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Mikrogeophagus maculicauda, a new dwarf cichlid (Teleostei: Cichlidae) from the eastern drainage of the upper Rio Guaporé, Brazil

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Abstract
Mikrogeophagus maculicauda sp. n. is described from the upper Rio Guaporé drainage in the Estado Mato Grosso in Brazil. It can be distinguished from the congeners by the presence of the following characteristics: a large rectangular or square dark spot extending almost over the entire caudal peduncle, a greenish metallic sheen on the sides of the body, and in adult males very long filiform extensions of the posterior soft dorsal fin and the marginal rays of both the upper and the ventral lobe of the caudal fin.

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Introduction
For a long time, the nomenclature of both the South-American cichlid genus *Mikrogeophagus* Meulengracht-Madsen, 1968 and the generic assignation of the different species were subject to controversial disputes (e.g. Kullander 1977; Robins and Bailey 1982; Géry 1983), and finally, Kullander (2011) settled the problem. Presently *Mikrogeophagus* comprises only the two species *M. altispinosus* (Haseman, 1911) from the Rio Mamoré and the middle and lower Rio Guaporé basins in Bolivia and Brazil and *M. ramirezi* (Myers and Harry, 1948) from the Llanos of the Orinoco basin in Colombia and Venezuela (Kullander 2003). A third form was exported from the Rio Pindatuba (upper Rio Guaporé basin) and is now known only from aquarium literature (Koslowski 2002; Staeck 1993a, 2017). Its taxonomy has not been examined because of the lack of suitable materials. The objective of this paper is to present the formal description of this dwarf cichlid.

Material and Methods
The following description is based on specimens, legally exported from Brazil for the commercial pet trade. Since no directed collections were possible, the number of types is comparatively low, as is often the case with descriptions of South American dwarf cichlids (cf. Kullander 1980a, 1981; Mesa and Lasso 2011). As the type specimens were fixed in 10% formalin and later transferred into 70% ethanol, no molecular analyses were made. All the types are deposited in the Coleção Ictiológica do Centro de Ciências Agrárias e Ambientais (CICCAA) of the Universidade Federal do Maranhão (UFMA) in Brazil.

Counts and morphometric variables were taken according to Kullander (1980a, 1986). Scale rows are numbered as described by Kullander (1990). The fork length is measured from the tip of the snout (including the upper lip) to the middle caudal fin rays. This is identical to the total length of Kullander (1980a). Total length is measured from the most anterior point of the specimen (including the upper or lower lip) to the most posterior point of the caudal fin, including filaments. Numbers in brackets after counts indicate the number of specimens examined with that condition. Measurements were made with an electronic digital calliper reading to the nearest

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Figure 1. Male *Mikrogeophagus maculicauda* sp. n., holotype, male 59.6 mm SL (CICCAA 02697).

0.1 mm. Specimen lengths are given as standard length (SL). The species concept used is the diagnostic variant of the phylogenetic species concept advocated by Nixon and Wheeler (1990). This includes recognizing phenotypically different sister populations as separate taxonomic units if the difference is connected with evolutionary traits or the sexual mating selection system.

The type specimens are listed under the species account. Comparisons were made with two specimens of *M. altispinosus* (ZFMK ICH-122460, ICH-122461, 2, 44.1-47.1 SL; southwest of Trinidad, road to Puerto Almacén, Beni, Bolivia) and by consulting published sources (e.g. Haseman 1911; Kullander 1980b, 1981). Examined material of *M. ramirezi* is listed in Staeck (1993b).

Results

Mikrogeophagus maculicauda new species (Table 1, Fig. 1)

Holotype: CICCAA 02697, male 59.6 mm SL. Rio Pindaituba (or Ribeirão Pintaituba) north of Vila Bella da Santissima Trinidade (Estado Mato Grosso, Brazil), tributary to the Rio Sararé. Legal import of the commercial pet trade via the aquarium fish wholesaler Gerald Kellner (Mehring, Germany) in 1991.

Paratypes: CICCAA 02698, 53.1 mm SL. Same data as in holotype. CICCAA 02699 (2 ex.) 53.4-55.7 mm SL. Legal import of the commercial pet trade via the aquarium fish wholesalers Ruinemans Aquarium (Montfoort, Holland) and Panta Rhei (Wiedemark, Germany) in 2018.

