

**LIFE HISTORY AND LABORATORY REARING OF
BELOSTOMA LUTARIUM (HETEROPTERA: BELOSTOMATIDAE)
WITH DESCRIPTIONS OF IMMATURE STAGES**

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Abstract.—The life history of *Belostoma lutarium* was studied in southern Illinois, and the immature stages are described. The bug also was reared from egg to adult in the laboratory. This apparently bivoltine species overwintered as adults in leaf litter and detritus in very shallow water along the shoreline and became active in early March. Eggs were found between the 3rd week of April and early August and were laid on the backs of males. First instars appeared in early May followed by marked overlapping of the subsequent instars. Active adults were last observed in November. This species was reared on *Chaoborus americanus* larvae under a 16L:8D photoperiod at $26.7 \pm 1.5^{\circ}\text{C}$. The incubation period averaged 9.9 days. Durations of the 5 subsequent stadia averaged 6.3, 6.4, 10.7, 12.9, and 13.7 days, respectively.

The giant water bug *Belostoma lutarium* (Stål) is primarily a species of the southeastern United States; it has been collected from Massachusetts south to Florida, and west to Michigan, Illinois, Kansas, Oklahoma, and Texas (Lauck, 1964), but apparently has not been found in New York or Pennsylvania. *B. flumineum* Say, which occurs in the southern half of Canada, throughout the continental U.S., and in northern Mexico, becomes rather scarce where its range overlaps that of *B. lutarium* (Lauck, 1964). In Illinois *B. flumineum* occurs primarily in the northern $\frac{2}{3}$ of the state and *B. lutarium* in the southern $\frac{1}{3}$, with little overlap in their ranges (Lauck, 1959).

Little is known about the life history of *B. lutarium*. It has been taken from pools and ponds containing cattails, along grass borders and among stems of *Polygonum*, in shallow stock ponds filled with submerged and emergent vegetation, and from ponds and swamps with abundant growth of emergent grasses (Bobb, 1974; Lauck, 1959; Wilson, 1958). Adults have been collected in Mississippi from March to November, egg-carrying males as early as March, and nymphs from June to November (Wilson, 1958). Nymphs have been collected in Illinois as early as late May (Lauck, 1959).

For the past 3 years (1983-1985), we have studied the life history of a population of *B. lutarium* occurring in the La Rue-Pine Hills Ecological Area. This area, located ca. 18 miles northeast of Cape Girardeau, Missouri, in the northwest corner of Union County, Illinois, is part of the Shawnee National Forest. It encompasses only about 3 square miles, but contains both dry forests and hill prairies atop limestone bluffs, and moist forests at the base of these bluffs that surround La Rue Swamp and Winters

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Pond. These aquatic habitats are continuous, and it is here that our study was conducted. Much of the study area is blanketed with duckweeds (i.e., *Lemna*, *Spirodela*, *Wolffia*, and *Wolffiella*) along the shoreline.

This paper presents information on the life history and laboratory rearing of *B. lutarium* and includes descriptions of the immature stages.

We are pleased to dedicate this paper to Dr. R. C. Froeschner for his many contributions to the study of the Hemiptera and for his constantly warm and friendly personality and a continuing willingness to help others with their own research efforts. Thanks, Dick!

