



<http://dx.doi.org/10.11646/zootaxa.4012.1.5>

<http://zoobank.org/urn:lsid:zoobank.org:pub:29BAC0D7-D4F5-4882-A803-4EC67C45D602>

## Taxonomic revision of *Chironius flavolineatus* (Jan, 1863) with description of a new species (Serpentes: Colubridae)

BRENO HAMDAN<sup>1,2,3,5</sup> & DANIEL S. FERNANDES<sup>2,4</sup>

<sup>1</sup>Laboratório de Coleções Biológicas e Biodiversidade, Instituto Vital Brazil, Rua Maestro José Botelho, 64, Vital Brazil, Niterói, 24230-410, Rio de Janeiro, Brazil

<sup>2</sup>Laboratório de Répteis, Departamento de Zoologia, Instituto de Biologia, Centro de Ciências da Saúde, Universidade Federal do Rio de Janeiro, Rio de Janeiro, 21941-902, Rio de Janeiro, Brazil

<sup>3</sup>Laboratório de Biologia Evolutiva Teórica e Aplicada, Departamento de Genética, Instituto de Biologia, Centro de Ciências da Saúde, Universidade Federal do Rio de Janeiro, Rio de Janeiro, 21941-617, Rio de Janeiro, Brazil

<sup>4</sup>Departamento de Vertebrados, Museu Nacional, Universidade Federal do Rio de Janeiro, Quinta da Boa Vista, Rio de Janeiro, 20940-040, Rio de Janeiro, Brazil

<sup>5</sup>Corresponding author. E-mail: [hamdanbreno@gmail.com](mailto:hamdanbreno@gmail.com)

### Abstract

We conducted a taxonomic review of *Chironius flavolineatus* on the basis of continuous and discrete morphological characters. We recognize a new species which is distinguished from all currently recognized congeners by the following unique combination of characters: first third of body black or dark gray; vertebral stripe yellowish or creamish white distinct from dorsals of nape and extending throughout almost whole body length; head dorsum tan to brown, distinct from background color of first third of body; posterior temporal scales ranging one to four; cloacal shield frequently divided; two to four rows of keeled dorsal scales at midbody; venter ground color gradually darkening towards cloaca; region of medial constriction of hemipenis slightly covered with spinules separating calyces of apex from spines below region of constriction; in lateral view, sulcus spermaticus positioned on convex face of hemipenis; ascending process of premaxilla oblique anteroposteriorly to longitudinal axis of skull; optic fenestrae not exceeding frontoparietal suture; posterior border of supratemporal exceeding braincase; dorsoventral axis of quadrate oblique mesolaterally, moving away from longitudinal axis of skull. Furthermore, we provide data on morphological variation, distribution, and an emended diagnosis for *C. flavolineatus*.

**Key words:** morphological variation, External morphology, Skull, Cephalic glands, Hemipenis

### Resumo

Conduzimos uma revisão taxonômica de *Chironius flavolineatus* utilizando caracteres morfológicos contínuos e discretos. Nós reconhecemos uma nova espécie, a qual é distinguida da demais congêneres pela combinação única dos seguintes caracteres: primeiro terço do corpo preto ou cinza escuro; faixa vertebral amarelada ou esbranquiçada, distinta desde as primeiras escamas dorsais da nuca e estendendo-se por praticamente toda a extensão do corpo; dorso da cabeça pardo ou marrom, distinto da coloração de fundo do primeiro terço do corpo; uma a quatro escamas temporais posteriores; escudo cloacal frequentemente dividido; duas a quatro fileiras de escamas dorsais quilhadas no meio do corpo; coloração do ventre escurecendo gradativamente em direção à cloaca; região da constrição medial do hemipênis levemente recoberta por espinulas separando os cálices do ápice do órgão dos espinhos na região abaixo da constrição; em vista lateral, sulco espermático posicionado na face convexa do hemipênis; processo ascendente do pré-maxilar anteroposteriormente oblíquo ao eixo longitudinal do crânio; fenestras ópticas não ultrapassam sutura frontoparietal; borda posterior do supratemporal ultrapassa a caixa craniana; eixo dorsoventral do quadrado oblíquo mesolateralmente, afastando-se do eixo longitudinal do crânio. Além disso, nós fornecemos dados de variação morfológica, distribuição e uma emenda à diagnose de *C. flavolineatus*.

**Palavras chave:** Variação morfológica, Morfologia externa, Crânio, Glândulas cefálicas, Hemipenis

## Introduction

Racers of the genus *Chironius* Fitzinger, 1826 comprise 21 currently recognized species (Hollis 2006; Kok 2010; Klaczko *et al.* 2014; Wallach *et al.* 2014; Fernandes & Hamdan 2014) widely distributed in Central and South America (Dixon *et al.* 1993; Hollis 2006; Kok 2010).

Bailey (1955) conducted the first taxonomic revision of the genus and recognized seven taxa including a new subspecies, *Chironius multiventris foveatus*. Later Dixon *et al.* (1993) performed a comprehensive systematic revision of *Chironius*, presenting data on meristic, morphometric, color pattern, and hemipenial characters. These authors proposed the first hypothesis of phylogenetic relationships of the genus, although not employing a cladistic methodology, and described four new taxa. Hollis (2006) proposed the first cladistic hypothesis of phylogenetic relationships of representatives of the genus *Chironius* also based on morphological data. Klaczko *et al.* (2014) performed combined morphological and molecular phylogenetic analyses and corroborated the *Chironius* monophyly as previously hypothesized by Dixon *et al.* (1993) and Hollis (2006).

*Chironius flavolineatus* (Jan, 1863) is characterized by a conspicuous bright yellow vertebral stripe bordered anteriorly by black (Boettger 1885; Boulenger 1894; Bailey 1955; Dixon *et al.* 1993). Hamdan *et al.* (2014) corroborated the authorship of *Chironius flavolineatus* to Jan (1863) and designated a lectotype for the species.

According to literature, *C. flavolineatus* occurs in lowlands of Peru (Lehr 2002) and throughout open formations of Bolivia, Paraguay, and Brazil (Bailey 1955; Dixon *et al.* 1993). The taxon was described based on two specimens and no detailed further analysis of morphological variation was performed despite its wide distribution (Bailey 1955; Dixon *et al.* 1993). Dixon *et al.* (1993) just noted that specimens from Bolivia show meristic characters statistically different from specimens distributed in central and southern Brazil, but they took no taxonomic decision. Furthermore, the authors provided no comments on populations from Paraguay, Peru, and Brazil. Moreover, Fernandes & Hamdan (2014) described a new species, *Chironius diamantina*, and reported that specimens of the later taxon were previously identified as *C. flavolineatus* in collections, revealing that the specific limits of *C. flavolineatus* were overestimated.

The above mentioned morphological variation in addition to personal observations in field trips led us to test whether specimens commonly identified as *Chironius flavolineatus* correspond to one or more evolutionary lineages.

## Material and methods

Specimens and additional material (hemipenes, cephalic glands, and skulls) examined are listed in Appendix (for data and material examined of *C. diamantina* see Fernandes & Hamdan 2014). Institutional abbreviations follow Sabaj Pérez (2014), except for Coleção Científica de Serpentes Instituto Vital Brazil (IVB), Niterói, RJ, Brazil; Museu de Zoologia da Universidade Estadual de Santa Cruz (MZUESC), Ilhéus, BA, Brazil; Coleção Herpetológica da Universidade Federal do Ceará (CHUFC), Fortaleza, CE, Brazil; Coleção Herpetológica da Universidade Federal do Rio Grande do Norte (CLAR), Natal, RN, Brazil; Coleção Herpetológica da Universidade Federal de Sergipe (UFS), Aracaju, SE, Brazil.

We follow Peters (1964) for the terminology of cephalic shields, Dowling (1951) for the method of counting ventral and subcaudal scales, and Dixon *et al.* (1993) for the biometric measurements. We follow Pesantes (1994) for hemipenes preparation. During the process of hemipenis eversion we immersed the organ in alcoholic solution of Alizarin Red until the spines and other calcified structures of the hemipenes become stained, a procedure originally described by Uzzel (1973) and modified by Nunes *et al.* (2012). We follow Zaher (1999) for hemipenial terminology. We removed skin of the head for study muscles and cephalic glands and follow the terminology used by Zaher (1997) for these structures. We follow Hangay & Dingley (1985) for skulls preparation and Cundall & Irish (2008) for osteological nomenclature. We photographed hemipenes, skulls, and cephalic glands with a digital camera Olympus DP25 attached to a binocular stereoscopic microscope Olympus SZX7. We measured total (CT), snout–vent (SVL), and caudal length (CL) with a flexible ruler to the nearest 1.0 mm. We used a dial caliper to the nearest 0.05 mm for head length (HL), head width (HW), rostro–orbital distance (RD), rostro–orbital width (RW), midbody width (MW), and midbody height (MH). We measured head scales only on the right side of the head according to Fernandes & Hamdan (2014). We examined the following qualitative characters: presence of dorsal

apical pits on anterior (PA), at midbody (PM), or posterior (PP) region of the body, and tail (PT), the later counted at a distance of one head posterior to cloaca; condition of cloacal shield (entire or divided). We obtained data on color pattern through direct observation of preserved and, occasionally, live specimens. Sex was determined through a ventral incision at the base of the tail. We compared data from specimens examined with literature data from Bailey (1955), Dixon *et al.* (1993), Hollis (2006), Kok (2010), and Klaczko *et al.* (2014).

**Concept and criteria for delimiting species.** We here adopt the general lineage concept of species (De Queiroz 2007) considering species as unique evolving metapopulation lineages. The limits of a given species are herein established allowing some level of polymorphism in the diagnostic characters as stated by Wiens & Servedio (2000). Therefore, if an OTU (see “Statistical analysis”) shows a unique combination of one or more state(s) of character(s) distributed in 95% or more of its representatives we considered this OTU as a valid species. Thus, hereafter the term “frequently” corresponds to a state of a given character occurring at minimum frequency of 95%.

**Statistical analysis.** Based on previous observations of general color pattern, specimens were partitioned into two operational taxonomic units (OTUs), Morphotype “A”: represent specimens with general ground color of body light brown and venter white, and Morphotype “B”: represent polychromatic specimens with general ground color of body dark brown to blackish and venter blackish. We conducted analyses of variance to study variation between and within each defined morphotype (Zar 1999). In parallel, we performed principal components analysis (PCA) to evaluate distribution of specimens in multivariate space without *a priori* definition of morphotypes.

In order to assess the presence of sexual dimorphism we employed the Student *t* test. Assumptions of univariate normality and homoscedasticity were evaluated with Kolmogorov-Smirnov and Levene’s test, respectively. We performed statistical tests with a significance level of 0.05 using the software Statistica 7.0 (Statsoft 2010). Males and females with SVL larger than 507 mm and 606 mm, respectively, were considered mature according to Pinto *et al.* (2010). Mature and immature specimens were analyzed separately, except for meristic characters, to avoid possible bias due to ontogenetic variation. The following characters were employed in statistical analyses: SVL, CL, HL, HW, RD, RW, MW, and number of ventrals, subcaudals, number of rows of keeled dorsal scales at midbody, and maxillary teeth. The relative frequency of occurrence of each state of a given character (percentage) for each of OTUs is presented in brackets followed by the total sample size (*n*).

## Results

We examined 289 specimens from Brazil, Bolivia, and Paraguay comprising 149 localities (see Appendix). The PCA was unable to differentiate the morphotypes and most of the analyzed characters showed a high degree of polymorphism. The comparative analysis of nine cephalic glands and associated muscles from morphotypes A and B showed no significant differences. Nonetheless, morphotype A showed sexual dimorphism in the number of ventrals ( $t=7.65$ ;  $df=170$ ;  $p<0.01$ ;  $n=172$ ) and subcaudal scales ( $t=-2.95$ ;  $df=128$ ;  $p<0.05$ ;  $n=130$ ), while morphotype B showed dimorphism only in the number of ventral scales ( $t=-5.12$ ;  $df=72$ ;  $p<0.01$ ;  $n=74$ ).

Eight characters relative to skull morphology, hemipenis, and ventral ground color showed fixed states (frequencies  $\geq 95\%$ ) uniquely distributed between each one of the two morphotypes. Comparisons of these characters for each morphotype are showed in Table 1. Moreover, females ( $t=-3.18$ ;  $p<0.05$ ;  $n=140$ ) and males ( $t=2.45$ ;  $p<0.05$ ;  $n=106$ ) of both morphotypes differed significantly in the number of ventral scales, despite some overlapping (Table 2).

The unique combination of such fixed traits in each morphotype revealed they actually represent two distinct species. Comparing the examined representatives of both morphotypes with the lectotype of *C. flavolineatus* (MSNM Re2729) (see Hamdan *et al.* 2014), we concluded that morphotype A actually represents *C. flavolineatus* by sharing the ventral ground color uniformly creamish white (*vs.* ventral ground color gradually darkening towards cloaca as found in the morphotype B). The combination of states of characters showed by the representatives of morphotype B is not suitable for any other species of the genus *Chironius* (see below in comparisons) and, therefore, we concluded that this taxon represents a new species that we intent to describe herein.