Diagnosis: A comparatively small geophagine cichlid (maximum SL approx. 60 mm). The new species is distinguished from *M. altspinosus* and *M. ramirezi* by having a conspicuous large rectangular or square black blotch extending almost over the entire caudal region of the body. It also differs from both congeners by having a greenish metallic sheen on the sides of the body and adult males with very long filiform extensions of the posterior soft dorsal fin and the upper and lower caudal-fin rays.

Description: Refer to Figs. 1–7 for general appearance and color pattern. Measurements are summarized in Table 1. A comparatively small geophagine Cichlid with only slight morphological sexual dimorphism and no obvious sexual differences in color pattern. Males grow larger than females and develop longer threadlike elongations of their dorsal and caudal fin. Body comparatively deep, laterally compressed. Dorsal and ventral contours of head more or less equally arched. Mouth terminal, lower jaw slightly longer than upper one.

Dorsal fin particularly high. First and second anterior dorsal-fin spines very short, fourth or fifth longest; lappets produced, between the fourth and fifth spine very long. Caudal fin truncate or subtruncate with filaments on the outer rays. In large male specimens, the posterior soft dorsal-fin rays and the marginal caudal-fin rays are

Table 1. Standard length (in mm) of the types of *Mikrogeophagus maculicauda* sp. n. (CICCAA 02697, and CICCAA 02698) and proportional measurements of morphometric data as a percentage of SL. Min = lowest value, max = highest value, mean = arithmetic mean, ± = standard error of mean.

Measurement	Holotype	Holotype + Paratypes		
		min	max	mean±se
Standard length	59.6	53.1	59.6	55.4
Total length	174.3	127.2	174.3	146.4±12.3
Fork length	128.7	128.7	131.3	129.9±0.62
Head length	32.9	30.5	32.9	31.4±0.54
Orbit diameter	11.7	11.6	12.4	11.9±0.18
Interorbital width	12.8	12.8	13.3	13.0±0.12
Preorbital depth	7.9	7.3	7.9	7.6±0.13
Body depth	46.6	44.9	47.1	46.3±0.47
Predorsal-fin length	41.3	39.0	41.3	40.5±0.54
Preanal-fin length	70.3	70.3	75.1	72.9±1.14
Caudal peduncle depth	16.3	15.6	16.3	15.8±0.15
Caudal peduncle length	13.3	13.3	14.6	13.9±0.29
Pectoral-fin length	34.2	32.4	36.3	33.9±0.90
Pelvic-fin length	38.3	35.6	38.5	37.1±0.74
Last dorsal-fin spine length	18.0	16.8	18.3	17.5±0.36
Dorsal-fin base length	57.0	54.4	57.8	56.5±0.73
Anal-fin base length	19.3	18.6	19.3	19.1±0.17

spectacularly produced. The extension of the posterior soft dorsal fin may reach the posterior end of the caudal fin and the long filiform extensions of the upper and lower lobe of the caudal fin may be as long as the fin.

E1 scales 26(3) or 27(1). Upper lateral line with 13(1), 14(1) or 16(2); lower with 7(2) or 8(2) scales. Scales absent from fins except on caudal fin. Dorsal fin 15(2) or 16(2) spines and 8(1) or 9(3) soft rays, total spines and rays 24(3) or 25(1). Anal fin with 3(4) spines and 8(4) soft rays. Pectoral fin with 13 rays. Serration of preopercle variable and most rudimentary, more recognizable at corner. Gill rakers in one examined specimen: 3 on epibranchial lobe, 1 in corner and 6 on first ceratobranchial.

Coloration of live specimens (Figs. 2-7)**:** Based on observations of specimens kept in an aquarium.

Living specimens are colorful. However, their coloration variable, depending on mood. Body with greyish white to beige ground color, often with greenish metallic sheen on the sides. Shoulder region orange. Dorsal fin hyaline, membranes between first and fifth dorsal spines black, following tipped with red. In large males, its posterior soft section red with bright blue dots. Caudal fin hyaline with bright red upper and lower margin, in males with reddish tinge and minute bright blue dots in center and bright red filiform extension of upper and lower lobe. Anal fin red with small blue dots in distal soft section. Pelvic fins red with narrow bright blue longitudinal lines.

