

Description of *Apistogramma paulmuelleri* sp. n., a new geophagine cichlid species (Teleostei: Perciformes) from the Amazon river basin in Loreto, Peru *

UWE RÖMER^{1,2,3}, JOSCHA BENINDE^{1,2}, FABRICE DUPONCHELLE^{1,4,5}, CARMEN ROSA GARCÍA DÁVILA^{1,6}, ANTONIA VELA DÍAZ^{1,6} & JEAN-FRANÇOIS RENNO^{1,5,6}

¹ Laboratoire Mixte International – Evolution et Domestication de l’Ichtyofaune Amazonienne [LMI – EDIA] — ² University of Trier, Inst. Biogeography, Dep. Geo-Sciences, 54286 Trier, [UTIB] Germany — ³ Linteler Straße 19, 33334 Gütersloh; Germany; Email: eu.roemer@t-online.de (corresponding author) — ⁴ Universidad Nacional Federico Villareal, Facultad de Oceanografía y Ciencias Alimentarias, 350 calle Roma, Miraflores, Lima, Perú — ⁵ Institut de Recherche pour le Développement (IRD), UMR ISE-M, 361 rue Jean-François Breton BP5095, 34196 Montpellier Cedex 5, France — ⁶ Instituto de Investigaciones de la Amazonia Peruana (IIAP), km 2.5, Avenida Abelardo Quiñones, Iquitos, Perú

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Abstract

A new species of *Apistogramma* is described from Peru, based on a total of 28 specimens collected in a small forest stream in the catchment of a nameless tributary of the Rio Amazonas about 80 kilometres south of Iquitos, Departamento Loreto (approximately 73° 34' W / 04° 24' S). At first sight *Apistogramma paulmuelleri* sp. n. resembles *A. regani*, but is differentiated from the latter and all other *Apistogramma* species by the combination of a large band-like spot on the caudal-fin base, four distinct abdominal stripes, a roundish, banded caudal fin, a low dorsal fin without any striking features, in adult males yellow on the chin between the gill covers and on parts of the branchiostegal membranes, ivory sides to the head below the cheeks, and reversal of the band pattern during aggression and courtship display. *Apistogramma paulmuelleri* sp. n. is currently thought to be a representative of the *Apistogramma eunotus* complex within the *Apistogramma regani* lineage.

Resumen

Una nueva especie de *Apistogramma* es descrita del Perú, sobre la base de un total de 28 especímenes colectados en un pequeño arroyo forestal anónimo, tributario del río Amazonas a unos 80 kilómetros al sur de Iquitos, departamento del Loreto (aproximadamente 73° 34' W / 04° 24' S). A primera vista *Apistogramma paulmuelleri* sp. n. se parece a *A. regani*, pero se diferencia de esta última y todas las demás especies de *Apistogramma* por la combinación de un punto grande formando una banda en la base de la aleta caudal, cuatro líneas abdominales bien distintivas, una aleta caudal arredondeada con bandas, una aleta dorsal baja sin características notables, en los machos adultos coloración amarilla en el mentón entre el opérculo y en las partes de las membranas branquiostegales, las porciones laterales de la cabeza por debajo de las mejillas son de color marfil, y el inverso del patrón de coloración en bandas durante la agresión y la exhibición del cortejo. Actualmente, se piensa que *Apistogramma paulmuelleri* sp. n. es un representante del complejo *Apistogramma eunotus* dentro del linaje *Apistogramma regani*.

Kurzfassung

Eine neue *Apistogramma*-Art wird auf Basis von 28 Exemplaren beschrieben, die aus einem kleinen Urwaldbach im Einzugsgebiet eines namenlosen Nebenflusses des Rio Amazonas etwa 80 Kilometer südlich von Iquitos, Departamento Loreto, Peru (nahe 73° 34' W / 04° 24' S) stammen. *Apistogramma paulmuelleri* sp. n. Ähneln auf den ersten Blick *A. regani*, ist aber von dieser und allen anderen *Apistogramma*-Arten durch die Kombination von großem bandartigen Fleck auf der Schwanzwurzel, vier Unterkörperstreifen, rundlicher ge-

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bänderter Schwanzflosse, niedriger Dorsale ohne auffällige Modifikationen, bei adulten Männchen gelber Färbung des Kinns zwischen den Kiemendeckeln und auf Teilen der Branchiostegalmembran, elfenbeinfarbenen Kopfseiten unterhalb der Wangen und der Umkehrung des Bändermusters in Aggression und Balzstimmung unterschieden. *Apistogramma paulmuelleri* sp. n. ist nach derzeitiger Kenntnis ein Vertreter des *Apistogramma-eunotus*-Komplexes innerhalb der *Apistogramma-regani*-Linie.

Key words

Amazonia Occidental, biodiversity, endemism, ecology, freshwater, Iquitos, Neotropics, new taxa, systematic.