MATERIALS AND METHODS

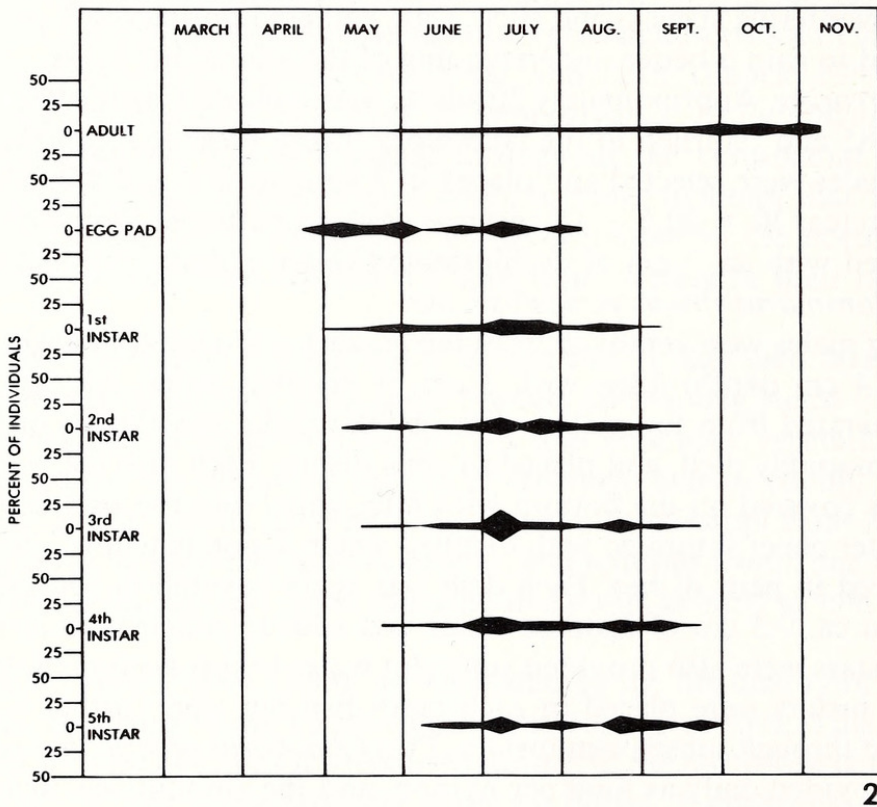
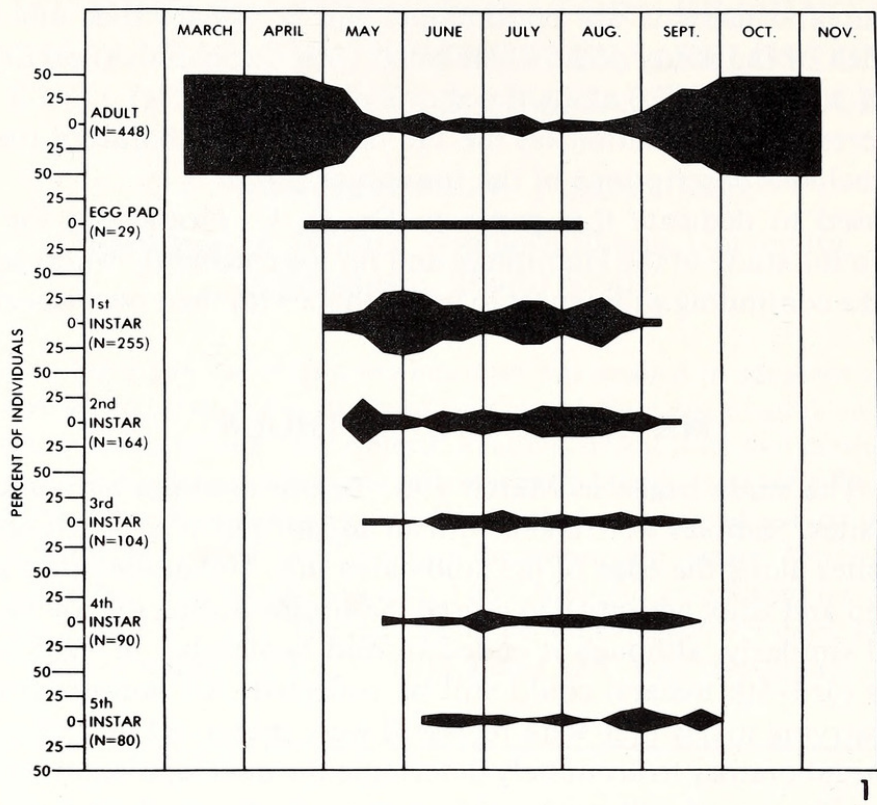
Life history. The study began in March 1983 before the bugs had emerged from overwintering sites. Samples were taken with an aquatic net at approximately weekly intervals at 6 sites along the edge of the study area into November after all nymphs had disappeared and adult activity had ceased. Sampling during the following 2 years was conducted similarly, although it ended in mid-September in 1985 when occasional nymphs (3rd–5th instars) could still be collected. All samples (minus some captured egg-carrying males that were released) were preserved in 75% ethanol and examined in the laboratory to accurately determine the developmental stages present in each sample. Occasional collections also were made during the winter months to determine overwintering stage(s) and sites. Data gathered during the 3 years of study were combined to gain a better understanding of the annual life cycle.