**TABLE 1.** Occurrence of characters states in the morphotypes A and B with frequencies equal or higher than 95%.

Characters	Morphotype A Character states / Frequency	Morphotype B
Ventral ground color	Uniformly creamish white / 100%, <i>n</i> = 195	Gradually darkening anteroposteriorly / 100%, <i>n</i> = 78
Sulcus spermaticus orientation	Concave face of hemipenis / 100%, <i>n</i> = 7	Convex face of hemipenis / 100%, <i>n</i> = 7
Medial constriction of hemipenis	Without spinules / 100%, <i>n</i> = 7	Covered with spinules / 100%, <i>n</i> = 7
Ascending process of premaxilla	Perpendicular to longitudinal axis of skull / 100%, <i>n</i> = 5	Oblique anteroposteriorly to longitudinal axis of skull / 100%, <i>n</i> = 6
Optic fenestra	Exceeding frontoparietal suture / 100%, <i>n</i> = 5	Not exceeding frontoparietal suture / 100%, <i>n</i> = 6
Posterior border of supratemporal	Not exceeding braincase / 100%, <i>n</i> = 5	Exceeding braincase / 100%, <i>n</i> = 6
Dorsoventral axis of quadrate	Straight mesolaterally / 100%, <i>n</i> = 5	Oblique mesolaterally / 100%, <i>n</i> = 6

## Taxonomy

### *Chironius flavolineatus* (Jan, 1863)

*Herpetodryas carinatus* var. *flavolineata*: Jan 1863:80.

*Herpetodryas flavolineatus*—Boettger 1885:234.

*Herpetodryas carinatus* var. *flavolineata*—Boettger 1898:55.

*Chironius flavolineatus*—Bailey 1955:13 [*partim*]; Peters & Orejas-Miranda 1970:60 [*partim*]; Dixon *et al.* 1993:112 [*partim*]; Hamdan *et al.* 2014:139.

**Lectotype.** Adult male, MSNM Re2729, from Brazil without specific locality (see Hamdan *et al.* 2014 for additional informations).

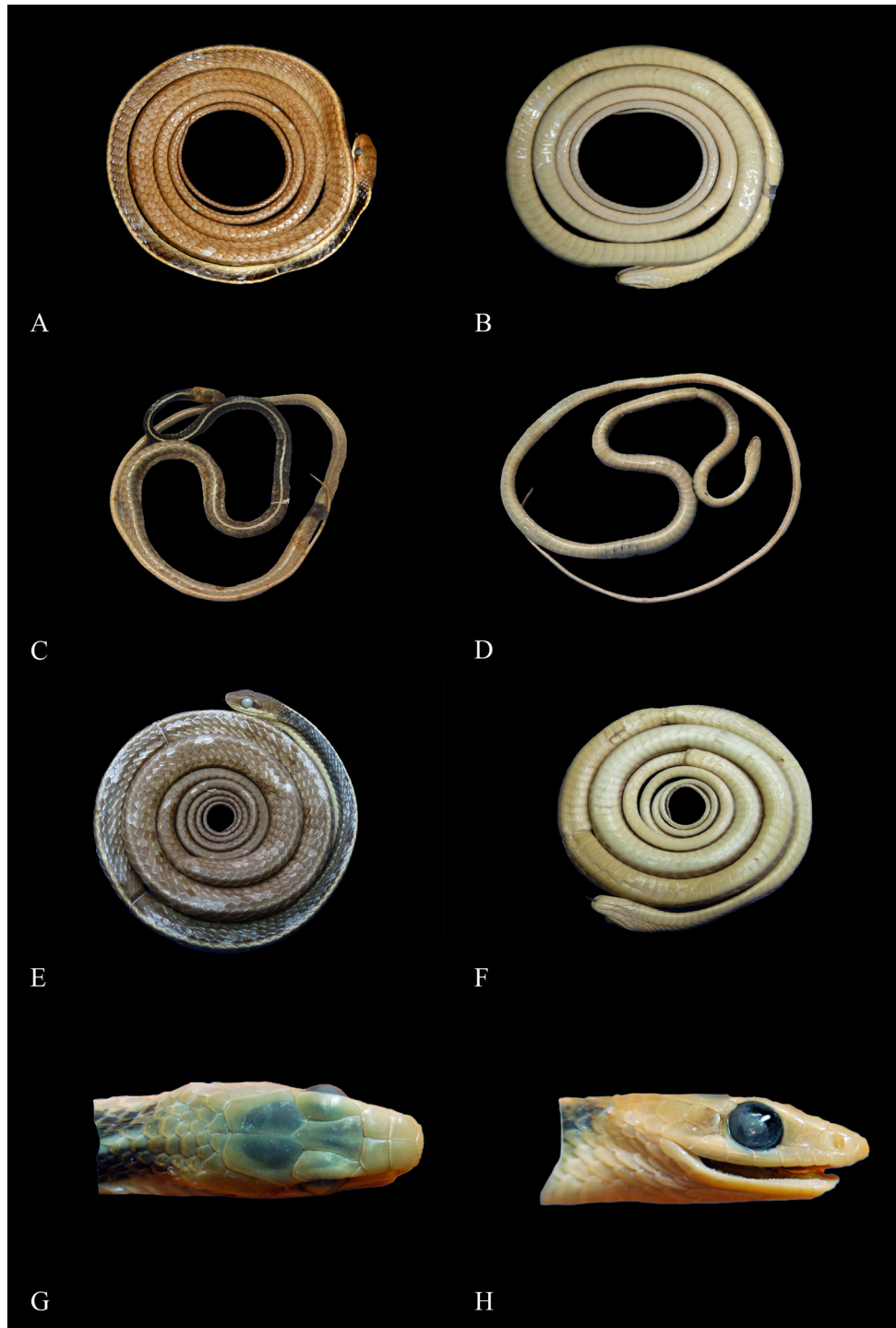
**Diagnosis.** *Chironius flavolineatus* can be distinguished from all congeners by the following unique combination of states of character: first third of body black or dark gray; vertebral stripe yellowish or creamish white, distinct from dorsals of nape and extending throughout almost whole body length; head dorsum tan to brown, distinct from background color of first third of body; posterior temporal scale one; cloacal shield divided; maximum of two rows of keeled dorsal scales at midbody; ventral ground color completely creamish white or yellowish without ornamentation; dark longitudinal stripes (in “zigzag”) along midventral portion of subcaudals absent; hemipenis with no spinules separating calyces of apex from spines below region of constriction on asulcate side; sulcus spermaticus positioned on concave face of hemipenis in lateral view; ascending process of premaxilla perpendicular to longitudinal axis of skull; optic fenestra exceeding frontoparietal suture; posterior border of supratemporal not exceeding braincase; dorsoventral axis of quadrate straight, not moving away from longitudinal axis of skull.

**Comparisons.** *Chironius flavolineatus* is distinguished from all currently recognized congeners, except *C. diamantina*, by having first third of body black or dark gray, vertebral stripe yellowish or creamish white, distinct from dorsals of nape and extending throughout almost whole body length, and head dorsum tan to brown distinct from background color of first third of body. *Chironius flavolineatus* differs from *Chironius diamantina* (character states in parentheses) by having posterior temporals frequently one (*vs.* two to four); cloacal shield divided (*vs.* entire); number of rows of keeled dorsal scales at midbody 0–4 (*vs.* 6–10 rows of keeled dorsal scales at midbody); ventral and subcaudal scales creamish white without pigmentation (*vs.* ventral scales with dark edges forming conspicuous transverse bars virtually throughout whole belly and conspicuous dark longitudinal stripes in “zigzag” at midventral suture of subcaudals).

**Color pattern variation in preservative (alcohol 70%, Fig. 1).** Dorsum of head tan to brown, distinct from background color of first third of body, which is black or dark gray. A yellowish or creamish white vertebral stripe

one scale wide, distinct from dorsals of nape and extending throughout almost whole body length, gradually fading around midbody where it merges into dorsal body coloration. Postocular region with no pigmentation (71%), with dark postocular spot (27%), or, most rarely, dark postocular stripe reaching postoculars, temporals, and last supralabials (2%). Ventral surface of head creamish white. Dorsal ground color of body brownish; dorsal scales may show whitish or black edges. Ventral ground color yellowish, occasionally with longitudinal lines ( $n = 145$ ; 55%). Ontogenetic variation not detected with hatchlings showing the same color pattern of adults.

**Color in life (Fig. 2).** General color of head, venter and body similar to preserved specimens (alcohol 70%). Some individuals have a reddish brown dorsum. No ontogenetic variation detected.



**FIGURE 1.** Color pattern variation in preservative of adults of *C. flavolineatus* from Bolivia (A–B, MNKR 2254), Paraguay (C–D, MNHNP 5201), and Brazil (E–H, UFPB 4669). Photos by R. Sosa (A–B) and M. Motte (C–D).

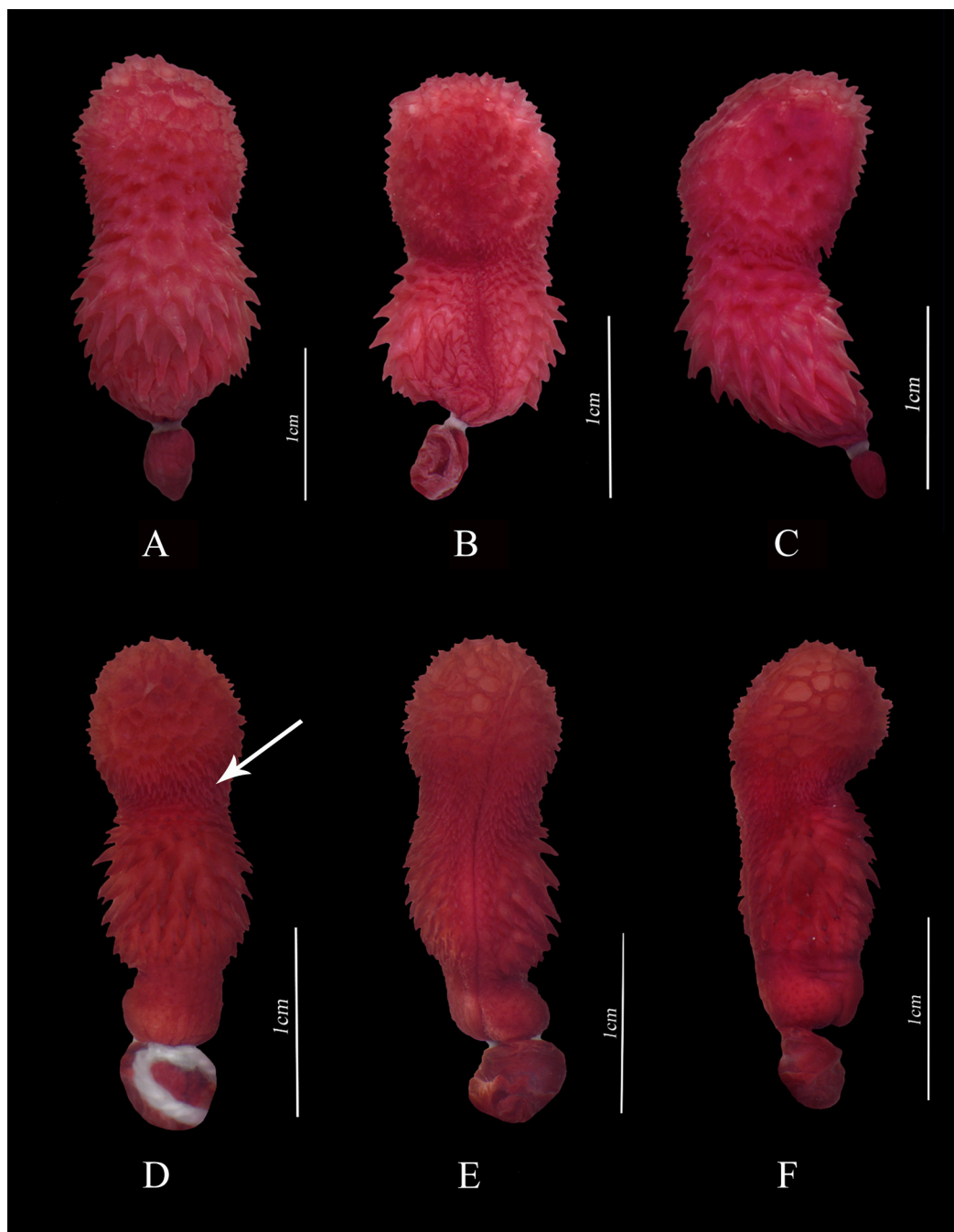


**FIGURE 2.** General view of adult (A–F) and hatchlings (G–H) of *Chironius flavolineatus* in life. Photos by D. Santana (C), W. Pessoa (D), and C. Cintra (E–F).