Prefatory Remarks

In recent years numerous new *Apistogramma* species have been described from Peru (ORTEGA & VARI 1998; ORTEGA *et al.* 2011, 2012) (table1), but there are still numerous forms awaiting scientific description within the genus from this region. In 2010 and 2011 members of the LABORATOIRE MIXTE INTERNATIONAL (LMI) had the opportunity to visit numerous *Apistogramma* habitats in Peru and to collect several species of these small Neotropical cichlids there. During these activities by the LMI local fishermen indicated that a potentially new form of *Apistogramma*, locally provisionally referred to as *Apistogramma* sp. “Apache”, had been found in a small brook in the rainforest south of Iquitos. Within the framework of the project we had the opportunity to collect sufficient material for ichthyological, behavioural, and genetic studies on this species. Our observations suggested that these fish were the same species as individuals that have been presented in the aquarium literature as *Apistogramma* sp. “Masken” (KOSLOWSKI, 2002; STAECK, 2003). As a result of our studies we now present the formal description of the 82nd species of the genus *Apistogramma* in this paper.

tions on all paratypes. Some preserved specimens had to undergo “brushing” (for details see RÖMER *et al.*, 2011) before they could be used for analysis.

As we are basically following the morphological/genetic cluster concept (M/GC) for species delimitation (*cf.* SITES & MARSHALL, 2004; also DAVIS & NIXON, 1992; WIENS & SERVEDIO, 2000), comparative statistical analysis of all data was performed using the PC program STATISTICA 6.0 for Windows (StatSoft Inc., Tulsa, USA). DNA samples were taken, preserved as described in RÖMER *et al.* (2011) immediately before (or exceptionally after) preservation and stored as detailed in RÖMER *et al.* (2012). Photographs of all specimens have been taken under standardised conditions detailed in RÖMER *et al.* (2011). Gill rakers, pharyngeal elements, and dentition have not been included in this study (for reasons see RÖMER *et al.*, 2011). The description of live coloration of this species is based on observation and photographs of the type material taken in aquaria, as detailed in RÖMER *et al.* (2011). RÖMER (2000, 2006) and RÖMER *et al.* (2003, 2004, 2006) have explained at length the reasons for giving precise descriptions of live coloration in *Apistogramma* species.

In the list of material we will also include a number of non-type-specimens clearly belonging to the species described herein, which we designate as “authorized specimens” (for definition see RÖMER *et al.* 2012). For museum acronyms see LEVITON *et al.* (1985).

Methods

Methods for counts and measurements are as detailed in RÖMER (2006), RÖMER & HAHN (2008), and RÖMER *et al.* (2003, 2004, 2006, 2011, 2012) except where otherwise stated. GPS locality data were taken using a GPSmap 76 CSx (Garmin Int. Inc., Lenexa, USA). Preservation of all specimens followed the “low temperature preservation protocol”, (LTPP) described in detail by RÖMER & HAHN (2008) and RÖMER *et al.* (2011), in the laboratory of the IIAP in Iquitos after observing behaviour and colour patterns of specimens collected (for reasons see RÖMER *et al.*, 2011). Several specimens were initially preserved in 95 % ethanol to be able to take DNA samples, with most being transferred into 75 % ethanol later on. The description is based on the holotype, supplemented by observa-

Apistogramma paulmuelleri sp. n.

Material: 28 specimens.

Holotype (fig. 1): MUSM 41805, male, 41.2 mm SL; collected in a small *quebrada* (stream) close to the *carretera* (road) from Iquitos to Nauta, Departamento Loreto, Peru; [field-station F8-P-2011-R: position 04°24'S / 73°34'W] August 4th 2011, by Roger MORI sr., Roger MORI jr, Uwe RÖMER, Joscha BENINDE, Fabrice DUPONCHELLE, and François KERVAREC.

Paratypes (figs. 2–3) (27 specimens): MTD F 32638, 1 male, 41.3 mm SL, 1 female, 32.1 mm SL; MTD F 32639, 1 male, 30.6 mm SL; MUSM 41806, 2 males, 25.1–37.1 mm; MUSM 41807, 1 male, 25.7 mm SL, 1 female, 30.2 mm SL; MUSM 41808, 2 males, 25.1–39.1 mm SL, 1 female, 23.6 mm SL; collection data as for holotype. MTD F 32635, 1 male, 39.6 mm SL; MTD F 32636, 1 male, 39.6 mm SL, 1 female, 28.9 mm SL; MTD F 32637, 3 males, 27.6–38.6 mm SL, 1 female, 28.8 mm SL; MTD F 32643, 1 male, 26.4 mm SL; MUSM 41809, (topotype) 1 male, 40.5 mm SL; MUSM 41810, 2 males, 31.8–37.2 mm SL; MUSM 41811, 1 male, 32.00 mm SL, 1 female, 29.1 mm SL; CAS 233863, 1 male, 39.4 mm SL, 1 female, 29.7 mm SL; CAS 233864, 1 male,

