The Great Lakes Entomologist

Volume 20
Number 4 - Winter 1987 *Number 4 - Winter 1987*

Article 4

December 1987

Life History and Laboratory Rearing of *Gerris Argenticollis* (Hemiptera: Gerridae) with Descriptions of Immature Stages

Peter P. Korch III
Southern Illinois University

J. E. McPherson
Southern Illinois University

LIFE HISTORY AND LABORATORY REARING OF *GERRIS ARGENTICOLLIS* (HEMIPTERA: GERRIDAE) WITH DESCRIPTIONS OF IMMATURE STAGES[1]

Peter P. Korch III and J. E. McPherson[2]

ABSTRACT

The life history of *Gerris argenticollis* was investigated in Jackson County, Illinois, March–June 1986, and the immature stages were described. The water strider also was reared from egg to adult under laboratory conditions. This univoltine species overwintered as adults that became active in early March, appearing on a temporary woodland pond after the air temperature exceeded 12°C. Seasonal occurrence of the adults and immatures is discussed. Adults were last observed in mid-June. Feeding records are given. *G. argenticollis* was reared on *Drosophila melanogaster* adults under a 10L:14D photoperiod (ca. 2800 lux) at ca. 21°C. The incubation period averaged 12.5 days. The average durations of the five nymphal stadia were 9.0, 7.6, 8.0, 9.2, and 12.0 days. The total developmental period averaged 58.3 days.

Members of the family Gerridae are probably the most familiar bugs found near water. They are opportunistic predators (Lumsden 1949) and, as with other members of the Infraorder Gerromorpha, are epineustonic. This ability has allowed them to exploit a number of unique habitats, from the open ocean (Andersen and Polhemus 1976) to temporary pools formed on car hoods after rainstorms (Vepsalainen 1971). Their ability to move about easily on aquatic surfaces has earned them the common names of water strider and wherryman. The family is represented in North America by 4 subfamilies, 8 genera, and 46 species (Polhemus 1984).

The genus *Gerris* Fabricius contains 15 species in America north of Mexico (Sanderson 1982), nine of which (*sensu* Calabrese 1980) occur in Illinois. North American water striders overwinter as adults and lay eggs singly under the surface on floating sticks, vegetation, and other materials (Polhemus and Chapman 1979). Most north temperate species are bivoltine (Spence and Scudder 1980).

G. argenticollis Parshley ranges from New England (Drake and Harris 1934) south to Florida (Calabrese 1974), and west to Louisiana (Drake and Harris 1934), Arkansas (Kittle 1977), Missouri (Froeschner 1962), Michigan (Hussey 1922), and probably Wisconsin (Hilsenhoff 1986).

Little life history information is available for *G. argenticollis*. Sprague (1967) found nymphs during the spring and early summer in New England, but Calabrese (1977) found this water strider to be so rare in Connecticut that she suspected it might not breed there but be present only because of dispersal flights from the south. Hussey (1922) found it to be one of the most abundant water striders in woodland pools in Michigan. Drake and Harris (1934) reported it to be related to *G. buenoi* Kirkaldy, and to replace it to some

---

[1]Part of a thesis submitted to Southern Illinois University by the senior author in partial fulfillment of the requirements of the M.A. degree in Zoology.

[2]Department of Zoology, Southern Illinois University, Carbondale, IL 62901.

extent in the southern United States; however, Michel (1961), on the basis of male genitalia, stated the two species were not related.

G. argenticollis has been reared in the laboratory from egg to adult at constant temperature and the stadia have been determined (Wilson 1958). The egg (Wilson 1958) and 5th instar (Sprague 1967) have been briefly described, and mean lengths and widths provided for all immature stages (Wilson 1958). The male and female adult genitalia have been described and illustrated by Parshley (1916) and Calabrese (1974), respectively.

This paper presents information on the field life history and laboratory rearing of *G. argenticollis* and includes detailed descriptions of the immature stages.

MATERIALS AND METHODS

Study Site

In spring 1985, *G. argenticollis* adults were discovered on a temporary pond in southern Illinois. Subsequent visits showed this water strider to be present in high numbers, suggesting that a detailed life history was possible. Therefore, a study of this population was conducted from March to June 1986.

The study pond (37°42′25″N, 89°12′32″W) is hook-shaped and located on the campus of Southern Illinois University at Carbondale (SIU-C), Jackson County, Illinois. For a description of the geology and soils of the county, see Herman et al. (1979). Water originates from precipitation and run-off. Maximum surface area (ca. 3900 m^2) during this study occurred in early April. At that time, maximum depth was ca. 0.9 m. As summer progressed the water level gradually dropped until by late June, the pond had completely dried up. Riparian vegetation consisted of *Acer rubrum* L., *A. saccharum* Marshall, *Asimina trilobata* (L.), *Ligustrum obtusifolium* Hasskarl, *Rosa carolina* L., *Glyceria striata* (Lamarck), *Cicuta maculata* (L.), *Impatiens biflora* (Walter), and *Cinna arundinacea* (L.). The only emergent vegetation present consisted of *Betula nigra* (L.), *Fraxinus tomentosa* Michaux, and *Saururus cernuus* (L.), although during the period of maximum surface area, some *C. arundinacea* was partially submerged.

