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Comparative Study of Life Histories, Laboratory Rearing, and Immature Stages of *Euschistus Servus* and *Euschistus Variolarius* (Hemiptera: Pentatomidae)

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COMPARATIVE STUDY OF LIFE HISTORIES, LABORATORY REARING, AND IMMATURE STAGES OF *EUSCHISTUS SERVUS* AND *EUSCHISTUS VARIOLARIUS* (HEMIPTERA:PENTATOMIDAE)[1]

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ABSTRACT

A comparative study was conducted of the field life histories of *Euschistus servus* and *E. variolarius* in southern Illinois, their life cycles under controlled laboratory conditions, and their immature stages.

The results indicate that *E. servus* is bivoltine and *E. variolarius* is univoltine. Adults of both species emerged from overwintering sites during early April, began feeding and copulating on leaves of common mullein (*Verbascum thapsus*) and surrounding vegetation, and reproduced shortly thereafter. Neither eggs and first instars of either species, nor second instars of *E. variolarius*, were collected in the field. Seasonal occurrences of the adults and subsequent immature stages are discussed for each species. No individuals were found after the first week of November.

Both species were reared on green beans (*Phaseolus vulgaris*) under a 16L:8D photoperiod and constant temperature of 23 ± 0.06° C. The incubation period averaged 5.8 days for *E. servus* and 5.4 days for *E. variolarius*. Durations of the 5 subsequent stadia averaged, respectively, 5, 6, 6.7, 9.3, and 11.5 days for *E. servus*, and 4.9, 5.7, 7.8, 9.7, and 13.3 days for *E. variolarius*. Comparisons of incubation period and stadia between the two species showed that only the stadia for the first instars were not statistically different. Total developmental period was longer for *E. variolarius* than for *E. servus*.

The external anatomy of the egg and each of the five nymphal instars is described for each species.

The brown stink bug, *Euschistus servus* (Say), and one-spotted stink bug, *E. variolarius* (Palisot de Beauvois), are common throughout most of the continental United States, and occur statewide in Illinois (McPherson 1982). They are similar in appearance and often occur in the same habitats, and even on the same plant species. For example, both species feed on soybean, mullein, beans, tomatoes, peas, cotton, wheat, corn, tobacco, and peach (McPherson 1982). They are close enough genetically that Foot and Strobell (1914) and Sailer (1955) were able to obtain fertile hybrids.

Euschistus servus is bivoltine and *E. variolarius* has been listed as univoltine and bivoltine; both overwinter as adults (McPherson 1982). They have been reared under controlled conditions and the eggs and nymphal instars have been described (McPherson 1982). However, neither a comparative study

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of their field life histories nor of their life cycles under controlled conditions has been conducted, and comparison of the developmental stages has been somewhat superficial. However, because these species are economically important, and often occur together, such a study would be useful. Thus, the purposes of the present study were to compare: (1) their field life histories in southern Illinois, including the temporal distribution of the various stages, (2) their life cycles under controlled laboratory conditions, and (3) their immature stages.

MATERIALS AND METHODS

Field Life History. *Euschistus servus* and *E. variolarius* nymphs and adults, excluding those found on field and fruit crops, seem to prefer open disturbed roadsides in southern Illinois, and often feed and reproduce on common mullein (*Verbascum thapsus*). Four sites were selected in disturbed areas, each of which contained some mullein plants. Two were located near the La Rue-Pine Hills Ecological Area (now Research Natural Area), one along north Levee Road 30 m east of Illinois Route 3 (Union County) and the other at the junction of Illinois Route 3 and the Big Muddy River (Jackson County). The remaining sites were located in Carbondale, Jackson County, one on Reservoir Road (near the water reservoir) and the other at the junction of Pleasant Hill Road and the railroad tracks, 200 m east of U. S. Route 51. The study was conducted from April to November 1991 and March to November 1992. This seasonal interval began before the bugs emerged and continued after they entered overwintering sites.

Samples were collected by sweeping and hand picking one to three times per week. Nymphs, which are very similar in appearance for both species, were brought to the laboratory, grouped by instar, and reared to adults on green beans (*Phaseolus vulgaris*) as described by McPherson (1971) and briefly described in the "Laboratory Rearing" section of this paper.