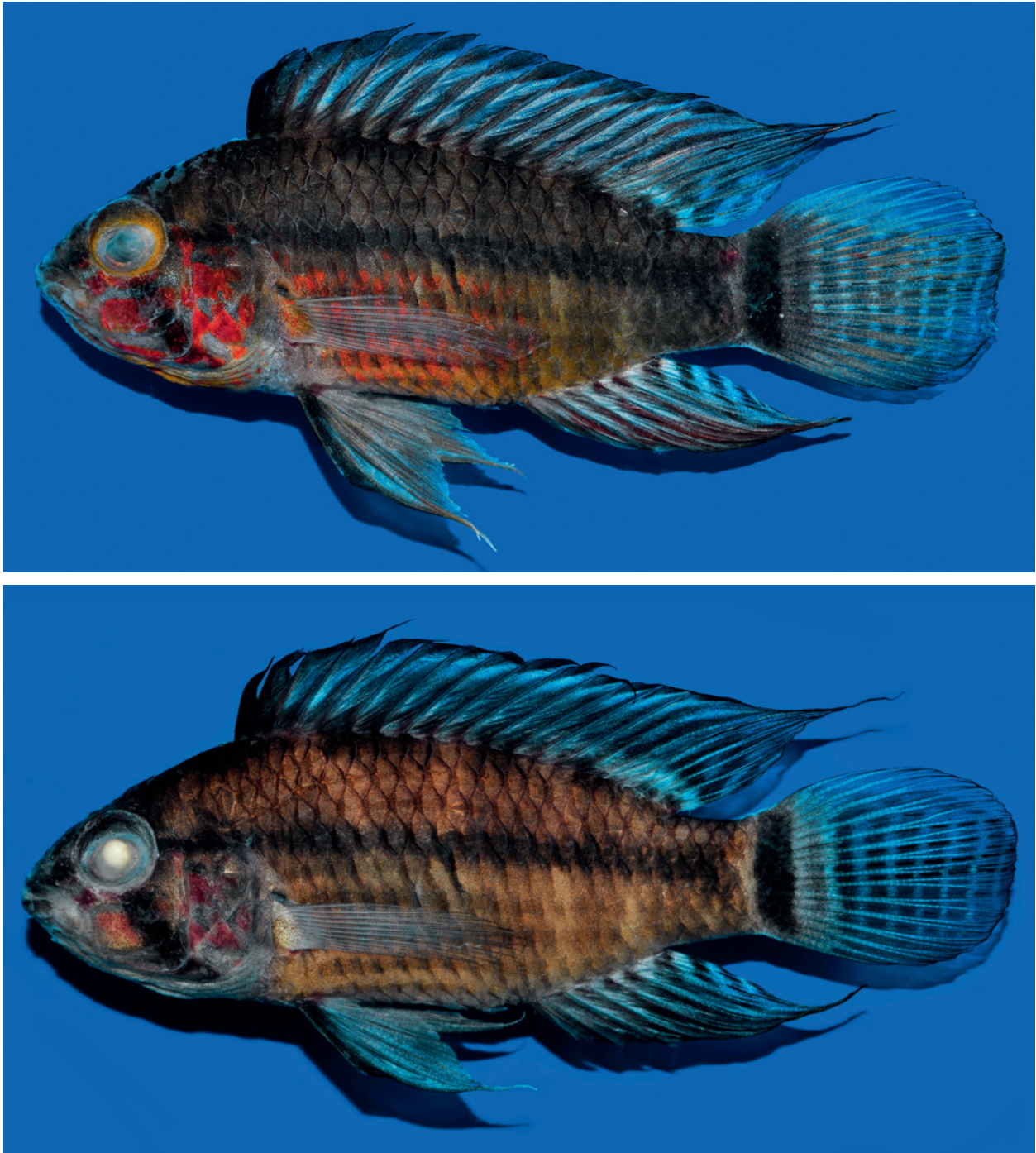


Fig. 1. *Apistogramma paulmuelleri* sp. n., holotype, MUSM 41805, male, 41.2 mm SL. Top: one week after preservation; bottom: six months after preservation. All figures: U. Römer.

32.0 mm SL, 1 female, 28.5 mm SL; all collected in the small isolated source area of a small *quebrada* (stream) close to the *carretera* (road) from Iquitos to Nauta, Departamento Loreto, Peru; field-station F15-P-2011-R (04°23'S / 73°34'W), August 12th 2011, by Roger MORI sr., Roger MORI jr., Joscha BENINDE, François KERVAREC, and Uwe RÖMER.

Comparative material: *Apistogramma cinilabra* RÖMER *et al.* (type series), all *Apistogramma* specimens in the collection of MUSM (RÖMER *et al.* in prep.). *Apistogramma caetei* KULLANDER, 1980 (holotype, FMNH 54164; 2 paratypes, FMNH 95176). *Apistogramma inconspicua* KULLANDER, 1982 (designated as paratype, formerly CMC 2737, now FMNH 54168). *Apistogramma ort-*

manni EIGENMANN, 1912 (part of type series: holotype, formerly CMC 2306, now FMNH 53801; 10 paratypes, FMNH 53973). *Apistogramma payaminonis* KULLANDER, 1986 (holotype, FMNH 56564; paratype, female, formerly FMNH 56564, now FMNH 105928). *Apistogramma pertensis* (HASEMAN, 1911) (holotype, formerly CMC 2741, now FMNH 54171). *Apistogramma playayacu* RÖMER *et al.* 2011 (type series). Others as listed in RÖMER (1994, 1997, 2006), RÖMER & HAHN (2008), RÖMER & WARZEL (1997), and RÖMER *et al.* (2003, 2004, 2006, 2011, 2012).

