Taxonomic key for the genera of Elmidae (Coleoptera, Byrrhoidea) occurring in Goiás State, Brazil, including new records and distributional notes

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ABSTRACT. A taxonomic key for the genera of Elmidae (Coleoptera, Byrrhoidea) occurring in Goiás State, Brazil, including new records and distributional notes. Despite their great diversity and high abundance in Neotropical aquatic environments, the fauna of Elmidae remains practically unknown in some areas and even entire biomes in this region. In this work we bring, for the first time, faunistic data for the Elmidae of central Brazil. The aim of this work was to inventory the Elmidae fauna in central, southwestern and southeastern Goiás State, Brazil and to produce a taxonomic key, at genus level, for adults from the studied region. The taxonomic key presented herein offers means for the identification of all the 13 genera known to occur in Goiás, 11 of them being new records for the State. Moreover, the number of named species registered for Goiás increased from one to nine.

KEYWORDS. Cerrado biome; Insecta; Neotropics; Riffle beetles.

The family Elmidae Curtis, 1830 has a cosmopolitan distribution, with about 1,500 species in 149 genera (Slipinski et al. 2011), with two subfamilies: Larainae (LeConte, 1861) and Elminae Curtis, 1830 (Jäch & Balke 2008). Among the water beetle families, Elmidae corresponds to the fourth most specious one (Jách & Balke 2008).

For South America, more than 250 species are known, distributed in 39 genera (Manzo 2005; Manzo & Archangelsky 2008; Maier & Spangler 2011; Segura et al. 2011a), and of these, 29 are Elminae and ten are Larainae. Of the 39 genera, 15 have no larva described (Manzo 2005; Manzo & Archangelsky 2008; Vanin & Costa 2011; Kodada et al. 2012).

Until now, the Brazilian fauna comprises 148 described species of Elmidae and 24 genera (Segura et al. 2011b), with only three genera belonging to Larainae. In Goiás State, only two genera, Hexacycloepus Hinton, 1940 and Austrolimnus Carter & Zeck, 1929, and one species, Austrolimnus (Helonoma) eris Hinton, 1971, had been reported previously to this present study, however, the exact locations of collection sites are uncertain (Brown 1973; Hinton 1971).

Although riffle beetles are recognized in the scientific literature as effective bioindicators of water quality (Brown 1972a; García-Criado & Fernández-Aláez 2001; Elliot 2008), there is a large limitation of knowledge about the family in Brazil, as well as information on biology and its importance in dynamics of aquatic ecosystems (Vanin & Ide 2002; Passos et al. 2007).

The main barrier to study this family in the Neotropics is the outdated taxonomy, with few specialists, besides, the small body size and the environment in which they live (Passos et al. 2007). The lack of taxonomic keys for all regions of Brazil, species lists and current reviews make more complicate an adequate identification of specimens. In addition, there is probably a large number of species not yet known in Brazil (Vanin & Ide 2002; Passos et al. 2007).

The State of Goiás is located in the central zone of Brazil and its predominant biome is the Cerrado, the Brazilian Savanna, and represents the second largest Brazilian biome in terms of area (IBGE 2004; Mittermeier et al. 2004). It is considered one of the 34 world biodiversity hotspots; such classification includes the most threatened and diverse biomes. In the case of the Cerrado, it is estimated that no more than 21.3% of primary vegetation remains, and protected areas correspond to only 5.5% of the total area occupied by the biome (Mittermeier et al. 2004).

With the aim to improve the knowledge concerning the family Elmidae in Brazil, this work provides the first species inventory for central Brazil, based on collections held in central, southwestern and southeastern Goiás State; and a taxonomic key for the identification of adults of the genera occurring in Goiás State, Brazil.

MATERIAL AND METHODS

The collecting was carried out in 43 first to fourth order streams (Strahler 1957) in three different regions of Goiás State; corresponding to the central region, the southwestern region and one stream in southeastern Goiás State (Fig. 1). The first region was sampled from August to October/2008 and June/2010, the second in April/2010 and the third in September/2010.

All samples were fixed with 80% ethanol and stored in microvials in the entomological collection of the Laboratório de Meio Ambiente e Recursos Hídricos (CELAMARH), of the Universidade Federal de Goiás.
The adult specimens were identified to genus level with the aid of the works of Hinton (1940a), Brown (1972a), White & Brigham (1996), Manzo (2005) and Passos et al. (2007). Species identification was based mainly in the works of Hinton (1939, 1940a, 1940b, 1940c, 1940d, 1941, 1945a, 1945b, 1946, 1971, 1972), Brown (1972b), Bug (1973), Spangler & Perkins (1989), Spangler (1990), Spangler & Santiago-Fragoso (1992) and Manzo (2006). For most of the species we were not able to confirm the identifications by checking type material. The main structures observed for the identification and for the development of taxonomic keys are illustrated in Fig. 2.

