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

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The taxonomic knowledge about immature stages of the insect order Odonata (dragonflies and damselflies) is rather limited in tropical America. Here, the larvae of *Epigomphus jannyae* Belle, 1993 and *E. tumefactus* Calvert, 1903 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 segments (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 epiproct with a pair of dorsal tubercles at basal 0.50. Differences with other species were found in 3rd antennomere, lateral spines of S7-9, and the caudal appendages. *Epigomphus* larvae inhabit small, shallow creeks (1st order streams) where they live in fine benthic sediments. When mature, the larva leaves the water in shady places, climbing small rocks at the water's edge and metamorphosing horizontally on flat rocks. These new descriptions bring the total number of *Epigomphus* species with known larval stages to eight; only 28% of the species in this genus are known as larva.

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Abstract

The taxonomic knowledge about immature stages of the insect order Odonata (dragonflies and damselflies) is rather limited in tropical America. Here, the larvae of *Epigomphus jannyae* Belle, 1993 and *E. tumefactus* Calvert, 1903 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 segments (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 epiproct with a pair of dorsal tubercles at basal 0.50. Differences with other species were found in 3rd antennomere, lateral spines of S7-9, and the caudal appendages. *Epigomphus* larvae inhabit small, shallow creeks (1st order streams) where they live in fine benthic sediments. When mature, the larva leaves the water in shady places, climbing small rocks at the water's edge and metamorphosing horizontally on flat rocks. These new descriptions bring the total number of *Epigomphus* species with known larval stages to eight; only 28% of the species in this genus are known as larva.

Introduction

Gomphidae is a cosmopolitan insect family of Odonata (dragonflies and damselflies) with over 980 species (Dijsktra et al. 2013). The family is diverse in streams and rivers, but also has several species that inhabit lentic environments (e.g., ponds, lakes) (Garrison, Ellenrieder & Louton, 2006). Taxonomically, the adults in this group of dragonflies have been well-studied, although new species are frequently described. In contrast, and 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 inhabits small streams and rivers in the neotropics. *Epigomphus* comprises 28 species (Garrison, Ellenrieder & Louton, 2006), but only six are known as larvae (larval descriptions in parentheses): *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,

65 respectively. Both species have restricted distributions and have been reported from a single
66 country, *E. jannyae* is endemic to Panama and *E. tumefactus* to Costa Rica.
67
68 **Materials & Methods**
69
70 *Epigomphus* larvae were collected in Panama and Costa Rica. Larvae were collected from the
71 stream bottom and transported alive to the laboratory. Individuals emerging in the field were
72 also collected. The male exuvia of *E. jannyae* was preserved in 96% ethanol while the teneral
73 imago was maintained alive for a couple of days before it died and then preserved in ethanol. A
74 couple of last instars (i.e., F−0) larvae of *E. tumefactus* were reared until emergence; another two
75 F−0 larvae die and were preserved in ethanol. Emerged adults were identified using original
76 descriptions and comparisons with identified specimens deposited at the Instituto de Ecología,
77 A.C., Xalapa, Mexico.
78
79 Mandible nomenclature follows Watson (1956); labium nomenclature follows Corbet (1953).
80 Photographs were obtained with a CANON PowerShot G10 digital camera mounted on a
81 stereomicroscope ZEISS Stemi 2000-C. Measurements (in mm) were made with a calibrated
82 ocular micrometer as follows: Head width, across compound eyes; total length, dorsally from
83 anterior-most margin of labrum to tips of caudal appendages; abdomen length, ventrally from
84 anterior margin of segment 1 to posterior margin of segment 10; hind femur, along midline of
85 external surface. S1−10 = abdominal segments 1 to 10.
86
87 **Results**
88
89 ***Epigomphus jannyae* Belle**
90 (Figs. 1, 2a, 3-4, 5a-b, 7a-b)
91
92 **Material.** One exuvia (male, emerged in the field). PANAMA: Panamá Oeste Province, Capira
93 District, Altos de Campana Park, Sendero Panamá, stream (08° 41.033 N; 79° 55.528 W, 835
94 masl), 25 April 2015 (1 male exuvia, emerged around noon), D. Delgado, A. Ramírez, R. Novelo
95 leg. Deposited in the Colección Entomológica del Instituto de Ecología, A.C., Xalapa (IEXA).
96
97 **Description.** Medium-sized exuvia, body robust, antennae, legs, sides of thorax and abdomen
98 setose, gently tapering caudad, body light yellow-brown and lacking any particular pattern (Fig.
99 1).
100
101 Head: Wider than long, even wider than pro- and mesothorax and basal abdomen (Fig. 1a).
102 Labrum 0.6 mm long, mostly bare, anterior border with dense brush of golden setae, flattened
103 ventrally; anteclypeus bare; postclypeus, frons, vertex and occiput finely granulose; a tuft of
104 long, upturned, golden setae on fronto-lateral margins of frons; occiput mostly granulose with