**Meristic and morphometric variation.** Largest male (MNRJ 10929) 738 mm SVL, 450 mm CL; largest female (MZUFV 1090) 880 mm SVL, 524 mm CL. Total length 405–1188 mm ( $n = 56$ ) in males, 235–1404 mm ( $n = 86$ ) in females; snout length 3.5–7.9 mm ( $n = 64$ ) in males, 3.3–8.9 mm ( $n = 98$ ) in females; snout width 3.3–7.1 mm ( $n = 64$ ) in males, 2.9–7.9 mm ( $n = 98$ ) in females; head length 13.4–25 mm ( $n = 67$ ) in males, 12.0–29.2 mm ( $n = 101$ ) in females; head width 5.1–13.1 mm ( $n = 65$ ) in males, 4.9–15.0 ( $n = 98$ ) in females; body width at midbody 3.3–12.8 mm in males, 3.0–16.7 mm ( $n = 102$ ) in females; body height at midbody 2.9–13.7 mm ( $n = 64$ ) in males, 3.2–18.5 mm ( $n = 100$ ) in females. The number of occipitals contacting parietals 2–6 ( $\bar{x} = 4.1$ ;  $s = 0.71$ ;  $n = 106$ ); gulars 3–4. Dorsal scales rows formulae 12/12/8 ( $n = 66$ ; 93%) or 12/12/10 ( $n = 6$ ; 7%) in males, and 12/

12/10 ( $n = 109$ ; 100%) in females, showing sexual dimorphism. Variation of other meristic and morphometric data for *C. flavolineatus* is summarized in Table 2.

**Ornamentation of dorsal scales.** Apical pits in adults generally restricted to neck ( $n = 28$ ; 23%) or found at midbody and/or near cloacal region ( $n = 95$ ; 77%). Neck with high density of apical pits, some specimens showing scales with two apical pits.

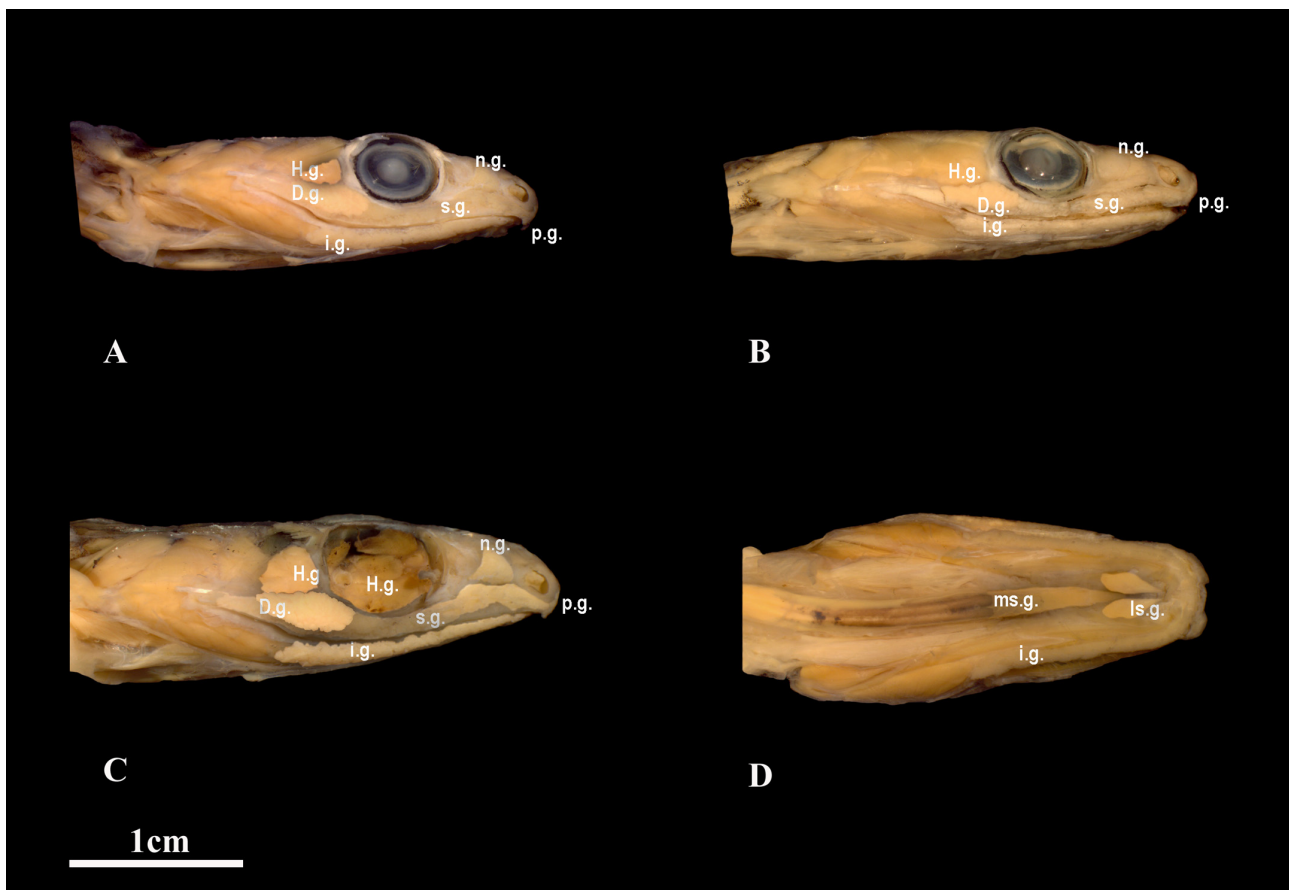


**FIGURE 3.** Asulcate (A, D), sulcate (B, E), and lateral (C, F) views of the hemipenis of *C. flavolineatus* (upper, UFS 419) and *C. brazili* (lower, MZUFV 1746). Arrow indicates region of medial constriction of hemipenis slightly covered with spinules.

**Hemipenis ( $n = 7$ , Fig. 3).** Organ unilobed, cylindrical, and unicalyculate. Hemipenis with large spinulate and well developed calyces on most of the apical portion. Medial portion of hemipenis with constriction region with no spinules separating calyces of apex from spines below region of constriction on asulcate side. Medium to large curved spines covering lateral and asulcate sides and spinules covering sulcate side of hemipenis. Sulcus spermaticus simple, centrolineal, bordered by spinules along its extension, and positioned more laterally at basal portion of hemipenis, gathering more centralized position from the end of proximal third of hemipenis. In lateral

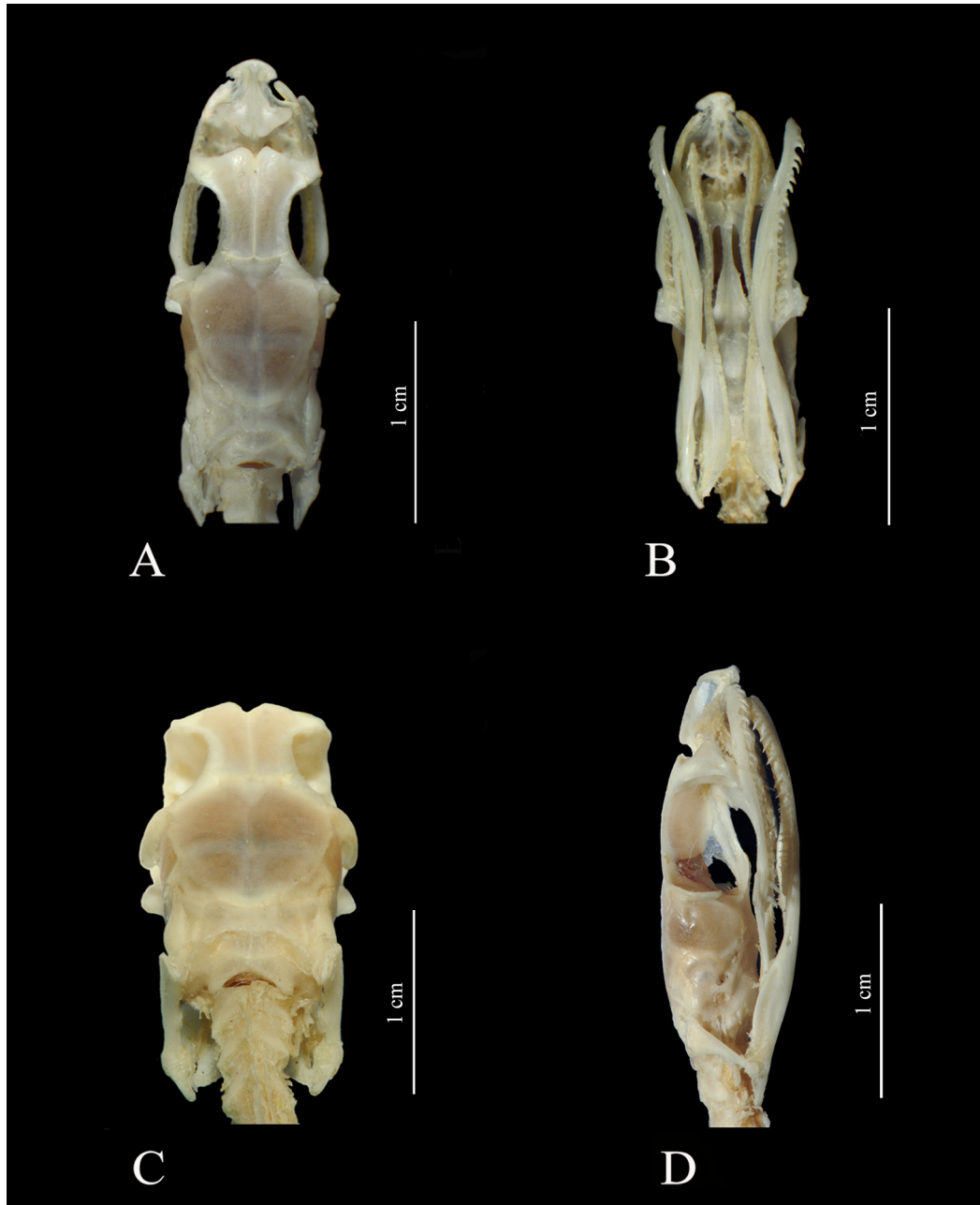
view, sulcus spermaticus positioned on concave face of the organ. Basal portion of hemipenis with few spinules irregularly distributed.

**Cephalic glands (n = 4, Fig. 4).** PREMAXILAR: triangular, contacting supralabial gland and dorsally reaching the level of internasal scales. NASALS: irregular shape, ventrally higher than long, anteriorly limited by nasal capsule, anterodorsally by nasal, posteroventrally by anterior portion of prefrontal, and ventrally by supralabial gland; nasal gland reaches or surpasses dorsal edge of orbit in dorsal view. SUPRALABIALS: rear portion partially overlaid by Duvernoy gland and anterior end contacting premaxilar gland; posterior limit located ventrally to rear portion of postorbital lobe of Harder gland; supralabial glands contact part of the muscles *adductor mandibulae externus medialis* (hereafter aem) and *adductor mandibulae externus profundus* (hereafter aep). HARDER: postorbital lobe partially visible, dorsal portion partly covered by *musculus adductor mandibulae externus superficialis* (hereafter aes) and ventral portion contacting Duvernoy gland; laterally, after removal of muscle aes, postorbital lobe extends posteriorly to the level of muscle aep; dorsal edge reaches first third of orbital cavity, not reaching dorsal portion of parietal; orbital lobe with irregular dorsal edge, convex, occupying major portion of orbital cavity from its ventral edge; orbital and postorbital lobes about the same size. DUVERNOY: poorly developed, covering posterior portion of supralabial gland and the ventral limit of Harder gland, with no contact to adductor muscles of mandible; maximum height less than one third of height of orbital cavity. RICTAL: indistinct or absent. INFRALABIALS: elongated, rear limit contacting muscle aem and reaching about the same level of posterior limit of Duvernoy gland; infralabial glands with no anteromedial contact and mesoposterior portion slightly wider. MEDIAL SUBLINGUAL: elongated, anteriorly located between mesial portion of lateral sublingual glands, with rear limits about the level of posterior extremity of infralabial glands. LATERAL SUBLINGUAL: elipsoidal, diverging anteroposteriorly.



**FIGURE 4.** Lateral (A–C) and ventral (D) views of cephalic glands of *C. flavolineatus* (B, UFS 1329) and *C. brazili* (A, C, D, MCNR 2077). D.g.= Duvernoy gland; H.g.= Harder gland; i.g.= Infralabial glands; ls.g.= Lateral sublingual glands; ms.g.= Medial sublingual gland; n.g.= Nasal gland; p.g.= Premaxilar gland; and s.g.= Supralabial glands.





**FIGURE 5.** Dorsal (A), ventral (B), posterior (C), and lateral views (D) of the skull of *Chironius flavolineatus* (UFS 1329).