Laboratory Rearing: Thirty four adults (18 ♂♂, 16 ♀♀) of *E. servus* and 28 (17 ♂♂, 11 ♀♀) of *E. variolarius* were collected on mullein plants at the Reservoir Road site on 17 and 20 April 1992, respectively, brought to the laboratory, and placed in oviposition cages. Each cage consisted of a Mason jar (ca. 0.95 liter) covered on the bottom with filter paper. Green beans served as food for the bugs and their offspring. A strip of paper toweling was added which, together with the filter paper, increased absorption of excrement and provided a good walking surface. The jar was closed with wire screen and paper toweling and secured with the band of the 2-piece Mason jar lid. A cheesecloth strip, which served as an oviposition site, was placed inside the jar with one end over the lip and held in place by the band. The food, filter paper, cheesecloth, and strip were changed every 3 to 4 days.

Cheesecloth with attached egg clusters was removed daily and placed on moist filter paper in petri dishes (ca. 9 cm diam., 2 cm depth) and covered with the lids. Water was added daily to keep the paper moist.

The first instars (an apparently nonfeeding stage) were kept in the same dishes. The second through fifth instars were kept in Mason jars prepared similarly to the oviposition cages except for the absence of cheesecloth. Nymphs were separated and maintained in different groups by molting dates to accurately determine the stadia.

All specimens were kept in an incubator maintained at 23 ± 0.06° C and a 16L:8D photoperiod (ca. 2797 lux [260 ft-c]).

Anatomical Descriptions of Immature Stages: Eggs and first-fifth instars were collected from the laboratory culture and preserved in 75% ethanol. The

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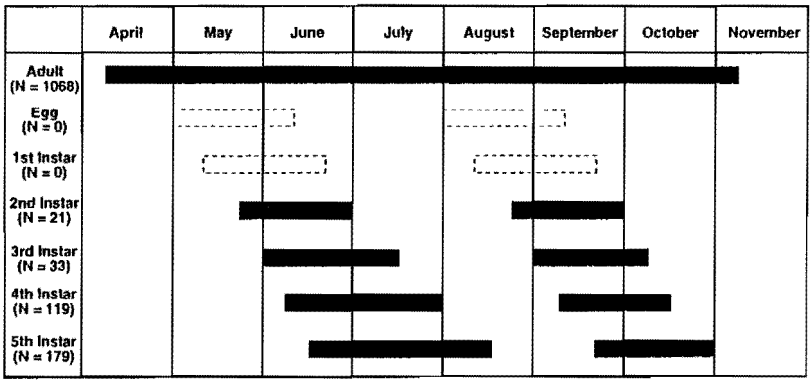

Figure 1. Seasonal occurrence of *E. servus*. Dashed lines represent probable occurrence (estimated from lengths of stadia in laboratory) since no specimens were found.

description of each stage is based on 10 individuals. Drawings were made with the aid of a camera lucida, measurements with an ocular micrometer. Measurements are expressed in mm as mean ± SE.

RESULTS AND DISCUSSION

Field Life History. The life cycle data gathered during the two years of this study were combined to gain a clearer understanding of the annual cycles of the two species.

Adults overwintered and became active during early April (Fig. 1-2), began feeding and copulating on leaves of common mullein and surrounding

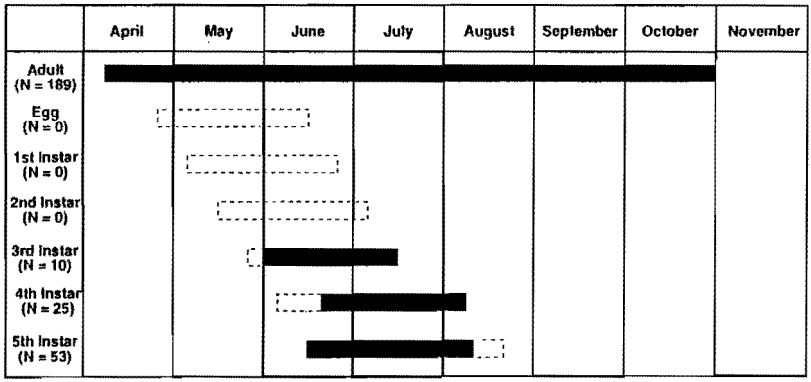

Figure 2. Seasonal occurrence of *E. variolarius*. Dashed lines represent probable occurrence (estimated from lengths of stadia in laboratory) since no specimens were found.

vegetation, and reproduced shortly thereafter; the mating position was end-to-end as is characteristic of pentatomoids (McPherson 1982).