To obtain the images we used a camera attached to a stereomicroscope, photographs were taken focusing on different levels of the body of the specimens, and overlapped using the software Combine ZP. Measurements were taken with the aid of an ocular micrometer.

RESULTS

A total of 255 adults belonging to 13 genera, Austrolimnius Carter & Zeck, 1929, Cyloepus Erichson, 1847, Gyrelmis Hinton, 1940, Heterelmis Sharp, 1882, Hexacylloepus Hinton, 1940, Macrelmis Motschulsky, 1859, Microcyloepus Hinton, 1935, Neoelmis Musgrave, 1935, Oolimnius Hinton, 1939, Stegoelmis Hinton, 1939, Stenhelmoides Grouville, 1908, Xenelmis Hinton, 1936 and Phanocerus Sharp, 1882, were examined. From these, 85 adults in seven genera (Gyrelmis, Macrelmis, Microcyloepus, Oolimnius, Stenhelmoides, Xenelmis and Phanocerus) belong to eight already known species. With the exception of Phanocerus clavicornis Sharp, 1882, all species collected belong to the subfamily Elminae Curtis, 1830.

Taxonomic key for adults of the Elmidae genera from Goiás State, Brazil

Note. Plastron on the Elmidae genera Stenhelmoides and Stegoelmis differs in general aspect from that of the remaining genera recorded for Goiás. The plastron in both genera confers to the cuticle a grayish and opaque look, very noticeable on dried specimens, distributed both on ventral and dorsal surfaces. In other genera (e.g. Macrelmis, Xenelmis, Gyrelmis, Neoelmis, Microcyloepus, Heterelmis, Hexacylloepus, Cyloepus), the plastron confers a shiny, golden or silver, velvety aspect, and is distributed only on the ventral surface. This difference is due to the microsculpture variation of the plastron among the different genera. The need of SEM micrographs for adequate visualization of the plastron, results in the lack of plastron structure descriptions for many genera. According to Kodada & Jäch (2005), until now, plastron on Elmidae can be classified as being composed by scale-like setae (e.g. Macronychus Müller, 1806, Stegoelmis), flattened hair-like...

1. Microplastron absent. Body densely pubescent (subfamily Larainae). Antennae clavate. Pronotum with a median longitudinal impression and a lateral longitudinal impression extending from the posterior margin until middle length, where it bends toward the lateral margin of (Fig. 3A). 2.0–4.5 mm long ........................... *Phanocerus* Sharp, 1882

2. (1') Pronotum and elytra covered with plastron (confers to 1') Microplastron present. Body not pubescent, except for tomentum on legs or small isolated areas (subfamily Elminae). Antennae filiform. Pronotum may have variable impressions, but not with pattern described above ... 2

2'. Pronotum and elytra without plastron (cuticle shiny, very noticeable on dried specimens). Elytra without carinae .................................................. 3

3. (2) Pronotum without plastron on the median area, forming a shiny longitudinal band of variable size; without protuberances or gibbosities. Elytra without protuberances, with punctures usually indifferent (Fig. 3B). 2.0–4.5 mm long ........................... *Stenhelmoidea* Grouvelle, 1908

3'. Pronotum entirely covered with plastron; pronotum with protuberances and gibbosities on basal 1/2, usually four, distributed in a transverse row. Elytron with a robust and short spine-like protuberance, near the posterolateral margin; with distinct punctures (Fig. 3C). 3.8–5.6 mm long ........................... *Stegoelmis* Hinton, 1939

4. (2') Elytra with a short accessory stria at base, between the first and second stria (Figs. 3D, E). 2.8–6.0 mm long ........................... *Macrelmis* Motschulsky, 1859

4'. Elytra without accessory stria .......................................................... 5

5. (4') Epipleura with granules arranged in one or two well defined lines (Fig. 3F). Pronotum without transverse impression (Fig. 3G). 1.0–2.0 mm long ........................... *Austrolimnius* Carter & Zeck, 1929

5'. Epipleura with or without granules, if present, arranged randomly, not forming definite lines .............................. 6

6. (5') Pronotum without impressions .......................................................... 7

6'. Pronotum with impressions ...................................................... 9

