The larvae of *Epigomphus jannyae* Belle, 1993 and *E. tumefactus* Calvert, 1903 (Insecta: Odonata: Gomphidae) (#10466)

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Rodolfo Novelo-Gutiérrez, Alonso Ramirez, Débora Delgado

The knowledge about immature stages of the insect order Odonata (dragonflies and damselflies) is rather limited. Here, the larvae of *Epigomphus jannyae* Belle and *E. tumefactus* Calvert are described, figured, and compared with other described congeners. *E. jannyae* larva is characterized by 3rd antennomere 1.6 times longer than its widest part; ligula very poorly developed, with ten short, truncate teeth on middle, apical lobe of labial palp rounded and smooth. Lateral margins on abdominal S5-9 serrated, lateral spines on S6–9 small and divergent; male's epiproct with a pair of dorsal tubercles at basal 0.66; tips of cerci and paraprocts strongly divergent. The larva of *E. tumefactus* is characterized by 3rd antennomere 2.3 times longer than its widest part, ligula with 6-7 truncate teeth, apical lobe of labial palp acute and finely serrate. Lateral margins of S6-9 serrate, lateral spines on S7-9; male´s epiproct with a pair of dorsal tubercles at basal 0.50. Mainly differences with other species were found in 3rd antennomere, lateral spines of S7-9, and the caudal appendages. *Epigomphus* larva inhabit small, shallow creeks (1st order streams) where they can be found in areas of fine benthic sediments. The larvae emerges by climbing small rocks close to margin and in shady places. Emergence is horizontal on flat rocks. These new descriptions bring the total number of *Epigomphus* species with known larval stages to eight, thus only 28% of the species in the genus are known as larva.

The larvae of *Epigomphus jannyae* Belle, 1993 and *E. tumefactus* Calvert, 1903 (Insecta: Odonata: Gomphidae)

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Abstract

The knowledge about immature stages of the insect order Odonata (dragonflies and damselflies) is rather limited. Here, the larvae of *Epigomphus jannyae* Belle and *E. tumefactus* Calvert are described, figured, and compared with other described congeners. *E. jannyae* larva is characterized by 3rd antennomere 1.6 times longer than its widest part; ligula very poorly developed, with ten short, truncate teeth on middle, apical lobe of labial palp rounded and smooth. Lateral margins on abdominal S5-9 serrated, lateral spines on S6–9 small and divergent; male epiproct with a pair of dorsal tubercles at basal 0.66; tips of cerci and paraprocts strongly divergent. The larva of *E. tumefactus* is characterized by 3rd antennomere 2.3 times longer than its widest part, ligula with 6-7 truncate teeth, apical lobe of labial palp acute and finely serrate. Lateral margins of S6-9 serrate, lateral spines on S7-9; male´s epiproct with a pair of dorsal tubercles at basal 0.50. Mainly differences with other species were found in 3rd antennomere, lateral spines of S7-9, and the caudal appendages. *Epigomphus* larva inhabit small, shallow creeks (1st order streams) where they can be found in areas of fine benthic sediments. The larvae emerges by climbing small rocks close to margin and in shady places. Emergence is horizontal on flat rocks. These new descriptions bring the total number of *Epigomphus* species with known larval stages to eight, thus only 28% of the species in the genus are known as larva.

Introduction

Gomphidae is a cosmopolitan insect family of Odonata (dragonflies and damselflies) with over 900 species (Garrison, Ellenrieder & Louton, 2006). The family is diverse in streams and rivers, but also has several species that inhabit lentic environments (e.g., ponds, lakes). Taxonomically, the adults in this group of dragonflies have been well-studied, although new species are constantly described. In contrast, similar to most insect groups, the immature stages are poorly known. Garrison, Ellenrieder & Louton (2006) report 255 species of gomphids for the New World, with only 177 of them known as larvae (69%). This lack of knowledge of the larval stages greatly limits our ability to understand the ecological role of insects in their ecosystems.

The genus *Epigomphus* is a poorly-known group of gomphids that inhabit small streams and rivers in the neotropics. *Epigomphus* comprises 28 species (Garrison, Ellenrieder & Louton, 2006), but only six are known as larvae: *E. paludosus* Hagen in Selys, 1854 (Martins, 1968); *E. echeverrii* Brooks, 1989, *E. subobtusus* Selys, 1878, *E. subsimilis* Calvert, 1920 (all three by Ramírez, 1996); *E. hylaeus* Ris, 1918 (Fleck, 2002); and *E. crepidus* Kennedy, 1936 (Novelo-Gutiérrez, Gómez-Anaya & Smith-Gómez, 2015). In this paper, a detailed description and illustrations of the larvae of *E. jannyae* Belle and *E. tumefactus* Calvert are provided, based upon a specimen found emerging at the field, and reared larvae, respectively.

Materials & Methods

Epigomphus larvae were collected during separated field trips to Panama and Costa Rica. Larvae were collected from the stream bottom and transported alive to the laboratory. Emerging individuals in the field were also collected. The male's exuvia of *E. jannyae* was preserved in 96% ethanol while the teneral imago was maintained alive for a couple of days when it died. A couple of F−0 larvae of *E. tumefactus* were reared until emergence, other two F−0 larvae die and were preserved in ethanol. Emerged adults were identified against original descriptions and material from the lead author's reference collection at the Instituto de Ecología, A.C., Xalapa, Mexico.

