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A Description of the Third Instar of Platambus flavovittaus (Larson and Wolfe, 1998) with Comments on the Larval Morphology of Platambus stagninus (Say, 1823) and a Key to the Agabini (Coleoptera: Dytiscidae) of Georgia

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A DESCRIPTION OF THE THIRD INSTAR OF *PLATAMBUS FLAVOVITTAUS* (LARSON AND WOLFE, 1998) WITH COMMENTS ON THE LARVAL MORPHOLOGY OF *PLATAMBUS STAGNINUS* (SAY, 1823) AND A KEY TO THE AGABINI (COLEOPTERA: DYTISCIDAE) OF GEORGIA

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ABSTRACT

Mature Agabini larvae collected from a small temporary road-side habitat were reared to the adult stage and identified as *Platambus flavovittattus* (Larson and Wolfe, 1998). The mature larva is described and illustrated with an emphasis on leg morphology. Important differences between cranial temporal curvatures of *P. flavovittatus* and *P. stagninus* (Say, 1823) are described. A larval key is constructed to facilitate identification of Georgia agabine genera and species.

Key Words: Cranial anatomy, mandibles, reproductive habitats, prey regimes, distribution.

INTRODUCTION

Members of *Agabus* Leach, 1817, previously classified in the *semivittatus*-group (1, 2), were recently reassigned to *Platambus* Thomson, 1859 (3). Turnbow and Smith (4) listed *Platambus johannis* (Fall, 1922) as a component of the southern Georgia Coastal Plain fauna, and Barman *et al*. (5) described mature larvae collected from a lower Piedmont marsh habitat as *P. stagninus* (Say, 1823). *Platambus flavovittatus* (Larson and Wolfe, 1998) has a reported range (6) from extreme southern Ontario to Tennessee, Arkansas, Mississippi, Louisiana, and east Texas, although no published records of its occurrence in Georgia have been found. Larvae of *P. johannis* and *P. flavovittatus* have not been described. The objectives of this study were to describe the mature larva of *P. flavovittatus*, compare its morphology and natural history to that of the sympatric *P. stagninus* (5), and to provide a key to the mature larvae of Georgia agabine species.

MATERIAL AND METHODS

Descriptions are based on seven third instars collected 3 April 2007 in Bibb County, Georgia (N 32° 52.738'; W 83° 46.906') and identified after eclosion as *P. flavovittatus*. Five third instars of *P stagninus* examined were previously identified and described (5). Larvae of *P. flavovittatus* and *P. stagninus* are stored in the Georgia College & State University Insect Museum (GCIM).

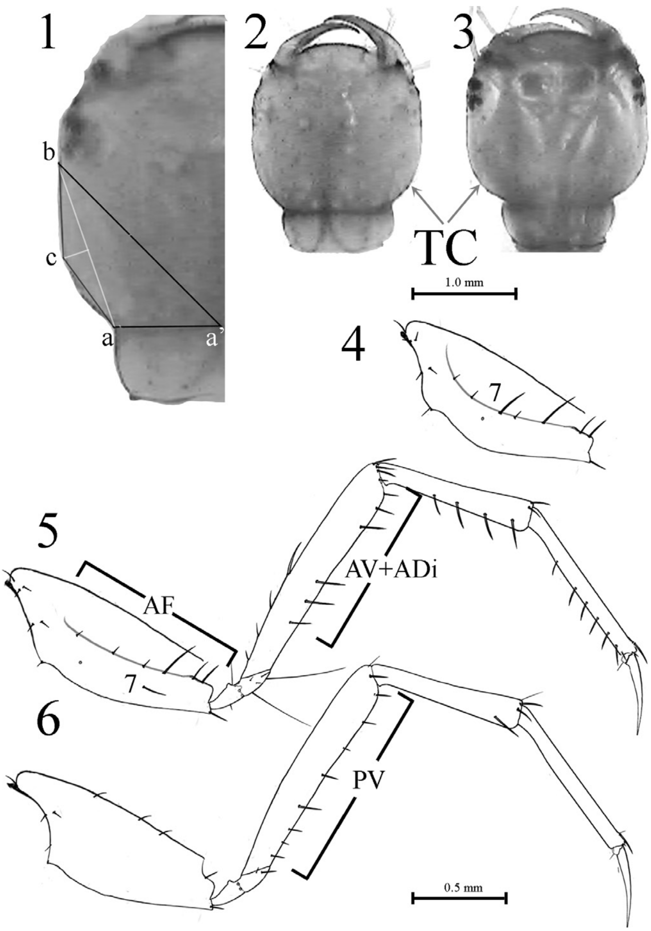
Observations and measurements were of dismembered specimens preserved in 70 per cent glycerated ethyl alcohol. To minimize distortions, all material was examined on concave slides. Head lengths were measured dorsally from the posterior margin of the head capsule to the distal margin of the frontoclypeus, excluding the frontoclypeal marginal lamellate sensilla. Head widths were measured dorsally at the widest point of the head. Mandibular lengths were measured ventrally along a straight line from the apex to the center of the ball of articulation with inter-mandibular distance (≈ gape) measured ventrally from the center of the balls of the right and left mandibular articulations (7). Other measurements were taken along the greatest length of each structure.