Only two clusters of eggs were found during this study, one (17 eggs) on the underside of a water smartweed leaf (*Polygonum amphibium* L.) on 12 June 1992, the other (14 eggs) on the underside of a mullein leaf on 2 September 1992. Unfortunately, both clusters were parasitized and, thus, could not be identified to species. Two clusters of hatched eggs were also found on 19 September 1992 and had probably hatched during the previous week because several cast first instar exuviae were found nearby.

No first instars of either species were found during this study, nor were second instars of *E. variolarius* (Fig. 1-2). However, sufficient numbers of the remaining instars were found to give some indication of the life cycles.

For *E. servus*, second instars were found from late May to late June and from late August to late September, third instars from early June to mid-July and from early September to early October, fourth instars from early June to late July and from early September to mid-October, and fifth instars from mid-June to mid-August and from late September to late October (Fig. 1).

Adults had three peaks of abundance. Of the 1,068 adults collected during this study 37.5% were taken from early April to mid-May, 29.7% from early July to late August, and 15.7% from mid-September to late October. No adults were found after the first week of November.

These observations indicate that *E. servus* is bivoltine, and that the three peaks of adult abundance corresponded to the emergence of overwintered individuals in the spring, and the appearance of the first (summer) and second (overwintering) generations, respectively.

For *E. variolarius*, third instars were found from early June to mid-July, fourth instars from late June to early August, and fifth instars from mid-June to early August. No nymphs were collected after late August (Fig. 2).

Adults were most abundant from mid-April to mid-June. Of the 189 adults collected during this study, 60.3% were collected during this time. These must have been overwintered adults because they preceded the appearance of fifth instars in the field (Fig. 2). Thereafter, numbers dropped sharply and no readily discernible peaks were seen during the rest of the season. New adults apparently appeared late June to late August, this again based on the seasonal occurrence of fifth instars. These observations indicate that *E. variolarius* is univoltine.

Our conclusions about voltinism in each of the two species are further supported by the temporal patterns of adults observed *in copula*. Of the 27 pairs of *E. servus*, 11 were observed after late August. Of 10 pairs of *E. variolarius*, all were observed in the spring.

The data strongly suggest that *E. servus* was more abundant than *E. variolarius* (Fig. 1-2). However, this could simply be due to chance. The eggs and early instars are difficult to find because they are small and, because both species feed and reproduce on a wide range of plants, are scattered in distribution.

The tachinid parasite *Cylindromyia binotata* (Bigot) emerged in the laboratory on 14 July 1992 from an *E. servus* adult collected on a mullein plant in early July 1992.

Laboratory Rearing. Precopulatory and copulatory behaviors have been studied in detail (Drickamer and McPherson 1992). Oviposition also has been discussed by other authors (Esselbaugh 1946, Parish 1934, Woodside 1946).

In the present study, *E. servus* eggs were laid in clusters of 8 to 41, averaging 17.6 eggs per cluster (N = 15); the incubation period averaged 5.8 days (Table 1). The first through fifth stadia averaged 5, 6, 6.7, 9.3, and 11.5 days, respectively. The total developmental period averaged 44.3 days (Table 1).

Table 1. Duration (in days) of each immature stage of *E. servus* under laboratory conditions.

Stage	Number completing stadium	Range	$\bar{x} \pm SE$**	Cumulative mean age**
Egg	238*	5–7	5.8 ± 0.04	5.8
Nymph				
1st instar	212	4–7	5.0 ± 0.04	10.8
2nd instar	178	5–8	6.0 ± 0.05	16.8
3rd instar	157	5–13	6.7 ± 0.12	23.5
4th instar	147	7–14	9.3 ± 0.11	32.8
5th instar	137	8–20	11.5 ± 0.21	44.3

*264 eggs were laid.
**Means are rounded to the nearest tenth.