Mandible nomenclature follows Watson (1956); labium nomenclature follows Corbet (1953). Photographs were obtained with a CANON PowerShot G10 digital camera mounted on a stereomicroscope ZEISS Stemi 2000-C. Measurements (in mm) were made with a calibrated ocular micrometer as follows: Head width, across compound eyes; total length, dorsally from anterior-most margin of labrum to tips of caudal appendages; abdomen length, ventrally to posterior-most margin of abdominal segment 10; hind femur along midline of external surface. S1–10 = abdominal segments 1 to 10.

Results

***Epigomphus jannyae* Belle**
(Figs. 1, 2a, 3-4, 5a-b, 7a-b)

Material. One exuvia (male, emerging at the field). PANAMA: Panamá Oeste Province, Capira District, Altos de Campana Park, Sendero Panamá, stream (8° 41.033 N, 79° 55.528 W, elevation 835m asl), 25 April 2015 (1male exuvia, emerging around noon), D. Delgado, A. Ramírez, R. Novelo leg. Deposited in Colección Entomológica del Instituto de Ecología, A.C., Xalapa (IEXA).

Description. Medium-size exuvia (25.3 mm total length), body robust, antennae, legs, sides of thorax and abdomen setose, gently tapering caudad, body light yellow-brown lacking any particular pattern (Fig. 1).

Head: Wider than long, even wider than pro- and mesothorax and basal abdomen (Fig. 1a). Labrum 0.6 mm long, mostly bare, anterior border with dense brush of golden setae, flattened ventrally; anteclypeus bare, postclypeus, frons, vertex and occiput finely granulose, a tuft of long, upturned, golden setae on fronto-lateral margins of frons, occiput mostly granulose with some bare, irregular areas, with long, golden setae on occipital lobes,

anterior margin of frons concave. Antennae 4-segmented (Figs. 1a, 2), covered with some sparse granuli on dorsum, scape globose, pedicel subglobose, both with abundant, small, scale-like setae on apical margin, 3rd antennomere largest, claviform, flattened dorso-ventrally, 1.6 times longer than its widest part, lateral and apical margins beset with abundant, small, scale-like setae, tightly packed on apical margin, dense rows of long, yellowish setae on lateral margins, those on external margins longest, those on internal margins stiff, with small, regularly spaced, circular structures close to the border, 4th antennomere a small sphere; scape, pedicel and 3rd antennomere yellow brown, 4th antennomere reddish-brown, size proportions: 0.34, 0.15, 1.0, 0.06. Compound eyes moderately developed; ocelli pale. Occipital lobes rounded, bulging; a well-developed longitudinal carina beset with small, stiff setae to each side of ventral surface of head (Fig. 1b). Mandibles (Fig. 3) with molar crest, formula: L 1234 0 a($m^{1,2,3,4}$)b / R 1234 y a($m^{1,2}$)b, in both mandibles tooth a>b. Maxillae: Galeolacinia (Fig. 4) with 7 moderately incurved teeth, three dorsal teeth more or less of same length and robustness, 4 ventral teeth of different size, apical one largest; maxillary palp thick and robust. Ventral pad of hypopharynx pentagonal, whitish, soft, with a row of antero-ventral, subapical, long, stiff setae, a laterobasal, triangular-shaped sclerite to each side of midline. Labium: Prementum-postmentum articulation reaching posterior margin of procoxae. Prementum reddish-yellow, subquadrate, as long as its widest part (Fig. 5a), lateral margins with long whitish setae, slightly sinuate at apical 0.60, slightly sinuate and moderately convergent on basal 0.40, basal margin sinuate, without a longitudinal, central sulcus on ventral surface (Fig. 5a), a small, shallow, concavity just below ligula beset with some long setae (Fig. 5b), ligula poorly developed (Fig. 5b), apical margin slightly convex, with a ventral row of 10 reddish-brown, short, truncate teeth on middle and a dorsal row of short, stout piliform setae; labial palp stout (Figs. 5a-b), reddish-brown, with abundant, long delicate, whitish setae on external surface; apical lobe stout, tip rounded and smooth, internal margin concave with 10–12 small teeth, the basal 6–7 teeth truncate and very close each other, remainder 4–5 teeth acutely pointed and more separate each other, external margin gently convex and smooth; movable hook reddish-brown, almost as long as palp, sharp and moderately incurved.

Thorax: Pro- and mesothorax slightly narrower than head, setose on inferior border. Anterior margin of pronotum straight, lateral margins convex and bulging (similar to Fig. 6), posterior margin convex; a large, subquadrate glabrous area on each side of midline, remainder of pronotum granulose. Synthorax granulose, some tufts of long, curled setae on inferior margins, meso- and metaspiracles present. Legs short (e.g.: when fully extended, hind legs scarcely reaching posterior margin of abdominal segment 7), strongly setose (Fig. 1), with long, yellow-brown, delicate setae mainly on sides and shorter, stiff, reddish setae mainly on anterior surfaces of tibiae and tarsi; burrowing hooks moderately developed (Fig. 1); dorsal margins of metafemora of the same length of metatibiae; tarsal formula 2-2-3, claws simple, with a pulvilliform empodium. Wing sheaths reaching posterior margin of

S3, strongly divergent (Fig. 1a), mostly granulose, with abundant long, delicate setae on borders.