Diagnosis. *Apistogramma paulmuelleri* sp. n. is a medium-size (males to 42 mm, females to 33 mm SL), mod-



Fig. 2. *Apistogramma paulmuelleri* sp. n., paratype, CAS 233863, male, 39.4 mm SL, three weeks after preservation.

erately high-backed, laterally compressed and slightly elongate *Apistogramma* species with a fairly robust body, exhibiting sexual size dimorphism and sexual dichromatism. The species can be distinguished from all other *Apistogramma* species known to date on the basis of the combination of the following characters: Caudal fin rounded, but in most males upper lobe slightly longer than lower, producing slightly asymmetric shape; rounded in females and immaculate, as in most small, and some medium-size males; larger males with six to (rarely) eight vertical lines of faint, inconspicuous, dusky spots covering central half of fin; rest of fin basically transparent with light metallic green to bluish sheen. Dorsal fin about half to two thirds as high as body, without any noteworthy extensions. Distinct band-like black spot occupying complete height of caudal peduncle and narrow mid-ventral stripe in both sexes; up to four conspicuous abdominal stripes; adult males with striking bright red markings and metallic bluish lines on cheeks and gill covers; in large males lower half of abdomen frequently yellow to orange, with up to 7 lines composed of series of orange to red, more or less roundish spots on centres of scales on sides between head and base of anal fin; occasionally up to 5 single-scale irregular-shaped lateral spots on longitudinal dark lateral band occupying interspaces between vertical bars when latter (almost) completely faded (reverse pattern). Lateral band, about two thirds scale width, slightly wider in caudalmost part above soft portion of anal fin, extending to vertical band 7 and terminating noticeably before spot on caudal peduncle; distinct pattern of vertical bars and/or dorsal spots; in adult females, depending on mood, lateral band reduced to row of up to six longitudinal-oval lateral spots. No reduction in number of head pores.

Description

Morphological characters. (n=28; 23.6 to 41.3 mm SL) For summarised biometric data see tables 1 & 2, for raw data table 3, and for morphometric data table 4.

Habitus (figs. 1–13). Body moderately elongate in small males and females and (in larger specimens) relatively deep (33.0 to 38.4 % SL, mean 36.4 % SL), strongly compressed laterally, approximately more than twice as deep as wide, head only moderately long (31.4 to 36.8 % SL, mean 34.3 % SL), caudal peduncle of average length for genus (11.3 to 14. % SL, mean 13.2 % SL), these proportions in combination producing a fairly robust appearance. No statistically significant differences in morphometrics between sexes except size: adult males usually about 20 % larger than females. With increasing size pre-dorsal length, diameter of eye, and pelvic-spine length reduced relative to SL; depth of head, cheek, and caudal peduncle, length of upper jaw, dorsal-fin base, and dorsal spine increased. Upper head profile slightly convex, degree of curvature increasing progressively with increasing size of specimen creating steeper frontal contour, convexity not continued by upper contour of body, which is more flattened and straight to distal end of dorsal-fin base; lower head profile strongly convex in very large males, only slightly so in most medium to large males and some larger females, virtually straight from lip to posterior margin of lower jaw in smaller and few medium-sized specimens. Mouth terminal; tip of snout rounded, appearing slightly pointed in some larger females; jaws not enlarged; lips not hypertrophied; maxillary extending to point just behind vertical below anterior margin of eye; eye in adults relatively small for