Laboratory rearing. Approximately 20 adults were collected during late March and early April 1985 and returned to the laboratory. From these individuals, 7 pairs of males and females were selected and placed in 2 aquaria (4♂♂ and 4♀♀; 3♂♂ and 3♀♀). Each aquarium (ca. 30 × 20.5 × 15 cm) was covered on the bottom with aquarium gravel and filled with ca. 7 cm of dechlorinated water. Adults were maintained on amphipods, *Gammarus minus pinicollis* Cole.

Egg-carrying males were removed from the aquaria and placed in finger bowls (ca. 11 cm diam, 4 cm depth) filled with 3 cm of distilled water. All egg pads were eventually separated from the males, either by the males themselves or by us after the males prematurely died, and placed in petri dishes. Each dish (ca. 9 cm diam, 2 cm depth) was covered on the bottom with filter paper and the eggs kept moist by keeping the filter paper saturated with distilled water. Upon hatching, the 1st instars were also placed in petri dishes. Each dish was again covered on the bottom with filter paper but ca. 0.5 cm of distilled water was added, sufficient to just cover the bugs. Later instars were also provided sufficient water to just keep them submerged. About 10 1st instars were placed in each petri dish but were further separated as they developed through subsequent instars. Two *Chaoborus americanus* (Johannsen) larvae were provided daily as food per nymph, and the amount was increased by 2 for each subsequent instar. Dishes were checked daily for exuviae and any prey carcasses removed. Water and paper were changed every 3–4 days.

The aquaria, finger bowls, and petri dishes were kept in incubators maintained at ca. $26.7 \pm 1.5^{\circ}\text{C}$ and a 16L:8D photoperiod (ca. 260 ft-c).

Descriptions of immature stages. Eggs and 1st–5th instars were selected from field samples that had been preserved in 75% ethanol. The description of each stage is



Figs. 1, 2. 1. Percent of individuals in each stage per sample during 1983-1985 combined seasons in Union Co., Illinois. Egg pads were not included in calculations. 2. Percent in each sample of total individuals of same stage during 1983-1985 combined seasons in Union Co., Illinois.

Table 1. Duration (in days) of each immature stage of *B. lutarium* under controlled laboratory conditions.

Stage	Number completing stadium	Range	$\bar{x} \pm SE$	Cumulative mean age
Egg	182	9–11	9.9 ± 0.5	9.9
Nymph				
1st instar	148	5–12	6.3 ± 0.1	16.2
2nd instar	107	4–24	6.4 ± 0.3	22.6
3rd instar	96	4–27	10.7 ± 0.5	33.3
4th instar	95	7–24	12.9 ± 0.4	46.2
5th instar	95	10–20	13.7 ± 0.2	59.9

based on 10 individuals. Drawings were made with the aid of a camera lucida; measurements, with an ocular micrometer. Dimensions are expressed in mm as $\bar{x} \pm SE$.