7. (6) Pronotum generally without sublateral carinae and, if present, composed of line of granules, extending from base to about apical 1/4 (Fig. 3H). 1.2–2.2 mm long ........................... *Xenelmis* Hinton, 1936

7'. Pronotum always with sublateral carinae, never composed of line of granules .......................................................... 8

8 (7') Pronotal disc without granules. Elytra with two sublateral carinae in the fifth and seventh intervals, never composed of line of granules (Fig. 3I). 1.4–2.9 mm long

8'. *Gyrelmis* Hinton, 1939

9. (6') Pronotum with complete transverse impression or restricted to the lateral margin of the pronotum ...................... 10

9'. Pronotum with or without transverse impression, if present, restricted to median region .......................... 11

10. (9) Pronotum without median longitudinal impression; often with complete transverse impression. Elytra generally with one sublateral carinae (Fig. 4A). Epipleura with plastron (Fig. 4B). 1.3–2.7 mm long ........................... *Oolimnius* Musgrave, 1935

10'. Pronotum with median longitudinal impression, U-shaped on posterior 4/5; with oblique impression on each side. Elytra with two sublateral carinae, rarely with one (Fig. 4C). Epipleura without plastron (Fig. 4D). 0.6–2.3 mm long ........................... *Microcylloepus* Hinton, 1935

11. (9') Pronotum with transverse impression on median region, and oblique impression on basal 1/3 (Fig. 4E). 1.8–4.0 mm long ........................... *Heterelmis* Sharp, 1882

11'. Pronotum without transverse or oblique impressions .......................... 12

12 (11'). Hypomeron generally without plastron, if present, restricted to a small area adjacent to anterior coxa, but never forming a band (Fig. 4H). 2.3–4.6 mm long ........................... *Hexacylloepus* Hinton, 1940 (Fig. 4F)

12'. Hypomeron generally without plastron, if present, restricted to a small area adjacent to anterior coxa, but never forming a band (Fig. 4I). 1.5–2.3 mm long ........................... *Cylloepus* Erichson, 1847 (Figs. 2A, B)

**Checklist of species of Elmidae in Goiás State, Brazil**

*Elminae Curtis, 1830*

**Austrolimnius** Carter & Zeck, 1929 (Figs. 3F, G)

Two unidentified morphospecies collected. One in Goiás: Jaraguá, 1 ex. One in Goiás: Rio Verde, 1 ex.

**Austrolimnius (Helonoma) eris** Hinton, 1971

BRAZIL: Goiás: Rio Chim; Goiás: Mosquito, Retiro (Hinton 1971). Distribution. Known from Argentina, Brazil, Guatemala, Mexico and Panama (Hinton 1971; Manzo 2007). This species was not found in the present study, its presence in Goiás being known only from previous records by Hinton (1971).

**Cylloepus** Erichson, 1847 (Figs. 2A, 2B, 4H)

Two unidentified morphospecies collected. One in Goiás: Jaraguá, 2 ex. and Goiás: Morro Agudo de Goiás, 1 ex. One in Goiás: São Francisco de Goiás, 5 ex., Goiás: Jaraguá, 1 ex., Goiás: Itapuranga, 6 ex., Goiás: Morro Agudo de Goiás, 1 ex. and Goiás: Rio Verde, 1 ex.

**Gyrelmis** Hinton, 1940 (Fig. 3I)

One unidentified morphospecies collected. Goiás: Rio Verde, 1 ex.
**Gyrelmis brunnea** Hinton, 1940


Other locations in Brazil. Pará: Belém, Estrada de Ferro de Bragança (Hinton 1940b, Passos et al. 2010).

Distribution. Known from Brazil and French Guiana (Hinton 1940b; Passos et al. 2010).

**Gyrelmis rufomarginata** (Grouvelle, 1888)

[= *Helmis rufo-marginata* Grouvelle, 1888]
[= *Heterelmis rufomarginata* Hinton, 1936]
[*Gyrelmis rufomarginata basalis* Hinton, 1940 – according to Delève (1970)]
[*Gyrelmis rufomarginata rufomarginata* (Grouvelle, 1888) – according to Delève (1970)]
[*Gyrelmis rufomarginata thoracica* Hinton, 1940 – according to Delève (1970)]


**Heterelmis** Sharp, 1882 (Fig. 4E)


**Hexacylloepus** Hinton, 1940 (Figs. 4F, G)

Three unidentified morphospecies collected. One in Goiás: Santa Isabel, 2 ex. One in Goiás: São Francisco de Goiás, 1 ex., Goiás: Itapuruanga, 3 ex. and Goiás: Morro Agudo de Goiás, 1 ex. One in Goiás: Rio Verde, 3 ex.