Life History

Counts of all instars and adults, with notes on their activity, were taken weekly. Samples were usually collected during 1300–1800 hrs on sunny days. Ten samples were collected during each visit, five within 1 m of the shoreline and five at least 1 m away from either shoreline (but never more than 6 m), until the pond was too small for the second series (ca. mid-June). This allowed sampling from both near-shore and open-water habitats. A quadrat sampling method suggested by Spence (1980) was used to determine density. This method involved wading to a randomly chosen site on the pond, standing still for 2 min to allow any water striders frightened away to return, dropping a box (open top and bottom) of known area onto the water, and then counting all water striders captured. The sampling box frame (50 × 50 × 28 cm) was constructed with pine slats, the sides with plastic sheeting. All water striders within the box were removed with a soft nylon aquarium net with a mesh size of 1.5 mm, and placed in a white enamel pan for field sorting to instar. Individuals that could be identified positively were recorded and released; those that could not (because of size, coloration, etc.) were preserved in 75% ethanol and returned to the laboratory for closer examination. Instars were identified with keys by Sprague (1967) and Calabrese (1974). Prey upon which the water striders were feeding (i.e., grasped and [or] beak inserted) were preserved in 75% ethanol.

Laboratory Rearing

Three adult females were collected from the pond on 20 April 1986, taken to the laboratory, and placed in individual plastic aquaria. Each aquarium (ca. 30 × 15 × 21 cm) contained 11 cm of distilled water, with available surface area of 450 cm. Each female was fed three *Drosophila melanogaster* Meigen adults daily, and the carcasses were removed the following day. Sections of pine dowel rod (ca. 7.0 × 0.6 cm) were provided as oviposition sites.

The dowel rods were examined daily for eggs. Those with eggs were placed in separate petri dishes (ca. 9 cm diam., 2 cm depth) and covered with enough distilled water to allow them to float (ca. 0.6 cm). Water was added daily to maintain that level. All rods eventually became water logged and sank to the bottom of the dish, usually within 24 hrs.

First–5th instars were reared in similar dishes, each containing ca. 1 cm of distilled water. Each dish was covered with cloth mesh (pore size ca. 1.5 mm), which was secured with a rubber band. Cannibalism in water striders is well documented (see Jarvinen and Vepsalainen 1976). Therefore, a maximum of five 1st instars was placed in each dish, and the bugs were further separated as they developed through subsequent instars. Approximately 0.5–1 *D. melanogaster* adults were provided daily for every 1st instar, one for every 2nd, two for every 3rd and 4th, and three for every 5th. Dishes were checked daily for exuviae, and prey carcasses removed. A new dish with clean water was provided at every molt.

The aquaria and dishes were kept in incubators maintained at 21 ± 1.5°C, and a 10L:14D photoperiod (three fluorescent "daylight" lamps, ca. 2800 lux).

Anatomical Descriptions of Immature Stages

First–5th instars were selected from field samples collected at the pond, eggs from those deposited in the laboratory by field-collected adults. All specimens had been preserved in 75% ethanol. The description of each stage is based on 25 individuals. Drawings were made with the aid of a camera lucida, measurements with an ocular micrometer. Dimensions are expressed in millimeters as $\bar{x}$ ± SE (SE < 0.005 listed as 0.00).

RESULTS AND DISCUSSION

Life History

G. argenticollis emerged from overwintering sites in early March and was the first species of water strider to appear at the pond. *G. marginatus* Say, the second species to appear, was not observed until 21 days later. Landin and Vepsalainen (1977) showed that a critical lower temperature threshold of 12–13°C is required to initiate the flight response in *G. argentatus* Schummel. Air temperature data recorded at the Southern Illinois Airport, Carbondale, indicate that the minimum temperature on the day that *G. argenticollis* was first seen (9 March) was 12.8°C, within the range reported for *G. argentatus*.

Precopulatory behavior was not observed. Adults were observed during apparent copulation, however, with the male resting on the dorsum of the female, his prothoracic legs grasping her prothorax and his genital segments extending ventrally and anteriorly. Pairs were observed in this position for over 1 hr.