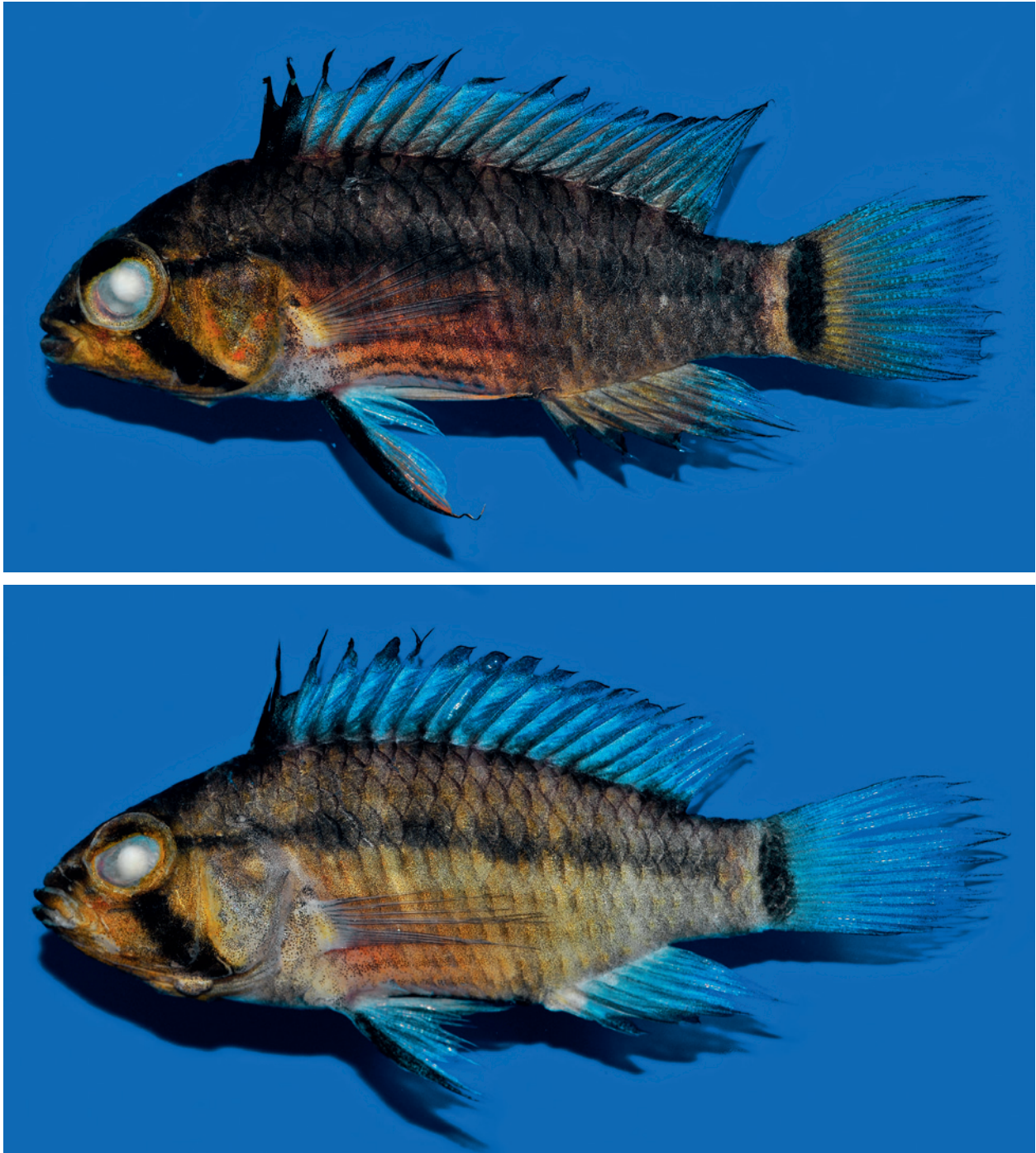


Fig. 3. *Apistogramma paulmuelleri* sp. n., paratype females: *top*: CAS 233864, 32.4 mm SL, two weeks after preservation; *bottom*: MUSM 41807, 30.2 mm SL, six months after preservation.

species of this phylogenetic group, significant negative correlation to increasing SL (diameter 10.8 to 13.7 % SL, mean 12.3 % SL); cheek height strongly positive correlated to increasing SL, completely scaled, scale pattern as described for *Apistogramma cinilabra* in RÖMER *et al.* (2011), but scales on average smaller than in that species; 5 dentary and 4 infraorbital pores; gill covers completely scaled. Ventral [V 1.5 (n=28)] pointed, slightly prolonged in smaller individuals, usually extending to base of third anal-fin ray in most adults, extending to end of anal-fin base only in exceptionally large males.

Pectoral [11 (n=3), 12 (n=25)], rounded, extending back to above first anal-fin spine. Dorsal fin [XIV.7 (n=1), XIV.7.i (n=3), XIV.8 (n=1), XV.6 (n=1); XV.6.i (n=6), XV.6.ii (n=1); XV.7 (n=7), XV.7.i (n=5), XVI.6.i (n=1), XVI.7 (n=2)] with spines increasing in length from D1 to last, but significantly less from D6 or D7, last dorsal spine normally longest; dorsal membranes in large males slightly pointed and prolonged past tips of spines; in adult males extensions of membranes from D1 to D6 about 20 % to 30 %, from D7 to last spine about 10 %, longer than related spines; in females tips of lappets from

Table 1. Summarised biometric data of *Apistogramma paulmuelleri* sp. n. type specimens (data given in mm).

