Life History of *Megamelus davisi*[1] with Descriptions of Immature Stages[2]

S. W. WILSON[3] AND J. E. McPHERSON

Department of Zoology, Southern Illinois University, Carbondale, Illinois 62901

ABSTRACT

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The life history of *Megamelus davisi* Van Duzee was investigated in southern Illinois from February to November 1979, and the immature stages were described. This insect was also reared in the laboratory.

M. davisi feeds and reproduces on waterlily, *Nuphar advena* (Aiton), is trivoltine, and overwinters as a 5th instar in leaf litter along the shoreline.

This insect was reared on pieces of waterlily leaves. The incubation time for eggs was not determined. Durations of the five nymphal stadia were 6.0, 3.7, 4.1, 4.5, and 6.7 days, respectively.

Eggs are parasitized by a species (or species) of mymarid wasp, and adults are parasitized by a pipunculid fly, *Pipunculus varius* Cresson. Nymphs are preyed upon by a water treader, *Mesovelia mulsanti* White.

Megamelus davisi Van Duzee ranges from New York south to Florida and west to Kansas (Beamer 1955, Metcalf 1943). Its host plant is waterlily, or spatterdock, *Nuphar advena* (Aiton) (Brimley 1938, Denno 1978, Oman 1947, Osborn 1905, 1938, Swezey 1904, Van Duzee 1897), although it has also been recorded from *Nymphaea odorata* Aiton (Beamer 1955). All the remaining literature on this insect is taxonomic.

This paper presents the life history of this planthopper in southern Illinois, laboratory rearing, and descriptions of the immature stages.

Materials and Methods

Field Study

Observations and collections were made once per week from 23 February to 17 November 1979 at Etherton Pond, Jackson County, ca. 5.5 km north of Pomona, Ill.

Nymphs and adults were generally found on waterlily (*N. advena*), and were collected by being tapped into shell vials. A piece of waterlily leaf, for moisture, was added to each vial, and the vial was plugged with cotton. The insects were returned to the laboratory for more detailed examination. Eggs were inserted into waterlily leaves but could not be detected in the field (see below). Thus, five leaves were collected per week, returned to the laboratory, and examined for eggs.

Population counts of nymphs and adults on the waterlilies were made once per week as follows: from 1 to 60 steps, determined from a random-number table, were paced off south to north along the shoreline beginning at the south end of the pond. The final step along the shoreline determined the origin of a perpendicular line extending out into the pond. The number of individuals on the first 50 plants encountered along this perpendicular line was counted.

Laboratory Study

Field-collected and laboratory-reared adults were maintained, and nymphs were reared, on pieces of waterlily leaves. Paired adults and individual nymphs were kept in separate petri dishes (9 cm diameter, 2 cm depth). Each dish was lined on the bottom with a disc of moistened filter paper and closed with plastic secured by an elastic band and the lid. The plastic prevented early instars from escaping between the dish and lid.

Field-collected eggs were left in the plant tissue; we had found earlier that eggs removed from the tissue failed to hatch. Sections of the plants with eggs were placed in petri dishes prepared similarly to those used for adults and nymphs.

Eggs, nymphs, and adults were kept in incubators under a 16L:8D photoperiod at 23 ± 1.1°C. Food was replaced every 3 to 4 days; filter paper was changed approximately once per week and moistened every 1 to 2 days.

Field-collected and laboratory-reared adults neither copulated nor laid eggs in the laboratory. Few of the nymphs that hatched from field-collected eggs reached adult stage. Thus, laboratory nymphs were supplemented with field-collected nymphs. Since field-collected nymphs had already undergone some development before collection, data gathering for these nymphs began after they had undergone one molt in the laboratory. Data were collected daily on the number of eggs hatched and the number and instar of nymphal molts.

Field-collected specimens were examined daily for the emergence of parasitoids. Parasitoids that emerged as larvae were left in their hosts' petri dishes until they reached adult or died, and were then preserved in 95% ethyl alcohol; those that emerged as adults were preserved within 1 day after emergence.

Descriptions of Immature Stages

Specimens to be described were preserved in 95% ethyl alcohol. The description of each stage is based on 10 field-collected specimens. The 1st instar is described in detail, but only major changes from previous instars are described for subsequent instars. Comparative statements refer to previous instars (e.g., "darker"). Dimensions of eggs and nymphs are expressed in millimeters as mean ± SE. For nymphs, length was measured from tip of vertex to tip of abdomen; width was measured across the widest part of the body. Thoracic length

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[3] Present address: Dept. of Biological Sciences, California State University, Chico, CA 95929.