**Skull ( $n = 5$ , Fig. 5).** Rectangular in dorsal view, with constriction at level of frontals. Dorsal surface flat and smooth, except for occipital region with ridges and slope from posterior portion of supraoccipital. In lateral view, height of skull gradually rises to the level of frontals and become relatively flat from this region until the distal portion of skull. Ventrally, hemimandibles with arched shape slightly approach each other in the medial portion of skull. **PREMAXILLA:** triangular in frontal view, dorsal extremity of ascending process tapered with no contact to nasals; transverse processes oblique approaching maxillary bones and positioned slightly more anteriorly; short convergent vomerine processes forming a “V” anteroposteriorly, without contact each other, reaching anterior portion of vomer; total length of transverse processes greater than height of ascending process from base to apex. **SEPTOMAXILLA:** ascending lateral processes short, not reaching lateral extremities of nasals; medial portion contacts vertical lamina of nasals and ascending process of premaxilla, while rear portion contacts vomer. **NASALS:** triangular in dorsal view, base of triangle on the region of contact between nasals; anterior border tapered, not contacting premaxilla; nasals contact frontals through vertical lamina of nasals, which also contacts septomaxilla and vomer. **VOMER:** dorsally connected to septomaxilla; mesoventral portion of vomer globular with

circular opening corresponding to exochoanal fenestra; in this portion, vomers approach each other in mesial region. PREFRONTALS: region of contact with frontals oblique; ventral portion contacts maxillary process and choanal process of palatine medially; in lateral view, prefrontals with conspicuous and acuminate anterior process; posterior portion concave, shaping anterior border of orbital cavity; in rear view, large lacrimal foramen visible in most basal portion. FRONTALS: dorsal surface smooth with medial suture separating the bones; lateral surface with conspicuous constriction; anterolateral edges oblique, projected, and contacting prefrontals; medial region of anterior margin “V” shaped; suture contacting parietal straight or slightly curved; posterolateral region, near suture with parietal, with 0–3 foramens; vertical lamina of frontals contacting dorsal projection of parabasisphenoid ventrally and nasals and septomaxilla anteriorly. PARIETAL: overall aspect rounded in dorsal view, as long as broad, with anterior margins concave or straight contacting frontals; lateral ridges visible in dorsal view, extending up to region of contact with supraoccipital; lateral ridges not touching each other; anteriormost portion contacts frontals lateroventrally and parabasisphenoid ventrally; rearmost portion of parietals contacts prootic and supratemporal posterolaterally. POSTORBITALS: shape rearward portion of orbital cavity and have no contact with frontals; straight in lateral view, with no ventral curvature and not approaching region of contact between ectopterygoid and maxilla. SUPRAOCCIPITAL: dorsally contacts parietal anteriorly through curved suture; supratemporal and prootic laterally, and exoccipital posteriorly; mesoanterior portion undergoes constriction relative to lateral regions; posterolateral region with two conspicuous and oblique ridges towards supratemporals; among these side crests emerges a rather pronounced medial ridge, restricted to posterior portion of supraoccipital, occasionally touching exoccipitals; this region shows a depression relative to anteriormost portion of supraoccipital. EXOCCIPITALS: irregular shape in dorsal view, showing medial constriction and two lateral ridges corresponding to maintenance of posterolateral ridges of supraoccipital; medially exoccipitals may show a rather conspicuous ridge representing maintenance of medial supraoccipital ridge; exoccipitals contact basioccipital ventrally and prootic in lateral surface, where is situated *fenestrae ovalis*, between supraoccipital and prootic; jugular foramen positioned just beneath this fenestra. BASIOCCIPITAL: hexagonal, contacting parabasisphenoid complex anteriorly, and prootic and exoccipitals in anterior and posterolateral portions, respectively; mesoanterior portion with three conspicuous ( $n = 4$ ) or slightly distinct ( $n = 1$ ) dentigerous processes, away from suture with parabasisphenoid. PROOTIC: contacts supratemporal dorsally, parietal anterolaterally, parabasisphenoid and basioccipital ventrally, supraoccipital dorsoposteriorly, and exoccipital posterolaterally; two lateral foramina represent maxillary and mandibular branches of trigeminal nerve; posterior edge of prootic contacts exoccipital, constituting anterior margin of *fenestrae ovalis*. PARABASISPHEOID COMPLEX: spear shaped, with rear end broader than anterior portion tapering from the level of contact between ectopterygoid and maxilla; contacts basioccipital posteriorly, prootic and parietal posterodorsally, frontal dorsoanteriorly, and choanal process of palatine anteroventrally; posterior Vidian foramen near sutures with prootic and parietal in posterolateral region; basisphenoid with medial ridge, more conspicuous on the level of posterior boundary of orbital cavity. MAXILLAE: arched towards premaxilla in dorsal view, with a slight lateral twist on the level between prefrontal and ectopterygoid; laterally maxilla corresponds to inferior border of orbital cavity, extending from the level of premaxillary vomerine processes up to the level of postorbital, when contacts ectopterygoid; maxilla corresponds to more than half of length of braincase; ventral surface with 31–35 subequal, curved, and rear facing teeth, with posterior teeth slightly larger and having no diastema; palatine process situated in first third of maxilla and completely covered by prefrontal; ectopterygoid process situated posteriorly. ECTOPTERYGOIDS: narrow, slightly curved, with anterior end in half moon shape, superimposed on ectopterygoid process of maxilla; rear end contacting dorsolateral portion of pterygoid. PTERYGOIDS: elongated, corresponding approximately to half size of braincase; ventral surface with 33–37 subequal teeth; anterior portion tapered contacting palatine and gradually widening from the region of contact with ectopterygoid in anteroposterior direction; pterygoids nearly parallel along its length, except in rear end, at the end of tooth line, from which pterygoids taper again and move apart until contact quadrate dorsolaterally. PALATINES: slender, straight, slightly shorter than length of dentary; ventral surface with 20–23 subequal teeth; choanal process of palatine medially directed towards parabasisphenoid, contacting small portion of ventromedial face of prefrontal; anterolateral process contacts palatine process of maxilla; in dorsal view, forked rear end contacts pterygoid, with medial branch longer than lateral branch; palatine contacts pterygoid approximately at the level of ectopterygoid process of maxilla. SUPRATEMPORALS: laminar shape, elongated, approximately same length of quadrate; anterior end contacts or surpasses suture with parietal; contacts prootic and exoccipital laterally; rear end articulates with quadrate. QUADRATES: dorsal portion

flattened, contacting supratemporal laterally; medial portion with process corresponding to region of contact with *columella auris*; ventral portion contacts glenoid cavity of retroarticular process of mandible; ventromedial portion contacts rear end of pterygoid; quadrate tapers dorsoventrally. DENTARIES: anterior end curved towards opposite hemimandible; lateral face convex with mentonian foramen medially located; after this foramen, dentary branches into dorsal (longer) and ventral processes; dorsal surface with 32–36 conical rear facing teeth. SPLENIALS: tapered anteriorly, in the region of contact with dentary; anterior mylohyoid foramen limited by angular. ANGULARS: elongated, triangular, tapered posteriorly, contacting dentary anterodorsally and splenial anteroventrally; posterior mylohyoid foramen near suture with splenial; angular-splenial joint visible in ventral view. COMPOUND BONE: correspond approximately to three-quarters of mandible; surangular crest with rounded dorsal edge and lower than prearticular crest; in lateral view, compound bone tapers anteriorly, fitting between dorsal and ventral processes of dentary; posterior foramen of surangular exposed.

**Distribution and natural history (Fig. 6).** *Chironius flavolineatus* is distributed in the Chaco of department of Santa Cruz, Bolivia; department of Amambay, Paraguay, and the Cerrado, Caatinga, Amazonian, and Atlantic Forest biomes in Brazil throughout the states of Amazonas, Amapá, Maranhão, Pará, Tocantins, Ceará, Rio Grande do Norte, Paraíba, Pernambuco, Alagoas, Sergipe, Bahia, Goiás, Mato Grosso, Mato Grosso do Sul, Minas Gerais, and São Paulo from 3–1171 m above sea level, hereafter asl (generally 100–400 m asl). We examined photographs of a supposed specimen of *C. flavolineatus* from Peru (UNMSM 2889) (Lehr 2002) and concluded this specimen is not a *C. flavolineatus* as it has no vertebral stripe and other diagnostic characters of this taxon. Thereby, as far as we know there are no records of *C. flavolineatus* to Peru.

Some preserved specimens of *C. flavolineatus* (MNRJ 3981, 17183, 17155) had amphibians (*Scinax* gr. *fuscovarius*, *Scinax* gr. *x-signatus*, a non-identified species of Hylidae, and *Leptodactylus fuscus*) as stomach contents ingested in posterior-anterior direction. Three specimens of *C. flavolineatus* were observed on April 28, 2006 by one of us (BH) entwined on the litter of an anthropized fragment of Atlantic Forest in the municipality of Salvador, state of Bahia, Brazil. During the present report no aggressive behavior or male combat was observed. After approximation, snakes split up and tried to escape. One specimen (a female, total length 1002 mm, Figs. 2A–B) climbed a tree and was captured. At this moment specimen held a cloacal discharge, opened its mouth, and attempted to bite. This specimen was held in captivity and after eight days laid four eggs. Three months later, on August 10, two hatchlings were born (Figs. 2G–H). Some specimens examined in the present study (MZUSP 14172; CHUNB 21959, 24908) showed 3–8 eggs in the oviduct.

### ***Chironius brazili*, sp. nov.**

*Chironius flavolineatus*—Bailey 1955:13 [*partim*]; Peters & Orejas-Miranda 1970:60 [*partim*]; Dixon *et al.* 1993:112 [*partim*].

**Holotype.** Adult male, MNRJ 17480, collected by A.C.A. Lopes in October 2008 at RPPN Santuário do Caraça (20°05′, 43°29′W, 1262m asl), municipality of Catas Altas, state of Minas Gerais, Brazil.

**Paratypes.** Eight specimens all from Brazil: adult female, IVB 3290, collected by T. Filadelfo in February 2013 at Poço Azul waterfall (15°36′03″S, 48°03′16″W, 1220m asl), Parque Nacional de Brasília, municipality of Brasília D.C.; adult female, CHUNB 19699, collected at municipality of Alto Paraíso de Goiás (14°12′S, 47°41′W, 1250m asl), state of Goiás; juvenile male, MNRJ 18936, collected by A.C.A. Lopes in April 21 2009 same data as the holotype; adult female, IVB 3342, collected by G.A. Cotta on January 1997 at district of Vila Del Rey (20°00′S, 43°56′W, 1050m asl), municipality of Nova Lima, state of Minas Gerais; adult female, MZUFBA 2448, collected by O.M. Sampaio in November 1986, municipality of Rio Acima (20°05′S, 43°47′W, 740m asl), state of Minas Gerais; adult female, MCNR 2790, collected at municipality of Conceição do Mato Dentro (19°02′S, 43°25′W, 685m asl), state of Minas Gerais; adult male, MCNR 3384, collected at municipality of Igarapé (20°04′S, 44°17′W, 810m asl), state of Minas Gerais; adult male, MCNR 4386, collected at municipality of Ouro Preto (20°19′S, 43°33′W, 1050m asl), state of Minas Gerais.