For *E. variolarius*, eggs were laid in clusters of 6 to 27, averaging 16.2 eggs per cluster (N = 18); the incubation period averaged 5.4 days. The first to fifth stadia averaged 4.9, 5.7, 7.8, 9.7, and 13.3 days, respectively. The total developmental period averaged 46.8 days (Table 2).

Most mortality for both species occurred during the first and second stadia and resulted from incomplete ecdysis or from drowning in water condensation on the lids of the dishes.

Comparisons of incubation period and stadia between the two species showed that only the stadia for the first instars were not statistically different (Table 3). Total developmental period was longer for *E. variolarius* than *E. servus*.

Anatomical Descriptions of Immature Stages. The first instar is described in detail, but only major changes from previous instars are described for subsequent instars. Comparative statements refer to previous instars or to the same instar for both species. Length is measured from tip of tylus to tip of abdomen; width is measured across the widest part of the body (i.e., abdominal segments 2–3). All measurements are given in millimeters.

Euschistus servus

Egg (Fig. 3A). Length, 1.13 ± 0.02; width, 0.96 ± 0.02. Eggs usually laid in clusters of 14; each egg somewhat kettle-shaped, yellowish white, slightly greenish when first deposited. Chorion with irregular triangular and quadran-

Table 2. Duration (in days) of each immature stage of *E. variolarius* under laboratory conditions.

Stage	Number completing stadium	Range	$\bar{x} \pm SE$**	Cumulative mean age**
Egg	253*	4–7	5.4 ± 0.05	5.4
Nymph				
1st instar	229	4–6	4.9 ± 0.04	10.3
2nd instar	194	4–9	5.7 ± 0.06	16.0
3rd instar	175	6–13	7.8 ± 0.11	23.8
4th instar	167	7–14	9.7 ± 0.12	33.5
5th instar	154	9–21	13.3 ± 0.16	46.8

*292 eggs were laid.
**Means are rounded to the nearest tenth.

Table 3. Comparisons of developmental periods between *E. servus* and *E. variolarius*, using Student's T-test.

Stage	Species[a]	N	$\bar{x} \pm SE$	df	T
Egg	S	238	5.8±0.04		
	V	253	5.4±0.05	483.5	5.70[b]
1st instar	S	212	5.0±0.04		
	V	229	4.9±0.04	439.0	0.55
2nd instar	S	179	6.0±0.05		
	V	194	5.7±0.06	360.1	2.62[b]
3rd instar	S	157	6.7±0.12		
	V	175	7.8±0.11	330.0	-6.58[b]
4th instar	S	147	9.3±0.11		
	V	167	9.7±0.12	312.0	-2.65[b]
5th instar	S	137	11.5±0.21		
	V	154	13.3±0.16	289.0	-6.47[b]
Total period	S	137	44.3±0.30		
	V	154	46.8±0.27	289.0	-6.02[b]

[a]S = *E. servus*, V = *E. variolarius*.
[b]Significant at 0.01 level.

gular reticulations; spine at apex of each angle. Operculum present, surrounded by 30–35 micropylar processes, each process about 0.06 mm long and slightly expanded distally.

First instar (Fig. 3B-C). Length, 1.52 ± 0.04; width, 1.14 ± 0.07. Form oval to nearly circular, usually longer than broad, greatest width at abdominal segments 2–3. Punctures present dorsally and ventrally on brown sclerotized areas, all punctures minute.

Head strongly declivent, anterolateral margins slightly sinuate; yellowish brown to brown dorsally with vertex often yellower medially and tylus yellowish red to brown; often with pair of reddish ocellar spots posteromediad of eyes. Tylus exceeding juga; line extending from each eye posteromedially and disappearing beneath pronotum. Eyes red. Antennae 4-segmented; segments 1–3 brown to red; segment 4 largest, fusiform, reddish brown to brown; incisures lighter, often albidus; distinct constrictions at junctures of 2–3 and 3–4; ratio of segment lengths approximately 2:3:3:7. Ventral surface of head whitish to yellowish brown. Beak 4-segmented, yellowish basally, brownish distally.