105 some bare, irregular areas and with long, golden setae on occipital lobes, anterior margin of frons
106 concave. Antennae 4-segmented (Figs. 1a, 2a), covered with some sparse granuli on dorsum;
107 scape globose, pedicel subglobose, both with abundant, small, scale-like setae on apical margin;
108 3rd antennomere largest, claviform, flattened dorso-ventrally, 1.6 times longer than its widest
109 part, lateral and apical margins beset with abundant, small, scale-like setae, tightly packed on
110 apical margin; dense rows of long, yellowish setae on lateral margins, those on external margins
111 longest, those on internal margins stiff, with small, regularly spaced, circular structures close to
112 the borders; 4th antennomere a small sphere; scape, pedicel and 3rd antennomere yellow brown,
113 4th antennomere reddish-brown, length proportions: 0.34, 0.15, 1.0, 0.06. Occipital lobes
114 rounded, bulging; a well-developed longitudinal carina beset with small, stiff setae on each side
115 of ventral surface of head (Fig. 1b). Mandibles (Fig. 3) with molar crest, formula: L 1234 0
116 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
117 seven moderately incurved teeth; three dorsal teeth more or less of same length and robustness
118 and four ventral teeth of different size, apical one largest; maxillary palp thick and robust.
119 Ventral pad of hypopharynx pentagonal, whitish, soft, with a row of antero-ventral, subapical,
120 long, stiff setae and a latero-basal triangular-shaped sclerite to each side of midline. Labium:
121 Prementum-postmentum articulation reaching posterior margin of procoxae (Fig. 1b).
122 Prementum reddish-yellow, subquadrate, as long as its widest part (Fig. 5a); lateral margins with
123 long whitish setae, slightly sinuate at apical 0.60, slightly sinuate and moderately convergent on
124 basal 0.40; basal margin sinuate, without a longitudinal, central sulcus on ventral surface (Fig.
125 5a); a small, shallow, concavity just below ligula beset with some long setae (Fig. 5b). Ligula
126 poorly developed (Fig. 5b), apical margin slightly convex, with a ventral row of 10 reddish-
127 brown, short, truncate teeth on middle and a dorsal row of short, stout piliform setae. Labial palp
128 stout (Figs. 5a-b), reddish-brown, with abundant, long delicate, whitish setae on external surface;
129 apical lobe stout, tip rounded and smooth, internal margin concave with 10–12 small teeth, the
130 basal 6–7 teeth truncate and very close each other, remaining 4–5 teeth acutely pointed and more
131 separate each other; external margin gently convex and smooth; movable hook reddish-brown,
132 almost as long as palp, sharp and moderately incurved.
133
134 Thorax: Pro- and mesothorax slightly narrower than head, setose on inferior border of pro-and
135 mesopleura. Anterior margin of pronotum straight, lateral margins convex and bulging (similar
136 to Fig. 6), posterior margin convex; a large, subquadrate glabrous area on each side of midline,
137 remainder of pronotum granulose. Meso and metathorax granulose, some tufts of long, curled
138 setae on inferior borders of meso- and metapleura, meso- and metaspiracles evident. Legs short
139 (e.g., when fully extended, hind legs scarcely reaching posterior margin of abdominal segment
140 7), strongly setose (Fig. 1), with long, yellow-brown, delicate setae mainly on sides and shorter,
141 stiff, reddish setae mainly on anterior surfaces of tibiae and tarsi; burrowing hooks moderately
142 developed (Fig. 1); dorsal margins of metafemora the same length as metatibiae; tarsal formula
143 2-2-3, claws simple, with a pulvilliform empodium. Wing sheaths reaching posterior margin of
144 S3, strongly divergent (Fig. 1a), mostly granulose, with abundant long, delicate setae on borders.