Manifestation and intensity of black or dark brown markings variable and mood-dependent: A black vertical stripe extending from occiput to eye and from the eye down to preopercle. Between operculum and large caudal blotch, fife dark lateral bars present, sometimes subdivided into 10 narrow vertical stripes. Upper half of first bar sometimes transformed into a black blotch on nape. On second (and third) vertical bar a large vertically oriented black mid-lateral blotch extending over flanks, sometimes split into two (or four) vertical stripes. In

Figure 2. Dominant adult male of *Mikrogeophagus maculicauda* sp. n. (no type) from Rio Pindaituba photographed in the aquarium.

Figure 3. Adult female of *Mikrogeophagus maculicauda* sp. n. (no type) from Rio Pindaituba (photographed in the aquarium).

posterior section of body a large rectangular or square black spot extending almost over entire caudal peduncle. Scales on body sides sometimes with dark centers forming about seven horizontal lines.

Coloration in alcohol (Fig. 1)**:** Body, head and fins greyish or yellowish, slightly darker in dorsal region. Dark markings and patterns on body and fins as described above. Suborbital stripe, black anterior dorsal-fin membranes, black mid-lateral blotch and caudal-peduncle spot prominent.

Distribution and ecology (Fig. 8)**:** As currently known, the distribution of *Mikrogeophagus maculicauda* sp. n. is restricted to the eastern tributaries of the upper Rio Guaporé. So far, the only documented collecting sites are situated in the Rio Pindaituba (or Ribeirão Pintaituba), a tributary to the Rio Sararé in the Estado Mato Grosso.

Figure 4. Subadult female of *Mikrogeophagus maculicauda* sp. n. (no type) from Rio Pindaituba exhibiting diagnostic neutral color pattern (photographed in the aquarium).

Figure 5. Pair of *Mikrogeophagus maculicauda* sp. n. during courtship (no types), female in the rear (Note the lack of sexual dichromatism and the distinct fin dimorphism).

The Rio Pindaituba is a small river, the water level seasonally fluctuates by several meters. At the beginning of April 1999, its soft and acidic water had quite a strong current during the high-water season. Several measurements of parameters of the water, which the first author took on the road between Ponte e Lacerda and Vilhena (Mato Grosso), had the following results: air temperature of 29.5°C, water temperatures of 25.3°C, pH of 6.5, electrical conductivity of 20 µS/cm, and total and temporary hardness of <1°dH.

Reproductive biology: Observations under aquarium conditions revealed that *Mikrogeophagus maculicauda* sp. n. is a monogamous open brooder. Brood care is biparental and both sexes share all the duties of it. Once a male and a female form a pair, both partners establish a territory. While courting proceeds, both clean the selected spawning surface.

Figure 6. Stressed male of *Mikrogeophagus maculicauda* sp. n. (no type) exhibiting elements of the species-specific dark color pattern.

Figure 7. Juvenile *Mikrogeophagus maculicauda* sp. n. (TL approx. 25 mm, no type) exhibiting complete pattern of vertical dark lateral bars.

After the approximately one-week courtship phase, during which the male is clearly more active, the eggs are commonly attached to the horizontal surface of a flat stone. As long as the pair cares for eggs or larvae, the female is more active and mainly cares for the brood while the male defends the spawning territory against intruders. Female absences are short, and when she leaves the eggs, she is immediately replaced by the male.

At a water temperature of 27 degrees Celsius, it takes around 60 hours for the larvae to hatch, but around 72 hours at 25 degrees. As soon as the fry hatch about three days post spawning, the larvae are hidden in previously

Figure 8. Rio Pindaituba during the high-water season in April 1999 at the road between Ponte e Lacerda and Vilhena (Mato Grosso, approx. 15°00'S, 59°17'W).

prepared small pits, where they remain until they start free-swimming. These "nests" have a diameter of about four centimeters. After approximately six days, the fry have passed the larval stage and swim through the aquarium as a shoal under the guidance of their parents. Both guide their babies by signaling them with spasmodic shaking their bodies and fins. From this point on, the parents defend their breeding grounds with particular vigor. *Mikrogeophagus maculicauda* sp. n. practice a long-term biparental defense of their mobile fry. Even if the parents spawn a second time, they sometimes do not chase the fry out of the breeding territory.
Etymology: The specific epithet is a combination of the Latin words *macula* (= blotch, spot) and *cauda* (= tail) and refers to the prominent dark blotch on the caudal peduncle.