Abdomen: Yellow-brown, light reddish-brown on middle third of tergites 8–9, and the whole surface of S10 (Figs. 1, 7a-b), more or less spindle-shaped, ventral surface flat, dorsal surface convex, lacking dorsal protuberances, widest on S5–6; lateral margins of S1–7 with long, stiff yellowish setae, shorter on S8–10, lateral margins of S5–9 serrate (Figs. 1, 7a), serrations on S5 very small and only visible in lateral and ventral view, serrations on S6–9 short and stout, dark reddish-brown, S6–9 ending in a short (very small on S6 only visible ventrally), triangular, divergent spines increasing in size and robustness posteriorly, those on S9 slightly upturned (Fig. 7a); tergites 2–10 granulose, with long, delicate setae mainly on latero-dorsal thirds. Sternites following the same color pattern as tergites (Fig. 1b); sternites 3–8 divided into five plates, sternites 2 and 9 divided into three plates, ventral sutures parallel on 2–3, moderately divergent on 4–8, strongly divergent on 9. Male gonapophyses lacking. Caudal appendages pyramidal, obtusely pointed (Figs. 1, 7b), epiproct and paraprocts reddish-brown, cerci dark reddish-brown, granulose on external surfaces, small, delicate, white setae on internal surfaces; male´s epiproct with a pair of dorsal tubercles at basal 0.66 rounded apically and divergent; cerci and paraprocts, in dorsal view, mostly convergent except the extreme tips of cerci which are suddenly and strongly outcurved; dorsal and ventral margins of paraprocts ridged; paraprocts the shortest, epiproct the longest.

Measurements. Exuvia (N= 1): Total length (incl. caudal app.) 25.3; abdomen (ventral, excl. caudal app.) 16; maximum width of head 5.5; hind femur (lateral) 4.3; maximum width of abdomen (ventral) 6.5; epiproct 1.3, cerci 1.1, paraprocts 1.0; lateral spines on S6 0.10, on S7 0.12, on S8 0.20, on S9 0.4.

Habitat. A transforming individual was found in a small, shallow creek of 1st order, emerging on a small rock located close to the creek's margin in shady place. Emergence was horizontal, on a flat rock surface and lasted for more 40 minutes.

***Epigomphus tumefactus* Calvert**
(Figs. 2b, 5c, 6, 7c, 8)

Material. Two exuviae (male, female, reared), 2 F−0 larvae (male, female). COSTA RICA: Heredia; Horquetas, Finca El Plástico, (10° 17.0 N; 84° 01.60 W, elevation 700m asl), 25 March 1995 (4 F−0 larvae, 1male, 1female F−0 emerged, 1male, 1female F−0 preserved in ethanol), A. Ramírez leg. Deposited in IEXA and in the Museo de Zoologia, Universidad de Cosa Rica (MZUCR).

Description. Medium-size larvae (26.7-29.7mm total length), body robust, integument finely and abundantly granular, antennae, legs, sides of thorax and abdomen setose, gently tapering caudad, body yellow brown lacking any particular pattern (Fig. 8).

Head: As described for *E. jannyae* except: Labrum 0.7 mm long; occiput mostly and finely granulose with some bare, irregular areas (Fig. 6). Antennae yellow brown (Figs. 2b, 8), 3rd antennomere spindle-shaped, 2.3 times longer than its widest part, 4th antennomere a subconical rudiment, size proportions: 0.30, 0.14, 1.0, 0.10. Mandibles: L 1234 0 a($m^{1,2,3}$)b / R 1234 y a($m^{1,2 \text{ or } 1,2,3}$)b, in both mandibles tooth a>b. Prementum yellow, subquadrate, slightly wider than long, lateral margins smooth and slightly sinuate; ligula (Fig. 5c) with a ventral row of 6-7 (usually 7) reddish-brown, short, truncate teeth on middle, and a dorsal row of short, stout piliform setae; apical lobe of labial palp stout, tip acute and finely serrate, internal margin concave with 9-11 large, truncate teeth, the 2-3 most apical teeth acutely pointed, external margin strongly convex and smooth (Fig. 5c); movable hook slightly shorter than palp.

Thorax: As described for *E. jannyae* (Fig. 6).

Abdomen: As described for *E. jannyae* except: Yellowish-brown to light brown (Fig. 8), reddish-brown to dark brown on middle third of tergites 8-9, and the whole surface of S10; lateral margins of S1-6 with long, stiff, yellowish setae, shorter on S7-10, lateral margins of S6-9 serrate, serrations on S6 very small and only visible in lateral and ventral view (absent in one exuviae), serrations on S7-9 short and acute (Figs. 7c, 8), light brown to brown, S7-9 ending in a sharply pointed spines, divergent on S7-8, parallel on S9, which increase in size and robustness posteriorly (Fig. 7c), those on S9 slightly upturned. Caudal appendages pyramidal (Fig. 7c), sharply pointed, reddish-brown to dark brown, subequal in length; male´s epiproct with a pair of dorsal tubercles at basal 0.50, widely convex apically and divergent (Fig. 7c); tips of cerci slightly divergent, tips of paraprocts parallel, dorsal and ventral margin of paraprocts carinated.