RESULTS AND DISCUSSION

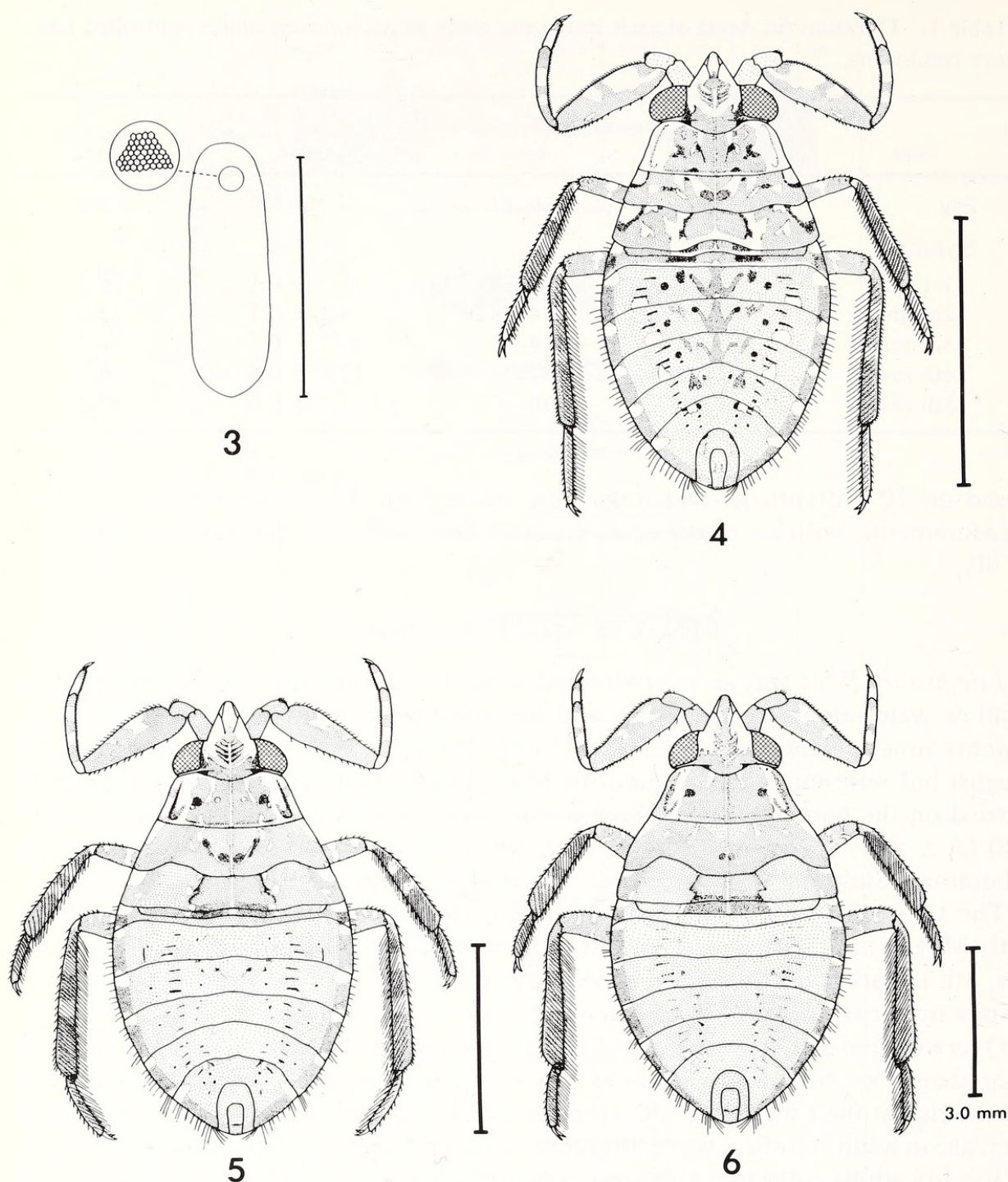
Life history. This species overwintered as adults in leaf litter and detritus in very shallow water along the shoreline, and became active in early March (Figs. 1, 2). Twenty-nine egg-carrying males were found from the 3rd week of April to early August but were most common during May (13 pads) and July (8 pads). Eggs were carried on the backs by being glued to the hemelytra. Pad size ranged from 36 to 180 ($\bar{x} \pm SE = 116.3 \pm 7.9$, $N = 19$), which is somewhat misleading since our laboratory results showed that a pad can consist of eggs laid on successive days.

The 1st instars were found from early May to early September, 2nd instars from early May to mid-September, 3rd instars from mid-May to the 3rd week of September, 4th instars from the 3rd week of May to the 3rd week of September, and 5th instars from early June to late September (Figs. 1, 2).

Overwintered adults were most abundant during late March to May and died off soon thereafter. New adults began to appear in late June and early July as evidenced by the rise in their numbers following the 1st appearance of 5th instars. This small increase in adult numbers was followed by a much larger increase in the fall. In fact, of the 448 adults collected, 85% were collected after late June. No active adults were found after November.