145

146 Abdomen: Yellow-brown; light reddish-brown on middle third of tergites 8–9, and the whole
147 surface of S10 (Figs. 1, 7a-b); more or less spindle-shaped, ventral surface flat, dorsal surface
148 convex, lacking dorsal protuberances, widest on S5–6; lateral margins of S1–7 with long, stiff
149 yellowish setae, shorter on S8–10; lateral margins of S5–9 serrate (Figs. 1, 7a), serrations on S5
150 very small and only visible in lateral and ventral views, serrations on S6–9 short and stout, dark
151 reddish-brown; S6–9 ending in short (very small on S6 and only visible ventrally), triangular,
152 divergent spines increasing in size and robustness posteriorly, those on S9 slightly upturned (Fig.
153 7a); tergites 2–10 granulose, with long, delicate setae mainly on the latero-dorsal margins,
154 covering the lateral third of the sternite. Sternites following the same color pattern as tergites
155 (Fig. 1b); sternites 3–8 divided into five plates, sternites 2 and 9 divided into three plates, ventral
156 sutures parallel on 2–3, moderately divergent on 4–8, strongly divergent on 9. Male
157 gonapophyses lacking. Caudal appendages pyramidal, obtusely pointed (Figs. 1, 7b), epiproct
158 and paraprocts reddish-brown, cerci dark reddish-brown, granulose on external surfaces, small,
159 delicate, white setae on internal surfaces; male´s epiproct with a pair of dorsal tubercles at basal
160 0.66 rounded apically and divergent; cerci and paraprocts, in dorsal view, mostly convergent
161 except for the extreme tips of cerci, which are suddenly and strongly outcurved; dorsal and
162 ventral margins of paraprocts ridged; paraprocts the shortest, epiproct the longest.

163

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

167

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

171

172

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

175

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

181

182 **Description**. Medium-sized larvae, body robust, integument finely and abundantly granular,
183 antennae, legs, sides of thorax and abdomen setose, gently tapering caudad, body yellow-brown
184 lacking any defined pattern (Fig. 8).

185

186 Head: As described for *E. jannyae* except: Labrum 0.7 mm long; occiput mostly finely granulose
187 with some bare, irregular areas (Fig. 6). Antennae yellow brown (Figs. 2b, 8), 3rd antennomere
188 spindle-shaped, 2.3 times longer than its widest part, 4th antennomere a subconical rudiment,
189 length proportions: 0.30, 0.14, 1.0, 0.10. Mandibles: L 1234 0 a(m^{1,2,3})b / R 1234 y a(m$^{1,2 \text{ or}}$
190 ^{1,2,3})b, in both mandibles tooth a>b. Prementum yellow, subquadrate, slightly wider than long,
191 lateral margins smooth and slightly sinuate. Ligula (Fig. 5c) with a ventral row of 6-7 (usually 7)
192 reddish-brown, short, truncate teeth on middle, and a dorsal row of short, stout piliform setae;
193 apical lobe of labial palp stout, tip acute and finely serrate, internal margin concave with 9-11
194 large, truncate teeth, the 2-3 most apical teeth acutely pointed, external margin strongly convex
195 and smooth (Fig. 5c); movable hook slightly shorter than palp.

196

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

198

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

209

210 **Measurements.** Exuviae (N=2): Total length 27.4- 29.6; abdomen 16.3- 17.7; hind femur 4.8-
211 4.9; maximum width of abdomen (ventral) 6.9- 7.2; caudal appendages 1.3- 1.4; lateral spines on
212 S7 0.4, on S8 0.6, on S9 0.6- 0.7. Larvae (N=2): Total length 26.7- 28.6; abdomen 17.4- 17.8;
213 maximum width of head 5.6- 6.0; hind femur 4.9; maximum width of abdomen (ventral) 7.2-7.5;
214 caudal appendages 1.3; lateral spines on S7 0.4- 0.5, on S8 0.6-0.7, S9 0.7- 0.8.

215

216 **Habitat.** *E. tumefactus* larvae were collected in 1st order streams draining mature forest. Larvae
217 emerged on top of flat rocks on the channel margin.