Thoracic nota generally yellowish brown, yellow medially; yellow mediolongitudinal line extending from anterior margin of pronotum nearly to or reaching posterior margin of metanotum; lateral margins entire and slightly explanate. Pro- and mesonota sclerotized, posterior margins arcuate; metanotum sclerotized except posteriorly, posterior margin of metanotal plate slightly arcuate medially, bending cephalad laterally. Pleura light brown; pro- and mesopleura fused to respective nota; metapleuron separated from metanotal plate by membranous areas. Spiracles on posterior margins of pro- and mesopleura. Sterna yellowish, concolorous with ventral surface of abdomen. Coxae yellowish brown, each with central brown spot on lateral surface; remaining segments, tarsal claws, and pulvilli yellowish brown to brown; tibiae weakly sulcate, front tibiae each with bifurcate spine on inner posterior margin of distal one-third; tarsi 2-segmented, apex of segment 2 often darker than remainder of tarsi.

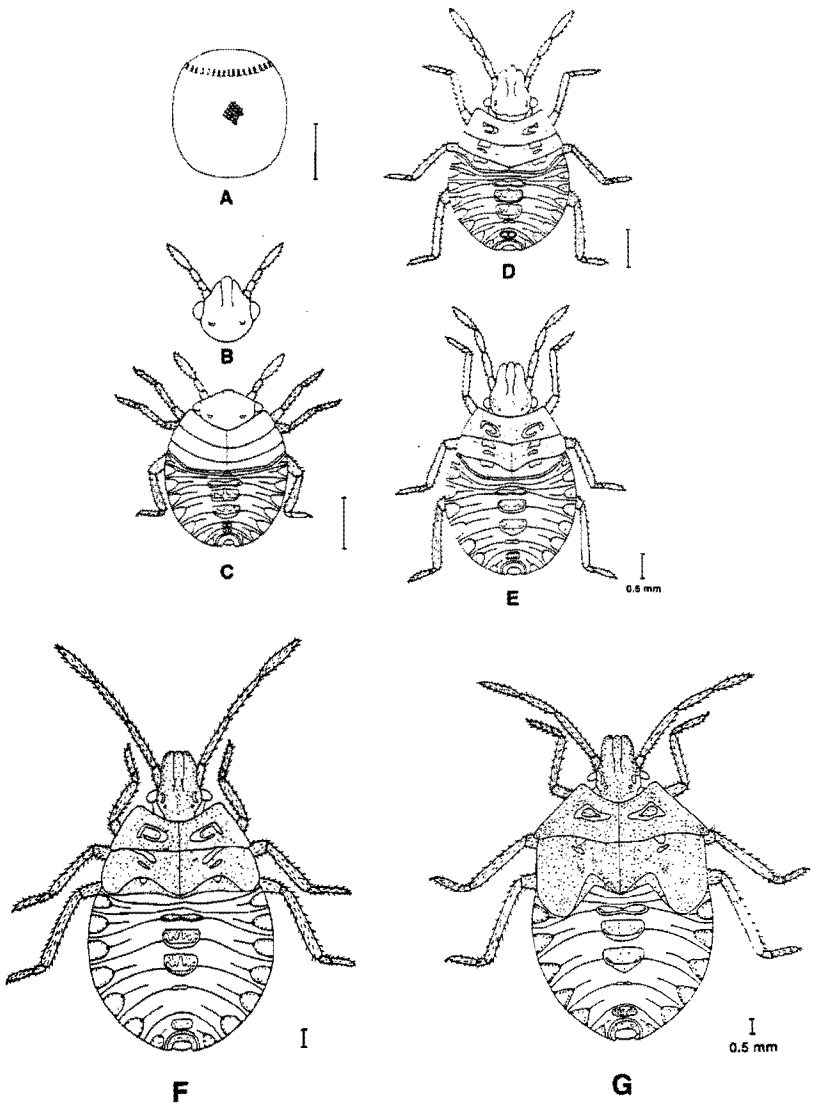

Figure 3. Immature stages of *E. servus*. A, egg; B-C, 1st instar; D, 2nd instar; E, 3rd instar; F, 4th instar; G, 5th instar.