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was measured along the midline from the anterior margin of the pronotum to the posterior margin of the metanotum; this measurement was included because total length measurements are affected by the various shapes of the head within and between species, and because the abdomen occasionally becomes bloated when preserved in ethyl alcohol due to relatively broad intersegmental membranous areas. Drawings were made on tracing paper with the aid of a camera lucida.

Results and Discussion

Field Study

M. davisi adults and nymphs feed on all emergent parts of waterlilies, including stems, upper and under sides of leaves, and midveins. This species is trivoltine and overwinters as 5th instars in leaf litter; there is apparently some overlapping of generations during the season. The nymphs began leaving their overwintering sites along the shoreline of Etherton Pond in late March and early April and moved onto the surface of the water and emerging waterlilies. Adults were found from the first week of April until mid-May; copulation was first noted in mid-April, at which time a random sample of 50 plants averaged 0.96 adults (range = 0 to 4) per plant. The method we used for finding eggs (see above) was unsuccessful during the first generation, but was successful during later generations when numbers of adults were higher.

Eggs were inserted singly into waterlily leaves, midveins and stems. Many were found in plant tissue that bore no apparent external oviposition scars; evidently, the incisions made during oviposition are subsequently covered by new plant tissue. After hatching, the plants bore small, ragged, circular scars, apparently resulting from emergence of 1st instars.

First-generation 1st instars were found from early May to early June, 2nd instars were found from mid-May to early June, 3rd instars were found from the 3rd week in May to early June, 4th instars were found from late May to the 3rd week in June, and 5th instars were found from late May to late June. Adults were found from early June to approximately late July (Fig. 1).

Second-generation eggs were found from mid-June to approximately late July, when they overlapped with those of the third generation, 1st instars were found from mid-June to early August, 2nd instars were found from late June to mid-August, 3rd instars were found from early July to late August, 4th and 5th instars were found from mid-July to late August, and adults were found from late July to early September (Fig. 1). The number of adults began increasing in late July, as the new adults emerged, reaching a peak in mid-August, at which time a random sample of 50 plants averaged 21.0 adults per plant (range = 1 to 79).

Third-generation eggs were found from approximately late July to early September, 1st instars were found from early August to early October, 2nd instars were found from mid-August to mid-October, 3rd instars were found from late August to late October, and 4th instars were found from late August to early November (Fig. 1). Fifth instars appeared in mid-September and remained on the waterlilies until almost all the plants had died back. This decline in number of available plants became noticeable by early October. Fifth instars began moving to their overwintering sites in early November. Observations on 23 February showed that nymphs are active on relatively warm days (ca. 7°C) during winter.

The third generation was the largest of the three (Fig. 1A). The number of adults began decreasing from its peak in mid-august; adults were not found after early September. The number of immatures began increasing in late August and reached its peak in early September; a random sample of 50 plants taken in early September averaged 0.72 adults (range = 0 to 16) and 137.4 immatures (range = 10 to 506) per plant.

During the present study, nymphs and adults were found only on waterlilies during spring, summer, and early fall. However, in late fall, after the plants had died back, the 5th instars fed on several plants along the shoreline, including common anemone (*Anemone virginiana* L.), white snakeroot (*Eupatorium rugosum* Houttuyn), round-leafed cat-brier (*Smilax rotundifolia* L.), and blackberry (*Rubus* sp.).

On 25 August, five waterlily leaves were collected and placed in petri dishes in the laboratory. Between 27 and 31 August, over 100 *M. davisi* nymphs hatched from eggs in these leaves. Several adult parasitoids were also found in the dishes and represented two mymarid species (Hymenoptera: Mymaridae). Over 50 of them, which presumably emerged from *M. davisi* eggs, were identified as *Polynema ciliata* (Say) (this was the only available name for this wasp, which may prove to be an undescribed species [L. Knutson, personal communication]). Three were identified as *Anagrus armatus* (Ashmead). These specimens may have emerged from the eggs of some other insect, although only *M. davisi* eggs were found in the waterlily stems. *A armatus* has been recorded from several leafhopper and planthopper hosts (Krombein et al. 1979).

M. davisi adults were attacked by the bigheaded fly, *Pipunculus varius* Cresson (Diptera: Pipunculidae). Seven fly larvae emerged from field-collected adults (four adults collected in April, one in June, and two in November) and pupated in their hosts' petri dishes. Adult flies emerged an average of 12.6 days later (range 12 to 14).