Temporal curvatures (TC) were determined (Fig. 1) from enlarged dorsal cranial images, beginning with a horizontal line, a-a', between the maximum parietal constrictions just anterior to the occipital carina. A line was drawn at a 45° angle from the intersection of line a-a' with the coronal suture to intersect the anterolateral cranial margin at point b. A 90° line was extended from the mid-point of line a-b to intersect the lateral boundary of the temporal region of the crania at point c. The angle acb was inserted into the following formulae: TC = 360° - 2 (angle acb) for computation of TC for right and left temporal regions of each larva. The TC for each larva is then presented as an average of these two computations and evaluated using an unpaired t test (8).

The numbers of sensilla are given by region or area of origin, according to a system proposed by Wolfe and Roughley (9) that uses commonly employed anatomical terms to designate individual sensilla and/or series of sensilla. Anatomical abbreviations employed when describing sensilla of individually designated leg segments include: AF, anterior face; AV, anteroventral; D, dorsal; Di, distal; PV, posteroventral; and V, ventral. Sensilla of mature larvae include both secondary sensilla and homologues of primary sensilla with the latter identified and coded individually (10, 11). When identifiable and germane, homologues of ancestral sensilla are noted using individual sensillar designations. Other morphologic terms employed are those of Larson *et al.* (6) and Snodgrass (12).

DESCRIPTION OF THIRD INSTAR OF *PLATAMBUS FLAVOVITTATUS* (LARSON AND WOLFE, 1998)

Body. Sub-cylindrical, narrowing toward abdominal apex, length (near end of third stadium and excluding urogomphi) abt. 14 mm. *Color*. Sclerotized areas light reddish-brown, with obscure cruciform pattern on frontoclypeus, membranous areas pale yellow.



Figures 1-6. 1. Methodology for estimating temporal curvature; 2. *Platambus flavovittatus* (Larson and Wolfe) and 3. *P. stagninus* (Say) dorsal views of crania; *P. flavovittatus*, 4. procoxa, anterior view; 5. meta-thoracic leg, anterior view; 6. meta-thoracic leg, posterior view. Abbreviations are: AF, anterior face; AV, anteroventral; Di, distal; PV, posteroventral; and TC, temporal curvature. The apparent homologues of ancestral sensilla CO7 are indicated with respective Arabic numbers.

Head (Fig. 2; Table I). Orientation, prognathic; length 2.00-2.20 mm ($\bar{x}$ = 2.08 ± 0.05 mm); maximum width near the mid-point between the posterior apex of the frontoclypeus and the occipital carina, 1.74-1.90 mm ($\bar{x}$ = 1.84 ± 0.05 mm); frontoclypeus 0.70-0.84 mm, ($\bar{x}$ = 0.77 ± 0.05 mm), nasale broadly rounded, not extending beyond apices of prominent adnasalia (anterolateral lobes), bearing abt. 36-40 anterodistal lamellate sensilla; coronal suture 1.26-1.38 mm ($\bar{x}$ = 1.29 ± 0.04 mm); corneal lenses (13) in a lateral elliptical pattern, bounded posteriorly by an arc-like series of hair-like sensilla; 3-4 prominent temporal sensilla in oblique lateral series; temporal curvature, 58.0-64.0° ($\bar{x}$ = 60.4 ± 2.6°); prominent posterior parietal constriction; pronounced posteroventral emargination. *Antenna*. Length, excluding palpifer, 0.93-1.19 mm ($\bar{x}$ = 1.06 ± 0.08 mm), antennomere (AN) 1, 0.22-0.36 mm ($\bar{x}$ = 0.30 ± 0.04 mm), AN2, 0.26-0.33 mm ($\bar{x}$ = 0.29 ± 0.02 mm), AN3, 0.28-0.34 mm ($\bar{x}$ = 0.31 ± 0.03 mm) without protruding accessory appendage (A3′), AN4, 0.12-0.18 mm ($\bar{x}$ = 0.15 ± 0.02 mm), AN4 significantly ($p < 0.0001$) shorter than AN3.