This species is apparently bivoltine. Our conclusion, in part, is based on the fluctuations in numbers of the various stages during the season. Although there was marked overlapping of the various stages and, thus, any particular sample could have any combination of individuals (Fig. 1), weekly plotting of data for each stage showed 2 peaks of abundance for the eggs and 3rd–5th instars, and 3 for the adults (i.e., overwintered, summer, and fall adults); peaks for the 1st and 2nd instars were less obvious (Fig. 2).

Laboratory rearing. As in the field, eggs were laid on the backs of males. The incubation period averaged 9.9 days (Table 1). Eggs were yellowish brown at oviposition but darkened during maturation.



Figs. 3–6. Immature stages of *B. lutarium*. 3. Egg. 4. First instar. 5. Second instar. 6. Third instar.

The 1st instar emerged through a semicircular opening in the cephalic end of the egg. It was yellowish white at this time but soon darkened to its normal color. It fed on *C. americanus* larvae within 1 day.

The 1st, 2nd, 3rd, 4th, and 5th stadia averaged 6.3, 6.4, 10.7, 12.9, and 13.7 days, respectively. The total developmental period averaged 59.9 days.

Newly emerged F_1 adults placed in 2 aquaria (4♂♂, 6♀♀; 5♂♂, 7♀♀) prepared similarly to those of their parents and maintained under the same conditions matured (i.e., produced fertile eggs) as early as 21 days (\bar{x} = 33, range = 21–45, N = 5). This short

Table 2. Measurements (mm)^a of *B. lutarium* instars.

	Nymph				
	1st instar	2nd instar	3rd instar	4th instar	5th instar
Body length	4.90 ± 0.03	6.88 ± 0.05	8.56 ± 0.11	13.72 ± 0.13	18.52 ± 0.30
Body width ^b	2.55 ± 0.03	3.72 ± 0.03	4.81 ± 0.05	7.48 ± 0.05	10.25 ± 0.14
Width at eyes	1.46 ± 0.01	1.98 ± 0.01	2.60 ± 0.02	3.43 ± 0.02	4.39 ± 0.04
Synthlipsis	0.67 ± 0.01	0.85 ± 0.01	1.09 ± 0.02	1.47 ± 0.01	1.90 ± 0.02
Head length ^c	0.97 ± 0.03	1.32 ± 0.01	1.61 ± 0.03	2.27 ± 0.05	2.84 ± 0.07
Pronotal length ^c	0.47 ± 0.01	0.73 ± 0.01	1.15 ± 0.04	1.64 ± 0.01	2.35 ± 0.04
Mesonotal length ^c	0.40 ± 0.02	0.74 ± 0.01	1.16 ± 0.04	1.94 ± 0.03	3.02 ± 0.05
Metanotal length ^c	0.31 ± 0.01	0.46 ± 0.01	0.62 ± 0.01	0.82 ± 0.01	0.91 ± 0.02
Leg lengths:					
Profemur	1.39 ± 0.01	1.83 ± 0.01	2.56 ± 0.02	3.45 ± 0.02	4.52 ± 0.05
Protibia	0.88 ± 0.02	1.18 ± 0.01	1.70 ± 0.01	2.30 ± 0.02	3.02 ± 0.04
Protarsus	0.37 ± 0.01	0.45 ± 0.01	0.61 ± 0.01	0.75 ± 0.01	0.95 ± 0.01
Mesofemur	1.58 ± 0.02	2.14 ± 0.01	2.86 ± 0.02	3.96 ± 0.03	5.33 ± 0.07
Mesotibia	1.40 ± 0.02	1.86 ± 0.01	2.48 ± 0.03	3.44 ± 0.02	4.62 ± 0.06
Mesotarsus	0.58 ± 0.01	0.74 ± 0.01	1.01 ± 0.02	1.38 ± 0.02	1.84 ± 0.03
Metafemur	1.85 ± 0.02	2.56 ± 0.02	3.46 ± 0.03	4.86 ± 0.05	6.56 ± 0.09
Metatibia	1.84 ± 0.02	2.53 ± 0.02	3.38 ± 0.03	4.62 ± 0.02	6.27 ± 0.08
Metatarsus	0.78 ± 0.01	1.02 ± 0.01	1.43 ± 0.03	1.95 ± 0.01	2.68 ± 0.06

^a $\bar{x} \pm \text{SE}$.
^b Measured across 3rd abdominal segment.
^c Measured along midline.

prematuration period further supports our conclusion that this species is bivoltine in southern Illinois.