Two adult water treaders, *Mesovelia mulsanti* White (Hemiptera: Mesoveliidae), were collected, each with an early-instar *M. davisi* nymph impaled on its beak.

Laboratory Study

Neither field-collected nor laboratory-reared females laid eggs in the laboratory. Field-collected eggs (n = 111) removed from the surrounding plant tissue failed to hatch. Thus, rearing data are from field eggs not removed from surrounding tissue, and from field-collected 1st instars. The 1st, 2nd, 3rd, 4th, and 5th stadia averaged 6.0, 3.7, 4.1, 4.5, and 6.7 days, respectively (Table 1).

Descriptions of Immature Stages

The following descriptions are based on field-collected specimens. The description of the 5th instar is based on the brachypterous form; only one macropterous form was found among the 1,624 5th instars collected.

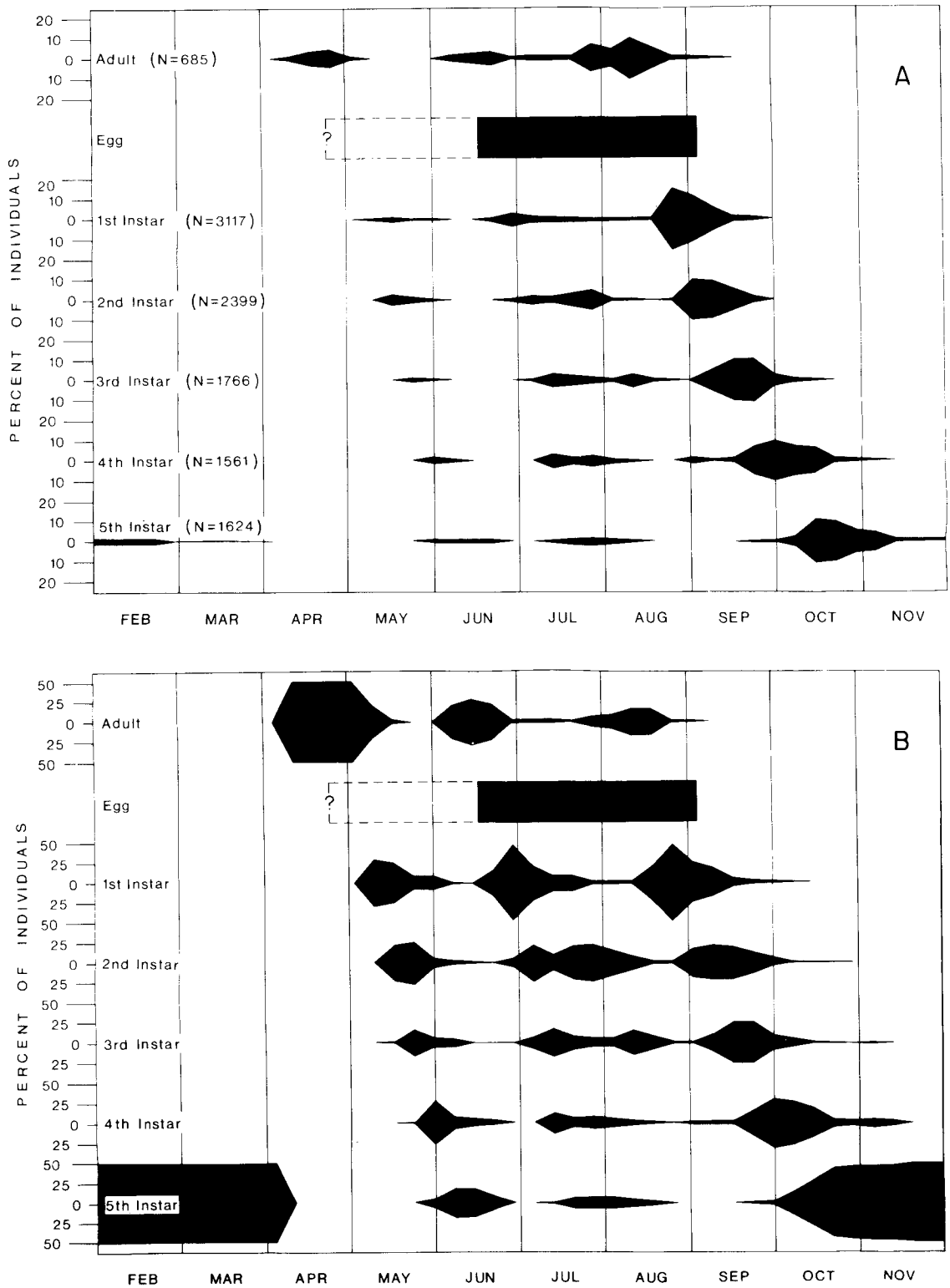

FIG. 1.—Seasonal occurrence of *M. davisi* instars to southern Illinois. (A) Number of individuals of each stage is expressed as percentage of total individuals of that stage. (B) Number