Table I. Comparative analyses of selected cranial and mandibular parameters for mature larvae of *Platambus flavovittatus* (Larson and Wolfe) and *P. stagninus* (Say). Geometric parameters are in degrees (°).

Parameter	*P. flavovittatus*	*P. stagninus*	Significance (a = 0.05)
Head length	2.08 ± 0.05 mm	2.16 ± 0.04 mm	0.0068
Head width	1.84 ± 0.05 mm	1.90 ± 0.11 mm	none
Mandibular length	0.94 ± 0.03 mm	0.98 ± 0.02 mm	0.0217
Inter-mandibular distance	1.31 ± 0.04 mm	1.32 ± 0.05 mm	None
Temporal curvature	60.4 ± 2.6°	70.8 ± 3.8°	0.0020
Lateral Arc	115.8 ± 5.5°	117.0 ± .6.0°	None
Medial Arc	62.0 ± 8.1°	61.4 ± 6.0°	None
Angle of attack	46.6 ± 2.1°	46.6 ± 2.2°	None

Mouthparts. *Mandible*, length 0.87-0.99 mm ($\bar{x}$ = 0.94 ± 0.03 mm) about 2.5 times width, inter-mandibular distance, 1.24-1.36 mm ($\bar{x}$ = 1.31 ± 0.04 mm), lateral arc 110.0-123.0° ($\bar{x}$ = 115.8 ± 5.5°), medial arc 52.0-73.0° ($\bar{x}$ = 62.0 ± 8.1°), angle of attack 43.0-48.5° ($\bar{x}$ = 46.6 ± 2.1°), mandibular channel present, a tuft of hair-like spinulae proximal to minute ventromedial teeth. *Maxilla*. Cardo reduced; stipes prominent, trapezoidal with two prominent falcate medial sensilla; galea finger-like, approximately1/3 the length of palpomere (MP) 1; palpus length, excluding palpifer, 0.72-0.86 mm ($\bar{x}$ = 0.80 ± 0.05 mm), MP1, 0.25-0.32 mm ($\bar{x}$ = 0.28 ± 0.02 mm), MP2, 0.24-0.30 mm ($\bar{x}$ = 0.28 ± 0.02 mm), MP3, 0.20-0.28 mm ($\bar{x}$ = 0.24 ± 0.02 mm), bases of stipes and labium contiguous. *Labium*. Prementum short, approximately twice as wide as long, distal margin between palpi straight to moderately concave, dorsodistal sensilla minute; palpus 0.68-0.81 mm ($\bar{x}$ = 0.74 ± 0.04 mm), palpomere (LP) 1, 0.34-0.48 mm ($\bar{x}$ = 0.41 ± 0.04 mm), LP2, 0.31-0.36 mm ($\bar{x}$ = 0.33 ± 0.02 mm; n = 9).