218

219 **Discussion**

220

221 The larva of *Epigomphus jannyae* is similar to larvae of other described Epigomphus species,
222 although they can be separated by the following features (in parentheses those of other species,
223 including *E. tumefactus* above described): Integument abundantly granular (not granular but
224 covered with minute, scale-like setae, *E. crepidus*, *E. echeverrii*, *E. subobtusus*, *E. subsimilis*);

225   third antennomere claviform, 1.6 times longer than its widest part (spindle-shaped, 2 times
226   longer or more than its widest part, *E. crepidus, E. echeverrii, E. subobtusus, E. subsimilis, E.*
227   *tumefactus*); third antennomere with small, regularly spaced, circular structures close to borders
228   (lacking such structures, *E. crepidus*); lateral margins of prementum slightly sinuate at apical
229   0.60 (lateral margins slightly convex, *E. crepidus, E. echeverrii, E. subobtusus, E. subsimilis*;
230   straight and parallel at apical half, *E. hylaeus*); tip of palpal lobe rounded and smooth (tip of
231   palpal lobe rounded and finely serrate, *E. crepidus, E. echeverrii, E. subobtusus, E. subsimilis*;
232   tip of labial palp acute and finely serrate, *E. tumefactus*); movable hook almost as long as palp
233   (as long as palp, *E. hylaeus, E. subsimilis*); lateral margins of S5 finely serrate (not serrated, *E.*
234   *crepidus, E. hylaeus, E. echeverrii, E. subobtusus, E. subsimilis, E. tumefactus*); lateral margins
235   of S6 serrate (no serrate, *E. crepidus, E. hylaeus, E. echeverrii, E. subobtusus, E. subsimilis*);
236   lateral spines on S6–9 obtusely pointed (lateral spines on S7-9 sharply pointed, all other species);
237   extreme tips of cerci suddenly and strongly out-turned (extreme tips of cerci slightly divergent,
238   all other species).

239

240   The shape and length/width ratio of the 3rd antennomere and the rounded, smooth tip of the
241   labial palp makes the larva of *E. jannyae* most similar to that of *E. hylaeus*. However, they differ
242   by the larger stature of *E. jannyae* as well as the presence of serrations on the lateral margins of
243   S5-9 and the obtusely pointed lateral spines on S6-9 of this species. Likewise, by the shape and
244   length/width ratio of the 3rd antennomere, the larva of *E. tumefactus* appears related to *crepidus,*
245   *echeverrii, subobtusus,* and *subsimilis,* differing from all these species by the acute tips of its
246   labial palps. In this last feature it could be related to *E. paludosus*, according with the drawing
247   provided by Martins (1968).

248

249   The descriptions here provided would shed light on the relationship of *Epigomphus* with other
250   genera of Gomphidae. Several authors have tried to relate *Epigomphus* to other genera based
251   mainly on adult morphology (e.g., Williamson, 1920), while others have included some larval
252   characters (Carle, 1986; Belle, 1996). According to our present knowledge of the larvae, we
253   think that Carle's (1986) classification best reflects the relationships among the genera that he
254   placed in the subfamily Epigomphinae, excepting the Macrogomphini (*Macrogomphus* only),
255   whose larvae more resemble those of Carl's tribe Gomphoidini. *Epigomphus* is probably closely
256   related to the oriental *Leptogomphus* (tribe Leptogomphini) by the following combination of
257   features: antennae with abundant scale-like setae, dual shape of 3ʳᵈ antennomere; molar lobe of
258   right mandible with formula $a(m^{1-2})b$; shape of prementum, ligula poorly developed and slightly
259   convex; lateral margins of S6-9 serrate, with lateral spines on S7-9; anal pyramid short; sternum
260   3 divided in 5 sternites; the last 3 features are also shared with the larvae of *Heliogomphus*,
261   which also belongs to the Leptogomphini (*sensu* Carle, 1986). However, there are two striking
262   differences between *Leptogomphus* and *Epigomphus* - the presence in the former of a ventral,
263   longitudinal, median sulcus on prementum, and abdominal dorsal protuberances.