Measurements. Exuviae (N=2): Total length (TL) (incl. caudal app.) 27.4- 29.6; abdomen (AB) (ventral, excl. caudal app.) 16.3- 17.7; hind femur (HF) 4.8- 4.9; maximum width of abdomen (MWA) (ventral) 6.9- 7.2; caudal appendages (CA) 1.3- 1.4; lateral spines (LS) on S7 0.4, on S8 0.6, on S9 0.6- 0.7. Larvae (N=2): TL 26.7- 28.6; AB 17.4- 17.8; maximum width of head 5.6- 6.0; HF 4.9; MWA 7.2-7.5; CA 1.3; LS on S7 0.4- 0.5, on S8 0.6-0.7, S9 0.7- 0.8.

Habitat. *E. tumefactus* larvae were collected in 1st order streams draining mature forest, emerging larvae were observed on top of flat rocks on the channel margin.

Discussion

The larva of *Epigomphus jannyae* is similar to larvae of described other species, although they can be separated by the following features (in parentheses those of other species, including *E. tumefactus* above described): Integument abundantly granular (not granular but covered with minute, scale-like setae, *crepidus, echeverrii, subobtusus, subsimilis*); third antennomere claviform, 1.6 times longer than its widest part (spindle-shaped, 2 times longer or more than its widest part, *crepidus, echeverrii, subobtusus, subsimilis, tumefactus*); third antennomere with small, regularly spaced, circular structures close to borders (lacking such structures, *crepidus*); lateral margins of prementum slightly sinuate at apical 0.60 (lateral margins slightly convex, *crepidus, echeverrii, subobtusus, subsimilis*; straight and parallel at apical half, *hylaeus*); tip of palpal lobe rounded and smooth (tip of palpal lobe rounded and finely serrate, *crepidus, echeverrii, subobtusus, subsimilis*; tip of labial palp acute and finely serrate, *tumefactus*); movable hook almost as long as palp (as long as palp, *hylaeus, subsimilis*); lateral margins of S5 finely serrate and with long setae (only with long setae, *crepidus, hylaeus, echeverrii, subobtusus, subsimilis, tumefactus*); lateral margins of S6 serrate (no serrate, *crepidus, hylaeus, echeverrii, subobtusus, subsimilis*); lateral spines on S6–9 obtusely pointed (lateral spines on S7-9 sharply pointed, all other species); extreme tips of cerci suddenly and strongly out-turned (extreme tips of cerci slightly divergent, all other species).

By the shape and length/width ratio of the 3rd antennomere, and the tip rounded and smooth of labial palp, the larva of *E. jannyae* appears more similar to that of *E. hylaeus*. However, they differ by the larger stature, serrations present on lateral margins of S5-9, and obtusely pointed lateral spines on S6–9 of *E. jannyae*. Likewise, by the shape and length/width ratio of the 3rd antennomere, the larva of *E. tumefactus* appears related to *crepidus, echeverrii, subobtusus*, and *subsimilis*, differing of all these species by the acute tip of labial palp; in this last feature apparently could be related to *E. paludosus*, according with the drawing provided by Martins (1968).

The descriptions here provided shed light on the relationship of *Epigomphus* with other genera in the family Gomphidae. Several authors have intended to relate *Epigomphus* to other genera based mainly on adult morphology (e.g. Williamson, 1920), while others have included also some larval characteristics (Carle, 1986; Belle, 1996). According to our present knowledge of the larval forms, we think that Carle's (1986) classification reflects better the relationships among the genera he established into the subfamily Epigomphinae, excepting the Macrogomphini (*Macrogomphus* only), which larva shows more resemblance to members of Carl's tribe Gomphoidini. *Epigomphus* is probably closely related to the oriental *Leptogomphus* (tribe Leptogomphini) by the following combination of features: tennae with abundant scale-like setae, dual shape of 3rd antennomere; molar lobe of right

mandible with formula a(m^{1-2})b; shape of prementum, ligula poorly developed and slightly convex; lateral margins of S6-9 serrate, with lateral spines on S7-9; anal pyramid short; sternum 3 divided in 5 sternites; the last 3 features are also shared with *Heliogomphus* larva, which belongs to the Leptogomphini too (*sensu* Carle, 1986). However, two striking differences between *Leptogomphus* and *Epigomphus* are: the presence of a ventral, longitudinal, median sulcus on prementum, and abdominal dorsal protuberances in the former.

Finally, the larvae of *E. jannyae* and *E. tumefactus* would fit in the key provided by Novelo-Gutiérrez, Gómez-Anaya & Smith-Gómez (2015), after the following modification:

1- Third antennomere claviform (length/width proportion l.6:1); tip of labial palp rounded and smooth 2

1’ Third antennomere spindle-shaped (length/width proportion ≥ 2:1); tip of labial palp rounded or acute and finely serrate 3

2 Lateral margins of prementum slightly sinuate; lateral margins of S5–9 serrate; lateral spines on S6–9 triangular, obtusely pointed (very small on S6, visible only in ventral view); extreme tips of cerci suddenly and strongly out-turned; total length more than 23 mm ..... *jannyae*

2’ Lateral margins of prementum straight and parallel on apical half; lateral margins of S7–9 serrate; lateral spines on S7–9, sharply pointed; tips of cerci slightly divergent; total length less than 23 mm ..... *hylaeus*

3 Tip of labial palp acute; ligula with 6-7 truncated teeth; lateral margins of S6 serrate ..... *tumefactus*

3’ Tip of labial palp rounded; ligula with 8 or more truncated teeth; lateral margins of S6 no serrate .....4 (continues in original key)

Conclusion

Epigomphus continues to be a poorly known group, only eight of the 28 species are known as larva. However, descriptions here provided and comparisons with the literature allow for assessing major characters useful to separate species as larvae. Also, available information now allows to examine the placement of this genus within the family Gomphidae and helps advance taxonomic studies.