Thorax. Pro-, meso-, and metaterga widest near mid-point, protergum longer and wider than meso- and metaterga combined, meso- and metaterga sub-equal in length; protergum with distinct marginal antero- and postero-transverse carinae, prescutum narrow weakly, developed medially, meso- and metaterga with distinct anterotransverse and posterotransverse carinae, each prescutum with an additional carina; terga sparsely populated with small sensilla; spiracular openings present in membranous pleural area below the acute anterolateral boundary of the mesotergum. *Legs* (Figs. 4-6). Natatory sensilla absent; ventral spinulae present on tibiae and tarsi, not as well developed on metaleg; coxa robust and elongate, coxal suture prominent on anterior surface; trochanter divided into two regions, 1Tr and 2Tr; respective lengths (in mm) of individual segments of pro-, meso-, and metathoracic legs: coxae, 1.19-1.24 ($\bar{x}$ = 1.23± 0.02), 1.26-1.32 ($\bar{x}$ = 1.29± 0.02), 1.28-1.47 ($\bar{x}$ = 1.40± 0.06); trochanters, 0.40-0.50 ($\bar{x}$ = 0.45± 0.03), 0.44-0.52 ($\bar{x}$ = 0.48± 0.03), 0.49-0.56 ($\bar{x}$ = 0.52± 0.02); femora, 0.86-1.44 ($\bar{x}$ = 1.01± 0.06), 1.06-1.18 ($\bar{x}$ = 1.13± 0.04), 1.20-1.41 ($\bar{x}$ = 1.34± 0.07); tibiae, 0.48-0.63 ($\bar{x}$ = 0.57± 0.02), 0.62-0.74 ($\bar{x}$ = 0.68± 0.04), 0.84-0.98 ($\bar{x}$ = 0.93± 0.04); tarsi, 0.43-0.52 ($\bar{x}$ = 0.47± 0.03), 0.52-0.64 ($\bar{x}$ = 0.60± 0.03), 0.90-0.98 = 0.94± 0.03); anterior/posterior tarsal claws on pro- ($\bar{x}$ = 0.28 ± 0.02/ = 0.21 ± 0.04 mm), meso-, ($\bar{x}$ = 0.37 ± 0.03/ = 0.29 ± 0.02 mm), and metathoracic legs ($\bar{x}$ = 0.46 ± 0.04/ = 0.47 ± 0.03 mm), no ventroproximal spinulae. Apparent homologues of primary ancestral sensilla present (7), procoxal series, AF, 6-7 including homologue of CO7 (Fig. 4), meso- and metacoxal CO7, with a more distal and anteroventral origin (Fig. 5), PD, 3-5; trochanter, one small sensillum on the venter of 1Tr and one on the anterior face 2Tr of some specimens; femoral series, D, 4-5, AV+ADi, 11-12, PV + PDi,10; Tibia, AV 4-5, PDi, 4; Tarsus, AV, 5-6.

Abdomen. Segments 1-5 strongly sclerotized dorsally, anterotransverse carinae distinct, each prescutum with an additional anterior carina, numerous small sensilla with four longer hair-like sensilla, spiracles near each anterolateral tergal margin; AB6 strongly sclerotized dorsally, laterally, and ventrolaterally; ventral membranous area narrow, spiracles opening laterally at or near the dorso-pleural line distant from obscure lateral margin of turgum, carinae and chaetotaxy as on segments 1-5; segment 7 completely sclerotized, dorsal length 1.02-1.52 mm ($\bar{x}$ = 1.20 ± 0.15 mm), 1 obscure and 1 distinct anterotransverse carina, numerous small sensilla with about six longer, hair-like sensilla, spiracles opening below the dorso-pleural line; segment 8 completely sclerotized, dorsal length 1.74- 2.08 mm ($\bar{x}$ = 1.98 ± 0.12 mm) with well-developed siphon, length 0.22- 0.44 mm ($\bar{x}$ = 0.32 ± 0.07 mm), anterotransverse carinae distinct with additional carina. *Urogomphus*. One-segmented, homologues of primary sensilla only, UR3 and UR4 congruent, length 1.23- 1.55 mm ($\bar{x}$ = 1.34 ± 0.10 mm).

BIONOMICS

The road-side ditch habitat provided an ostensibly eutrophic oviposition site for *P. flavovittatus* with volume and currents varying in response to precipitation. Plant material included *Juncus* sp., filamentous algae, and terrestrial grasses (some in various states of decomposition). Larval *Celina* sp. were collected concurrently but rarely. The occurrence of mature larvae of *P. flavovittatus* suggests that oviposition was occurring at this site in March and April when respective average temperatures were 13 and 18°C (14).