No eggs were found. First and 2nd instars were found from mid-April to mid-May, 3rd instars from late April to late May, 4th instars from early May to early June, and 5th instars from early May to mid-June (Fig. 1). New adults began to appear in late

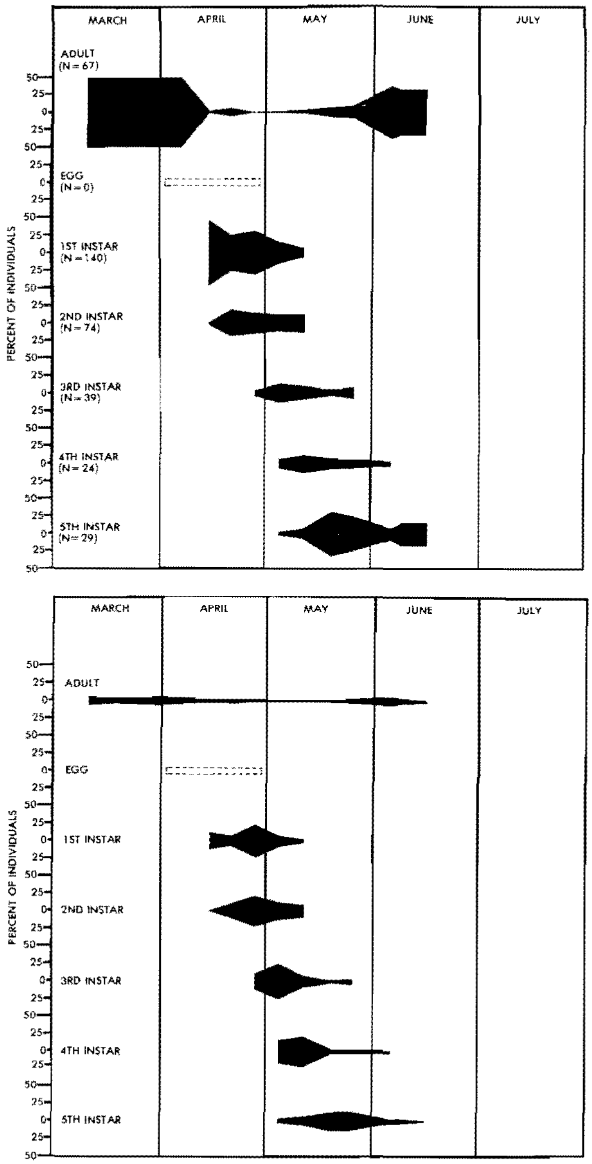

Fig. 1. (A) Percent of individuals in each stage per sample in Jackson County, Illinois, in 1986. (B) Percent in each sample of total individuals of same stage collected during season in Jackson County, Illinois, in 1986. For both figures, dashed lines indicate probable occurrence since no specimens were found.

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

Stage	Number completing stadium	Range	x̄ ± SE	Cumulative mean age
Egg[a]	244	8–40	12.5 ± 0.16	12.5
Nymph				
1st instar	100	4–16	9.0 ± 0.22	21.5
2nd instar	37	5–12	7.6 ± 0.30	29.1
3rd instar	28	5-12	8.0 ± 0.29	37.1
4th instar	17	7–14	9.2 ± 0.44	46.3
5th instar	3	11–13	12.0 ± 0.47	58.3

[a]503 eggs were laid.

May–early June as evidenced by the rise in their numbers following the first appearance of 5th instars. Adults were last collected in mid-June. The male:female adult ratio during the course of the study was 1:1.

Water striders locate food by vibrational (Murphey 1971) and probably visual (Jamieson 1973) cues. Both types of behavior were observed in *G. argenticollis*. Most often, the bug was observed moving across the water surface, grasping any small object in its path. This is similar to feeding behavior reported for *G. najas* DeGeer (Lumsden 1949). After a brief handling period, the object was dropped or the stylets were inserted. Small arthropods struggling on the water surface usually attracted nearby *G. argenticollis*. In one instance, an individual rejected a small, struggling ichneumonoid wasp after examination. Species found preyed upon during this study included single adult specimens of *Culicoides* sp., *Dicranoptycha winnemana* Alexander, *Ectemnia taeniatifrons* Enderlein, *Gymnopterus* sp., *Apis mellifera* L., *Camponotus pennsylvanicus* (DeGeer), and an unidentified empedid species.

On one occasion, an adult was observed carrying a small food item with its prothoracic legs. Suddenly, another adult leapt upon it and attempted to take the food. During the struggle, a third adult joined in the attempt. After several seconds of struggling and leaping from the water surface, the first adult broke free and skated away with its food. This is, to our knowledge, the first time this sort of intraspecific behavior has been noted in *Gerris*.

G. argenticollis occurs in both temporary and permanent habitats in southern Illinois and usually is found on shaded bodies of water or woodland ponds; it has been noted in similar habitats by other workers (Deay and Gould 1936, Ellis 1952, Gonsoulin 1974, Hussey 1922, Kittle 1977, Parshley 1916, Sprague 1967, Wilson 1958). Specifically, we have collected it in large swamps, on backwaters of rivers, on small streams, and on roadside pools during rainstorms.

Laboratory Rearing

All eggs were laid on dowel rods. During oviposition, the female thrust her abdomen beneath the water surface while clinging to the rod with the meso- and metathoracic legs. Eggs were cemented to the rod singly, although often in a loose row.