Acknowledgements

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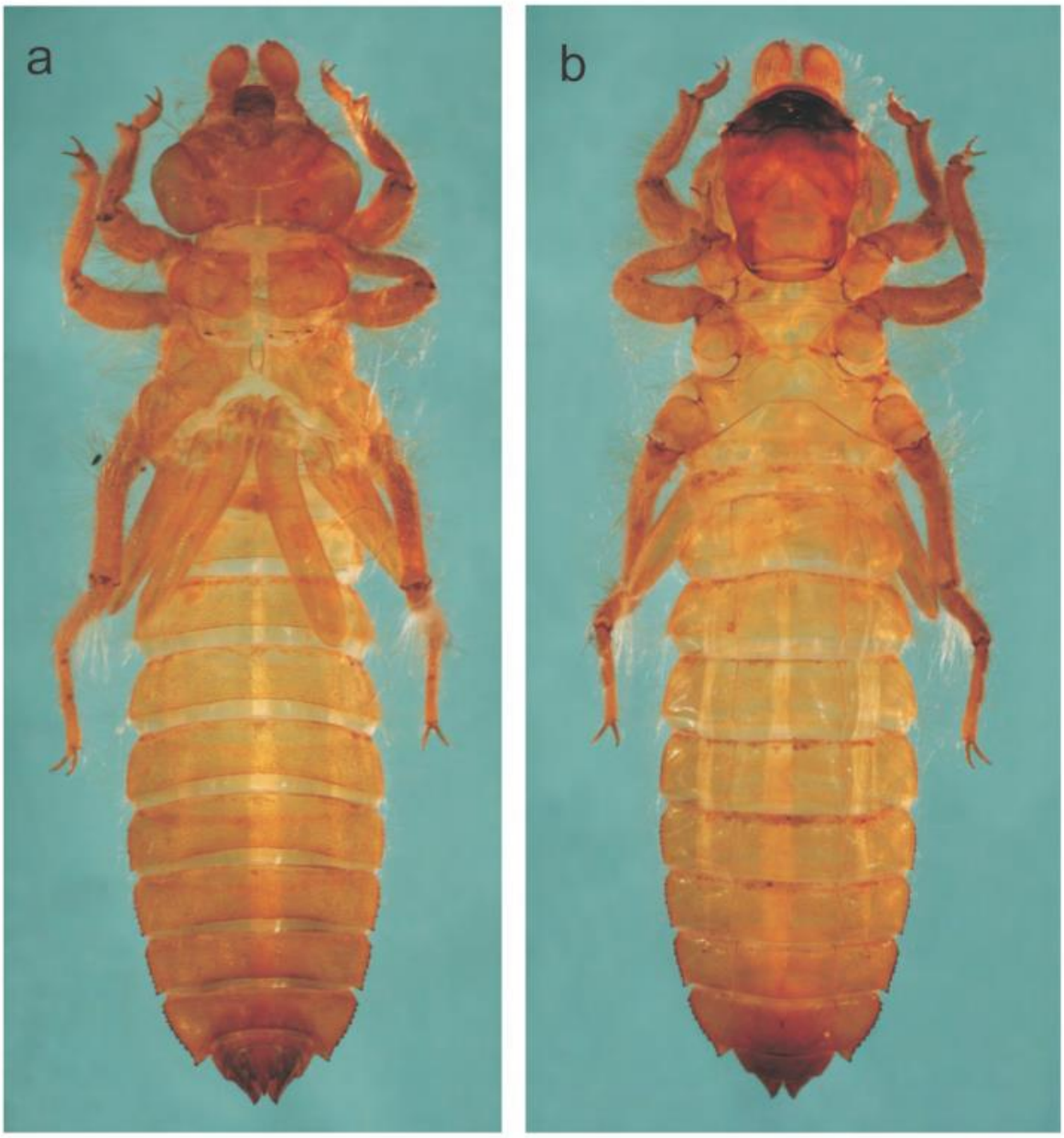

PLATE I Fig. 1. *Epigomphus jannyae*, last stadium exuvia, a) dorsal view, b) ventral view.