	all specimens							males							females				abbreviations	
	HT	n	mean	min.	max.	st.dev.		n	mean	min.	max.	st.dev.		n	mean	min.	max.	st.dev.		
SL	41.2	28	32.7	23.6	41.3	5.61		20	34.1	23.6	41.3	6.00		8	29.1	25.7	32.1	1.80	HT = Holotype	standard length
TL	56.6	28	43.7	31.4	56.6	7.84		20	45.8	31.4	56.6	8.34		8	38.5	35.0	42.9	2.35		total length
TLS	56.6	28	43.7	31.4	56.6	7.84		20	45.8	31.4	56.6	8.34		8	38.5	35.0	42.9	2.35		total length plus streamer
HL	14.2	28	11.2	8.6	14.7	1.93		20	11.8	8.6	14.7	1.99		8	9.8	9.2	10.8	0.55		head length
HD	12.2	28	9.3	6.9	12.4	1.81		20	9.8	6.9	12.4	1.91		8	8.1	7.0	8.6	0.56		head depth
BD	15.8	28	11.9	8.4	15.8	2.34		20	12.6	8.4	15.8	2.48		8	10.4	9.3	11.7	0.73		body depth
HW	7.3	28	5.8	4.2	7.3	0.96		20	6.0	4.2	7.3	1.03		8	5.2	4.4	6.1	0.46		head width
PDL	14.5	28	11.7	9.0	14.5	1.79		20	12.1	9.0	14.5	1.94		8	10.6	10.1	11.1	0.48		pre-dorsal length
TDL	36.9	28	29.1	21.4	36.9	5.02		20	30.3	21.4	36.9	5.41		8	26.0	23.2	28.7	1.54		trans-dorsal length
PVL	16.4	28	13.1	10.0	16.9	2.35		20	13.8	10.0	16.9	2.46		8	11.5	10.4	13.2	0.88		pre-pelvic length
PAL	28.7	28	22.8	16.7	29.3	4.17		20	23.9	16.7	29.3	4.43		8	20.1	18.0	22.6	1.44		pre-anal length
TAL	36.4	28	28.6	20.7	36.4	5.01		20	29.9	20.7	36.4	5.38		8	25.4	22.7	28.3	1.54		trans-anal length
Eye	4.5	28	4.0	3.1	4.8	0.47		20	4.1	3.1	4.8	0.52		8	3.7	3.5	3.9	0.15		eye diameter
SNL	3.5	28	2.5	1.5	3.5	0.53		20	2.6	1.5	3.5	0.57		8	2.2	1.7	2.5	0.30		snout length
CHD	4.0	28	2.7	1.7	4.0	0.70		20	2.9	1.7	4.0	0.78		8	2.3	2.1	2.6	0.16		cheek depth
POD	0.8	28	0.7	0.5	1.1	0.15		20	0.8	0.5	1.1	0.16		8	0.7	0.6	0.9	0.09		pre-orbital depth
IOW	3.1	28	2.4	1.8	3.4	0.44		20	2.5	1.8	3.4	0.46		8	2.1	1.8	2.4	0.15		inter-orbital width
UJL	4.0	28	3.2	2.1	4.3	0.71		20	3.4	2.1	4.3	0.75		8	2.7	2.4	3.1	0.25		upper-jaw length
LJL	4.7	28	4.0	2.5	5.9	0.87		20	4.3	2.5	5.9	0.85		8	3.3	2.9	4.1	0.39		lower-jaw length
CPD	6.6	28	5.1	3.5	6.9	1.04		20	5.4	3.5	6.9	1.09		8	4.4	3.8	5.0	0.43		caudal-peduncle depth
CPL	5.4	28	4.4	3.0	5.9	0.84		20	4.6	3.0	5.9	0.89		8	3.8	3.3	4.2	0.36		caudal-peduncle length
DFB	25.0	28	19.3	13.5	25.0	3.57		20	20.1	13.5	25.0	3.89		8	17.2	15.2	19.0	1.08		dorsal-fin base length
AFB	8.5	28	6.4	4.8	8.5	1.10		20	6.7	4.8	8.5	1.20		8	5.8	5.2	6.2	0.32		anal-fin base length
PecL	14.2	28	10.1	6.8	14.2	2.04		20	10.5	6.8	14.2	2.19		8	9.1	7.9	11.0	1.20		pectoral-fin length
PelL	15.0	28	11.1	7.5	15.8	2.57		20	11.9	7.5	15.8	2.64		8	9.3	8.0	11.5	1.06		pelvic-fin length
PelSL	5.1	28	4.9	3.6	6.5	0.66		20	5.1	4.2	6.5	0.63		8	4.4	3.6	5.1	0.45		pelvic-fin spine length
LDS	8.7	28	6.4	4.0	9.1	1.66		20	6.9	4.0	9.1	1.69		8	5.1	4.3	5.6	0.37		last dorsal spine length
LAS	7.6	28	6.3	4.7	8.5	1.15		20	6.6	4.7	8.5	1.21		8	5.5	5.0	6.0	0.34		last anal spine length

Table 2. Summarised biometric data of *Apistogramma paulmuelleri* sp. n. type specimens (data given as % of SL; except SL given in mm).