of individuals of each stage is expressed as percentage of total individuals of all stages collected per week. Differences between corresponding stages in A and B (i.e., lengths of total collection periods and gaps within each period) reflect the differences in the computation method used for each graph.

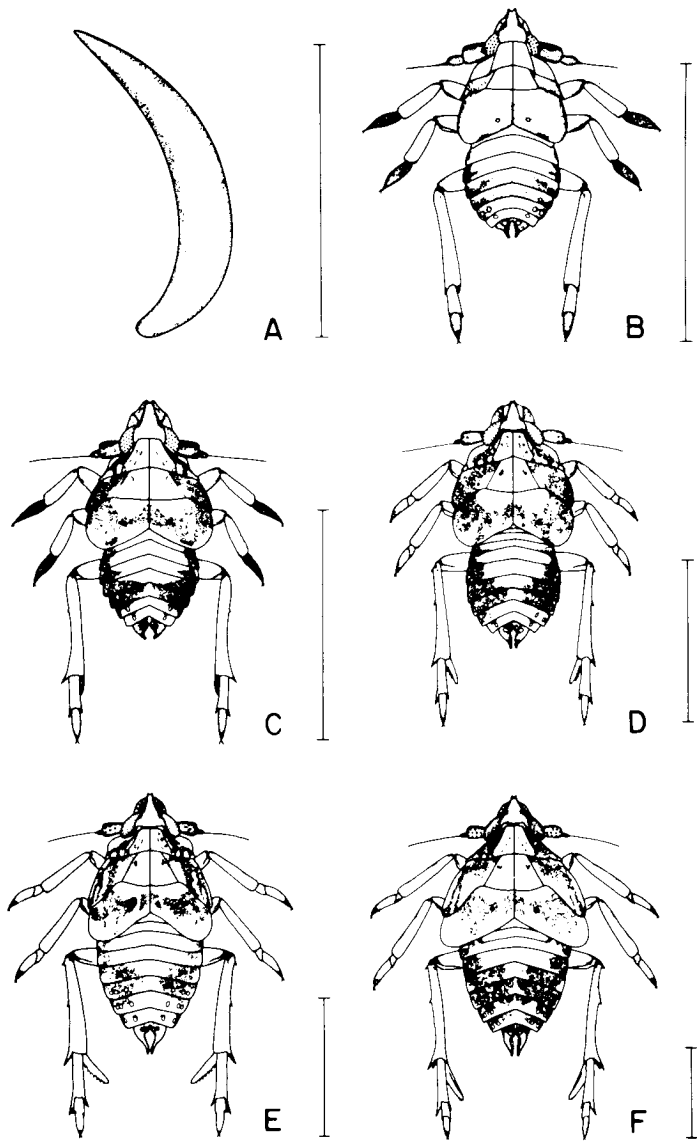

FIG. 2.—Immature stages of *M. davisi*. (A) egg; (B) 1st instar; (C) 2nd instar; (D) 3rd instar; (E) 4th instar; (F) 5th instar. Vertical bar = 1.0 mm.

Overwintering 4th and 5th instars and early spring adults are much darker (gray to black with grayish streaking) than those of other generations (yellow marked with brown to black).

Egg (Fig. 2A). Length 1.23 ± 0.012; width 0.24 ± 0.006. Eggs laid singly; each elongate, subconical, narrowest at apex, curved; white; chorion translucent, smooth.

1st Instar (Fig. 2B). Length 0.87 ± 0.021; thoracic length 0.30 ± 0.004; width 0.37 ± 0.007.

Form elongate, subcylindrical, widest across metathorax. Body pale yellow with light brown markings.