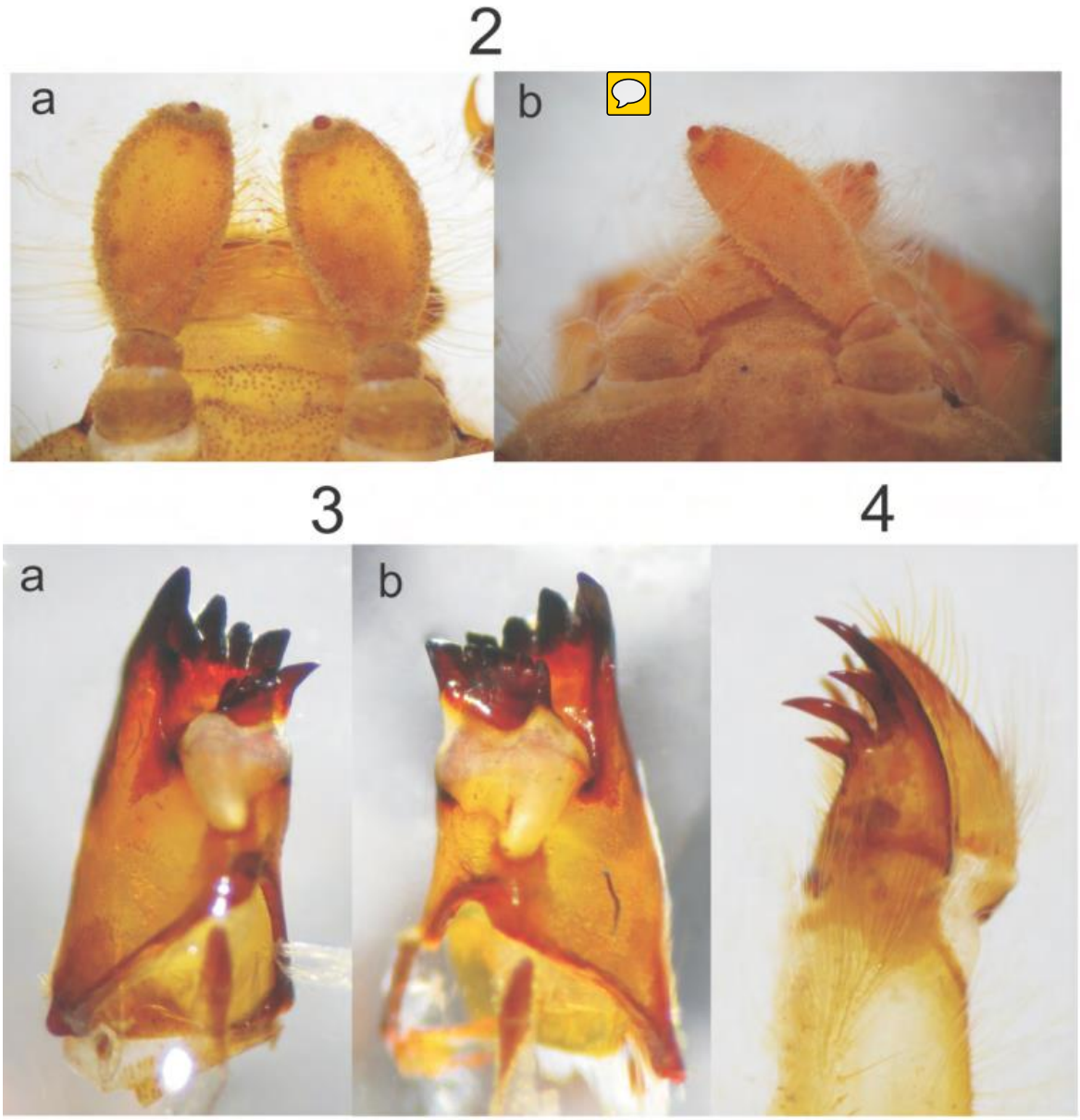

PLATE II. Figs. 2–4. Details of the morphology of *Epigomphus* spp. Fig 2. Dorsal view of antennae, a) *E. jannyae*, b) *E. tumefactus*; Fig. 3. Ventrointernal view of mandibles of *E. jannyae*, a) right mandible, b) left mandible. Fig. 4 Maxilla's galeolacinia of *E. jannyae*, ventral view.