264

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

267

268 1- Third antennomere claviform (length/width proportion l.6:1); tip of labial palp rounded and
269   smooth 2
270 1' Third antennomere spindle-shaped (length/width proportion ≥ 2:1); tip of labial palp
271   rounded or acute and finely serrate 3

272

273 2   Lateral margins of prementum slightly sinuate; lateral margins of S5–9 serrate; lateral spines
274   on S6–9 triangular, obtusely pointed (very small on S6, visible only in ventral view);
275   extreme tips of cerci suddenly and strongly out-turned; total length more than 23 mm
276   *jannyae*
277 2' Lateral margins of prementum straight and parallel on apical half; lateral margins of S7–9
278   serrate; lateral spines on S7–9 sharply pointed; tips of cerci slightly divergent; total length
279   less than 23 mm .... *hylaeus*

280

281 3   Tip of labial palp acute; ligula with 6-7 teeth; lateral margins of S6 serrate
282   .... *tumefactus*
283 3' Tip of labial palp rounded; ligula with 8 or more teeth; lateral margins of S6 no serrate   4
284   (continues in original key)

285

286

Conclusion

288

289 *Epigomphus* continues to be a poorly known group, only eight of the 28 species are known as
290 larvae. However, descriptions here provided and comparisons with the literature allow for the
291 assessment of important larval characters useful for the separation of species.

292

293

294

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296

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300

301

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303

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332

333
334   PLATE I Fig. 1. *Epigomphus jannyae,* last stadium exuvia, a) dorsal view, b) ventral view.
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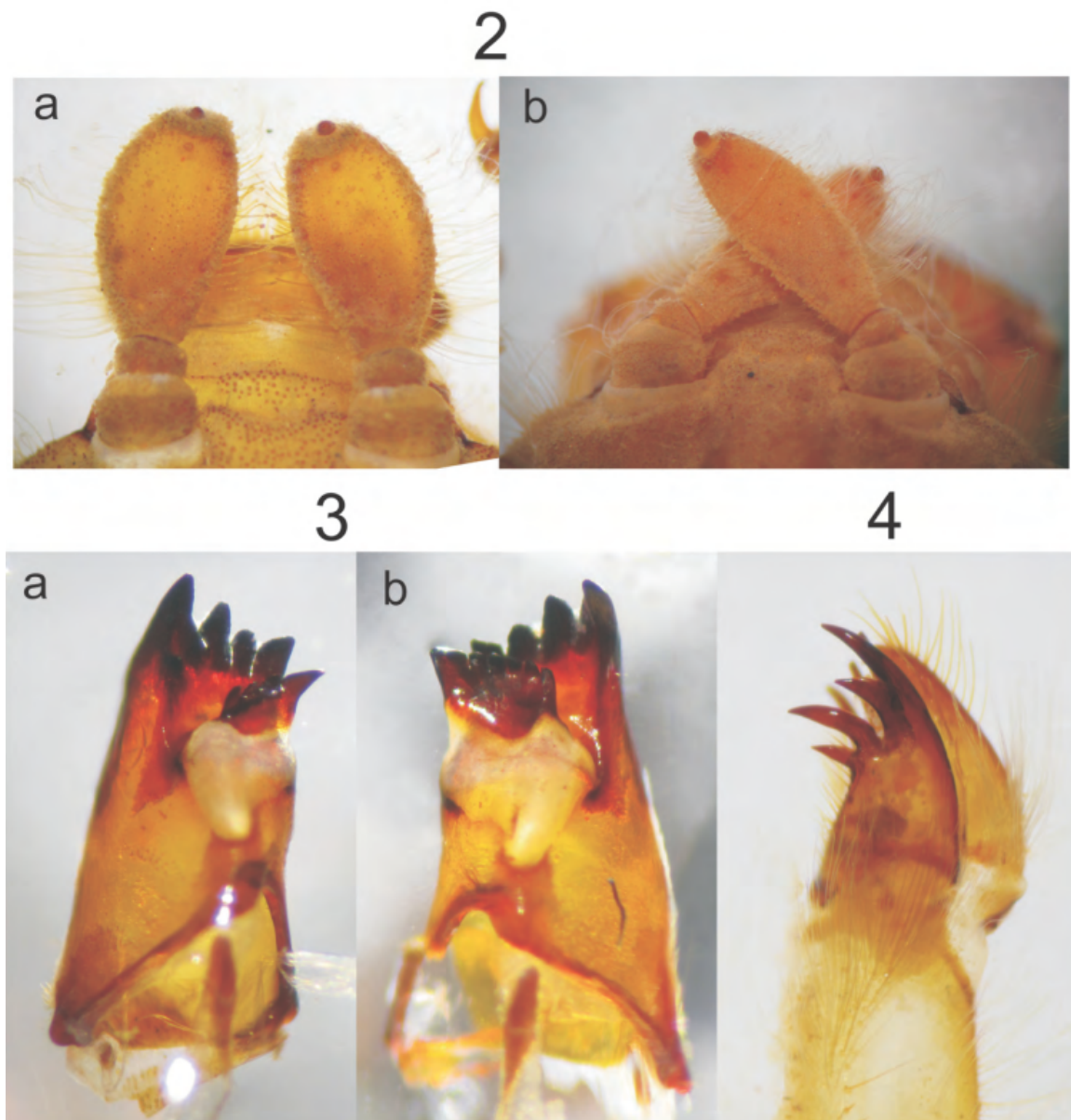
PLATE II. Figs. 2–4. Details of the morphology of *Epigomphus* spp. Fig 2. Dorsal view of antennae, a) *E. jannyae*, b) *E. tumefactus*; Fig. 3. Ventrointernal view of mandibles of *E. jannyae*, a) right mandible, b) left mandible. Fig. 4 Maxilla's galeolacinia of *E. jannyae*, ventral view.