Vertex pale yellow with brown in anterolateral angles; widest near posterior margin, abruptly narrowing anteriorly, posterior margin straight; lateral margins outwardly convex and carinate, forming a partial shelf over eyes that continues onto frons. Frons yellow with brownish gray markings dorsally, along lateral margins, and bordering the pits; subrectangular, longer than wide, broadest near clypeal border, lateral margins convex,

Table 1.—Duration (in days) of the nymphal instars of *M. davisi*[a]

Nymphal instar	No. beginning stadium	No. completing stadium	Days	
			Range	Mean ± SE
1st	53	40	3–9	6.0 ± 0.33
2nd	102	67	2–7	3.7 ± 0.14
3rd	79	46	2–10	4.1 ± 0.24
4th	66	43	2–9	4.5 ± 0.23
5th	52	42	3–16	6.7 ± 0.45

[a] Laboratory and field specimens combined.

dorsal and ventral margins concave; each lateral margin carinate (outer carina) and paralleled by a second carina (inner carina), which is continuous with that of the vertex and extends ventrally almost to clypeal border; area between inner carinae elevated; nine pits between each inner and outer carina and two pits between each outer carina and eye. Clypeus light grayish with pale yellow laterally; narrowing distally, consisting of a basal, subconical postclypeus and a beaklike cylindrical, distal anteclypeus. Beak three-segmented, white with black apex, extending just beyond metacoxae; segment 1 almost completely obscured by anteclypeus; segments 2 and 3 subequal. Eyes red. Antennae three-segmented; segment 1 short, cylindrical; segment 2 subcylindrical; segment 3 bulbous basally, with an elongate, bristle-like extension distally.

Thoracic nota divided by a longitudinal mid-dorsal line into three pairs of plates. Pronotum longest medially, extending anteriorly beyond posterior margin of eyes; with an elevated median subtrapezoidal area bordered laterally by oblique carinae which originate on anterior margin near inner border of eye and extend to approximately the middle of posterior margin of pronotum; each plate subrectangular, anterior margin appearing markedly sinuate in dorsal view and posterior margin sinuate, with two pits between midline of pronotum and carina and four pits (lateralmost pits not visible in dorsal view) between carina and lateral margin of pronotum. Mesonotum pale yellow, light brown laterally; longest medially, median length subequal to that of pronotum; with an elevated median subtrapezodial area bordered laterally by oblique carinae which originate on anterior margin at approximately one-third the distance from midline to lateral margin and extend posterolaterally to posterior margin of mesonotum; each plate subrectangular, posterior margin sinuate laterally, with two obscure pits between midline of mesonotum and oblique carina and two obscure pits near lateral margin of mesonotum. Metanotum light brown, pale yellow anteromedially; longest laterally, median length ca. 1.25 times that of mesonotum; each plate subrectangular, posterior margin almost straight, with one to two pits at approximately one-third the distance from midline of metanotum to lateral margin of metanotum. Coxae yellow; pro- and mesocoxae elongate, subcylindrical, posteromedially directed; metacoxae subrectangular, transverse; remaining segments of legs with very fine setae (not illustrated). Femora yellow infused with brown. Tibiae yellow infused with brown; metatibiae bearing an apical row of three black-tipped spines ventrally and a short moveable subconical spikelike spur apically, spur less that two times length of longest apical spine. Tarsi two-segmented, brownish gray; pro- and mesotarsi darker than metatarsi and with segment one wedge-shaped, metatarsi with segment 1 cylindrical and bearing an apical row of four black-tipped spines ventrally; all tarsi with segment 2 subconical and slightly curved, with a pair of black claws and a white pulvillus apically.

Abdomen nine-segmented, subcylindrical, widest across segments 4 and 5; segment 9 elongate vertically, surrounding anus. Segments 3 through 9 with tergites curving around lateral margin to ventral side. Each segment with the following number of pits on either side of midline (lateralmost and caudal pits often not visible in dorsal view): segment 5 with one to two lateral pits on tergite, segments 6 through 8 each with two lateral pits on tergite; segment 9 with three to four caudal pits.

2nd Instar (Fig. 2C). Length 1.37 ± 0.027; thoracic length 0.44 ± 0.008; width 0.58 ± 0.007.

Body pale yellow, more heavily marked with brown.

Frons with a dark brown longitudinal line between each inner and outer carina; broadest just beneath eyes; with 10 pits between each inner and outer carina and three pits between each outer carina and eye. Antennae with segment 2 bearing two sensory pits, each pit surrounded by a ring of short black teeth.