**Macrelmis** Motschulsky, 1859 (Figs. 3D, E)

Three unidentified morphospecies collected. One in Goiás: São Francisco de Goiás, 8 ex., Goiás: Morro Agudo de Goiás, 1 ex., Goiás: Goianésia,
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**Macrelmis isis** (Hinton, 1946)

[= *Elslius isus* Hinton, 1946]

BRAZIL: Goiás: Santa Isabel, 15°21'24.1"S, 49°22'44"W, 1 ex., sampling nets (2.0 mm mesh), rocks, August to October 2008, B. S. Godoy leg.; Itaberai, 16°9'44.8" S, 50°2'5.4" W, 1 ex., sampling nets (2.0 mm mesh), rocks and submerged vegetation, August to October 2008, B. S. Godoy leg.; Jaraguá, 15°44'11.8"S, 49°28’38.4”W, 2 exs., sampling nets (2.0 mm mesh), litter submerged, August to October 2008, B. S. Godoy leg.; Itapuranga, 15°36'29.6"S, 49°49'41.6"W, 1 ex., sampling nets (2.0 mm mesh), litter submerged, August to October 2008, B. S. Godoy leg.; Morro Agudo de Goiás, 15°21'33.3"S, 49°56'2.7"W, 1 ex., sampling nets (2.0 mm mesh), rocks and litter submerged, August to October 2008, B. S. Godoy leg.; Goianésia, 15°28’55.8”S, 49°7’2.6"W, 1 ex., sampling nets (2.0 mm mesh), rocks, August to October 2008, B. S. Godoy leg.; Pirenópolis, Córrego Vagafogo, 15°50’50”S, 49°0’W, 4 exs., sampling nets (2.0 mm mesh), 22 June 2010, A. S. Fernandes leg.; Rio Verde, 17°58’39.8”S, 51°0’W, 1 ex., sampling nets (2.0 mm mesh), litter submerged, 7–11 April 2010, A. S. Fernandes, F. F. Barbosa and L. F. R. Holanda leg.; Rio Verde, 18°9’16.3”S, 50°34’38.9”W, 1 ex., sampling nets (2.0 mm mesh), rocks, 7–11 April 2010, A. S. Fernandes, F. F. Barbosa and L. F. R. Holanda leg.; Goianésia, 15°28’55.8”S, 49°7’2.6”W, 1 ex., sampling nets (2.0 mm mesh), rocks, August to October 2008, B. S. Godoy leg.; Santo Antônio da Barra, 17°32’25.5”S, 50°37’39.6”W, 1 ex., sampling nets (2.0 mm mesh), rocks, 7–11 April 2010, A. S. Fernandes, F. F. Barbosa and L. F. R. Holanda leg.; Other locations in Brazil. Santa Catarina: Nova Teutonia (Hinton 1946; Brown 1984).

Distribution. Known from Argentina, Bolivia, Brazil and Paraguay (Hinton 1946; Brown 1984; Manzo & Archangelsky 2001, 2008; Shepard & Aguilar 2010).

**Microcylloepus hintoni**, 1935 (Figs. 4C, D)

Two unidentified morphospecies collected. One in Goiás: Morro Agudo de Goiás, 1 ex. One in Goiás: Pirenópolis, 1 ex.

**Microcylloepus inaequalis** (Sharp, 1882)

[= *Limmius mexicanus* Hinton, 1934]

[= *Microcylloepus mexicanus* Hinton, 1935]

BRAZIL: Goiás: Santa Isabel, 15°19’18.9”S, 49°24’29.2”W, 8 exs., sampling nets (2.0 mm mesh), rocks and litter submerged, August to October 2008, B. S. Godoy leg.; Santa Isabel, 15°21’24.1”S, 49°22’44”W, 2 exs., sampling nets (2.0 mm mesh), rocks, August to October 2008, B. S. Godoy leg.; Santo Antônio da Barra, 17°32’25.5”S, 50°37’39.6”W, 1 ex., sampling nets (2.0 mm mesh), rocks, 7–11 April 2010, A. S. Fernandes, F. F. Barbosa and L. F. R. Holanda leg.; Other locations in Brazil. Santa Catarina: Nova Teutonia (Hinton 1946; Brown 1984).