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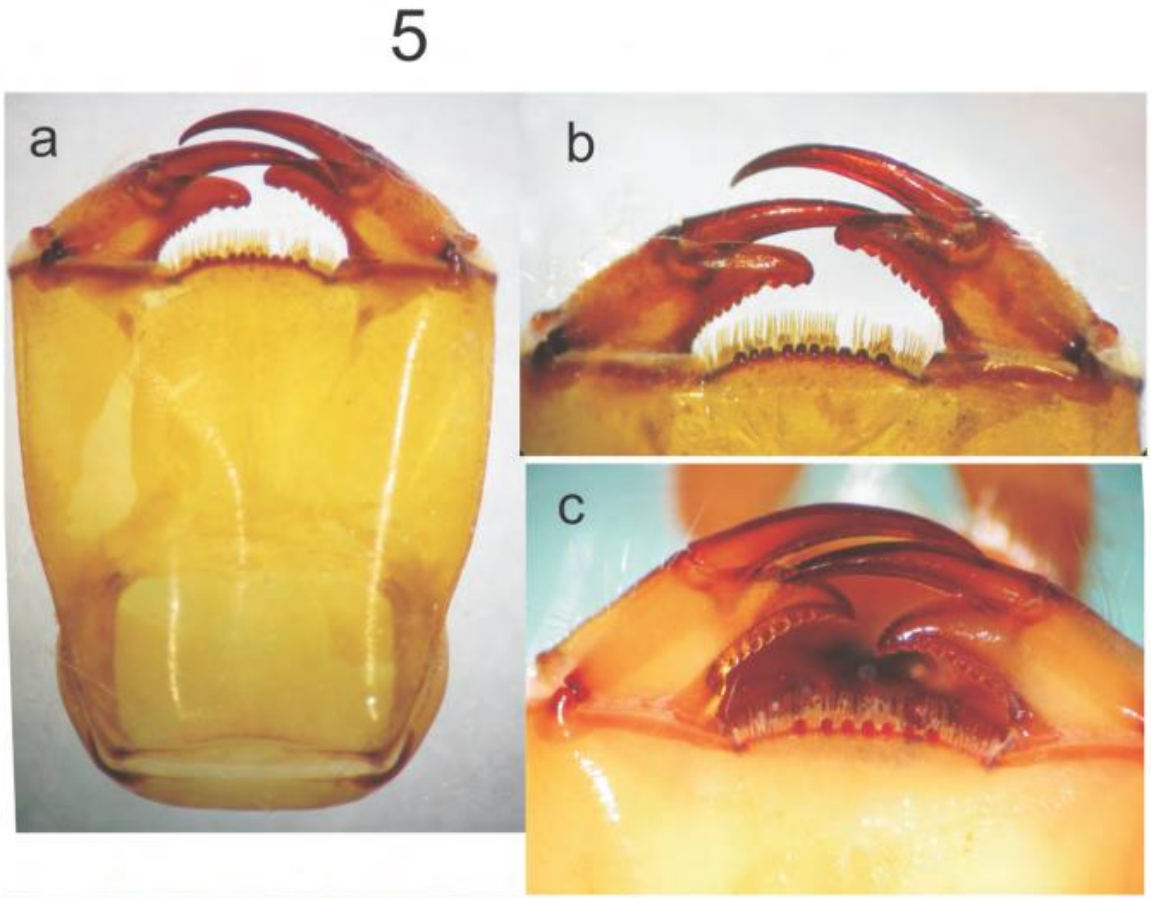

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369 PLATE III. Figs. 5-6. Details of the morphology of *Epigomphus* spp. Fig 5. Prementum,
370 ventral view: a) *E. jannyae*, b) Details of the ligula and labial palpi, *E. jannyae*, c)
371 *Ídem* but *E. tumefactus* (see acute tip of palpi).
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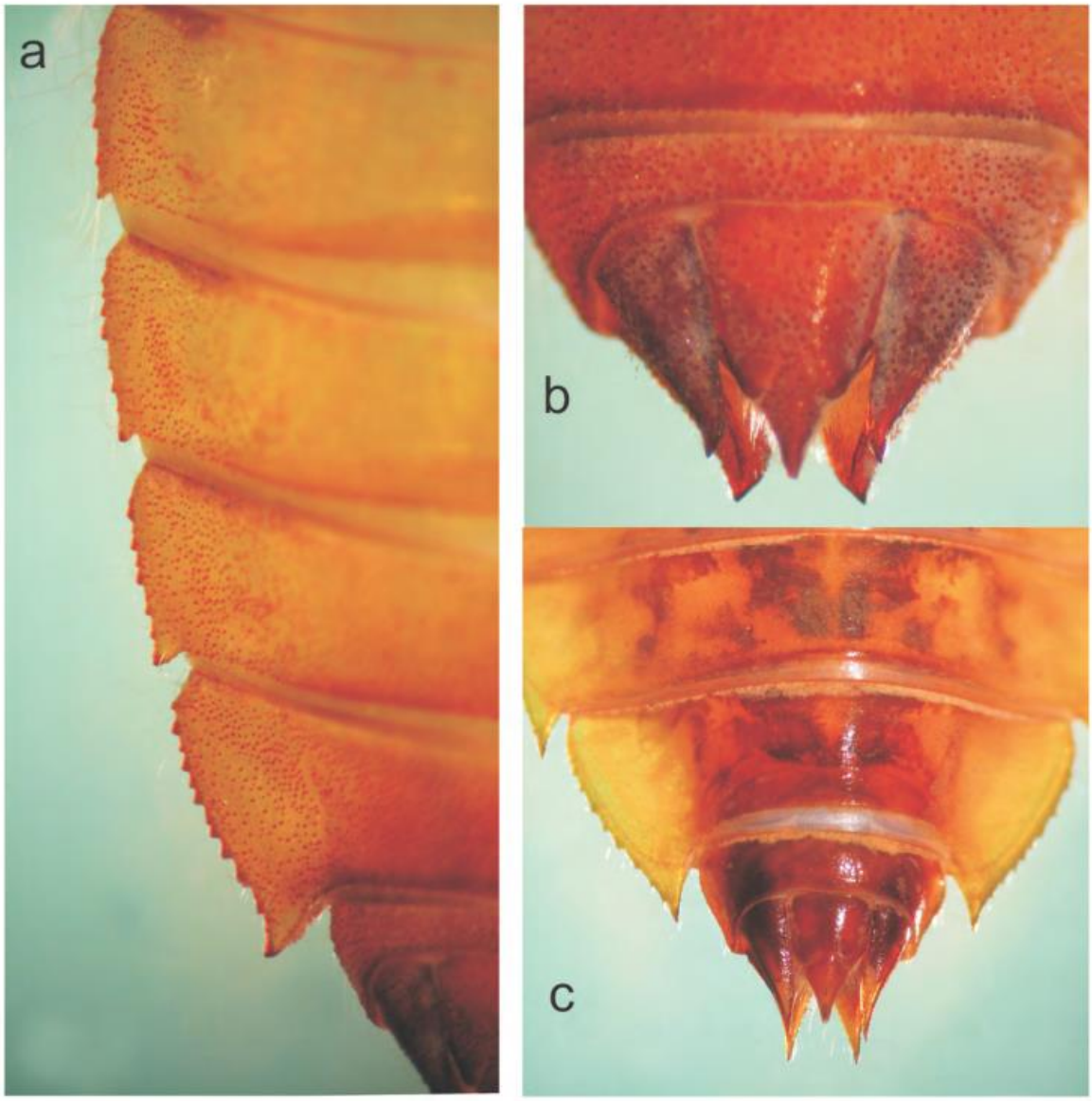