ADDITIONAL DESCRIPTIVE COMMENTS FOR THE THIRD INSTAR OF *PLATAMBUS STAGNINUS* (SAY, 1823)

As previously described (5). *Head* (Fig. 3; Table I), length, 2.12- 2.22 mm ($\bar{x}$ = 2.16 ± 0.04 mm), width, 1.74-2.40 mm ($\bar{x}$ = 1.90 ± 0.11 mm), inter-mandibular distance, 1.27-1.38 mm ($\bar{x}$ = 1.32 ± 0.05 mm), temporal curvature (n = 5), 67.0-77.0° ($\bar{x}$ = 70.8 ± 3.8°); *mandible*, 0.96-1.01 mm ($\bar{x}$ = 0.98 ± 0.02 mm), angle of attack, 44.5-50.0° ($\bar{x}$ = 46.6 ± 2.2°), medial arc, 55.0-68.0° ($\bar{x}$ = 61.4 ± 6.0°), lateral arc, 108.0-123.0° ($\bar{x}$ = 117.0 ± 6.0°); *urogomphus*, one-segmented.

DISCUSSION

There is a spine-like projection beyond the origins of four elongate sensilla (10; apparent homologues of UR5-8) on each urogomphus of *P. stagninus* and *P. flavovittatus*. This projection has been described as a "second" urogomphal segment in larvae of *P. semivittatus* (5) and *P. stagninus* (5, 15) with the prominence and close proximity of the origins of UR5-8 interpreted as either representing or concealing a joint separating two urogomphomeres. However, first instars of *P. glabrellus* (Motschulsky, 1859) have been described (as *Agabinus glabrellus*) as having one-segmented urogomphi (10), a condition persisting throughout larval development for this species (11). No convincing indications of urogomphal segmentation on *P. stagninus* and *P. flavovittatus* were observed, suggesting that urogomphi of larvae of members of the *A. semivittatus*-group (2) like *P. glabrellus*, are one-segmented.

The comparison of mature larvae of *P. flavovittatus* with those of *P. stagninus* (5) from a relatively large marsh habitat provided no traditional characters for separation of the two species. Larvae of *P. stagninus* tended to be darker than those of *P. flavovittatus*; however, intensity of pigmentation may be influenced by water chemistry (16). No overt differences in chaetotaxy or mandibular geometry were observed that would aid in identification of these larvae. There was, however, a significant (p = 0.001) difference in temporal curvatures (Table I) with that of *P. flavovittatus* ($\bar{x}$ = 60.4 ± 2.6°) less pronounced than that of *P. stagninus* ($\bar{x}$ = 70.8 ± 3.8°). Because of limited data and the small differences between the lower part of the temporal curvature range (67-77°) for *P. stagninus* and the upper end of the range (58-64°) for *P. flavovittatus*, the diagnostic value of this character is limited in the absence of statistical analysis.

Temporal curvatures (Table I) are influenced by the size (mass) and/or origin of the abductor and adductor muscles with both muscles having important roles in capture of and feeding on prey by dytiscid larvae. Greater resistance to predation (*e. g.*, because of a thicker or more rigid integument) may require larger (more massive) adductor muscles (17). Consequently, the interspecific variation observed in the temporal regions of *P. flavovittatus* and *P. stagninus* is likely an indication that these two species exploit different *in situ* prey regimes. Larvae of *P. flavovittatus* were taken from a habitat that appears structurally different from the marsh habitat (5, 18) utilized for reproduction by *P. stagninus*. Dytiscid larval predatory behavior varies with habitat structure (19, 20). Preliminary observations also suggest that *P. flavovittatus* breeds later in the season than does *P. stagninus*. It is probable then that the species and/or developmental composition of potential prey in the ditch differ from that of the marsh. Selection promoting efficient exploitation of prey regimes with different characteristics may then lead to interspecific variation in one or more components of mandibular geometry (7) and/or cranial architecture (17, 21), including temporal curvature.