DESCRIPTIONS OF IMMATURE STAGES

Egg (Fig. 3). Length, 3.18 ± 0.04 , width, 1.09 ± 0.01 . Eggs laid in clusters (pads), affixed to backs of males by gluing to hemelytra; each egg elongate, yellowish brown at oviposition but darkening during maturation; chorion with primarily irregular hexagonal pattern.

Nymphal instars

The 1st instar is described in detail, but only major changes that have occurred from previous instars are described for subsequent instars. Length is measured from tip of tylus to tip of abdomen, width across the 3rd abdominal segment. Additional measurements are given in Table 2.

1st instar (Fig. 4). Length, 4.90 ± 0.03 ; width, 2.55 ± 0.03 . Body broadly oval, greatest width at 3rd abdominal segment, dorsoventrally flattened; yellowish with light to dark brown maculations.

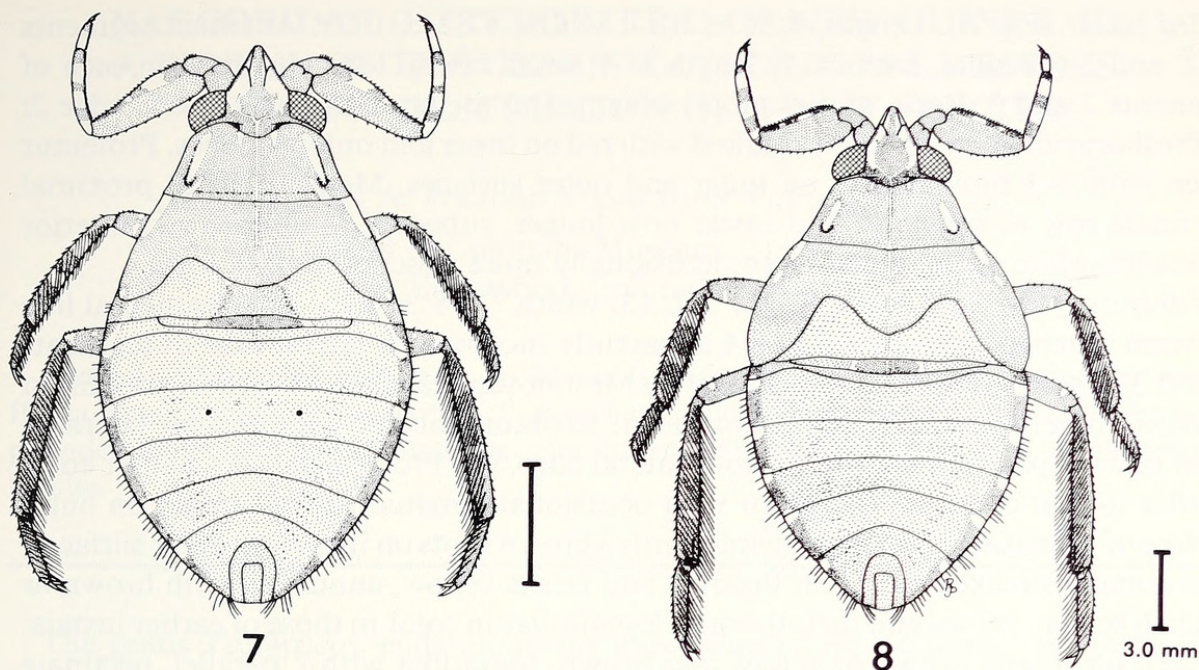
Head broadly triangular, porrect, anterolateral margins straight. Head yellowish