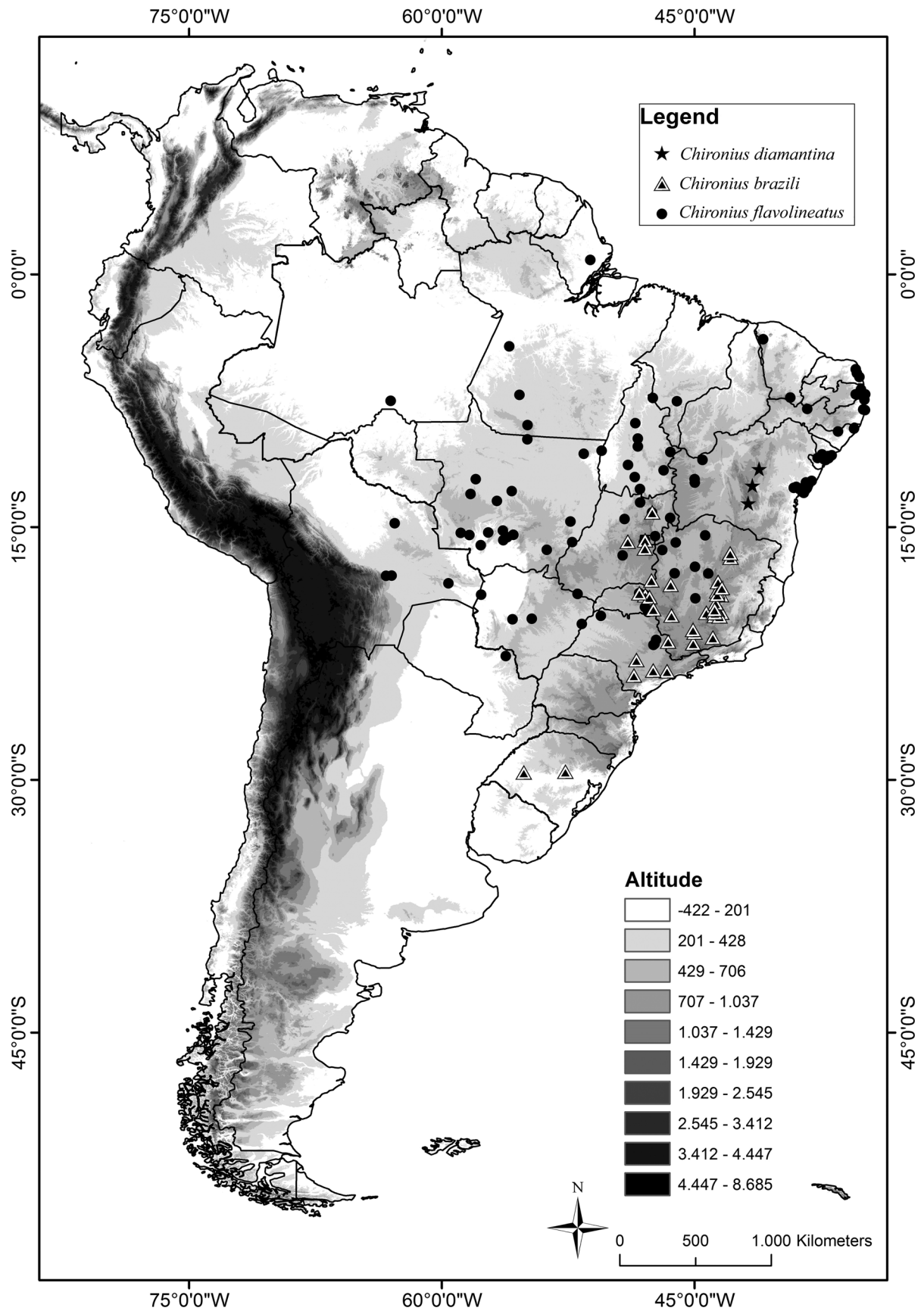
**Diagnosis.** *Chironius brazili* can be distinguished from all congeners by the following unique combination of states of characters: first third of body black or dark gray; vertebral stripe yellowish or creamish white, distinct from dorsals of nape and extending throughout almost whole body length; head dorsum tan to brown, distinct from background color of first third of body; cloacal shield frequently divided (96%); two to four rows of keeled dorsal

scales at midbody; ventral ground color gradually darkening towards cloaca; region of medial constriction of hemipenis slightly covered with spinules separating calyces of apex from spines below region of constriction; in lateral view, sulcus spermaticus positioned on convex face of hemipenis; ascending process of premaxilla oblique anteroposteriorly to longitudinal axis of skull; optic fenestra not exceeding frontoparietal suture; posterior border of supratemporal exceeding braincase; dorsoventral axis of quadrate oblique mesolaterally, moving away from longitudinal axis of skull.

**Comparisons.** *Chironius brazili* is distinguished from all currently recognized congeners, except *C. flavolineatus* and *C. diamantina*, by having first third of body black or dark gray, vertebral stripe yellowish or creamish white, distinct from dorsals of nape and extending throughout almost whole body length, and head dorsum tan to brown distinct from background color of first third of body. *Chironius brazili* differs from *C. flavolineatus* (character states in parentheses) by having ventral ground color gradually darkening towards cloaca (*vs.* venter uniformly creamish white); region of medial constriction of hemipenis slightly covered with spinules separating calyces of apex from spines below region of constriction on asulcate side (*vs.* region of medial constriction with no spinules separating calyces of apex from spines below region of constriction on the asulcate side); in lateral view, sulcus spermaticus positioned on the convex face of hemipenis (*vs.* sulcus spermaticus positioned on the concave face of hemipenis in lateral view); ascending process of premaxilla oblique anteroposteriorly to longitudinal axis of skull (*vs.* perpendicular to longitudinal axis of skull); optic fenestra not exceeding frontoparietal suture (*vs.* exceeding frontoparietal suture); posterior border of supratemporal exceeding braincase (*vs.* not exceeding braincase); and dorsoventral axis of quadrate oblique mesolaterally, moving away from longitudinal axis of skull (*vs.* straight, not moving away from longitudinal axis of skull). *Chironius brazili* differs from *C. diamantina* (character states in parentheses) by having two to four rows of keeled dorsal scales at midbody (*vs.* six to ten); cloacal shield frequently divided (*vs.* entire).

**Description of the holotype (Fig. 7).** Adult male; left and right hemipenes everted; head distinct from body; total length 1381 mm; SVL 845 mm; CL 536 mm; head length 287 mm; head width at broadest point 126 mm; snout length 86 mm; snout width 78 mm; body width at midbody 89 mm; body height at midbody 169 mm. Length/width of rostral (4.4/2.6 mm); prenasal (2.4/2.5 mm); postnasal (1.6/1.8 mm); internasal (3.5/2.9 mm); loreal (2.8/1.3 mm); prefrontal (3.8/3.9 mm); prefrontal suture 2.7 mm; preocular (2.5/3.4 mm); supraocular (7.2/3.8 mm); frontal (7.3/6.0 mm); frontal-supraocular suture 5.9 mm; parietal (9.6/5.9 mm); parietal suture 6.2 mm; anterior temporal (5.9/2.6 mm); posterior upper temporal (5.7/4.2 mm); posterior temporals fused; first pair of chin shields (7.4/2.9 mm); second pair of chin shields (9.7/3.3 mm); horizontal eyes diameter 5.3 mm; vertical eyes diameter 4.0 mm. Loreal longer than high, separated from orbit by preocular; loreal contacting postnasal anteriorly, preocular posteriorly, prefrontal dorsally, and second and third supralabials ventrally; preocular single, separated from frontal by suture between supraocular and prefrontal; pupil rounded; postoculars two; anterior temporal 1/1; posterior temporals 2/1; five occipital scales contacting parietals; supralabials 9/9, fourth, fifth, and sixth contacting eye; infralabials 10/10, first to fifth contacting first pair of chin shields; fifth and sixth contacting second pair of chin shields; gulars three. Maxillary teeth 34. Dorsal scales rows 12/12/10; low density of apical pits on the scales of neck; no rows of keeled dorsal scales on the anterior portion of body; two rows of keeled dorsal scales at midbody; two rows of keeled dorsal scales at posterior portion of body; keels very strong, mostly at midbody. Ventrals 156; subcaudals 141; cloacal shield (10.6/3.9 mm) divided.

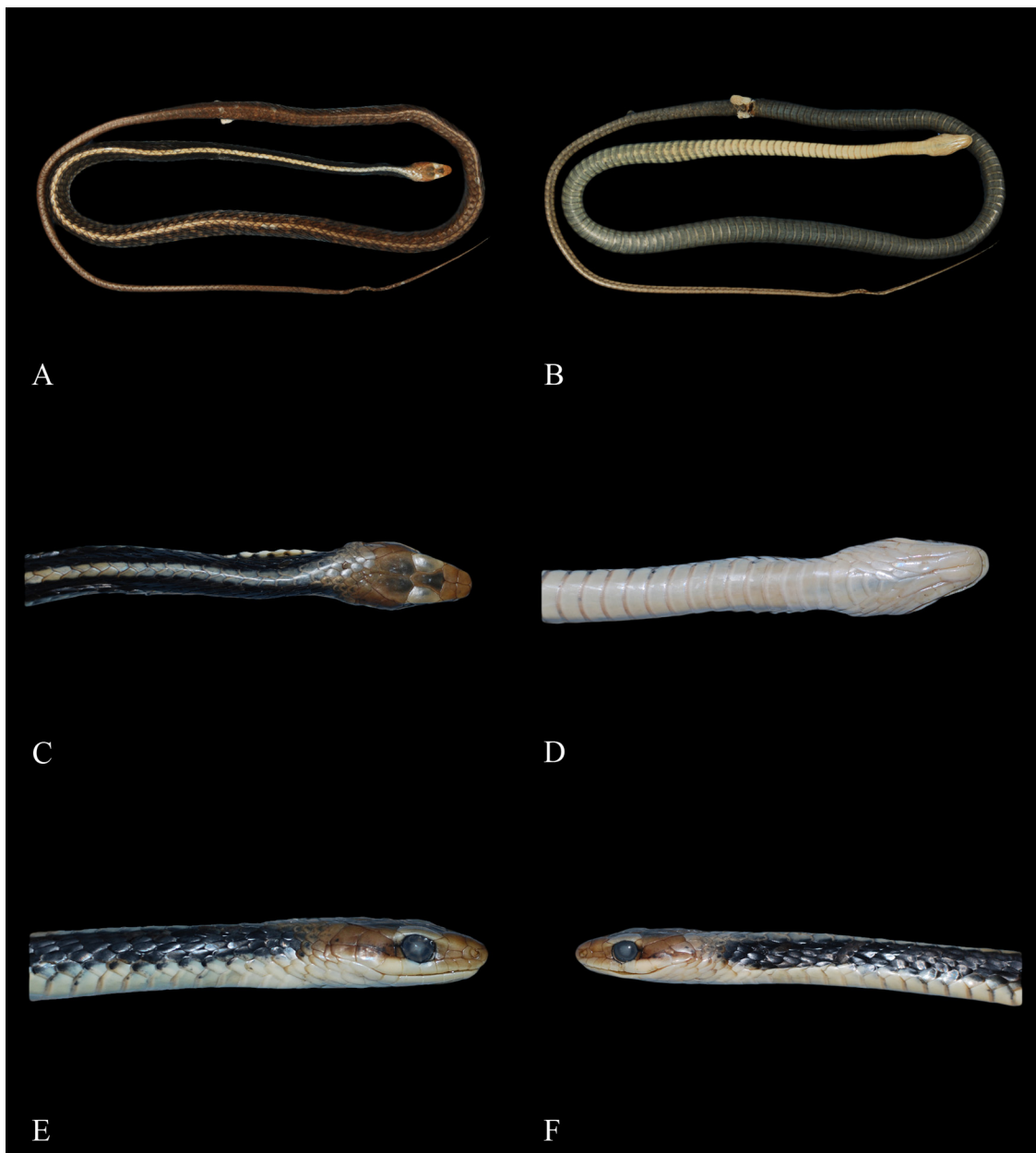
**Color of the holotype in preservative (alcohol 70%) (Fig. 7).** Dorsal surface of head brown with darker frontal and parietal scales; snout region, postoculars, and temporal region brown; orbit encircled by black; supralabials creamish white with brown spots; infralabials, and ventral surface of head creamish white; indistinct postocular blotch. First third of body blackish gradually fading to brown anteroposteriorly; anterior portion of vertebral stripe yellowish, gradually darkening anteroposteriorly, well distinct until posterior third of body where it gradually merges into body coloration; anterior portion of vertebral stripe two scales wide. First third of ventral ground color creamish white gradually darkening towards cloaca, where venter is dark gray; incomplete slight transversal dark bars corresponding to posterior margins of ventrals visible mostly in first third of venter. Cloacal shield and anterior portion of the ventral surface of tail dark gray gradually lightening towards terminal caudal spine; subcaudal scales occasionally with black or dark gray edges.



**FIGURE 6.** Geographic distribution of *Chironius flavolineatus*, *C. brazili*, and *C. diamantina*.

**Color pattern variation in preservative (alcohol 70%) (Fig. 8).** Postocular region without blotches or stripes (80%), with a dark blotch (17%), or with dark postocular stripe reaching postoculars, temporals, and last supralabials (3%). Dorsal ground color of body brown; dorsal scales may show white edges. Vertebral stripe with two (90%), one and a half (5%), or one (5%) scale wide. Venter with longitudinal lines ( $n = 71$ ; 95%); ground color generally gray to brown (Figs. 8B–D), always lighter in first third of venter. Juveniles with dorsolateral ground color of body brown with lighter crossbands ( $n = 5$ ) (Fig. 8C), indicating possible existence of ontogenetic variation.

**Color in life (Fig. 9).** General color of head, venter and body similar to the color of the preserved specimens. Dorsal color pattern occasionally reaches ventral region, more evident in tail region; dorsal scales occasionally encircled by black or white (Figs. 9A, E–F); paraventral scales in first third of body with orange or light brown spots (Figs. 9A–D). Ventral scales gradually covered with orange or grayish coloration anteroposteriorly. Some hatchlings and adults may show dark or gray variegated dorsal color pattern.



**FIGURE 7.** Dorsal (A, C) and ventral (B, D) views of the body and right (E) and left (F) lateral views of the head of the holotype of *Chironius brazili* (MNRJ 17480, SVL 845 mm, CL 536 mm) from Catas Altas, state of Minas Gerais, Brazil.



**FIGURE 8.** Color pattern variation in preservative of adult (A–B, MCNR 2790, SVL 840 mm, CL 537 mm) and juvenile (C–D, MNRJ 18936, SVL 256mm, CL 154 mm) of *Chironius brazili*.