	all specimens							males							females						
	HT	n	mean	min.	max.	st.dev.		n	mean	min.	max.	st.dev.		n	mean	min.	max.	st.dev.			
SL	41.2	28	32.7	23.6	41.3	5.61		20	34.1	23.6	41.3	6.00		8	29.1	25.7	32.1	1.80			
TL	137.5	28	133.5	128.0	137.5	2.40		20	134.1	129.6	137.5	2.17		8	132.3	128.0	136.4	2.62			
TLS	137.5	28	133.5	128.0	137.5	2.40		20	134.1	129.6	137.5	2.17		8	132.3	128.0	136.4	2.62			
HL	34.4	28	34.3	31.4	36.8	1.27		20	34.6	32.8	36.5	0.98		8	33.6	31.4	36.8	1.68			
HD	29.5	28	28.4	26.5	30.7	1.19		20	28.7	26.7	30.7	1.19		8	27.9	26.5	29.0	1.06			
BD	38.3	28	36.4	34.4	38.4	1.16		20	36.7	35.1	38.4	1.13		8	35.6	34.4	36.7	0.79			
HW	17.8	28	17.7	16.5	18.9	0.48		20	17.6	16.5	18.2	0.41		8	17.9	17.1	18.9	0.60			
PDL	35.2	28	35.9	33.5	39.2	1.35		20	35.7	33.5	38.0	1.11		8	36.4	34.0	39.2	1.78			
TDL	89.5	28	88.9	86.5	92.4	1.41		20	88.8	86.5	91.2	1.30		8	89.1	87.4	92.4	1.71			
PVL	39.8	28	40.2	37.7	42.4	1.15		20	40.4	38.9	42.4	1.03		8	39.6	37.7	41.2	1.30			
PAL	76.6	28	76.5	73.1	79.7	1.79		20	76.8	73.2	79.7	1.52		8	75.8	73.1	79.1	2.28			
TAL	88.3	28	87.5	84.7	89.9	1.36		20	87.5	84.7	89.9	1.41		8	87.3	85.3	89.4	1.28			
Eye	10.8	28	12.3	10.8	13.7	0.80		20	12.1	10.8	13.6	0.78		8	12.9	12.0	13.7	0.51			
SNL	8.5	28	7.6	5.9	9.2	0.89		20	7.5	5.9	9.2	0.88		8	7.6	5.9	8.5	0.98			
CHD	9.7	28	8.2	6.3	9.9	0.85		20	8.2	6.3	9.9	0.98		8	8.0	7.6	8.4	0.34			
POD	1.8	28	2.3	1.8	2.9	0.28		20	2.2	1.8	2.9	0.27		8	2.5	2.2	2.9	0.23			
IOW	7.5	28	7.3	6.7	8.2	0.36		20	7.4	6.7	8.2	0.41		8	7.2	7.1	7.4	0.11			
UJL	9.7	28	9.6	8.2	10.8	0.67		20	9.8	8.4	10.8	0.67		8	9.2	8.2	9.8	0.49			
LJL	11.4	28	12.4	9.8	14.6	1.39		20	12.7	9.9	14.6	1.17		8	11.5	9.8	14.1	1.64			
CPD	15.9	28	15.5	13.2	17.1	0.86		20	15.7	14.0	17.1	0.83		8	15.0	13.2	15.7	0.83			
CPL	13.0	28	13.3	11.3	14.9	0.83		20	13.4	12.2	14.9	0.78		8	13.2	11.3	14.3	0.99			
DFB	60.7	28	58.9	55.3	61.6	1.61		20	58.8	55.3	60.9	1.61		8	59.0	56.7	61.6	1.71			
AFB	20.7	28	19.7	18.5	21.4	0.76		20	19.7	18.5	21.4	0.78		8	19.9	18.9	21.1	0.74			
PecL	34.4	28	30.7	26.5	36.1	2.44		20	30.6	26.5	34.4	2.19		8	31.1	27.7	36.1	3.12			
PelL	36.5	28	33.8	27.7	38.8	3.03		20	34.6	28.3	38.8	2.61		8	31.8	27.7	38.1	3.30			
PelSL	12.4	28	15.1	12.0	20.7	1.83		20	15.1	12.0	20.7	2.02		8	15.1	12.0	16.6	1.37			
LDS	21.1	28	19.3	16.5	23.2	1.95		20	20.0	16.9	23.2	1.72		8	17.4	16.5	19.3	0.93			
LAS	18.4	28	19.3	17.8	21.0	0.80		20	19.5	18.4	21.0	0.73		8	19.0	17.8	20.5	0.90			

D1 to D4 rounded, remainder usually rectangular, extensions of lappets beyond spines significantly less than 10 % of spine length; soft dorsal fin rounded in females and smaller males, noticeably pointed in adult males and largest females, 3rd to 5th rays longest, membranes connected; tip of soft dorsal fin extending in smaller specimens of both sexes to middle, in largest males to significantly past posterior margin of caudal fin.

Anal fin [A. III.6 (n=14), III.7 (n=14)] rounded in small to medium-size specimens of both sexes, pointed in large females and medium-size to full-grown males, when folded soft portion extending to distal end of first quarter, or barely first third, of caudal fin, to about middle of caudal fin in adult males, exceptionally in some very large specimens to its distal edge. Caudal fin with 16 (n=28) principal soft rays, in most specimens soft rays D2 to D4 approximately up to 5 % longer than V2 to V4 producing slightly asymmetric ovoid shape to fin; posterior edge rounded in all specimens examined, in males first quarter to first third scaled, in females either unscaled (frequently) or scaled for up to first fifth (regularly) or quarter (exceptionally). Caudal peduncle about 20% deeper than long. Squamation as given for *Apistogramma cruzi* in KULLANDER (1986); scales in median longitudinal row 21 (n=20), 22 (n=7), or exceptionally 23 (n=1); upper lateral line canals 9–15 (mean 12.0, standard deviation 1.79, n=28), lower lateral line canals 0–4 (mean 2.1, standard deviation 1.41, n=28); 16 scales around caudal peduncle (n=28). Jaw teeth only slightly embedded in skin tissue, usually clearly visible, two fairly regular series in both jaws, but irregular across anterior part of lower jaw in largest specimens; unicuspid caniniform, almost straight, only slightly recurved in basal two thirds, distal third recurved, with dark brown or reddish brown outer tip.