Dorsum of abdomen white or yellow with red markings, markings more dense laterally. Sparsely punctate, light brown to brown medial and lateral plates present. Faint pseudointersegmental lines present on all but first and last segments, each originating at inner margin of lateral plate. Seven medial plates present; plate 1 small; plate 2 nearly linear and slightly constricted

medially, plate 3 subrectangular with irregular margins, slightly narrower than, and 4 to 5 times medial length of, plate 2, yellowish white anchor-shaped marking present; plate 4 subtrapezoidal with irregular margins, slightly narrower than, and 5 to 6 times medial length of, plate 2, yellowish white anchor-shaped marking present; plate 5 often consisting of anterior transverse strip and paired posterior pieces; plate 6 variable in shape, often split or partially split medially; plate 7 fused to laterals. Paired ostioles of scent glands located on plates 2, 3, and 4. Nine lateral plates present, subtriangular, extending dorsally and ventrally from margin of abdomen; plate 1 small; plates 2–6 largest; remainder generally decreasing in size posteriorly. Sterna generally concolorous with dorsum, occasionally redder; segments 5–9 occasionally with weakly sclerotized subrectangular medial plates, that of sternum 9 fused with laterals. Spiracles located on segments 2–8, those of segment 8 reduced, each with brown peritreme. Single trichobothrium located posteromesad to each spiracle on segments 3–7.

Second instar (Fig. 3D). Length, 2.42 ± 0.08; Width, 1.53 ± 0.09. Form broadly pyriform; dorsum of head and thorax with numerous large punctate brown spots; ventral punctures still minute.

Head less declivent, anterolateral margins more sinuate; yellowish white dorsally with dark brown band posteriorly, oval brown spot medial to each eye, red ocellar spots of first instar obscured by dark brown band, yellow area on vertex now concolorous with remainder of dorsal surface. Antennal segment 1 dark brown to black; segments 2–3 reddish brown to brown, each red distally; segment 4 brown; incisures albidus; ratio of segment lengths approximately 4:7:6:10. Ventral surface dark brown except for white area either side of, and white to red strip beneath, beak; lateral surface of head with white area between base of antennae and eyes.

Thoracic nota white to yellowish white; lateral margins explanate, dentate (dentation well developed on pronotum), posterior margins brown. Mesonotum with medial area extended posteriorly; intersegmental lines between metanotum and first abdominal tergum sclerotized either side of midline approximately one-half way between lateral margin and midline of body; pro- and metanota each with one pair, mesonotum with 2 pairs, of brown calli. Pleura whitish yellow to yellow, edged with brown, each with brown spots and longitudinal stripes. Coxae white to brown, each with lateral edge sometimes and central spot brown; trochanters white; femora each with proximal one-third to one-half brown; tibiae reddish brown to brown, often reddish basally, sulcate; tarsi brown.

Dorsum of abdomen white to yellow with numerous, short, longitudinal, red markings. Medial and lateral plates with minute punctures; medial plate 1 absent; plates 2–7 brown with yellowish markings; plate 2 with transverse yellowish strip; plate 3 approximately 3 times medial length of plate 2, with anchor-shaped marking now yellow; plate 4 approximately 4 times medial length of plate 2, anchor-shaped marking now yellow, short mediolongitudinal mark posterior to anchor; plate 5 small, not divided into anterior strip and posterior pieces; plate 6 usually undivided, yellow marking medially; plate 7 with yellow marking medially. Lateral plates white with brown margins, usually one to three brown spots in white areas. Ventrally, linear sclerite present posterior to each metacoxa. Sterna in lateral one-half concolorous with dorsum, whitish medially with sparse or no red markings; intersegmental lines between sterna 2–3, 3–4, and 5–6 sclerotized submedially; medial plates brown with minute punctures, plates now often on segments 4–9. Two trichobothria posterior to each spiracle on segments 3–7. Otherwise, similar to first instar.

Third instar (Fig. 3E). Length, 4.20 ± 0.05; width, 2.86 ± 0.01. Form

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pyriform; brown punctures and spots on head and thoracic nota more numerous.

Two red ocellar marks present posteromedially, usually obscured by dark brown band along posterior margin of head. Antennal segment 1 dark brown to black; segments 2–3 brown to reddish brown; segment 4 brown, often reddish brown apically; ratio of segment lengths approximately 3:6:5:7. Ventral surface of head brown except for white areas either side of beak and around bases of antennae, white area with brown spot, white not reaching eyes.