**Morphometric and meristic variation.** Largest male (MZUSP 7566) 895 mm SVL, 560 mm CL, largest female (FUNED 1696) 862 mm SVL, 572 mm CL. Total length in males 410–1455 mm ( $n = 30$ ), females 408–1434 mm ( $n = 30$ ); snout length in males 4.0–9.3 mm ( $n = 35$ ), females 3.5–10 mm ( $n = 33$ ); snout width in males 3.3–8.4 mm ( $n = 35$ ), 3.3–9.6 mm ( $n = 33$ ) in females; head length in males 14.5–28.8 mm ( $n = 36$ ), 13.5–31.9 mm ( $n = 34$ ) in females; head width in males 6.3–13 mm ( $n = 35$ ), 5.0–19.3 mm ( $n = 34$ ) in females; midbody width in males 3.8–15 mm ( $n = 34$ ), 4.6–15.5 mm ( $n = 34$ ) in females; midbody height in males 3–17.1 mm ( $n = 34$ ), 5.1–19.6 mm ( $n = 34$ ) in females. Number of occipitals touching parietals 3–7 ( $\bar{x} = 4.52$ ;  $s = 0.82$ ;  $n = 40$ ); gulars 3–7. Dorsal scales rows 12/12/10 ( $n = 75$ ; 97.5%) or 12/12/8 ( $n = 2$ ; 2.5%). Variation of other meristic and morphometric data for *C. brazili* is summarized in Table 2.

**Ornamentation of dorsal scales.** Apical pits in adults generally restricted to neck ( $n = 55$ ; 92%), occasionally also being found at midbody and/or near cloacal region ( $n = 2$ ; 3%), or apical pits rarely absent ( $n = 3$ ; 5%). Generally, *C. brazili* shows conspicuous depressions similar to apical pits, in preocular, postocular, loreal, temporals, and occasionally in supralabial scales. Rows of keeled dorsal scales along body show variation (see Table 2) but keels are generally more conspicuous in males than in females.

**Hemipenis ( $n = 7$ , Fig. 3).** Organ unilobed, cylindrical, and unicalyculate. Hemipenis with large spinulate and well developed calyces on most of the apical portion. Medial portion of hemipenis with pronounced constriction region slightly covered with spinules (Fig. 3D), separating calyces of apex from spines below region of constriction on the asulcate side. Medium to large curved spines covering lateral and asulcate sides and spinules covering sulcate side of hemipenis. Sulcus spermaticus simple and centrolineal, bordered by spinules along its extension, and positioned more laterally at basal portion of hemipenis. In lateral view, sulcus spermaticus positioned on the convex face of the organ. Basal portion of hemipenis with few spinules irregularly distributed.

**TABLE 2.** Summary of meristic characters for *Chironius brazili*, *C. flavolineatus*, and *C. diamantina*. The abbreviation are as follow: SL= supralabials; SO=supralabials contacting orbit; IL=infralabials; IL/CS=infralabials in contact with chin shields; PO=postocular; TEa= anterior temporals; TEp=posterior temporals; MT=maxillary teeth; KDA, KDM, and KDP=rows of keeled dorsal scales at anterior, midbody, and posterior portion of body, respectively;  $\bar{r}$ =range; n=sample size. \*Data from Fernandes & Hamdan (2014).

	<i>C. brazili</i>			<i>C. flavolineatus</i>			<i>C. diamantina</i> *		
	Males	Females		Males	Females		Males	Females	
SVL	256–895 mm (n=37)	256–995 mm (n=37)		255–738 mm (n=66)	216–880 mm (n=104)		545–720 mm (n=4)	450–895 mm (n=7)	
CL	154–560 mm (n=30)	152–572 mm (n=29)		150–475 mm (n=66)	127–524 mm (n=86)		340–391 mm (n=3)	251–373 mm (n=4)	
Ventrals	155.68±3.7 $\bar{r}$ =149–167	160.05±3.88 $\bar{r}$ =152–168		153.94±3.3 $\bar{r}$ =146–163	158.03±3.49 $\bar{r}$ =150–167		159.3±4.0 $\bar{r}$ =154–163	159.7±3.0 $\bar{r}$ =156–165	
Subcaudals	(n=38) 146.1±5.4 $\bar{r}$ =136–156	(n=37) 143.18±5.19 $\bar{r}$ =133–154		(n=68) 141.89±3.3 $\bar{r}$ =130–154	(n=104) 137.4±5.04 $\bar{r}$ =129–156		(n=4) 135.5±3.5 $\bar{r}$ =133–138	(n=7) 135.3±2.4 $\bar{r}$ =132–137	
VE+SC	(n=29) 301.82±6.71 $\bar{r}$ =292–322	(n=27) 303.18±7.62 $\bar{r}$ =285–317		(n=54) 295.57±7.52 $\bar{r}$ =276–311	(n=70) 295.65±6.93 $\bar{r}$ =280–311		(n=3) 295±8.5 $\bar{r}$ =289–301	(n=4) 294.8±3.8 $\bar{r}$ =291–298	
SL	(n=60); 10 (n=2) or 8 (n=1)	(n=27)		(n=53) 9 (n=147) or 10 (n=1)	(n=69)		(n=3) 9 (n=11)	(n=4) 4–6 (n=8) or 4–5 (n=3)	
SO	4–6 (n=53); 5–6 (n=4); 5–7 (n=2); or 4–5 (n=1)			4–6 (n=139); 4–5 (n=3); 5–6 (n=3) or 5–7 (n=1)					
IL	10 (n=62) or 11 (n=1)			10 (n=144) or 11 (n=1)					
IL/CS	1–5/5–6 (n=43); 1–6/6–7 (n=1); or 1–6/5–6 (n=1)			1–5/5–6 (n=114) or 1–6/6–7 (n=1)					
PO	2 (n=54); 3 (n=18) or 4 (n=2)			2 (n=150) or 3 (n=11)					
TEa	1 (n=73) or 2 (n=2)			1 (n=188)					
TEp	1 (n=20); 2 (n=33); 3 (n=9); or 4 (n=7)			1 (n=177); 2 (n=2); or 4 (n=1)					
MT	34±1.63 $\bar{r}$ =33–40 (n=24)			33.1±0.88 $\bar{r}$ =31–35 (n=53)					
Cloacal Shield	divided (n=74) or entire (n=4)			divided (n=188)					
KDA	0 (n=72) or 2 (n=3)			0 (n=158) or 2 (n=10)					
KDM	2–4 (n=72) or 6–10 (n=4)			2 (n=166); 0 (n=2) or 4 (n=1)					
KDP	0 (n=2); 2 (n=65) or 4 (n=6)			0 (n=39); 1 (n=1) or 2 (n=120)					





**FIGURE 9.** General view of adult of *Chironius brazili* in life (A–F). Photos by C. Cintra (A–B), I. Sazima (C), T. Filadelfo (D–E), and P. Machado (F).

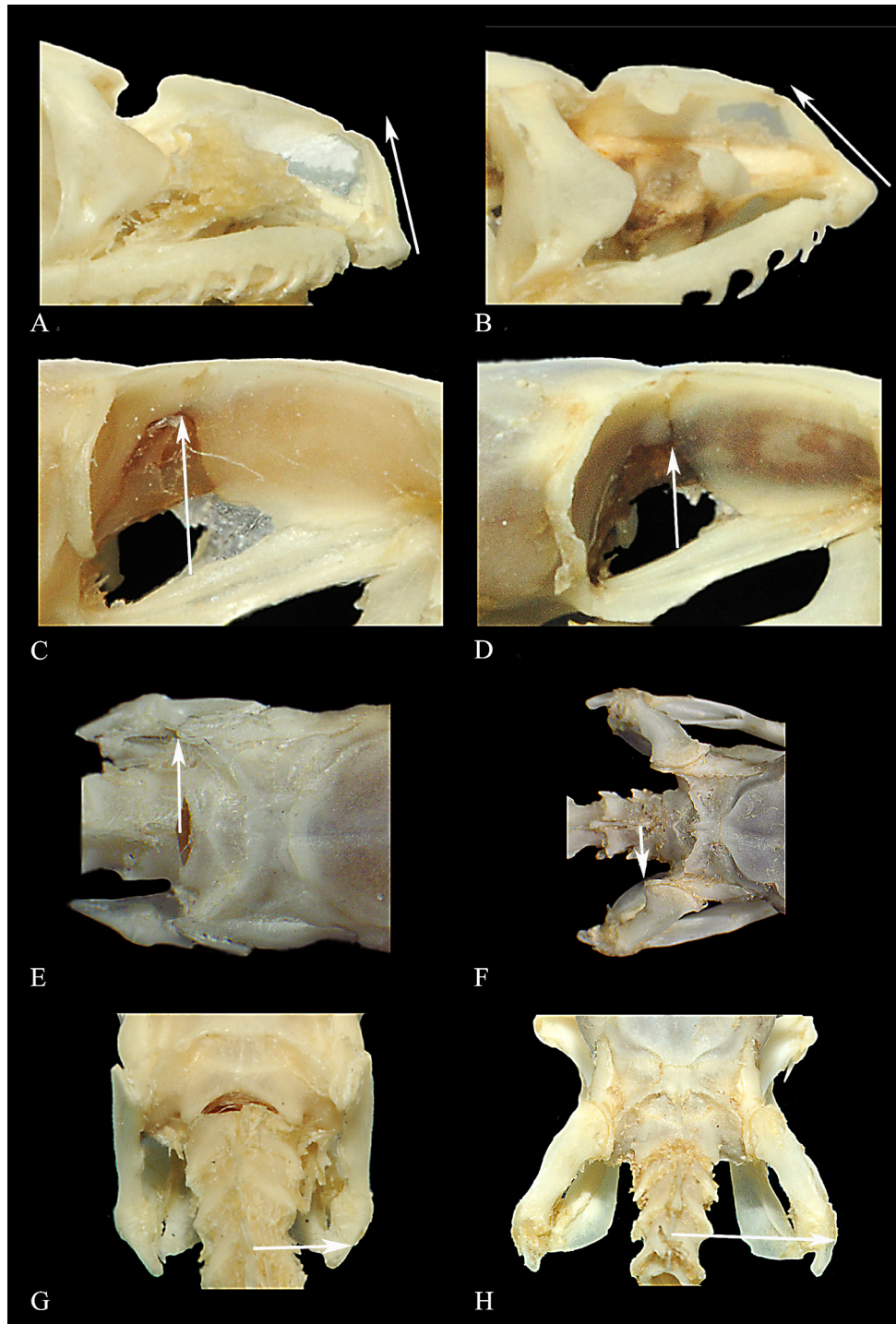
**Cephalic glands and skulls.** The cephalic glands of *C. flavolineatus* and *C. brazili* showed similar patterns (Fig. 4), while the main osteological differences in the skull of these taxa (Fig. 10) were those comparatively referred in the sections “Diagnosis” and “Comparisons”.

**Etymology.** The epithet “*brazili*” is a patronymic honoring Vital Brazil Mineiro da Campanha (1865–1950), Brazilian scientist who discovered the specificity of snakebite serum and founded two centers of excellence in research and production of strategic biological products for public health: Instituto Butantan in 1899 and Instituto Vital Brazil in 1919. Despite being a doctor by training, Vital Brazil was among the first Brazilian researchers to be concerned with the correct identification of the snakes received at that time at Instituto Butantan. Vital Brazil was honored with some species of snakes, such as *Rachidelus brazili* Boulenger, 1908, *Drymoluber brazili* (Gomes, 1918), and *Bothrops brazili* Hoge, 1954, which we can say that is still a modest honor given his great contribution to the science.