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376 PLATE IV. Fig. 7. Details of the abdomen of *Epigomphus* spp. a) Lateral margins of
377 segments 6-9 showing the serrate borders and apical spines; b) Segment 10 and
378 caudal appendages showing the divergent tips of cerci and paraprocts (a and b, E.
379 jannyae); c) Segments 8-10 showing acute lateral spines on 8-9, and caudal
380 appendages sharply pointed of *E. tumefactus* larva.

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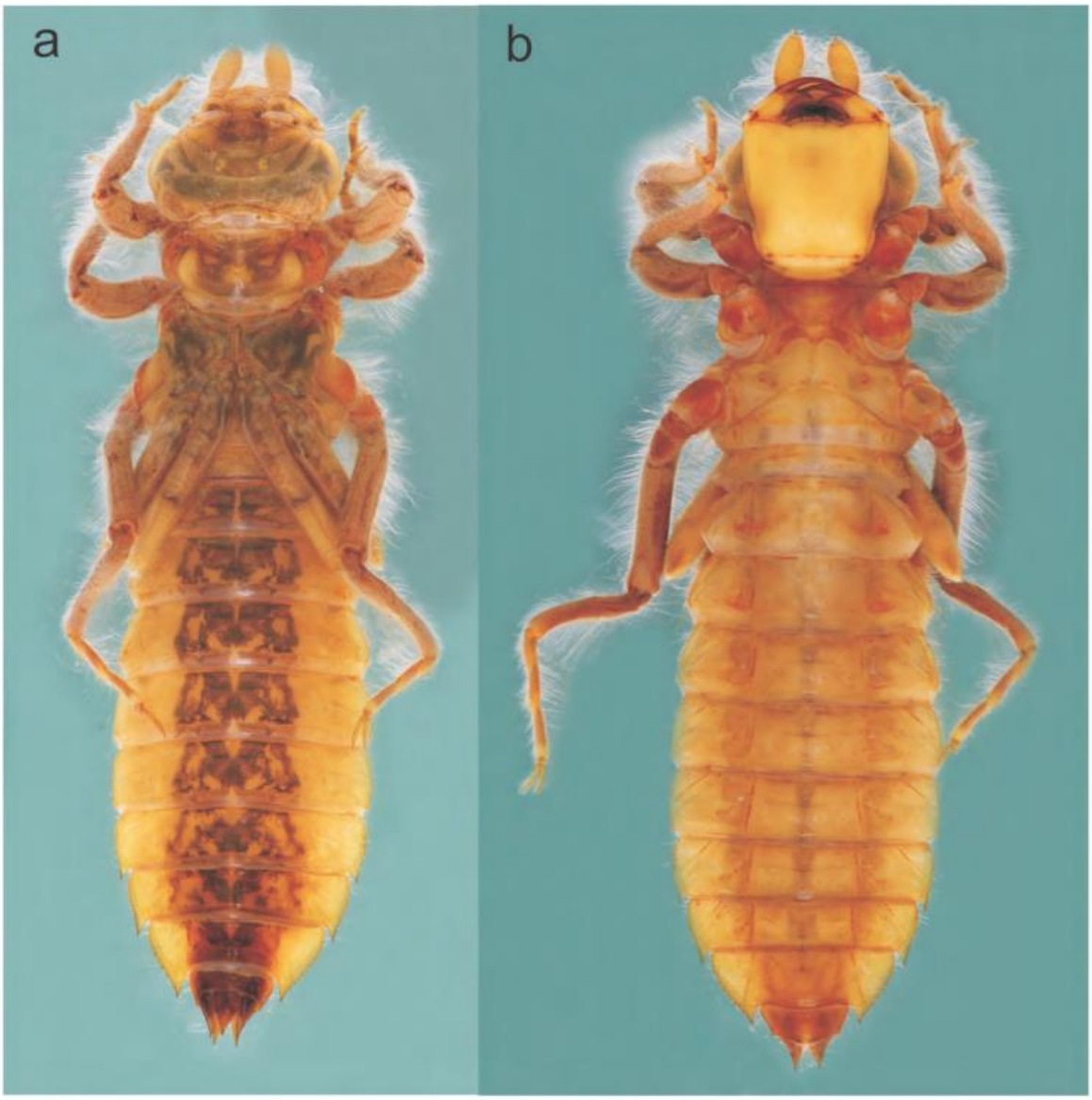

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387 PLATE V Fig. 8. *Epigomphus tumefactus*, last stadium exuvia, a) dorsal view, b) ventral
388 view.

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