dorsally with brown stripe along anterolateral margin between eye and apex of tylus; brown chevron-shaped mark on disc, and brown U-shaped mark along posterior margin; thin yellow line originating from inner margin of each eye anteriorly, both lines continuing posteriorly along anterior margin of U-shaped mark, meeting medially, and giving rise to short yellow line continuous with middorsal yellow line of thorax and anterior part of abdomen. Tylus elevated above and exceeding juga, apically reaching between bucculae, tylus and bucculae collectively forming a tubular socket holding modified base of labium. Eyes black dorsally, red ventrally; synthlipsis near anterior margin of eye ca. $1.8 \times$ width of eye. Head yellowish ventrally with brown stripe either side of middle and continuous from base of beak to back of head. Antennae brownish, arising near anteroventral margin of eye; knoblike, directed anteriorly, 3-segmented, segments 1 and 2 subequal, each ca. $\frac{1}{6}$ length of 3. Beak yellowish; 3-segmented, extending to procoxae; segment 1 subequal to 3, and ca. $\frac{1}{2}$ length of 2.

Thoracic nota yellowish with brown maculations. Pronotum trapezoidal, moderately convex, anterior margin arcuate medially, posterior margin nearly straight. Mesonotum narrower, ca. $0.9 \times$ length of pronotum along midline, with semicircular depression anteromedially; anterior margin nearly straight, posterior margin arcuate medially and sinuate laterally; wing pads weakly developed laterally. Metanotum narrowest of thoracic nota along midline, convex medially, posterior margin arcuate medially; ratio of mesonotal wing pad to metanotum along lateral edge ca. 1:1. Pro- and mesopleura brown with yellow lateral margin and medial stripe. Metapleuron brown laterally, white medially, prolonged posteriorly and partially encircling metacoxa, pleuron heavily fringed with long hairs. Prosternum brown medially, yellow posterolaterally, with small yellow notch posteromedially. Mesosternum whitish with broad, brown bar medially extending from posterior margin to near anterior margin. Metasternum whitish, triangular, with brown spot in each anterolateral corner.

Prothoracic legs raptorial. Procoxa white or white with irregular brown stripe on anteromedial surface; two brown, short, blunt projections present at base; coxa ca. $\frac{1}{2}$ length of femur. Protrochanter white; subglobular, with ventral patch of setae at apex; trochanter ca. $\frac{1}{4}$ length of femur. Profemur yellow with brown maculations; thickened proximally, narrowed distally, ventral surface nearly flat but with slight median groove basally, segment bordered by row of short spines on either side. Protibia and tarsus yellow, annulated with brown; together equal to length of femur; ventral surface of each segment nearly flat but with slight median groove, segments bordered by row of short spines on either side, these rows fitting within those of femur when segments are apposed; tarsus 1-segmented, the 2 claws of unequal length.

Meso- and metacoxae and trochanters similar to those of prothorax but patch of setae of trochanters diffuse. Meso- and metafemora yellow, annulated with brown; longer and narrower than profemur. Meso- and metatibiae yellow, annulated with brown; longer than protibia; metatibia with apical, pectinate row of spines on posterior surface. Meso- and metatarsi yellowish brown, longer than protarsus; meso- and metatibiae and tarsi flattened on anterior and posterior surfaces, furnished with row of swimming hairs on inner and posterior surfaces (inner row not readily apparent on mesotarsus), best developed on metathoracic legs, extending to distal area of respective femora (not shown in illustrations); tarsi 2-segmented, 1st segment very small, the 2 claws of equal length.



Figs. 7, 8. Immature stages of *B. lutarium*. 7. Fourth instar. 8. Fifth instar.

Abdomen yellow dorsally with brown maculations, and yellowish white spot at anterolateral corner of segments 3–7 that slightly overlaps preceding segment, and yellowish-white spot posteriorly near inner edge of lateral $\frac{1}{4}$ of same segments. Yellow ventrally with brown maculations and yellowish-white spots corresponding to those of dorsal surface; surface covered with long hairs, greatly convex in middle $\frac{1}{3}$; 7 pairs of spiracles evident, 1st pair more medially placed and hidden by metacoxae.

2nd instar (Fig. 5). Length, 6.88 ± 0.05 ; width, 3.72 ± 0.03 . Head markings dorsally similar to those of 1st instar or chevron color blending with posterior U-shaped mark.

