	Fifth instar	Total days	Sex	Date of maturity
I 30-29	4	5	5	7	7	28	♂	11/6/30
I 30-72	4	6	5	3	5	23	♀	12/31/30
I 30-76	5	4	5	4	7	25	♀	1/3/31
I 30-77	4	5	3	4	6	22	♀	12/31/30
I 30-78	4	4	3	4	6	21	♀	12/30/30
I 30-79	5	5	5	3	7	25	♂	1/3/31
I 30-80	4	5	4	4	5	22	♂	12/31/30
I 30-82	5	3	4	6	7	25	♀	1/6/31
I 30-83	5	3	4	4	8	24	♂	1/5/31
I 30-85	5	3	3	7	6	24	♂	1/6/31

I 30-86	4	4	3	4	7	22	♀	1/5/31
I 30-88	4	3	6	6d	-	-	-	-
I 30-91	3	4	5	4	5	21	♂	1/12/31
I 30-92	4	4	5	3	5	21	♂	1/12/31
I 30-93	6	3	4	4	1d	-	-	-
I 30-94	4	3	4	6	6	23	♀	1/16/31
I 30-95	5	6	2d	-	-	-	-	-
I 30-106	2	3	4	4	6	19	♀	1/26/31
I 30-107	4	5	4	4	7	24	♀	1/31/31
I 30-108	4	4	3	4	8	23	♂	1/31/31
I 30-109	3	4	4	4	2k	-	-	-
I 30-113	5	4	4	6	8	27	♂	1/6/31
I 30-114	4	4	4	5	7	24	♂	1/3/31
I 30-115	4	4	4	5	7	24	♀	1/3/31
I 30-116	4	3	4	6	7	24	♀	1/3/31
I 30-120	5	4	4	6	6	25	♀	1/5/31
I 30-122	4	4	3	7	7	25	♂	1/6/31
I 30-123	4	3	4	2k	-	-	-	-
I 30-124	4	4	3	6	5	22	♀	1/4/31
I 30-125	3	4	3	5	7	22	♂	1/3/31
I 30-128	4	3	4	6	6	23	♂	1/5/31
I 30-134	4	3	5	5	5d	-	-	-
I 30-138	4	3	2k	-	-	-	-	-
I 30-139	2	3	4	5	6	20	♂	1/5/31
I 30-147	3	4	5	4	9	25	♂	2/13/31
I 30-148	4	1	7	4	8	24	♀	2/12/31
I 30-154	5	4	4	5	9	27	♀	2/17/31

I 30-155	3	4	3	4	8	22	♂	2/13/31
I 30-158	5	4	5	6	8	28	♂	2/19/31
I 30-159	4	4	5	5	9	25	♀	2/16/31
I 30-160	5	4	3	7	9	28	♂	2/19/31
I 30-166	5	3	2d	-	-	-	-	-
I 30-169	5	3	5	7	7	27	♀	2/23/31
I 30-170	5	4	4	7	8	28	♀	2/24/31
I 30-172	5	4	7	8	7d	-	-	-
I 30-174	4	3	8dm	-	-	-	-	-
I 30-175	5	3	6	6	9dm	-	-	-
I 30-176	4	3	5	5	7	24	♂	2/24/31
I 30-179	4	4	7	6	9	30	♂	3/3/31
I 30-181	4	4	4dm	-	-	-	-	-
I 30-182	4	5	5	4	9	27	♀	2/2/31
I 30-183	4	5	4	5	1d	-	-	-
I 30-184	4	6	7	7	9d	-	-	-
I 30-185	4	6	6	7	8	31	♂	3/8/31
I 30-186	5	5	4	6	8	28	♀	3/6/31
I 30-187	5	4	5	6	9d	-	-	-
I 30-188	5	5	9dm	-	-	-	-	-
I 30-190	6	6	6	9dm	-	-	-	-
I 30-191	7	7	5	8	10	37	♂	3/16/31
I 30-193	6	7	6	9	10d	-	-	-
I 30-194	2	5	4	4	7	20	♀	2/28/31
I 30-195	3	3	4	3	6	19	♀	2/27/31
I 30-197	4	4	6	4	10	28	♀	3/10/31
I 30-200	3	5	4	8	17d	-	-	-