Discussion

After adding *M. maculicauda* sp. n., the genus *Mikrogeophagus* includes three valid taxa. The Orinocoan

M. ramirezi was redescribed by Kullander (1980b), and a summary of the information about *M. altispinosus* was provided by him a few months later (Kullander 1981). *Mikrogeophagus maculicauda* sp. n. is most similar to *M. altispinosus* from the Rio Mamoré and the lower Rio Guaporé basins. *M. maculicauda* sp. n. occurs in the eastern part of the upper Rio Guaporé drainage. Such allopatric putative species pairs may pose taxonomic problems because morphological differences are often small and make discrimination and classification difficult (Mayr 1969). In the cases mentioned above, differences in the dark color patterns are one of the most frequently applied separating characters in species descriptions of South American cichlids (Kullander 1980a, 1986; Kullander and Ferreira 1988). In several taxonomic publications on the taxonomy of geophagine cichlid fishes (e.g. Mesa and Lasso 2011; Varella and Britzke 2016; Ota et al. 2021), black elements (viz. bars, dots and blotches) of the color pattern were used as diagnostic characters (or character states) in the last decade. Here we also use such a pragmatic approach for species recognition (cf. Kottelat 1995).

Even minor deviations in the patterns of dark markings may be of biological significance as they are important in mate choice. In cichlid fishes mating preferences are mainly based on visual factors (Couldridge and Alexander 2002; Blais et al. 2009), and the females can discriminate between conspecific and heterospecific courting males even if they are closely related and look similar (Kocher 2004; Beisenherz et al. 2006; Ready et al. 2006, Engelking et al. 2010).

The prominent dark blotch on the caudal peduncle of *Mikrogeophagus maculicauda* sp. n. distinguishes the new species from both *M. ramirezi* and *M. altispinosus. Mikrogeophagus maculicauda* sp. n. and *M. altispinosus* differ from *M. ramirezi* by a higher number of spines in the dorsal fin (> XIV versus < XV) and rays in the pectoral fin (>12 versus <13). The two are characterized by their high dorsal fin and the comparatively great length of the fourth or fifth dorsal-fin spine (in the types of *M. maculicauda* 21.5-22.8% of SL in the fourth and 19.6-22.1% of SL in the fifth dorsal-fin spine). *Mikrogeophagus maculicauda* sp. n. is further distinguished from *M. altispinosus* by having a greenish metallic sheen on the sides of the body (vs. a yellow or whitish ground color), and in adult males by the unusually long filiform extensions (vs. moderate prolongation or no extensions) of the posterior soft dorsal fin and the upper and lower caudal fin rays.

The drainages of the Rio Mamoré and Rio Guaporé, where *Mikrogeophagus maculicauda* sp. n. and *M. altispinosus* occur are part of the Amazonian ichthyographic province (Géry 1969; Hubert and Renno 2006). Its Bolivian subbasin is situated between the Andes and the southwestern border of the Brazilian Shield. It is a semi-isolated region separated from the adjacent main Amazon basin by the rapids and waterfalls of the upper Rio Madeira (Sarmiento et al. 2014; Carvajal-Vallejos et al. 2014). The Rio Guaporé forming the border between Bolivia and Brazil drains the southeastern edge of this ichthyographic province. Unlike other right bank tributaries of the upper Rio Madeira, the Rio Guaporé is the only river that originates on the Brazilian Shield.

This results in different chemical and physical characteristics, which apparently combine with other evolutionary factors to produce significant differences in the ichthyofauna of the upper Rio Guaporé drainage when compared to the Rio Mamoré drainage (Sarmiento et al. 2014; Hablützel and Pantel 2017). The rivers draining the Beni plains are characterized by nutrient-rich, sediment-laden turbid whitewater (pH up to 7.6; usually between 70 and >100µS/cm (Barbosa et al. 1999; Roche and Fernandez 1988, Staeck pers. obs.). In contrast, the upper Rio Guaporé is a nutrient-poor, clearwater river with relatively high transparency, slightly acid pH (usually 6.3-6.8), a negligible or moderate concentration of solutes and, consequently, low (usually 20-34 µS/cm) electric conductivity (Roche and Fernandez 1988; Sarmiento et al. 2014; Staeck pers. obs.).