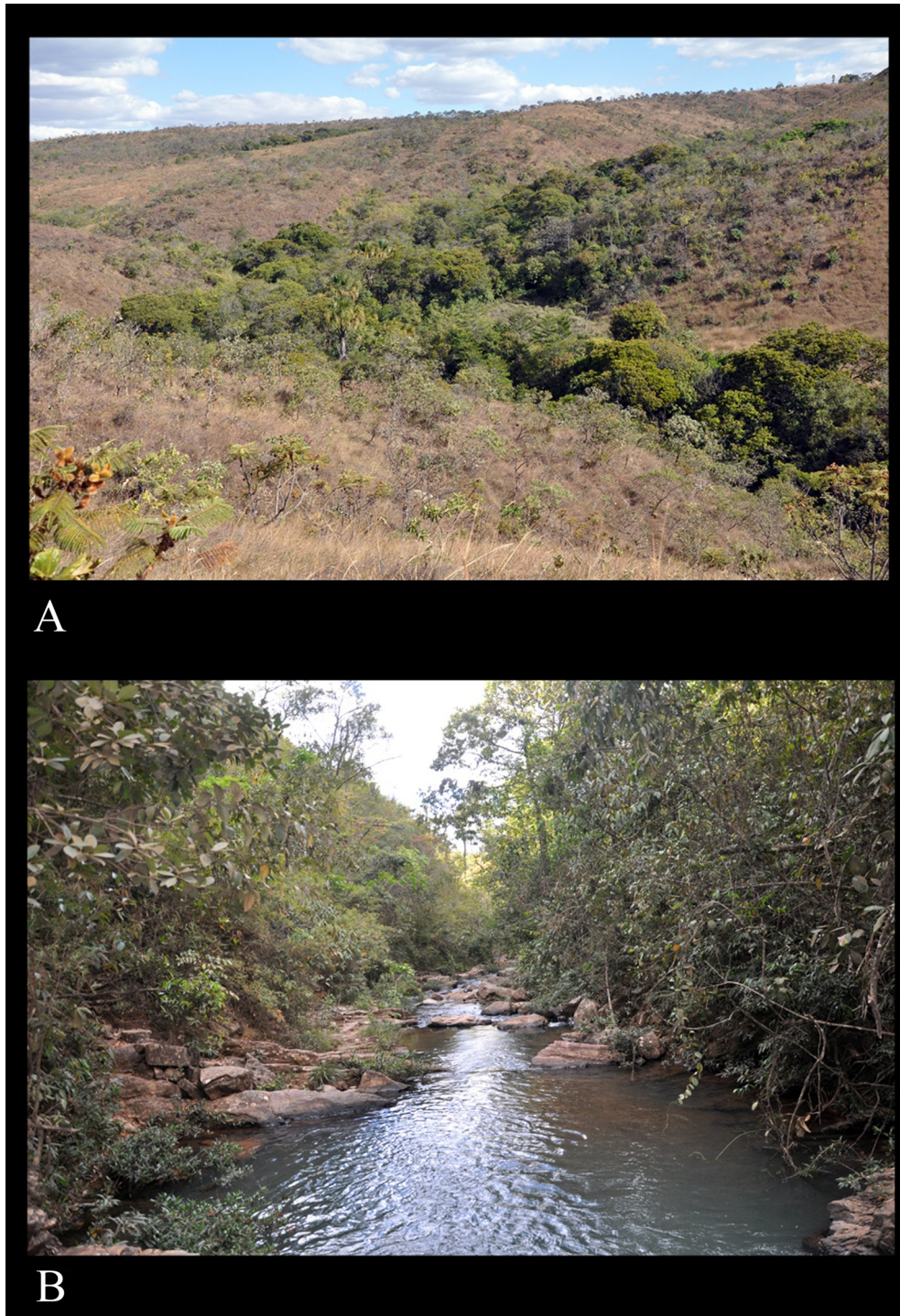
**Geographic distribution and natural history (Figs. 6, 11).** *Chironius brazili* is distributed in Cerrado biome of Brazil throughout the states of Goiás, Federal District, Minas Gerais, and São Paulo, from 70 up to 1360m asl

(generally 700–900m asl). An apparently disjunct population of *C. brazili* occurs in the state of Rio Grande do Sul, Brazil.

A female (IVB 3290; total length 995 mm) was observed in a gallery Forest of Parque Nacional de Brasília (1022m asl), foraging around 3:00 PM over rocks on the banks of a river (T. Filadelfo, pers. comm., Fig. 11). After approximation, the specimen adopted similar behaviors mentioned by Fernandes & Hamdan (2014) for *C. diamantina*. Regarding reproductive data, a single preserved female (CHUNB 3632) had five eggs in the oviduct.



**FIGURE 10.** Details of the osteological informative characters of *C. flavolineatus* (left column, UFS 1329) and *Chironius brazili* (right column, F, FUNED 41 and B, D, H, FUNED 1466). Position of the ascending process of premaxilla (A, B); Optic fenestra (C, D); posterior border of supratemporal (E, F); dorsoventral axis of quadrate (G, H).



**FIGURE 11.** Landscape of the Cerrado (A) and riparian forests (B) vegetal formations in the Parque Nacional de Brasília, where paratype of *C. brazili* (IVB 3290) was collected, municipality of Brasília, Federal District, Brazil. Photos by T. Filadelfo.

## Discussion

Although methods for species delimitation based solely on morphological characters have been criticized (Brower 1999; Hebert *et al.* 2003), recent studies continue supporting its effectiveness in solving taxonomic problems involving species complex (e.g. Passos & Fernandes 2009).

Dixon *et al.* (1993) reported on the morphological variation of *C. flavolineatus* through the examination of 109

specimens. These authors mention the presence of a zigzag line in the ventral surface of the tail of some specimens of this taxon (Dixon *et al.* 1993: 109). However, our results indicate that *C. flavolineatus* has ventral and subcaudal scales creamish white without pigmentations, whereas *C. brazili* may show dark longitudinal (in “zigzag”) stripes along midventral portion of subcaudals. This incongruence led us to examine some specimens included in the Dixon *et al.* (1993) taxonomic revision and we could find, at least, four individuals belonging to *C. brazili* (MZUSP 2438, 3853–55).

*Chironius flavolineatus*, *C. brazili*, and *C. diamantina* are morphologically similar species of the genus *Chironius*. Unlike *C. diamantina* (Fernandes & Hamdan 2014) and *C. brazili*, we found sexual dimorphism for *C. flavolineatus* in dorsal scale row formulae. Contrary to what was previously thought by Dixon *et al.* (1993), *C. flavolineatus* shows no ontogenetic change in color pattern, although *C. diamantina* (Fernandes & Hamdan 2014) and *C. brazili* present such variation. *Chironius diamantina* is the species morphologically most similar to *C. brazili*, but they can be easily distinguished from each other by the condition of cloacal shield and number of rows of keeled dorsal scales. *Chironius flavolineatus* and *C. brazili* show some level of sympatry, but *C. brazili* generally occurs in altitudes from 700–900 m asl, while *C. flavolineatus* is more commonly found in altitudes from 100–400 m asl. *Chironius diamantina* is apparently restricted to Caatinga biome (Fernandes & Hamdan 2014) and no sympatry with *C. flavolineatus* or *C. brazili* was observed.

Recognition of new lineages remains a challenge (Wiens & Servedio 2000; Sites & Marshall 2004). Efforts to set the specific limits of different taxa are fundamental to the development of any research dealing with species level (Goldstein & Brower 2002; Baum 2009). Moreover, a realistic estimate of species richness is critical to the reinforcement of strategies aiming the conservation of important biological areas and the mechanisms responsible for producing and maintaining biodiversity (Rojas 1992). Discovering of *C. diamantina* (Fernandes & Hamdan 2014) and *C. brazili* (present study), previously identified in literature and museum collections as *C. flavolineatus*, demands a reinterpretation of results from previous studies on ecology of these taxa (e.g., Pinto *et al.* 2010). Moreover, our findings corroborate the importance of taxonomic studies using different sources of morphological characters in order to achieve accurate descriptions of biodiversity, especially in regions where it is largely underestimated as in the Neotropics.

## Acknowledgments

We are grateful to P. Passos (MNRJ), H. Zaher (MZUSP), G.R. Colli (CHUNB), A. Argôlo (UESC), D. Borges–Nojosa (CHUFC), R. Faria and E. Dias (UFS), R. Feio (MZUFV), L.B. Nascimento (MCNR), G.A. Cotta (FUNED), I. Biondi (LAPH/MZUEFS), R.M. Lira da Silva (MZUFBA), G. Pontes (MCP–PUCRS), A. Garda (UFRN), M. Carvalho (UFMT), G. Vieira (UFPB), J.H. Córdova (MHNSM), R. Sosa (MNKM), M. Motte (MNHNP) and S. Scali (MSNM) who allowed us the study of specimens under their care. We thank U. Caramaschi (MNRJ), A. Melgarejo (IVB), P. Passos (MNRJ), and J. Klaczko (UNICAMP) for helpful comments on earlier versions of manuscript; F. Scramignon and I. Lampreia (IVB) by helping with the plates; D. Coelho (UFBA) and T. Porto (INEMA/BA) by helping with the map; and D.A. Adler (University of Manchester) for improving the use of English of the manuscript. We are also thankful to CNPq and FAPERJ for financial support.

## References

- Bailey, J.R. (1955) The snakes of the genus *Chironius* in southeastern South America. *Occasional Papers of the Museum of Zoology, University of Michigan*, 571, 1–21.
- Baum, D.A. (2009) Species as ranked taxa. *Systematic Biology*, 58, 74–86.  
<http://dx.doi.org/10.1080/14772000.2012.664177>
- Boettger, O. (1885) Liste von Reptilien und Batrachien aus Paraguay. *Zeitschrift Natur-Wissenschaft*, 58, 213–248.
- Boulenger, G.A. (1908) On a new genus of snake from Brazil. *Annals and Magazine of Natural History*, 2 (7), 31–32.  
<http://dx.doi.org/10.1080/00222930808692449>
- Boulenger, G.A. (1894) *Catalogue of the snakes in the British Museum (Natural History)*. Vol. 2. Trustees of the British Museum, London, 382 pp.  
<http://dx.doi.org/10.5962/bhl.title.54273>
- Brower, A.V.Z. (1999) Delimitation of phylogenetic species with DNA sequences: a critique of Davis and Nixon's population

- aggregation analysis. *Systematic Biology*, 48 (1), 199–213.
- Cundall, D. & Irish, F.J. (2008) The snake skull, *In*: Gans, C., Gaunt, A.S. & Adler, K. (Eds.), *Biology of the Reptilia. Vol. 20. Morphology H. The skull of Lepidosauria*. Society for the Study of Amphibians and Reptiles, Ithaca, New York, pp. 349–692.
- De Queiroz, K. (2007) Species concepts and species delimitation. *Systematic Biology*, 56, 879–886.  
<http://dx.doi.org/10.1080/10635150701701083>.
- Dixon, J.R., Wiest, J.A. Jr. & Cei, J.M. (1993) Revision of the Neotropical snake genus *Chironius* Fitzinger (Serpentes, Colubridae). *Museo Regionale di Scienze Naturali Monographie*, 13, 1–279.
- Dowling, H.G. (1951) A proposed standard system of counting ventrals in snakes. *British Journal of Herpetology*, 1, 97–99.
- Fernandes, D.S. & Hamdan, B. (2014) A new species of *Chironius* Fitzinger, 1826 from the state of Bahia, Northeastern Brazil (Serpentes: Colubridae). *Zootaxa*, 3881 (6), 563–575.  
<http://dx.doi.org/10.11646/zootaxa.3881.6.5>
- Fitzinger, L. (1826) *Neue Classification der Reptilien nach ihren natürlichen Verwandtschaften nebst einer Verwandtschafts-Tafel und einem Verzeichnisse der Reptilien-Sammlung des K. K. zoologischen Museums zu Wien*. J.G. Heubner, Wien, 66 pp.  
<http://dx.doi.org/10.5962/bhl.title.4683>
- Goldstein, P.Z. & Brower, A.V.Z. (2002) Molecular Systematics and the Origin of Species. New Synthesis or Methodological Introgessions? *In*: DeSalle, R., Giribet, G. & Wheeler, W. (Eds.), *Molecular Systematics and Evolution: Theory and Practice*. Switzerland, Birkhauser, pp. 147–161.  
[http://dx.doi.org/10.1007/978-3-0348-8114-2\\_11](http://dx.doi.org/10.1007/978-3-0348-8114-2_11)
- Gomes, J.F. (1918) Contribuição ao conhecimento dos ofídios do Brasil III. *Memórias do Instituto Butantan*, 1, 57–83.
- Hamdan, B., Scali, S. & Fernandes, D.S. (2014) On the identity of *Chironius flavolineatus* (Serpentes: Colubridae). *Zootaxa*, 3794, 134–142.  
<http://dx.doi.org/10.11646/zootaxa.3794.1.6>
- Hangay, G. & Dingley, M.O. (1985) *Biological Museum Methods. Volume I. Vertebrates*. Academic Press, Australia.
- Hebert, P.D.N., Cywinska, A., Ball, S.L. & Waard, J.R. (2003) Biological identifications through DNA barcodes. *Proceedings of the Royal Society*, 270, 313–321.  
<http://dx.doi.org/10.1080/14772000.2012.664177>
- Hoge, A.R. (1954) A new *Bothrops* from Brazil – *Bothrops brazili*, sp. nov. *Memórias do Instituto Butantan*, 25, 15–21.
- Hollis, J.L. (2006) Phylogenetics of the genus *Chironius* Fitzinger, 1826 (Serpentes, Colubridae) based on morphology. *Herpetologica*, 62, 435–453.  
[http://dx.doi.org/10.1655/0018-0831\(2006\)62\[435:POTGCF\]2.0.CO;2](http://dx.doi.org/10.1655/0018-0831(2006)62[435:POTGCF]2.0.CO;2)
- Jan, G. (1863) *Elenco Sistematico degli Ofidi Descritti e disegnati per l'Iconografia generale*. Tipografia A. Lombardi, Milano, 143 pp.
- Klaczko, J., Machado, F.A., Scrocchi, G. & Zaher, H. (2010) Taxonomic status of *Chironius multiventris* and *Chironius cochranæ* (Serpentes). *Herpetologica*, 66, 476–484.  
<http://dx.doi.org/10.1655/HERPETOLOGICA-D-09-00012.1>
- Klaczko, J., Montingelli, G.G. & Zaher, H. (2014) A combined morphological and molecular phylogeny of the genus *Chironius* Fitzinger, 1826 (Serpentes: Colubridae). *Zoological Journal of Linnean Society*, 171, 656–677.  
<http://dx.doi.org/10.1111/zoj.12147>
- Kok, P.J.R. (2010) A new species of *Chironius* Fitzinger, 1826 (Squamata: Colubridae) from the Pantepui region, northeastern South America. *Zootaxa*, 2611, 31–44.
- Lehr, E. (2002) *Amphibien und Reptilien in Peru*. Natur und Tier-Verlag (Münster), 220 pp.
- Nunes, P.M., Fouquet, A., Curcio, F.F., Kok, P.J.R. & Rodrigues, M.T. (2012) Cryptic species in *Iphisa elegans* Gray, 1851 (Squamata: Gymnophthalmidae) revealed by hemipenial morphology and molecular data. *Zoological Journal of the Linnean Society*, 166 (2), 361–376.  
<http://dx.doi.org/10.1111/j.1096-3642.2012.00846.x>
- Passos, P. & Fernandes, R. (“2008” 2009) Revision of the *Epicrates cenchría* complex (Serpentes: Boidae). *Herpetological Monograph*, 22, 1–30.  
<http://dx.doi.org/10.1655/06-003.1>
- Pesantes, O.S. (1994) A method for preparing the hemipenis of preserved snakes. *Journal of Herpetology*, 28, 93–95.  
<http://dx.doi.org/10.2307/1564686>
- Peters, J.A. (1964) *Dictionary of Herpetology*. Hafner Publishing Company, New York, 392 pp.
- Peters, J.A. & Orejas-Miranda, B. (1970) Catalogue of the Neotropical Squamata. Part I. Snakes. *United States National Museum Bulletin*, 297, 1–347.  
<http://dx.doi.org/10.5479/si.03629236.297.1>
- Pinto, R.R., Fernandes, R. & Marques, O.A.V. (2010) Reproductive biology of two sympatric colubrid snakes, *Chironius flavolineatus* and *Chironius quadricarinatus*, from the Brazilian Cerrado domain. *Amphibia-Reptilia*, 31, 463–473.  
<http://dx.doi.org/10.1163/017353710X518423>
- Rojas, M. (1992) The species problem and conservation: what are we protecting? *Conservation Biology*, 6 (2), 170–178.  
<http://dx.doi.org/10.1046/j.1523-1739.1992.620170.x>