The incubation period averaged 12.5 days (Table 1). Each egg was white at oviposition but developed brown reticulated bands during maturation. Eye spots appeared within 4 days.

The 1st instar emerged under water through a slit in the cephalic end of the egg that extended ca. ⅔ the egg's length. It was yellowish white at this time but developed its normal color (see description) within 24 hrs. Newly hatched nymphs rested on the bottom of the petri dish for a period of time (not determined) and eventually swam to the surface.

The 1st, 2nd, 3rd, 4th, and 5th stadia averaged 9.0, 7.6, 8.0, 9.2, and 12.0 days, respectively (Table 1). The total developmental period averaged 58.3 days.

These rearing data do not agree with those of Wilson (1958). Although he reared his water striders at a temperature lower than that of this study, his reported developmental times were faster and the instars larger. However, egg and nymphal developmental times in water striders are closely dependent on temperature (Vepsalainen 1973). A possible explanation for this difference might be that *G. argenticollis* is best adapted to cool temperatures. This is supported by its temporal distribution; it is the first *Gerris* to appear in the spring, and the first to disappear in early summer. Spence et al. (1980) noted a cool adaptation in *G. pingreensis* Drake and Hottes.

Highest mortality occurred during the 1st and 5th stadia. Much of the mortality during the 1st stadium resulted from cannibalism and, to a lesser extent, from drowning. Drowning occurred because the 1st instars emerged under water and were unable to overcome surface tension and climb to the surface. This was also observed by Torre-Bueno (1917) for *G. remigis* Say. All mortality during the 5th stadium occurred because of incomplete ecdysis; i.e., the emerging adult only partially emerged from the exuvium. Similar results were reported by Torre-Bueno (1917) for *G. remigis* and by Kaufmann (1971) for *Limnoporus rufoscutellus* Latreille (probably a misidentification; see Vepsalainen [1973]).

Anatomical Descriptions of Immature Stages

Egg (Fig. 2A). Length, 1.05 ± 0.01; width, 0.39 ± 0.00. Eggs glued singly and lengthwise to substratum; each egg elongate, subcylindrical, white at oviposition but developing brown reticulated bands during maturation; cephalic end broader than caudal; ventral side somewhat flattened; dorsal side convex; chorion with no reticulation pattern readily apparent; 1 micropyle apparently present at cephalic end as shallow pit.

Nymphal Instars. The 1st instar is described in detail, but only major changes that have occurred from previous instars are described for subsequent instars. Comparative statements refer to previous instars. Length is measured from posterior margin of anteclypeus to tip of abdomen; width is measured across mesonotum. Terminology follows that of Andersen (1982). Additional measurements are given in Table 2.

First Instar (Fig. 2B). Length, 1.27 ± 0.03; width, 0.61 ± 0.01. Body elliptical to elongate, greatest width at mesothorax; general ground color yellow dorsally, yellowish or whitish laterally and ventrally; body covered with dense, short setae.

Head often partially withdrawn into prothorax to level of posterior margin of eyes. Dorsally, head brown; anteclypeus protruding, narrowly rounded anteriorly; remainder of head excluding eyes subquadrate; ecdysial lines yellow, together Y-shaped, stem arising from posterior margin of head, arms extending to just before anterior margin of eyes; 4 pairs of trichobothria present, 1st pair just posterior to anteclypeus, 2nd pair just anterior to eyes, 3rd pair medial to 2nd pair, 4th pair near posterior margin of eyes. Eyes red, inner margin emarginate posteriorly; 2 setae present posterolaterally, 1st shorter than, and located anterodorsally from, 2nd. Antennae brown, 4-segmented; segment 1 curved, segments 2 and 3 subequal, segment 3 with yellow band present on basal ⅓, apical segment longest and fusiform. Lateral and ventral surfaces of head yellowish white; mandibular plate small, triangular, located just anterior to antennal socket; ventral lobe triangular, anterior margin ca. 0.5× length of anteclypeus. Labrum subtriangular. Beak generally yellowish, 4-segmented, extending to ca. midway between bases of pro- and mesocoxae; segments 1 and 2 short, subequal; segment 3 longest; apical segment acute, brown.