The Georgia agabine fauna appears limited to nine species: *Agabus disintegratus* (Crotch, 1873), *Agabus gagates* Aubé, 1838, *Agabus punctatus* Melsheimer, 1844, *Agabus. xyztrus* Larson, 2000 (as *Agabus aeruginosus* Aubé, 1838; 4, 6, 22), *Ilybius biguttulus* (Germar, 1824) (4), *Ilybius oblitus* Sharp, 1882 (23), *P. johannis* (Fall, 1922) (4), *P. stagninus* (5), and *P. flavovittatus*. Descriptive information is available for the mature larvae of six of these: *A. disintegratus* (24), *A. punctatus* (15, 18), *I. biguttulus*, *I. oblitus* (23), *P. stagninus* (5, 15), and *P. flavovittatus*. Matta (15) separated the mature larva of *A. aeruginosus* from that of *A. punctatus* by the presence of mesotibial dorsal sensilla on the former and their absence on the latter. The larval material described by Matta (15) was collected in Virginia where both *A. xyztrus* and *A. aeruginosus* occur. Consequently, that descriptive material may be for either species and is not validated for identification of *A. xyztrus*, a probable component of the Georgia fauna (6).

Mature (third instar) agabine larvae have spiracles on pleural regions of the mesothorax and abdominal segments 1-7 and head lengths of 1.6-2.4 mm. Agabine larvae will key to couplet 32 of Epler's key (22), and, with subsequent modifications given below, genera and some species of Georgia's limited agabine fauna may be identified.

MODIFICATIONS OF THE EPLER KEY (22) FOR IDENTIFICATION OF THIRD INSTAR AGABINE LARVAE OF GEORGIA

32 (31'). Lateral margins of sixth abdominal tergum well-defined and separated ventrally by a wide membranous area; spiracles near margin of tergum 33

32'. Margins of sixth abdominal tergum ill-defined and separated ventrally by a narrow membranous area or completely sclerotized; spiracles well-removed from obscure margins of tergum 34

33 (32). Protibia with a dorsal setal sensillum; frontoclypeus with a sharply defined sub marginal chevron directed anteriorly.....................................*Ilybius biguttulus* (Germar)
33'. Protibia without a dorsal setal sensilum; frontoclypeal chevron poorly defined.......................................*Ilybius oblitus* Sharp
34 (32'). Occipital carina present dorsally near posterior parietal constriction, urogomphi shorter than the dorsal length of the last abdominal segment.................................*Platambus* Thomson
34'. Occipital carina absent; urogomphi longer than the dorsal length of the last abdominal segment...................................36
36 (34'). Tibial natatory (swimming) sensilla absent ....*Agabus disintegratus* (Crotch)
36' Tibial natatory (swimming) sensilla present on all legs ....*Agabus punctatus* Melsheimer or *A. xyztrus* Larson

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REFERENCES

1. Larson DJ: Revision of North American *Agabus* Leach (Coleoptera: Dytiscidae): introduction, key to species groups, and classification of the *ambiguus-, tristis-,* and *arcticus*-groups. Canad Ent 121: 861-919, 1989.
2. Larson DJ and Wolfe W: Revision of North American *Agabus* (Coleoptera: Dytiscidae): the *semivittatus*-group. Canad Ent 130: 27-54, 1998.
3. Nilsson AN: 2000: A new view on the generic classification of the *Agabus*-group of genera of the Agabini, aimed at solving the problem with a paraphyletic *Agabus* (Coleoptera: Dytiscidae). Koleopterol Rundsch 70: 17-36.
4. Turnbow RH and Smith CL: An annotated checklist of the Hydradephaga (Coleoptera) of Georgia. J Ga Ent Soc 18: 429-443, 1983.
5. Barman EH, Holmes ED and Nichols GA: Biology of a central Georgia population of *Agabus stagninus* Say (Coleoptera: Dytiscidae) with a description of its mature larva and notes on the larva of *Agabus semivittatus* LeConte. Ga J Sci 57: 255-266, 1999.
6. Larson DJ, Alarie Y and Roughley RE: Predaceous diving beetles (Coleoptera: Dytiscidae) of the Nearctic Region, with emphasis on the fauna of Canada and Alaska. NRC Research Press, Ottawa, Ontario, Canada, 982 pp., 2000.