Pronotum with each pit between midline and oblique carinae bordered by a short brown bar. Mesonotum more heavily marked with brown; one of the two pits between midline of mesonotum and oblique carina bordered by a short brown bar. Each plate of metanotum with one to three pits approximately one-third the distance from midline of metanotum to lateral margin of metanotum. Metatibiae bearing two small black-tipped spines on lateral margin one near base and one in basal one-third to one-half; spur two or more times length of longest apical spine.

Abdominal segments 5 and 9 with the same number of tergal pits as previous instar, other segments with the following number of pits on either side of midline (lateralmost pits often not visible in dorsal view): segments 6 through 8 each with three lateral pits on tergite, segments 4 through 8 each with one to several obscure lateral pits on sternites.

Otherwise, similar to 1st instar.

3rd Instar (Fig. 2D). Length 1.52 ± 0.028; thoracic length 0.53 ± 0.006; width 0.76 ± 0.006.

Antennae with segment 2 bearing four sensory pits, each surrounded by a ring of short black teeth.

Each plate of pronotum with two pits (as in previous instar), and a shallow indentation anteriorly near midline of pronotum which appears as a pit, between midline of pronotum and oblique carina; five pits (lateralmost pits not visible in dorsal view) bordering posterior margin between oblique carina and lateral margin of pronotum. Each plate of mesonotum with one obscure pit near carina lying between it and lateral margin of mesonotum and three pits (only two may be visible in dorsal view) near lateral margin of mesonotum; wingpad lobate posterolaterally. Metanotum with median length subequal to that of mesonotum. Metatibiae bearing an apical row of four to five black-tipped spines ventrally; spur thick, slightly flattened, with one anteroventral tooth near apex (not visible in Fig. 2D) and three teeth on ventral margin. Tarsi lighter; metatarsi with segment 1 bearing an apical row of five black-tipped spines.

Otherwise, similar to 2nd instar.

4th Instar (Fig. 2E). Length 2.37 ± 0.075; thoracic length 0.73 ± 0.010; width 1.05 ± 0.016.

Specimens from overwintering generation dark brown to gray with pale yellow markings; abdomen pale ventrally. Those of other generations similar in color to 2nd and 3rd instars.

Frons with four pits between each outer carina and eye. Antennae with segment 2 bearing eight sensory

pits, each surrounded by a ring of short black teeth.

Each plate of pronotum with six pits (lateralmost pits not visible in dorsal view) bordering posterior margin between oblique carina and lateral margin of pronotum. Mesonotum with lateral brown markings streaked with pale yellow. Metatibiae with an apical row of five black-tipped spines ventrally; spur convex dorsally, with 5 to 10 ventral teeth. Metatarsi two-segmented, appearing three-segmented because of weak partial suture in middle of segment 2; segment 1 bearing an apical row of six black-tipped spines ventrally, segment 2 bearing two to three weakly developed black-tipped spines mid-ventrally.

Otherwise, similar to 3rd instar.

5th Instar (Fig. 2F). Length 2.87 ± 0.021; thoracic length 1.03 ± 0.004; width 0.34 ± 0.007.

Body yellow with darker brown markings. Specimens from overwintering generation dark brown to grayish, with light brown and pale yellow markings. Those of other generations similar in color to 2nd and 3rd instars.

Vertex occasionally with brown markings extending from anterolateral corners obliquely almost to posterior median border. Frons with outer carinae subparallel below eyes; with five pits between each outer carina and eye. Antennae with segment 2 bearing 14 sensory pits, each surrounded by a ring of short black teeth.

Each plate of pronotum with two shallow anterior indentations which appear as pits (posterior 1 bordered by a brown bar), between midline of pronotum and oblique carina; six to seven pits (lateralmost pits not visible in dorsal view) bordering posterior margin between oblique carina and lateral margin of pronotum. Mesonotum with median length ca. 1.5 times that of pronotum; wingpads lobate, slightly overlapping metanotal plates laterally; in macropterous form (not illustrated), wingpads narrow, extending to apex of metanotal wingpads laterally. Metanotum with wingpads extending to third abdominal tergite; in macropterous form, to fourth abdominal tergite. Mesocoxae and femora yellow marked with brown. Pro- and mesotibiae each with a pair of brown transverse bands ventrally. Metatibial spur with 12 to 19 lateral teeth. Pro- and mesotarsi two-segmented; metatarsi three-segmented, segment 1 bearing an apical row of six to seven black-tipped spines ventrally, segment 2 bearing four black-tipped spines ventrally, segment 3 similar to segment 2 of previous instar.

Otherwise, similar to 4th instar.

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