Thoracic nota yellowish, mostly membranous. Pronotum with pair of sclerotized, subquadrate plates separated medially, concolorous with head; pro-mesothoracic intersegmental line sclerotized on either side of midline. Meso- and metathoraces each

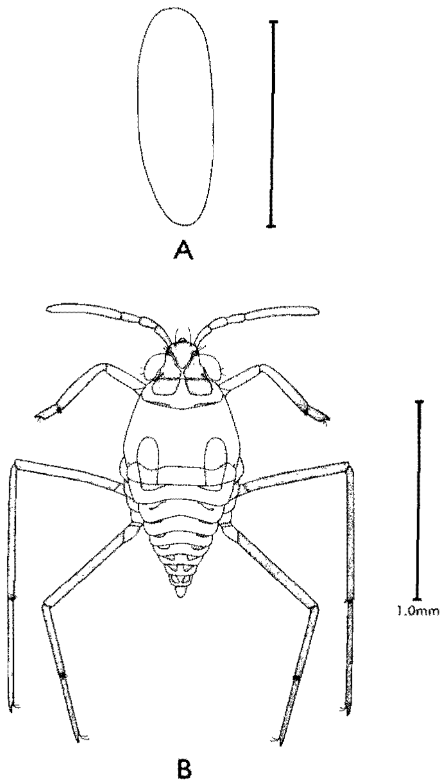

Fig. 2. Immature stages of *G. argenticollis:* (A) Egg, (B) 1st instar.

with pair of sclerotized plates with irregular edges, plates of each side continuous; mesonotal plates ca. 0.7× width of pronotal plates. Thoracic pleura and sterna yellowish white, mostly membranous; supracoxal lobes sclerotized. Spiracles round, located posterolaterally on pro- and mesonota; those of pronotum often concealed between the 2 segments.

Legs brown or yellowish brown, those of mesothorax longest; tibiae with grooming comb present distally; tarsi 1-segmented, tarsal claws subapical. Prothoracic legs somewhat raptorial; coxae subquadrate, ca. 0.5× length of profemora; trochanters curved, elongate, subequal in length to coxae. Mesothoracic legs with coxae rounded, ca. 0.4× length of femora; trochanters elongate, subequal in length to coxae. Metathoracic legs with coxae subquadrate, ca. 0.3× length of femora; trochanters elongate, subequal in length to coxae. Femora, tibiae, and tarsi of all 3 segments elongate, linear.

Abdomen yellowish dorsally with paired brown plates on or near anterior margins of terga; plates of segment 1 continuous with metanotal plates; those of segment 2 often reduced to narrow, transverse lines; those of segments 3–8 progressively increasing in length, those on segment 8 often fused posteromedially; segment 9 entirely sclerotized dorsally. Spiracles present on segments 1–8, those on segment 1 located dorsolaterally, those on segments 2–8 located ventrolaterally. Venter membranous.

Table 2. Measurements (mm)[a,b] of *G. argenticollis* instars.[c]

	Nymph				
	1st instar	2nd instar	3rd instar	4th instar	5th instar
Body length	1.27 ± 0.03	1.60 ± 0.04	2.62 ± 0.09	3.81 ± 0.10	5.55 ± 0.11
Notal length[d]	0.57 ± 0.01	1.39 ± 0.02	1.68 ± 0.04	1.80 ± 0.03	2.52 ± 0.03
Width at Mesonotum	0.61 ± 0.01	0.72 ± 0.01	1.16 ± 0.03	1.47 ± 0.03	1.89 ± 0.02
Head width at eyes	0.45 ± 0.00	0.57 ± 0.00	0.77 ± 0.00	1.09 ± 0.00	1.39 ± 0.00
Synthlipsis	0.22 ± 0.00	0.26 ± 0.00	0.37 ± 0.00	0.46 ± 0.00	0.59 ± 0.00
Antennal segments:					
1st	0.17 ± 0.00	0.26 ± 0.00	0.38 ± 0.00	0.58 ± 0.00	0.94 ± 0.00
2nd	0.13 ± 0.00	0.17 ± 0.00	0.24 ± 0.00	0.35 ± 0.00	0.57 ± 0.00
3rd	0.14 ± 0.00	0.19 ± 0.00	0.27 ± 0.00	0.39 ± 0.00	0.56 ± 0.00
4th	0.42 ± 0.00	0.53 ± 0.00	0.67 ± 0.00	0.84 ± 0.00	1.08 ± 0.00
Leg lengths:					
profemur	0.32 ± 0.00	0.47 ± 0.00	0.70 ± 0.00	1.19 ± 0.02	1.67 ± 0.01
protibia	0.36 ± 0.00	0.48 ± 0.00	0.69 ± 0.00	1.13 ± 0.01	1.59 ± 0.01
protarsus	0.18 ± 0.00	0.20 ± 0.00	0.25 ± 0.00	0.37 ± 0.00	0.50 ± 0.00
mesofemur	0.62 ± 0.00	1.11 ± 0.01	1.79 ± 0.02	2.60 ± 0.03	3.76 ± 0.03
mesotibia	0.76 ± 0.00	1.17 ± 0.00	1.67 ± 0.01	2.24 ± 0.03	3.10 ± 0.03
mesotarsus	0.63 ± 0.00	0.90 ± 0.00	1.23 ± 0.01	1.76 ± 0.01	2.20 ± 0.02
metafemur	0.56 ± 0.00	1.00 ± 0.00	1.58 ± 0.01	2.28 ± 0.03	3.36 ± 0.03
metatibia	0.39 ± 0.00	0.56 ± 0.00	0.78 ± 0.00	1.16 ± 0.00	1.73 ± 0.01
metatarsus	0.37 ± 0.00	0.48 ± 0.00	0.59 ± 0.00	0.80 ± 0.00	1.07 ± 0.01

[a]$\bar{x}$ ± S.E.
[b]Values < 0.005 listed as 0.00.
[c]Based on 25 individuals of each instar.
[d]Measured along midline from anterior margin of pronotum to posterior margin of metanotum.