7. Wall WP, Barman EH and Beals CM: A description and functional interpretation of the mandibular geometry of *Agabus punctatus* Melsheimer, 1844, *Rhantus calidus* (Fabricius, 1792) and *Acilius mediatus* (Say, 1823), (Coleoptera: Dytiscidae). Aq Insects 28: 277-289, 2006.
8. Anonymous: GraphPad InStat version 3.00 for Windows 95, GraphPad Software, San Diego California USA, www.graphpad.com. 2009.
9. Wolfe GW and Roughley RE: Description of the pupa and mature larva of *Matus ovatus ovatus* Leech (Coleoptera: Dytiscidae) with a chaetotaxal analysis emphasizing mouth parts, legs, and urogomphus. Proc Acad Natl Sci Philadel 137: 61-79, 1985.
10. Alarie Y: Primary setae and pores on the legs, the last abdominal segment, and the urogomphi of larvae of Nearctic Colymbetinae (Coleoptera: Adephaga: Dytiscidae) with an analysis of their phylogenetic relationship. Canad Ent 127: 913-943, 1995.
11. Alarie Y and Larson DJ: Larvae of *Agabinus* Crotch: Generic characters, description of *A. glabrellus* (Motschulsky), and comparison of with other genera of the subfamily Colymbetinae (Coleoptera: Adephaga: Dytiscidae). The Coleopt Bull 52: 339-350, 1998.
12. Snodgrass RE: “Principles of Insect Morphology.” McGraw-Hill: New York, 667 pp.; illus., 1935.
13. Shepley-James TA, White BP, Barman EH, Binkowski J and Treat A: Variation in stemmatal morphology of larvae of *Liodessus noviaffinis* Miller (Dytiscidae: Hydroporinae: Bidessini). Ga J Sci 67: 72-74, 2009.
14. Anonymous: Average monthly temperatures for Macon, Georgia, 1981-2010. National Oceanic and Atmospheric Administration. Available from: http://nowdata.rcc-acis.org/FFC/pubACIS_results, 2013.
15. Matta JF: *Agabus* (Coleoptera: Dytiscidae) larvae of southeastern United States. Proc Entomol Soc Wash 88: 515-520, 1986.
16. Lemieux BR, Barman EH and White BP: A redescription of the first instar of *Rhantus calidus* (Fabricius) (Coleoptera: Dytiscidae) with notes on its biology. Ga J Sci 69: 80-89, 2011.
17. Brannen, D, Barman EH and Wall WP: An allometric analysis of ontogenetic changes (variation) in the cranial morphology of larvae of *Agabus disintegratus* Crotch (Coleoptera: Dytiscidae), using distortion coordinates. Coleopts Bull 59: 351-360, 2005.
18. Barman EH, Nichols GA and Sizer RL: Biology, mature larva, and pupa of *Agabus punctatus* Melsheimer (Coleoptera: Dytiscidae). Ga J Sci 54: 183-193, 1996.
19. Galewski K: A study on morphobiotic adaptations of European species of the Dytiscidae (Coleoptera). Pol Pismo Ent 41: 488-702, 1971.
20. Yee DA: Behavior and aquatic plants as factors affecting predation

by three species of larval predaceous diving beetles (Coleoptera: Dytiscidae). Hydrobiol 637: 33-43, 2010.

21. Gorb S and Beutel RG: Head-capsule design and mandible control in beetle larvae; a three-dimensional approach. J Morph 244: 1-14, 2000.
22. Epler JH: The water beetles of Florida. An identification manual for the families Chrysomelidae, Curculionidae, Dryopidae, Dytiscidae, Elmidae, Gyrinidae, Haliplidae, Helophoridae, Hydraenidae, Hydrochidae, Hydrophilidae, Noteridae, Psephenidae, Ptilodactylidae, and Scirtidae. Florida Department Environmental Protection, Tallahassee, FL, 414 pp, 2010.
23. Barman EH, Blair ME and Bacon MA: Biology of *Ilybius oblitus* (Coleoptera: Dytiscidae) with a description of its mature larva and an evaluation of diagnostic characters for separation of southeastern *Ilybius* and *Agabus* larvae. J Elisha Mitchell Sci Soc 117: 81- 89, 2001.
24. Barman EH, Wright P and Mashke JE: Biology of *Agabus disintegratus* (Crotch) (Coleoptera: Dytiscidae) in central Georgia with a description of its mature larva. Ga J Sci 58: 208-216, 2000.