In their analysis of the zoogeography of the Bolivian cichlid fishes Hablützel and Pantel (2017) show that cichlid assemblages in the Bolivian subbasin of the Amazonian ichthyographic province are geographically structured and that different assemblages of cichlid fish species replace each other within distinct biogeographic

regions, e.g. within the Rio Mamoré and the upper Rio Guaporé drainages. The distribution patterns of *Mikrogeophagus maculicauda* sp. n. and *M. altispinosus* are in line with these findings.

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Literature cited

Barbosa F.A.R., Villarte F., Serrudo J.F.G., Renault G.d.P.C.P., Maia-Barbosa R.M., Menéndez P.M., Pereira M.C.F., Vianna J.d.A. 1999. Summary of the physico-chemical characteristics of the waters in the Upper Tahuamanu and Lower Nareuda/Middle Tahuamanu sub-basins during the AquaRAP expedition to Pando, Bolivia in September 1996. In: B. Chernoff, P.W. Willink (Eds.) A biological assessment of the aquatic ecosystems of the Upper Río Orthon basin, Pando, Bolivia. Bulletin of Biological Assessment 15: 76-78.

Beisenherz W., Römer U., Müller M., Engelking B. 2006. Wie wählen *Apistogramma*-Weibchen ihre Partner? Intra- und interspezifische Partnerwahl durch Weibchen von *Apistogramma cacatuoides* Hoedeman, 1951 (Teleostei, Perciformes, Cichlidae). In: H. Greven, R. Riehl (Eds.). Biologie der Aquarienfische. Tetra-Verlag, Berlin-Velten. pp: 7-18.

Blais J., Plenderleith M., Rico C., Taylor M.I., Seehausen O., van Ooseterhout C., Turner G.F. 2009. Assortative mating among Lake Malawi cichlid fish populations is not simply predictable from male nuptial colour. BMC Evolutionary Biology 9: 53.

Carvajal-Vallejos F.M., Bigorne R., Fernández A.J.Z., Sarmiento J., Barrera S., Yunoki T., Pouilly M., Zubieta J., De La Barra E., Jegú M., Maldonado M., van Damme P., Céspedes R., Oberdorff T. 2014. Fish-AMAZBOL: a database on freshwater fishes of the Bolivian Amazon. Hydrobiologia 732: 19-27.

Couldridge V., Alexander G.J. 2002. Color patterns and species recognition in four closely related species of Lake Malawi cichlid. Behavioral Ecology 13: 59-64.

Engelking B., Römer U., Beisenherz W. 2010. Intraspecific colour preference in mate choice by female *Apistogramma cacatuoides* Hoedeman, 1951 (Teleostei, Perciformes, Cichlidae). Vertebrate Zoology 60: 123-138.

Géry J.1969. The freshwater fishes of South America. In: E.J. Fittkau et al. (Eds.). Biogeography and Ecology in South America. Monographiae Biologicae 2: 828-848.

Géry J. 1983. Le nom de genre de *Apistogramma ramirezi* Myers & Harry. Revue française d'Aquariologie Herpétologie 10: 71-72.

Hablützel P.I., Pantel J.H. 2017. Strong spatial turnover in cichlid fish assemblages in the upper río Madera (Amazon basin) despite the absence of hydrological barriers. Hydrobiologia 791: 221-235.

Haseman J.D. 1911. An annotated catalog of the cichlid fishes collected by the Expedition of the Carnegie Museum to Central South America, 1907-10. Annals of the Carnegie Museum 7: 329-373.

Hubert N., Renno J.F. 2006. Historical biogeography of South American freshwater fishes. Journal of Biogeography 33: 1414-1436.

Kocher T.D. 2004. Adaptive evolution and explosive speciation: the cichlid fish model. Nature Reviews Genetics 5: 288-298.

Koslowski I. 2002. Die Buntbarsche Amerikas – *Apistogramma* & Co. Ulmer, Stuttgart. 318 p.

Kottelat M. 1995. Systematic studies and biodiversity – the need for a pragmatic approach. Journal of Natural History 29: 565-569.