Second Instar (Fig. 3A). Length, 1.60 ± 0.04; width, 0.72 ± 0.01. Sclerotization much lighter than in first instar, ground color yellowish brown to brown.

Head darkest at bases of trichobothria. Fused base of ecdysial lines (i.e., stem) of head usually lacking, thus V-shaped. Antennae yellowish brown; segment 1 yellow, darker on distal ¼ to ⅓; segment 2 with yellowish band on basal ⅓ to ½; segment 3 with yellowish band on basal ⅓; segment 4 with short, basal yellowish band. Mandibular plate proportionally larger. Ventral lobe with anterior margin 0.4× length of anteclypeus.

Pronotum often with medial notch in anterior margin; pronotal plates not as distinct, often appearing to cover more of surface of segment. Mesonotum with 2 pairs of lateral crescentic white lines originating from anterior margin, inner pair longest, extending to ca. midpoint of segment. Meso- and metanotal plates faint. Thoracic spiracles slitlike.

Prothoracic legs with coxae ca. 0.2× length of femora, trochanters ca. 0.4× length of femora; mesothoracic legs with coxae and trochanters subequal, each ca. 0.3× length of femora; metathoracic legs with coxae and trochanters subequal, ca. 0.2× length of femora.

Abdominal tergal plates narrower.

Otherwise similar to first instar.

Third Instar (Fig. 3B). Length, 2.62 ± 0.09; width 1.16 ± 0.03.

Mandibular plate proportionally larger.

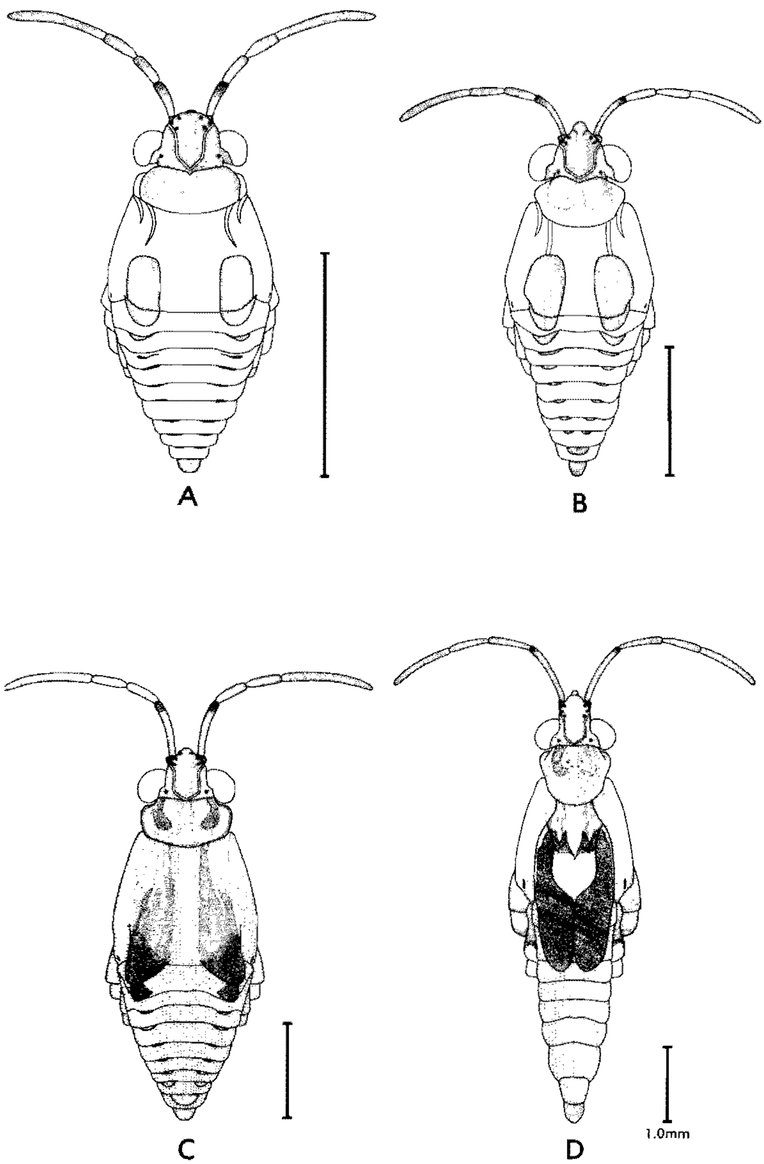

Fig. 3. Immature stages of *G. argenticollis:* (A) 2nd instar, (B) 3rd instar, (C) 4th instar, (D) 5th instar.