I 30-201	5	5	6	7	7	30	♂	3/16/31
I 30-202	7	7	1d	-	-	-	-	-
I 30-204	4	5	4	8	14d	-	-	-
I 30-205	3	3	5	6	3d	-	-	-
I 30-206	4	5	4	7	9	29	♂	3/17/31
I 30-209	4	4	4	5	7	24	♂	3/13/31
I 30-210	4	3	4	5	6	22	♂	3/14/31
I 30-211	5	3	5	7	6	26	♂	3/18/31
I 30-212	5	5	4	6	7	27	♂	3/20/31
I 30-213	6	4	6	5	7	28	♀	3/21/31
I 30-214	4	3	6	6	6	25	♀	3/18/31
I 30-215	5	4	4	7	7	27	♀	3/20/31
I 30-216	4	3	4	5	6	22	♀	3/15/31
I 30-223	4	4	4	5	7	24	♂	3/24/31
I 30-224	4	4	4	7	8dm	-	-	-
I 30-225	4	4	4	6	12d	-	-	-
I 30-226	4	3	4	6	8	25	♀	3/29/31
I 30-228	7	4	2d	-	-	-	-	-
I 30-229	4	3	5	5	9	26	♂	4/2/31
I 30-230	5	4	5	5	8	27	♂	4/3/31
I 30-231	4	3	4	4	7	22	♀	3/29/31
I 30-232	6	3	4	6	8	27	♀	4/3/31
I 30-233	5	4	5	5	8	27	♂	4/3/31

Average 4.34(87) 4.01(87) 4.48(79) 5.43(76) 7.15(61) 24.9(62)

Minimum 2 1 3 3 5 19 -

Maximum 7 7 7 9 10 37

♂-male ♀-female d-died dm-died molting k-killed for specimen
Proportion of sexes: Males 32, Females 30.

METHOD OF REARING

Adults were collected and divided according to species, after which they were isolated in finger bowls containing lake water and several pieces of decayed cattail leaf for oviposition. The water was changed daily, and houseflies served as food. When a large number of eggs were laid in the stem provided, it was then removed to a petri dish and given a number that corresponded with that on a card. Permanent data were, of course, kept on cards, which enabled one to keep an accurate account of hatching. An eye dropper was used to change the water in the egg containers, and a dropper or two full of water was sufficient for the daily change. Only a few nymphs hatched while the writer was in Michigan, so the pieces of cattail leaf containing the eggs were embedded in sphagnum moss in vials. These were then taken to Kansas on September 1 and re-isolated in petri dishes containing cistern water.

The little nymphs that hatched out were isolated in small stenders one inch deep and two inches in diameter and in some other stenders slightly larger. The stenders containing a single bug were numbered and a corresponding card was made. Each stender was supplied with a single dropper full of water, a small piece of white card, and two adult fruit flies for food. The card served as a support for the little fellows, and being white did not interfere in the search for molted skins. The bugs flourished with a daily

change of water and a fresh supply of food every other day, the remains of the previous feeding being removed at this time. Neither the size of the container nor the amount of food seemed to alter the size or the well being of the bugs.