Distribution. Known from Argentina, Bolivia, Brazil and Paraguay (Hinton 1946; Brown 1984; Manzo & Archangelsky 2001, 2008; Shepard & Aguilar 2010).
Isabel, 15°10′6.7″S, 49°27′3″W, 1 ex., sampling nets (2.0 mm mesh), litter submerged, August to October 2008, B. S. Godoy leg.; Itaberlai, 16°9′44.8″S, 50°2′5.4″W, 1 ex., sampling nets (2.0 mm mesh), litter submerged, August to October 2008, B. S. Godoy leg.; São Francisco de Goiás, 15°56′51.7″S, 49°16′35.8″W, 1 ex., sampling nets (2.0 mm mesh), submerged vegetation, August to October 2008, B. S. Godoy leg.; São Francisco de Goiás, 15°58′16.5″S, 49°18′39.5″W, 1 ex., sampling nets (2.0 mm mesh), rocks, August to October 2008, B. S. Godoy leg.; Goianésia, 15°30′4″S, 49°12′39.5″W, 2 exs., sampling nets (2.0 mm mesh), litter submerged, August to October 2008, B. S. Godoy leg.; Goianésia, 15°14′51.8″S, 49°04′55.5″W, 1 ex., sampling nets (2.0 mm mesh), rocks, August to October 2008, B. S. Godoy leg.; Goianésia, 15°9′36.1″S, 48°57′23.6″W, 4 exs., sampling nets (2.0 mm mesh), litter submerged and submerged vegetation, August to October 2008, B. S. Godoy leg.; Goianésia, 15°14′39.9″S, 49°11′29″W, 1 ex., sampling nets (2.0 mm mesh), litter submerged and submerged vegetation, August to October 2008, B. S. Godoy leg.; Goianésia, 15°25′23″S, 49°51′41.5″W, 1 ex., sampling nets (2.0 mm mesh), litter submerged, 6 September 2010, A. S. Fernandes, B. S. Godoy, F. F. Barbosa and L. F. R. Holanda leg.

Other locations in Brazil. Santa Catarina: Nova Teutonia (Hinton 1937, 1940a); Amazonas: Presidente Figueiredo, Igarapé da Onça, Recanto da Pantera; Sítio Dr. S. H. J. Passos (Passos et al. 2010); Rio de Janeiro: Angra dos Reis, Cachoeiras de Macacu, Guapimirim, Itatiaia, Macaé, Nova Friburgo, Parati, Rio de Janeiro, Teresópolis (Passos et al. 2009).

Distribution. Known from Belize, Brazil, Costa Rica, Cuba, Dominican Republic, Guatemala, Haiti, Honduras, Jamaica, Mexico, Panama, Puerto Rico and USA (Darlington 1936; Hinton 1937, 1940a, Passos et al. 2009, 2010; Schaeffer 1911; Sharp 1882; Spangler 1973, 1981; Spangler & Santiago-Fragoso 1992).

**ACKNOWLEDGMENTS**

This study provides, for the first time, information focusing in the taxonomy of Elmidae from the Goiás State, in Brazil. The number of recorded genera for Goiás state increased from two to 13. From the 24 known genera in Brazil, eleven of them remain unknown from Goiás (Segura et al. 2011b). The number of named species of Elmidae recorded for Goiás increased from one to nine (Brown 1973; Hinton 1971), and *Austrolimnius (Helonomia) eris* Hinton, 1971, the only previously recorded species in Goiás State (Hinton 1971), was not found in this study.

Four species (*Gyrelmis rufomarginata*, *Macrelmis isis*, *Microcloepus inaequalis*, and *Oolimnius salitii*) were reported previously for Santa Catarina (Hinton 1939, 1940b, 1946), one (*Gyrelmis brunnea*), for Pará (Hinton 1940b), one (*Phanocerus clavicornis*) for Santa Catarina, Amazonas and Rio de Janeiro states (Hinton 1940a; Passos et al. 2010) and one (*Stenhelmoides strictifrons*) for Mato Grosso, Pará and São Paulo states (Passos et al. 2010; Spangler & Perkins 1989).

*Xenelmis uruzuensis*, first described for Argentina and recorded also for Paraguay (Manzo 2006; Shepard & Aguilar 2010), is recorded in Brazil for the first time here. This record may indicate a very wide distributional range for the species, perhaps occurring in many localities and distributed along the entire southern half of South America.

It is essential that new taxonomic studies of Elmidae in other locations of Goiás State and Brazil, other drainage basins and aquatic habitats not yet explored, be performed, aimed at expanding our knowledge and understanding the geographical distribution status of this family in Brazil.

**DISCUSSION**

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