Pronotal notch indistinct.

Prothoracic legs with coxae ca. 0.1× length of femora, trochanters ca. 0.4× length of femora; mesothoracic legs with coxae ca. 0.1× length of femora, trochanters ca. 0.2× length of femora; metathoracic legs with coxae ca. 0.1× length of femora, trochanters ca. 0.2× length of femora.

Otherwise similar to second instar.

Fourth Instar (Fig. 3C). Length, 3.81 ± 0.10; width, 1.47 ± 0.03.

Ventral lobe lobate anteriorly, margin no longer clearly definable.

Pronotum with brown patch on each plate. Meso- and metanotal wing pads small, yellowish brown to brown; those of mesonotum extending to ca. middle of metanotum, those of metanotum partially covering anterolateral margin of abdominal segment 1.

Prothoracic legs with coxae ca. 0.2× length of femora, trochanters ca. 0.3× length of femora; mesothoracic legs with coxae ca. 0.1× length of femora, trochanters ca. 0.2× length of femora; metathoracic legs with coxae ca. 0.1× length of femora, trochanters ca. 0.2× length of femora.

Otherwise similar to third instar.

Fifth Instar (Fig. 3D). Length, 5.55 ± 0.11; width, 1.89 ± 0.02.

Antennal segment 1 yellowish with brown band in distal 1/10.

Mesonotal wing pads large and brown, extending to abdominal segments 2–7. Metanotal wing pads hyaline to clouded, covered by mesonotal wing pads, extending almost to apex of mesonotal wing pads.

Prothoracic legs with coxae ca. 0.2× length of femora, trochanters ca. 0.3× length of femora; mesothoracic legs with coxae ca. 0.1× length of femora, trochanters ca. 0.2× length of femora; metathoracic legs with coxae ca. 0.1× length of femora, trochanters ca. 0.2× length of femora.

Otherwise similar to fourth instar.

ACKNOWLEDGMENTS

We thank W. G. Dyer and G. S. Garoian, Department of Zoology, Southern Illinois University at Carbondale, for their critical reviews of the manuscript; R. H. Mohlenbrock, Department of Botany, for confirming or correcting our plant identifications; Kathy Fahey, Science Librarian, Morris Library, for help in obtaining needed literature; and Karen A. Schmitt, Scientific Photography and Illustration Facility, for the final illustrations of the immature stages. We also are grateful to G. W. Byers, W. L. Grogan, R. V. Peterson, D. R. Smith, and F. C. Thompson, Insect Identification and Beneficial Insect Introduction Institute, Beltsville, Maryland, for identification of the prey insects and to L. Knutson, Director, for expediting the identifications. Finally, we also thank John K. Bouseman, Illinois Natural History Survey, Urbana, for providing information on *Gerris* in the INHS Collection and Diane M. Calabrese, Dickinson College, Carlisle, Pennsylvania, for advice on laboratory rearing.

LITERATURE CITED

Andersen, N. M. 1982. The semiaquatic bugs (Hemiptera, Gerromorpha). Phylogeny, adaptations, biogeography and classification. Entomonograph 3. Scandinavian Sci. Press LTD, Klampenborg-Denmark. 455 pp.

Andersen, N. M., and J. T. Polhemus. 1976. Water-striders (Hemiptera: Gerridae, Veliidae, etc.). pp. 187–224 *in* L. Cheng (ed.). Marine insects. North Holland Pub. Co., Amsterdam.

Calabrese, D. M. 1974. The biology of the species of *Gerris* Fabricius in Connecticut. M.S. thesis, Univ. Connecticut, Storrs.

______. 1977. The habits of *Gerris* F. (Hemiptera: Heteroptera: Gerridae) in Connecticut. Ann. Entomol. Soc. Amer. 70:977–983.

______. 1980. Zoogeography and cladistic analysis of the Gerridae (Hemiptera: Heteroptera). Misc. Pub. Entomol. Soc. Amer. 11:1–119.

Drake, C. J., and H. M. Harris. 1934. The Gerrinae of the Western Hemisphere. Ann. Carnegie Mus. 23:179–241.

Deay, H. O., and G. E. Gould. 1936. The Hemiptera of Indiana, I. Family Gerridae. Amer. Midland Natur. 17:753–769.

Ellis, L. L. 1952. The aquatic Hemiptera of southeastern Louisiana (exclusive of the Corixidae). Amer. Midland Natur. 48:302–329.

Froeschner, R. C. 1962. Contributions to a synopsis of the Hemiptera of Missouri, Part V. Hydrometridae, Gerridae, Veliidae, Saldidae, Ochteridae, Gelastocoridae, Naucoridae, Belostomatidae, Nepidae, Notonectidae, Pleidae, Corixidae. Amer. Midland Natur. 67:208–240.