After the aphids used as food during early attempts at rearing proved to be inefficient, houseflies were tried. They served as good food but scarcity along the latter part of January necessitated the finding of a food supply plentiful enough to care for many rearings. It was found that adult fruit flies filled the need, and of course they were easy to rear in quantities. The technique used might well be related, however, for it affords a simple way of capturing the adults to be used as food for winter rearings. A lamp chimney covered at one end with a piece of cheesecloth, fastened by means of a rubber band, was placed over a pint jar in which a banana and the fruit flies were placed. In a short time, the chimney was swarming with the adults. To capture a hundred or more specimens, the writer slipped a four inch vial through a piece of cardboard, in which a sufficiently large hole had been cut, and placed it over the top of the chimney as soon as the cheesecloth was removed. Ordinary light attracted many of the adults into the vial, but with the use of an artificial light above the vial, the desired number could be readily secured. When this number was obtained, the vial was quickly corked and something put over the chimney until the adults were scattered again. The chimney was then re-covered with cheese-

cloth with the loss of but few adults. The adults in the vial could be killed by placing it over a hot radiator for a few minutes, or by striking a match and applying the flame to the bottom of the vial. In the latter case, the fruit flies could be forced to the bottom of the vial by sudden taps against something that would not break it. Heat kills the flies quickly and does not injure them for feeding purposes.

It is often difficult to find the newly hatched bugs, because they cling to the surface from which they issue. In changing the water of the egg cages daily, therefore, the fresh water was squirted directly on the surface mentioned and the young washed off into the clear water. These were then easily transferred to standers by tilting the petri dish and placing the tip of a pair of forceps under the nymph, thus lifting it out together with a drop of water. Although cistern water was substituted for lake water and later well water for cistern water, these changes affected neither the well-being of the long matured adults nor the rearings in progress.

SUMMARY

Mesovelis mulsanti bisignata Uhl., the largest and most common of the three species of American Mesovelis discussed in this paper, is found upon floating vegetation about the margins of ponds, bogs, and other bodies of water. All three species considered here feed on insects caught upon the surface film and probably upon small crustacea which are found near the surface of the water. They are thought to overwinter as adults, but conclusive evidence concerning this point is lacking; because frequent searches at Lake View throughout the winter months failed to reveal any hibernating adults. Laboratory experiments show that the eggs can withstand zero temperature for a month and hatch, so the bugs may pass the winter in the egg stage. This view is substantiated by the fact that the writer found only first instar nymphs at Lake View on May 2, 1931. Oviposition occurs in the spring, the eggs being deposited in the stems of plants. There are five instars, and a succession of generations throughout the season. The winged and wingless forms occur together. The 48 specimens carried through from the abandonment of the egg to maturity required an average of 20.02 days (minimum 17, maximum 24 days) for their nymphal development.

Mesovelis cryptophila Hung. dwells amongst the thick growth of Chamaedaphne in Nichol's Bog, a bog located in an upland pasture in the region of Douglas Lake, Michigan.

The females possess an ovipositor and lay eggs in the plant tissue as is true of the preceding and following species. Only apterous forms of this species are known. Mesovelia cryptophila Hung. has only four nymphal stages, an unusually number for Mesovelia as well as for most semi-aquatic Hemiptera. The five specimens reared from hatching to maturity required an average of 17.6 days (minimum 16, maximum 21 days) for their nymphal development.

Mesovelia douglasensis Hung. is found beneath the dense growths of Chamaedaphne about the margins of some bogs in the Douglas Lake region, Michigan. It was previously known to occur only in Bryant's Bog, so the writer is glad to record it from a larger one known as Livingston's Bog. Since the eggs laid in cattail leaves in August were still hatching in April, and since some of these were kept at 32°F. for a month and hatched, it is possible that the bugs pass the winter in the egg stage. There is apparently a succession of generations throughout the season. There are five nymphal instars in this species, and only apterous forms are known. Sixty-two specimens reared to maturity required an average of 24.9 days (minimum 19, maximum 37 days) to complete their nymphal development.

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Second instar

First instar

Third instar

Fourth instar

Egg

Fifth instar

Mesovelia douglasensis (male)

Mesovelia douglasensis (female)

Bryant's Bog, Douglas Lake Region, Michigan.

Lake View, Lawrence, Kansas.