Thoracic nota with brown areas along posterior margins reduced, particularly on metanotum; paired calli yellow with brown markings; mesonotum with medial area slightly extended posteriorly. Punctures on pleura more numerous. Femora each with proximal two-thirds white, distal one-third dark brown.

Dorsum of abdomen yellow with numerous short, longitudinal, red markings; medial plates 3–4 with markings similar to second instar, plate 2 often with brown spots on yellow area; plates 6–7 yellow, often with brown spots. Lateral plates with 4 to 8 small brown punctures and relatively thinner brown margin, border widest medially. Sterna with medial plates on segments 4–9 varying from almost transparent to yellow with brown spots; sclerotized stripes on intersegmental lines between segments 2–3, 3–4, and 4–5 often reduced or absent. Otherwise, similar to second instar.

Fourth instar (Fig. 3F). Length, 8.50 ± 0.07; width, 5.67 ± 0.04. Head yellowish dorsally with lateral one-third of juga occasionally reddish; tylus and juga subequal in length; oval spot mediad of eye yellow to yellowish brown, sometimes crescent-shaped; ocellar spots now usually evident, but partially obscured by brown. Antennal segment 1 yellow to yellowish white with brown spots; segments 2–3 yellow to reddish yellow with faint red to brown spots; segment 4 yellow to red proximally, brown to reddish brown distally; ratio of segment lengths approximately 6:17:13:17. Ventral surface of head yellow except for brown stripe extending from eye to near tip of juga, and from eye to posterior margin of head. Beak with segment 1 yellow; segment 2 yellow to brown; segments 3–4 yellowish brown to brown.

Thoracic nota with brown borders along posterior margins reduced or absent; humeri with brown spots more numerous; calli yellowish, often with brown marking. Meso- and metanotal wing pads approximately the same length, extending onto first abdominal segment. Pleura with dark brown spots and dark brown longitudinal stripes limited primarily to lateral one-half except for one black spot at base of each coxa. Sterna yellow. Coxae yellow, each with brown band on lateral edge and central brown spot reduced or absent; trochanters yellow; femora yellow with brown spots distally, apices brownish; tibiae yellowish with red to brown markings; tarsal segment 1 yellow, apex often brownish, segment 2 yellow basally, brown distally.

Dorsum of abdomen yellow with red spots medially. Medial plates 2–4 with brown spots; plates 3–4 with yellowish, anchor-shaped markings often obscured with brown spots and markings; plate 5 greatly reduced; plates 6–7 with brown spots more numerous. Lateral plates 2–7 yellowish, each with brown margin broken, margins with brown spot medially; small brown spots often more numerous (13–20) but may be absent. Sterna yellow; medial plates reduced or concolorous with sterna, and with few small brown spots; sclerotized stripes on intersegmental lines between segments 2–3, 3–4, and 4–5 absent. Otherwise, similar to third instar.

Fifth instar (Fig. 3G). Length, 10.37 ± 0.08; width, 6.70 ± 0.02. Head and thorax dorsally with red to brown punctures more numerous in some areas.

Head with posterior margin yellow to red or brown; ocellar spots evident; juga slightly exceeding tylus. Antennal segments 1–2 yellow with brown

spots, spots particularly evident on segment 1; segments 3–4 yellow to yellowish red, apex of segment 4 darker; ratio of segment lengths approximately 6:27:17:20. Ventral surface of head yellow with spots, spots red to brown or almost concolorous with ventral surface.

Humeri with brown spots more numerous, spots somewhat extended anteriorly in band along each lateral margin. Meso- and metanotal wing pads about same length, extending onto third abdominal segment. Pleura yellow with spots, spots red to brown or almost concolorous with pleural surface, dark spot at base of each coxa present; additional brown markings usually reduced or absent. Coxae without central brown spot on lateral surface; femora and tibiae with red to brown spots, those on femora originating nearer base of segment; tarsal segment 2 with apex dark.

Dorsum of abdomen yellow; red to brown spots reduced or absent. Medial plates 2–4 with brown to red spots more numerous; plate 5 reduced or absent. Otherwise, similar to fourth instar.

Euschistus variolarius

Egg. Length, 1.10 ± 0.03; width, 0.94 ± 0.01. Eggs generally laid in clusters of 14. Operculum surrounded by 27–33 micropylar processes, each about 0.06 mm long. Otherwise, similar to *E. servus*.