Gonsoulin, G. J. 1974. Seven families of aquatic and semiaquatic Hemiptera in Louisiana. Part IV. Family Gerridae. Trans. Amer. Entomol. Soc. 100:513–546.

Herman, R. J., C. C. Miles, L. A. Dungan, B. E. Currie, and P. W. Ice. 1979. Soil survey of Jackson County, Illinois. USDA Soil Cons. Serv. and Forest Serv. 192 pp.

Hilsenhoff, W. L. 1986. Semiaquatic Hemiptera of Wisconsin. Great Lakes Entomol. 19:7–19.

Hussey, R. F. 1922. Hemiptera from Berrien County, Michigan. Occ. Pap. Museum Zool. Univ. Michigan. 118:1-39.

Jamieson, G. S. 1973. Coexistence in the Gerridae. Ph.D thesis. Univ. British Columbia, Vancouver.

Jarvinen, O., and K. Vepsalainen. 1976. Wing dimorphism as an adaptive strategy in water-striders (*Gerris*). Hereditas 84:61–68.

Kaufmann, T. 1971. Ecology, biology and gonad morphology of *Gerris rufoscutellus* (Hemiptera: Gerridae) in Fairbanks, Alaska. Amer. Midland Natur. 86:407–416.

Kittle, P. D. 1977. The biology of water striders (Hemiptera: Gerridae) in northwest Arkansas. Amer. Midland Natur. 97:400–410.

Landin, J., and K. Vepsalainen. 1977. Spring dispersal flights of pond-skaters *Gerris* spp. (Heteroptera). Oikos 29:156–160.

Lumsden, W. H. R. 1949. A note on the ecology of *Gerris* (*Aquarius*) *najas* (DeGeer) (Hem., Gerridae) with special references to its prey. Entomol. Mon. Mag. 85:169–173.

Michel, F. A. 1961. The taxonomic value of the male genitalia of the genus *Gerris* Fabricius (Hemiptera: Heteroptera: Gerridae). M.S. thesis, Oregon State Univ., Corvallis.

Murphey, R. K. 1971. Sensory aspects of the control of orientation to prey by the waterstrider, *Gerris remigis*. Z. vergl. Physiol. 72:168–185.

Parshley, H. M. 1916. New and noteworthy Hemiptera from New England. Entomol. News. 27:103–105.

Polhemus, J. T. 1984. Aquatic and semiaquatic Hemiptera. pp. 231–260 *in* R. W. Merritt and K. W. Cummins (eds.). An introduction to the aquatic insects of North America (2nd edition). Kendall/Hunt Pub. Co., Dubuque, Iowa.

Polhemus, J. T., and H. C. Chapman. 1979. Family Gerridae. pp. 58–69 *in* A. S. Menke (ed.). The semiaquatic and aquatic Hemiptera of California (Heteroptera: Hemiptera). California Insect Surv. Bull. 21:1–166.

Sanderson, M. W. 1982. Aquatic and semiaquatic Heteroptera. pp. 6.1–6.94 *in* A. R. Brigham, W. U. Brigham, and A. Gnilka (eds). Aquatic insects and oligochaetes of North and South Carolina. Midwest Aquatic Enterprises, Mahomet, Illinois.

Spence, J. R. 1980. Density estimation for water-striders (Heteroptera: Gerridae). Freshwater Biol. 10:563–570.

Spence, J. R., and G. G. E. Scudder. 1980. Habitats, life cycles, and guild structure among water striders (Hemiptera: Gerridae) on the Fraser Plateau of British Columbia. Canadian Entomol. 112:779–792.

Spence, J.R., D. H. Spence, and G. G. E. Scudder. 1980. The effects of temperature on growth and development of water strider species (Heteroptera: Gerridae) of central British Columbia and implications for species packing. Canadian J. Zool. 58:1813–1820.

Sprague, I. B. 1967. Nymphs of the Genus *Gerris* (Heteroptera: Gerridae) in New England. Ann. Entomol. Soc. Amer. 60:1038–1044.

Torre-Bueno, J. R. de la. 1917. Life history and habits of the larger waterstrider, *Gerris remigis* Say (Hem.). Entomol. News. 28:201–208.

Vepsalainen, K. 1971. The role of gradually changing daylength in determination of wing length, alary dimorphism, and diapause in a *Gerris odontogaster* (Zett.) population (Gerridae, Heteroptera) in south Finland. Ann. Acad. Sci. Fenn. A, IV Biologica 183:1–25.

______. 1973. Development rates of some Finnish *Gerris* Fabr. species (Het. Gerridae) in laboratory cultures. Entomol. Scand. 4:206–216.

Wilson, C. A. 1958. Aquatic and semiaquatic Hemiptera of Mississippi. Tulane Stud. Zool. 6:115–170.

DOI: 10.22543/0090-0222.1622