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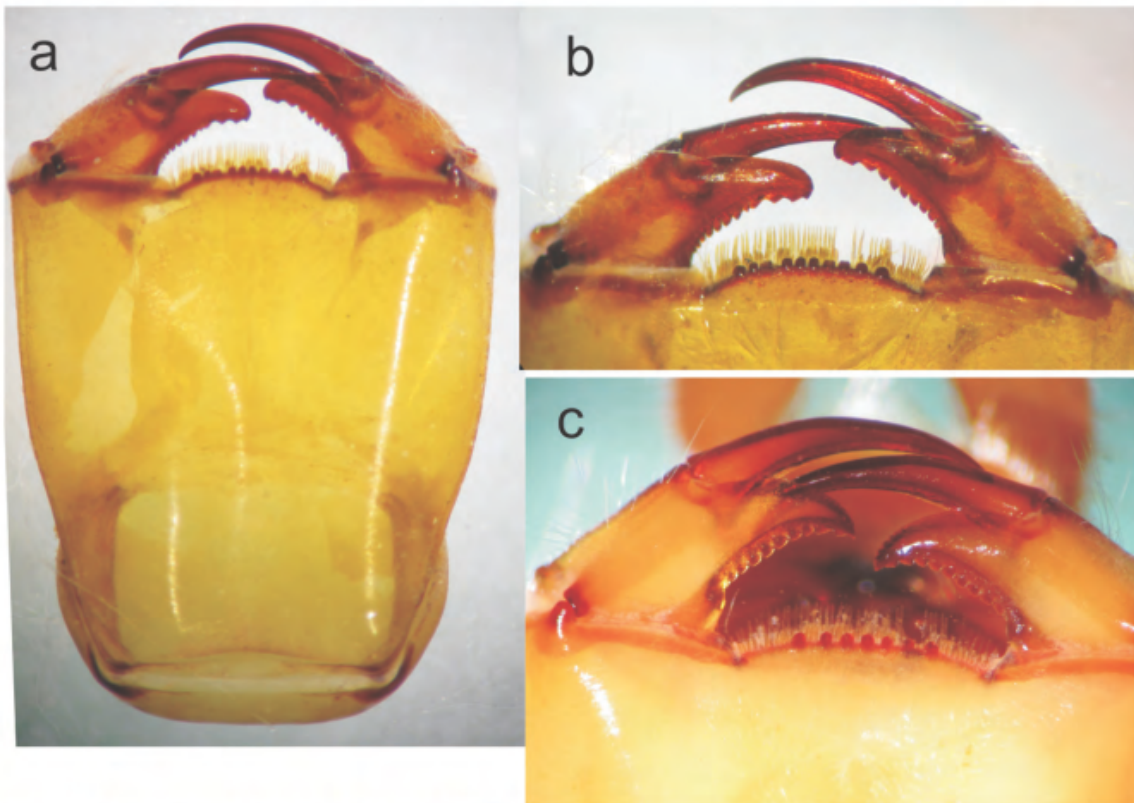
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355   PLATE III. Figs. 5-6. Details of the morphology of *Epigomphus* spp. Fig 5. Prementum, ventral
356   view: a) *E. jannyae*, b) Details of the ligula and labial palpi, *E. jannyae*, c) *Ídem* but *E.*
357   *tumefactus* (note acute tips of palpi). Fig 6. Occipital lobes of the head and prothorax,
358   dorsal view, of *E. tumefactus*.
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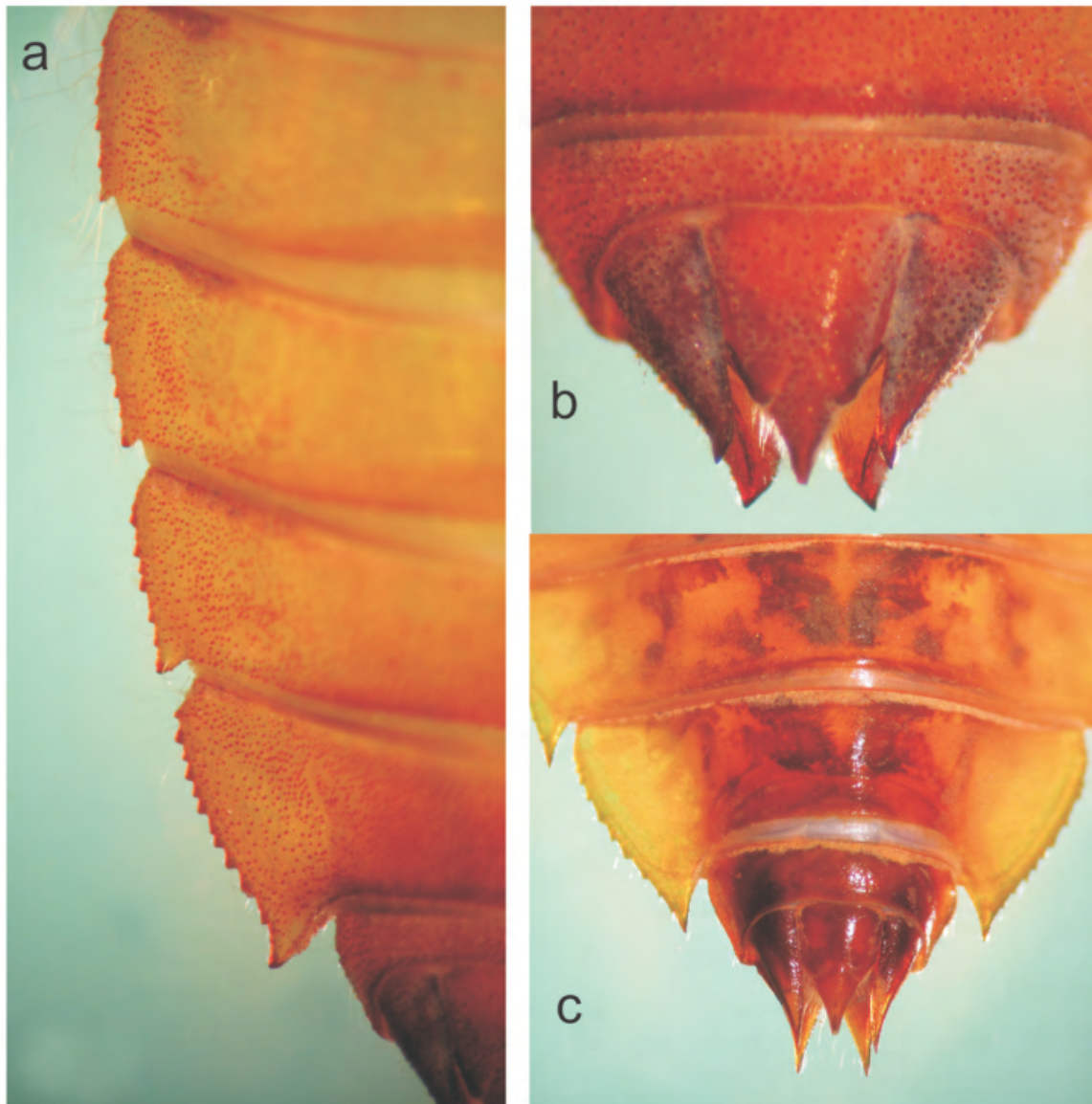
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363 PLATE IV. Fig. 7. Details of the abdomen of *Epigomphus* spp. a) Lateral margins of *E. jannyae*
364   segments 6-9 showing the serrate borders and apical spines; b) Segment 10 and caudal
365   appendages of *E. jannyae* showing the divergent tips of cerci and paraprocts; c) Segments
366   8-10 of *E. tumefactus* showing acute lateral spines on 8-9 and sharply pointed caudal
367   appendages.

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