Kullander S.O. 1977. *Papiliochromis* gen. n., a new genus of South American cichlid fish. Zoologica Scripta 6: 253-254.

Kullander S.O. 1980a. A taxonomical study of the genus *Apistogramma* Regan, with a revision of Brazilian and Peruvian species (Teleostei: Percoidei: Cichlidae). Bonner Zoologische Monographien 14: 1-152.

Kullander S.O. 1980b. A redescription of the South American Cichlid Fish *Papiliochromis ramirezi* (Teleostei: Cichlidae). Studies on Neotropical Fauna and Environment 15: 91-108.

Kullander S.O. 1981. The Bolivian Ram - a zoogeographical problem and its taxonomic solution. DCG-Informationen 12: 61-79.

Kullander S.O. 1986. Cichlid fishes of the Amazon River drainage of Peru. Swedish Museum of Natural History, Stockholm. 431 p.

Kullander S.O. 1990. *Mazarunia mazarunii* (Teleostei: Cichlidae), a new genus and species from Guyana, South America. Ichthyological Exploration of Freshwaters 1: 3-14.

Kullander S.O. 2003. Family Cichlidae. In: R.E. Reis et al. (Eds.). Check list of the freshwater fishes of South and Central America. Edipucrs, Porto Alegre. pp: 605-654.

Kullander S.O. 2011. Nomenclatural availability of putative scientific generic names applied to the South American cichlid fish *Apistogramma ramirezi* Myers & Harry, 1948 (Teleostei: Cichlidae). Zootaxa 3131: 35-51.

Kullander S.O., Ferreira E.J.G. 1988. A new *Satanoperca* species (Teleostei. Cichlidae) from the Amazon River basin in Brazil. Cybium 12: 343-355.

Mayr E. 1969. Principles of systematic zoology. McGraw Hill Book Co, New York. 428 p.

Mesa S.L.M., Lasso C.A. 2011. Revisión del género *Apistogramma* Regan, 1913 (Perciformes, Cichlidae) en la cuenca del río Orinoco. Serie Editorial Recursos Hidrobiológicos y Pesqueros Continentales de Colombia III. Instituto Humboldt, Bogotá. 193 p.

Nixon K.C., Wheeler Q.D. 1990. An amplification of the phylogenetic species concept. Cladistics 6: 211-223.

Ota R.R., Deprá G.C., Kullander S., da Graça W.J., Pavanelli C.S. 2021. A new species of *Satanoperca* (Teleostei: Cichlidae) from the Rio Tocantins basin, Brazil. Neotropical Ichthyology 19: e210116.

Ready J.S., Sampaio I., Schneider H., Vinson C., Dos Santos T., Turner G.F. 2006. Colour forms of Amazonian cichlid fish represent reproductively isolated species. Journal of Evolutionary Biology 19: 1139-1148.

Robins C.R., Bailey R.M. 1982. The status of the generic names *Microgeophagus*, *Pseudoapistogramma*, *Pseudogeophagus* and *Papiliochromis* (Pisces: Cichlidae). Copeia 1982: 208-210.

Roche M.A., Fernandez C. 1988. Water resources, salinity and salt yields of the rivers of the Bolivian Amazon. Journal of Hydrology 101: 305-331.

Sarmiento J., Bigorne R., Carvajal-Vallejos F.M., Maldonado M., Leciak E., Oberdorff T. 2014. Peces de Bolivia. IRD-Biofresh (EU) Plural editors, La Paz. 211 p.

Staeck W. 1993a. Eine neue Farbrasse von *Papiliochromis altispinosa* (Haseman, 1911). DCG-Informationen 24: 36-42.

Staeck W. 1993b. Zur Verbreitung und Ökologie von *Papiliochromis ramirezi*. Die Aquarien- und Terrarien-Zeitschrift 46: 239-242.

Staeck W. 2017. Kleine Buntbarsche - Amerikanische Cichliden I, Ein Handbuch für Bestimmung, Pflege und Zucht (9. Auflage). Tetra Verlag, Berlin-Velten. 315 p.

Varella H.R., Britzke R. 2016. *Apistogramma eleutheria* and *A. flavipedunculata*, two new species of dwarf cichlids from the rio Curuá on Serra do Cachimbo, Brazil (Teleostei: Cichlidae). Ichthyological Exploration of Freshwaters 27: 81-95.