First instar. Length, 1.50 ± 0.09; width, 1.22 ± 0.02. Ratio of antennal segment lengths approximately 2:3:3:7. Otherwise, similar to *E. servus*.

Second instar. Length, 2.85 ± 0.09; width, 2.06 ± 0.03. Antennal segments 1–4 brownish to black, apices may be lighter; ratio of segment lengths approximately 3:7:7:10. Transverse pale area on ventral side of head usually more extensive than in *E. servus*, almost forming continuous band from beneath beak to in front of eyes.

Thoracic sterna yellowish to brownish except for medial white yellow strip. Medial plates 2–7 brown with yellow to whitish markings. Otherwise, similar to *E. servus*.

Third instar. Length, 4.08 ± 0.05; width, 2.92 ± 0.01. Ratio of antennal segment lengths approximately 3:6:5:7. Ventral side of head with white band reaching or almost reaching eyes, band with brown spots. Medial plates 2–4 often with brown spots on paler area. Otherwise, similar to *E. servus*.

Fourth instar. Length, 6.67 ± 0.03; width, 4.18 ± 0.08. Antennal segment 1 yellow to brownish black; segment 2 yellowish or reddish to brownish black; segment 3 yellowish red to brownish black, those that are lighter often darker distally; segment 4 brownish black; paler areas of segments 1–3 with reddish to brown spots; ratio of segment lengths approximately 5:16:13:17. Beak with segment 1 yellowish white to yellow; segment 2 yellowish white to brown; segments 3–4 yellowish brown to brown.

Thoracic pleura with dark brown spots and dark brown longitudinal stripes, spots more generally distributed than in *E. servus*.

Dorsum of abdomen yellowish with red spots medially, minute spots present between medial and lateral plates. Medial plates 3–4 yellowish, anchor-shaped markings of third instar usually obscured with brown spots and markings. Lateral plates 2–7 yellow, each with brown margin, margins with brown spot medially; small brown spots often more numerous. Sterna yellowish white to yellow. Otherwise, similar to *E. servus*.

Fifth instar. Length, 10.35 ± 0.07; width, 6.35 ± 0.09. Head with posterior margin yellow to brown; juga subequal to or shorter than tylus. Antennal segment 1 yellow to brownish black; segment 2 yellowish or reddish to brownish black; segment 3 yellowish to brownish proximally, dark brown to black distally; segment 4 brownish black; paler areas of segments 1–3 with reddish

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to brown spots; ratio of segment lengths approximately 8:25:16:18. Ventral surface of head yellowish, with or without spots; if present, spots red to brown or almost concolorous with ventral surface.

Thoracic pleura yellow, with or without spots; if present, spots red to brown or concolorous with pleural surface, dark spot at base of each coxa reduced or absent.

Lateral plates 2–7 yellow, each with brown margin broken, margins with brown spot medially; small brown spots usually more numerous than in fourth instar but may be reduced in size. Otherwise, similar to *E. servus*.

DIAGNOSIS

The five nymphal instars of *E. servus* and *E. variolarius* are readily distinguishable by characters in addition to the differences in size, shape, and ratio of antennal segment lengths. The first instar has minute punctures dorsally and ventrally on brown sclerotized areas. The second instar has numerous and large brown punctures on the dorsum of the head and thorax but the ventral punctures are still minute. The lateral plates have one to three brown spots in white areas. The third instar has four to eight brown spots in each lateral plate. The mesonotum has the medial area slightly extended posteriorly, evidence of the developing scutellum. The fourth instar has more spots on the lateral plates (13–20) than the third and the developing wing pads are evident, extending onto first abdominal segment. The fifth instar has well developed wing pads, extending onto the third abdominal segment.

Distinguishing the two species is more difficult. The eggs differ only in the average number of micropylar processes. The first and second instars are almost identical in appearance. The third instars of *E. variolarius* can be distinguished by a white band on the ventral side of head that reaches or almost reaches the eyes; it does not do so in *E. servus*. This band becomes more extensive in the fourth and fifth instars of *E. variolarius* but remains very limited in *E. servus*. Finally, the last two antennal segments in the fourth and fifth instars are brownish black in *E. variolarius* and red to reddish brown in *E. servus*.

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