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A Description of the Third Instar of Platambus flavovittatus (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

R. Wilkes
B. P. White
G. W. Wolfe
E. H. Barman

Georgia College and State University, e.barman@gcsu.edu

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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

E. H. Barman1*, B. P. White2, G. W. Wolfe3 and R. Wilkes1
1Georgia College & State University, Milledgeville, GA 31061
2Georgia Military College, Warner Robins, GA 31093
3Georgia College & State University Insect Museum, Milledgeville, GA 31061

*Corresponding Author
e.barman@gcsu.edu

ABSTRACT
Mature Agabini larvae collected from a small temporary road-side
habitat were reared to the adult stage and identified as Platambus fla-
vovittatus (Larson and Wolfe, 1998). The mature larva is described
and illustrated with an emphasis on leg morphology. Important dif-
ferences 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 semivit-
tatus-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 Tennes-
see, 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 ($\bar{x} = 2.08 \pm 0.05$ mm); maximum width near the mid-point between the posterior apex of the frontoclypeus and the occipital carina, 1.74-1.90 mm ($\bar{x} = 1.84 \pm 0.05$ mm); frontoclypeus 0.70-0.84 mm, ($\bar{x} = 0.77 \pm 0.05$ 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 ($\bar{x} = 1.29 \pm 0.04$ 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° ($\bar{x} = 60.4 \pm 2.6^\circ$); prominent posterior parietal constriction; pronounced posteroventral emargination. **Antenna.** Length, excluding palpifer, 0.93-1.19 mm ($\bar{x} = 1.06 \pm 0.08$ mm), antennomere (AN) 1, 0.22-0.36 mm ($\bar{x} = 0.30 \pm 0.04$ mm), AN2, 0.26-0.33 mm ($\bar{x} = 0.29 \pm 0.02$ mm), AN3, 0.28-0.34 mm ($\bar{x} = 0.31 \pm 0.03$ mm) without protruding accessory appendage (A3’), AN4, 0.12-0.18 mm ($\bar{x} = 0.15 \pm 0.02$ 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 (°).

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

**Mouthparts.** **Mandible,** length 0.87-0.99 mm ($\bar{x} = 0.94 \pm 0.03$ mm) about 2.5 times width, inter-mandibular distance, 1.24-1.36 mm ($\bar{x} = 1.31 \pm 0.04$ mm), lateral arc 110.0-123.0° ($\bar{x} = 115.8 \pm 5.5^\circ$), medial arc 52.0-73.0° ($\bar{x} = 62.0 \pm 8.1^\circ$), angle of attack 43.0-48.5° ($\bar{x} = 46.6 \pm 2.1^\circ$), 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, approximately 1/3 the length of palpomere (MP) 1; palpus length, excluding palpifer, 0.72-0.86 mm ($\bar{x} = 0.80 \pm 0.05$ mm), MP1, 0.25-0.32 mm ($\bar{x} = 0.28 \pm 0.02$ mm), MP2, 0.24-0.30 mm ($\bar{x} = 0.28 \pm 0.02$ mm), MP3, 0.20-0.28 mm ($\bar{x} = 0.24 \pm 0.02$ 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 ($\bar{x} = 0.74 \pm 0.04$ mm), palpomere (LP) 1, 0.34-0.48 mm ($\bar{x} = 0.41 \pm 0.04$ mm), LP2, 0.31-0.36 mm ($\bar{x} = 0.33 \pm 0.02$ 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 (x = 1.23± 0.02), 1.26-1.32 (x = 1.29± 0.02), 1.28-1.47 (x = 1.40± 0.06); trochanters, 0.40-0.50 (x = 0.45± 0.03), 0.44-0.52 (x = 0.48± 0.03), 0.49-0.56 (x = 0.52± 0.02); femora, 0.86-1.44 (x = 1.01± 0.06), 1.06-1.18 (x = 1.13± 0.04), 1.20-1.41 (x = 1.34± 0.07); tibiae, 0.48-0.63 (x = 0.57± 0.02), 0.62-0.74 (x = 0.68± 0.04), 0.84-0.98 (x = 0.93± 0.04); tarsi, 0.43-0.52 (x = 0.47± 0.03), 0.52-0.64 (x = 0.60± 0.03), 0.90-0.98 (x = 0.94± 0.03); anterior/posterior tarsal claws on pro- (x = 0.28 ± 0.02/ = 0.21 ± 0.04 mm), meso-, (x = 0.37 ± 0.03/ = 0.29 ± 0.02 mm), and metathoracic legs (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 (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 (x = 1.98 ± 0.12 mm) with well-developed siphon, length 0.22- 0.44 mm (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 (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 ($\bar{x} = 2.16 \pm 0.04$ mm), width, 1.74-2.40 mm ($\bar{x} = 1.90 \pm 0.11$ mm), inter-mandibular distance, 1.27-1.38 mm ($\bar{x} = 1.32 \pm 0.05$ mm), temporal curvature ($n = 5$), 67.0-77.0° ($\bar{x} = 70.8 \pm 3.8°$); *mandible*, 0.96-1.01 mm ($\bar{x} = 0.98 \pm 0.02$ mm), angle of attack, 44.5-50.0° ($\bar{x} = 46.6 \pm 2.2°$), medial arc, 55.0-68.0° ($\bar{x} = 61.4 \pm 6.0°$), lateral arc, 108.0-123.0° ($\bar{x} = 117.0 \pm 6.0°$); *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* ($\bar{x} = 60.4 \pm 2.6°$) less pronounced than that of *P. stagninus* ($\bar{x} = 70.8 \pm 3.8°$). 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. xzytrus* 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. xzytrus* and *A. aeruginosus* occur. Consequently, that descriptive material may be for either species and is not validated for identification of *A. xzytrus*, 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 sensillum; 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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