- Sabaj Pérez, M.H. (2014) Standard symbolic codes for institutional resource collections in herpetology and ichthyology: an Online Reference. Version 5.0 (22 September 2014). American Society of Ichthyologists and Herpetologists, Washington, DC. Available from: <http://www.asih.org> (accessed 26 September 2014)
- Sites, J.W. Jr. & Marshall, J.C. (2004) Operational criteria for delimiting species. *Annual Review of Ecology, Evolution, and Systematics*, 35, 199–227.  
<http://dx.doi.org/10.1146/annurev.ecolsys.35.112202.130128>
- Uzzel, T. (1973) A revision of lizards of the genus *Prionodactylus*, with a new genus for *P. leucostictus* and notes on the genus *Euspondylus* (Sauria, Teiidae). *Postilla*, 159, 1–67.
- Wallach, V., Williams, K.L. & Boundy, J. (2014) *Snakes of the world - A catalogue of living and extinct species*. CRC Press, Boca Raton, 1227 pp.  
<http://dx.doi.org/10.1201/b16901>
- Wiens, J.J. & Servedio, M.R. (2000) Species delimitation in systematics: inferring diagnostic differences between species. *Proceedings of the Royal Society*, 267, 631–636.  
<http://dx.doi.org/10.1098/rspb.2000.1049>
- Zaher, H. (1997) Description of the cephalic muscles and gland morphology of *Clelia plumbea* and three presumably related species (Serpentes, Xenodontinae). *Papéis Avulsos da Zoologia*, 40, 17–63.
- Zaher, H. (1999) Hemipenial morphology of the South American xenodontine snakes with a proposal for a monophyletic Xenodontinae and a reappraisal of colubroid hemipenes. *Bulletin of the American Museum of Natural History*, 240, 1–168.  
<http://dx.doi.org/10.1590/S0031-10492009001100001>
- Zar, J.H. (1999) *Biostatistical Analysis*. 4<sup>th</sup> Edition Prentice Hall, Upper Saddle River, New Jersey.

#### APPENDIX. Specimens examined (" skull; \* hemipenis; # cephalic glands)

***Chironius flavolineatus***. BRAZIL: without specific locality: MSNM Re2729 (lectotype), MZUFBA 785, 1261, 1313, 1544. ALAGOAS: Camaragibe: MNRJ 3981, Matriz de Camaragibe: UFPB 4669, Quebrangulo: MZUSP 3169; AMAPÁ: Ferreira Gomes: CHUNB 219; AMAZONAS: Humaitá: CHUNB 217–18, MNRJ 19786; BAHIA: without specific locality: UEFS 686, Barreiras: MZUFBA 2131\*, MNRJ 3064–65, Cachoeira: MZUFBA 1647\*, Camaçari: MZUFBA 1199, Candeias: MZUFBA 592, Catú: MZUFBA 610, Cruz das Almas: UEFS 1525, Dias Dávila: UEFS 1469, MZUESC 1759, Itanagra: MZUFBA 401, Salvador: MZUFBA 1668, 1784, 1819\*#, 2278, Santa Rita de Cássia: MZUSP 3602, São Desidério: MZUFBA 2309\*#, MZUESC 7078–79, Saubara: MZUFBA 2280\*, Simões Filho: MZUFBA 1603; CEARÁ: Barbalha: CHUFC 2127, Ubajara: MZUSP 10504; FEDERAL DISTRICT: Brasília: CHUNB 24908; GOIÁS: Alto Paraíso de Goiás: IVB 3291, Aporé: CHUNB 48241, 48242, Buritinópolis: MZUSP 17770, Formosa: CHUNB 19698, Goiânia: CHUNB 56373, Minaçu: CHUNB 29774, 6669, 29777–78, 29783, 29769, 49133, 50423, MZUSP 11097–98, Uruaçu: MNRJ 7495; MARANHÃO: Balsas: CHUNB 52146; MATO GROSSO: Acorizal: MZUSP 7307, Araputanga: UFMT 5918, Barra do Tapirapé: MNRJ 588–89, Brasnorte: UFMT 8031, Cáceres: UFMT 1529, Chapada dos Guimarães: UFMT 542, 547, CHUNB 55217, MZUSP 5348, 11843, CHUNB 15378, 15380, 15417–18, Confresa: MZUSP 3812, Cuiabá: UFMT 8559, Guarantã do Norte: UFMT 5715, Guiratinga: MZUSP 20707, Jauru: UFMT 2817, Jupia: MZUSP 4425, Nossa Senhora do Livramento: UFMT 1527\*, Nova Xavantina: CHUNB 63633, MZUSP 3170, Porto Estrela: UFMT 8330, Primavera: UFMT 7608, São José do Rio Claro: MZUSP 11333, Utiariti: MZUSP 4751, Xavantina: MNRJ 6697, 9274, 9276; MATO GROSSO DO SUL: Aquidauana: MNRJ 1511, MZUSP 10158, Campo Grande: MZUSP 10157, Corumbá: UFMT 1463, Porto: MZUSP 11651; MINAS GERAIS: Arinos: MZUSP 3849, Buritizeiro: CHUNB 44474, Conquista: FUNED 392, Indianópolis: MCNR 607, FUNED 1695, Jaíba: MZUFV 946, Januária: MZUFV 1090, João Pinheiro: MNRJ 12900–01, 14853–55, 14901, 15251–52, 15299, 15312\*#, 15355, 15396, 17155–59, 17183, 17211, 17251, 17271, 17770–71, 17821–22, 19985, 19997, 20222, Joaquim Felício: MZUFV 1121, Nova Lima: MCNR 1474, Pompeu: MCNR 3818, Uberaba: MCNR 4141, Uberlândia: MCNR 608, Queimado Hydroelectric Power Plant, Unai: MNRJ 10929; PARÁ: Cachimbo: CHUNB 12798, Itaituba: MZUSP 3111, Novo Progresso: CHUNB 40091; PARAÍBA: Alhandra: UFPB 9374, Cruz do Espírito Santo: MZUSP 20271, Gurinhém: UFPB 4667, MZUSP 9656, João Pessoa: UFPB 4665, UFPB 4666, UFPB 8839, Mamanguape: MZUSP 3171, CHUNB 29018; PERNAMBUCO: Recife: MZUSP 8010, Serra Talhada: UFPB 4668, MZUSP 9011; RIO GRANDE DO NORTE: Ceará-Mirim: UFRN AAGARDA 1894, Macaíba: UFRN AAGARDA 3511, Nisia Floresta: UFRN AAGARDA 6236; SÃO PAULO: Emas: MZUSP 1894, Igarapava: FUNED 389, 417, 428, 429, 1305, MCNR 791, 792, 793, Jales: MZUSP 3987, Pirassununga: MZUSP 3989, Tambaú: CHUNB 24568, 24572; SERGIPE: Areia Branca: UFS 419\*, MZUSP 5444, Barra dos Coqueiros: MZUSP 17451, Itabaiana: UFS 2612, Itaporanga da Ajuda: UFS 519, Lagarto: CHUFC 892, Pirambu: UFS 14, 19, Santo Amaro das Brotas: MZUSP 6991, São Cristovão: UFS 337\*, 1329\*#, 1330; TOCANTINS: Aliança do Tocantins: UFPB 4860, 4861, Dianópolis: CHUNB 33433, Guarai: MZUSP 12697, Jalapão: CHUNB 24376, Lajeado: MZUSP 14171, 14172, Mateiros: CHUNB 41307, Palmas: CHUNB, 16175, 21959, Peixe: MZUSP 15513, CHUNB 3759, 52634, São Salvador do Tocantins: MZUSP 12125, 17681. **BOLÍVIA**: SANTA CRUZ DE LA SIERRA: Andres Ibañez: Barrio Los Olivos: MNKP 201, Ñuflo de Chávez: Perseverancia, MNKP 405; Chiquitos/Santiago de Chiquitos: MNKP 2254; Andres Ibañez, Santa Cruz de la Sierra: MNKP 5056; **PARAGUAY**: AMAMBAY: Parque Nacional Cerro Corá: MNHNP 5201;.

***Chironius brazili***. BRAZIL: without specific locality: MCNR 48, FUNED 1659 FEDERAL DISTRICT: Brasília: CHUNB

3633, 19700, 28934, 44783, 49623, MNRJ 3242, MZUSP 7198; *GOIÁS*: Alto Paraíso de Goiás: CHUNB 12426, 59063\*, 59125, 59555–58, Luiziana: MZUSP 17702, 17704–06, Pirenópolis: CHUNB 3632, 3637, Davinópolis: CHUNB 62371; *MINAS GERAIS*: without specific locality: MNRJ 9258, Águas de Contenda: ZUFRJ 1576, Belo Horizonte: MCNR 440, Catas Altas: MZUSP 3853–55, Conceição do Mato Dentro: MCNR 534, 3384\*, Conceição do Rio Verde: MNRJ 11902, Congonhas: MCNR 2219, Cristália: FUNED 2077”#, Diamantina: MZUSP 7557, 7566, Grão Mogol: MZUSP 7985–86, Lima Duarte: MNRJ 6698, Indianópolis: FUNED 1694, 1696”, Itabirito: FUNED 41”#, MCNR 4116, Jaboticatubas: MZUSP 9602, Lavras: FUNED 1440, Nova Lima: MCNR 1466\*”, Nova Ponte: FUNED 761, MNRJ 4696, Ouro Preto: MCNR 4376, São Roque de Minas: CHUNB 53270, Perdões: MCNR 509”#; Poços de Caldas: MZUSP 14061, Presidente Olegário: MNRJ 6702, Sabará: FUNED 555, Sacramento: MZUSP 7581, São Roque de Minas: MZUFV 1746\*, 1747, 15001–02, Serra do Cipó, RPPN Yllozia: MNRJ 15811\*”#, Serro: MZUSP 8058, Uberlândia: MCNR 1290; *RIO GRANDE DO SUL*: Santa Cruz do Sul: MCP 18429, São Francisco de Assis: MCP 18430; *SÃO PAULO*: Botucatu: MNRJ 19759, 20634\*, MZUSP 2438, Buri: MZUSP 12923, São Paulo: MZUSP 733, Sorocaba: UEFS 763.