Synthlipsis ca. $1.6 \times$ width of eye. Color ventrally similar to that of 1st instar, or brown with yellowish spot posteriorly or yellow with brown areas greatly reduced. Antennae 4-segmented, directed posteriorly, segment 1 short, ca. $\frac{1}{2}$ length of 2, segments 2 and 3 subequal, each ca. $\frac{1}{4}$ length of 4. Beak varying from yellow to brown with yellow markings.

Thoracic notal color similar to that of 1st instar or brown with yellow maculations. Mesonotum ca. equal in length to pronotum along midline, posterior margin subtruncate medially and arcuate laterally; ratio of mesonotal wing pad to metanotum along lateral edge 3:2. Thoracic pleural color similar to that of 1st instar or varying from almost completely yellow to predominantly brown. Thoracic sternal color similar to that of 1st instar or with brown areas more limited.

Prothoracic leg color similar to that of 1st instar or coxa and trochanter brown and profemur brown with yellow maculations. Protibia and tarsus yellow, annulated with brown. Meso- and metathoracic leg color similar to that of 1st instar or femur and tibia brown with yellow annulations and tarsi brown. Metatibia with short, pectinate row of spines just proximal to apical row on posterior surface, proximal row ca. $\frac{1}{2}$ – $\frac{2}{3}$ length of apical row.

Abdominal color similar to that of 1st instar or brown with yellow maculations, anterolateral and inner yellowish-white spots usually present in both color forms, inner spots sometimes lacking in dark individuals.

3rd instar (Fig. 6). Length, 8.56 ± 0.11 ; width, 4.81 ± 0.05 . Antennal segments 1, 2, and 3 subequal, each ca. $\frac{1}{2}$ length of 4; small lateral lobe apparent on each of segments 2 and 3. Ratio of mesonotal wing pad to metanotum along lateral edge 2:1. Prothoracic leg occasionally marked with red on inner and outer surfaces. Profemur often with 2–3 brown spots on inner and outer surfaces. Metatibia with proximal pectinate row of spines of 2nd instar now longer, subequal to apical row. Interior yellowish-white spots of abdomen occasionally more obscure in dark form.

4th instar (Fig. 7). Length, 13.72 ± 0.13 ; width, 7.48 ± 0.05 . Intersegmental line between antennal segments 3 and 4 apparently incomplete; lateral lobe of segments 2 and 3 longer, each ca. $\frac{3}{4}$ length of 4. Mesonotum ca. $1.2 \times$ length of pronotum along midline, posterior margin subtruncate to obtuse medially and arcuate laterally; ratio of wing pad to metanotum along lateral edge 5:1. Procoxa and trochanter color similar to that of earlier instars or with occasional longitudinal red streak on outer surface of procoxa. Profemur generally with 3 brown spots on inner and outer surfaces, occasionally streaked with red. Protibia and tarsus yellow, annulated with brown or reddish brown. Meso- and metathoracic legs similar in color to those of earlier instars, in dark form tarsi brown or yellow and brown. Metatibia with 2 parallel, pectinate rows of spines proximal to apical row, basal row sometimes split or fragmented; vertical row of setae present proximal to the 2 rows.

5th instar (Fig. 8). Length, 18.52 ± 0.30 ; width, 10.25 ± 0.14 . All antennal segments visible; lateral lobe of segments 2 and 3 longer, each subequal in shape and size to 4. Mesonotum ca. $1.3 \times$ length of pronotum along midline, posterior margin subacute medially and arcuate laterally. Wing pads of meso- and metanota (present but covered by those of mesonotum) extending to abdominal segment 2 laterally. Procoxa occasionally streaked with red on inner and outer surfaces. Profemur generally with 3 brown spots and red longitudinal streak on inner and outer surfaces. Protibia and tarsus yellow, annulated with brown or reddish brown, both segments occasionally tinged with red. Metatibia with 2 parallel, pectinate rows above apical row, both rows generally longer than in 4th instar and broken; vertical row of setae longer. Inner yellowish spots of abdomen more obscure in all forms.

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