Coloration of preserved specimens. (after 4 to 6 months in 75 or 90% ethanol) (figs. 1–3) Basic colour of body predominantly grey (males and some females) or brownish to light beige (females), in both sexes coloration slightly darker on three dorsalmost scale rows, some smaller specimens somewhat paler. Margins of body scales with narrow dark brown or, more frequently, blackish edgings, more intense within and above lateral band. Several large males with light yellow to orange sides below lateral band between pectoral-fin base and caudal end of anal-fin base; some such males and most others with pattern of intense orange, red or, less frequently, lemon-yellow spots on central anterior part of every body scale of rows L+3 to L-3 between head and last third of anal fin. Head usually slightly darker than body. Lips in both sexes basically dusky grey, more intense in males; edges light grey in males, yellowish in females, exceptionally with white on lower lip. Side of body in recently preserved males with pattern of bright red markings and light blue lines, covering gill cover, cheek, and preorbital with exception of black stripes on preorbital and cheek. Lower jaw, unscaled parts of cheek, chin, and central parts of branchiostegal membranes light

grey to whitish in males, slightly yellowish in females. Breast between bases of pectoral fins, ventral fins, and posterior part of branchiostegal membranes greyish, sometimes with small orange to red spots in males, white with few black chromatophores in females, small black zone around base of ventral fin. Mid-ventral region pale greyish in males, whitish or yellowish in females, faint ventral stripe from between bases of ventral fins and anal opening, the latter in some specimens framed by faint black line. Irrespective of sex, pectoral-fin base either white with scattered black chromatophores or yellow with orange speckles. No distinct interorbital stripe, but linear series of three linked round spots between orbitals, filling about three quarters of interorbital space. Operculum light grey in males with more or less extensive wine-red markings and pattern of narrow blue lines, light grey to yellow in females, occasionally with small orange or red dots. Cheek in males light grey or red; cheek stripe blackish, about two thirds as wide as pupil in both sexes, beginning between foramina 1 and 2 of posterior orbital of suborbital series (for terminology see KULLANDER 1987), running backwards in slight curve between lateral canal foramina (LCF) 10 and 11 across posterior half of cheek to lower posterior margin of preoperculum and to posterior tip of interoperculum, in some specimens interrupted at posterior edge of preoperculum. Blackish snout stripe straight, about half as wide as cheek stripe in all specimens, wider on occlusal than on buccal end of snout. Upper head and nape from interorbital to dorsum below first dorsal spine dark grey (males) to blackish (females). Frontal part of head from interorbital to lips either pale grey (males), dirty yellow (females) or, exceptionally, of same dark colour as adjacent upper head and nape. Iris either whitish to light grey in old material or, in fresh material, mix of grey and bright yellow with dots of black pigment, upper anterior part either dark grey (old material) or black (freshly preserved material). Dorsal spots only diffuse, not clearly separated, in most specimens merging into narrow stripe below dorsal-fin base, absent in some specimens. Seven broad vertical bars expressed in most specimens, usually more distinct in females, not split vertically, with interspaces less than one scale wide; bars 1 to 3 restricted to upper half of body, 4 to 7 complete; first six straight, seventh together with lateral band forming Y-shaped pattern on caudal peduncle (fig. 2). Lateral band virtually straight in males, curved parallel to dorsal profile in females, one scale wide behind operculum, half as wide above operculum, occupying lower third to half of L+1 scale row and upper quarter to third of L-0 scale row, extending from slightly above median of posterior edge of orbital to 7th vertical bar, terminating about two scales before separate caudal spot. Lateral band posterior to operculum wider in females than in males, extending further on L-0 scale row. No distinct separate lateral spot, but in some specimens pigmentation more intense at intersections with vertical bars 2 to 5, giving impression of row of three to four (exceptionally five) narrow horizontal lateral spots. Distinct single dark grey to blackish caudal-peduncle spot, upright oval or

band-like, occupying approximately full height of caudal peduncle. Independent of sex, most specimens with three to four distinct narrow dark grey to blackish abdominal stripes extending from pectoral base onto vertical bar 5; abdominal stripes composed of merging irregular horizontal dashes or (occasionally) rounded spots, occupying approximately quarter of height of scales of L-1 and L-2 rows centrally, central fifth in L-3 and L-4 rows. In some large males irregular rows of triangular to round orange spots between abdominal stripes, more distinct anteriorly. Under microscope all fins with regular dense pattern of small round light greyish chromatophores, less frequent on anal fin. Dorsal fin in males dusky grey on tips of membranes (black in females), grey along spines, somewhat lighter along soft rays, basal fifth of fin membranes with dark grey to blackish spots (smaller or absent in females), interspaces on membranes in central part of fin milky white to bluish, in males first two, in females three, spines and adjacent membranes blackish. Anal fin of males mostly whitish blue on basal parts, grey or brownish along tips of membranes, grey spines, and in some large males reddish distal third of membranes; in mature females milky white to dirty orange with dark grey to black outer margin. Caudal fin in large males with six to (rarely) eight vertical rows of dusky spots on centre, immaculate in females; scaled portion grey or similar to basic coloration of body, remainder whitish transparent to hyaline blue. Pectoral fin hyaline transparent, rays and basal part whitish, latter with irregular orange spots in some large males; few small greyish spots along fin rays, mostly absent on membranes. Ventral fin with dark grey (males) to black (females) spine; first membrane black in females, hyaline blue or whitish grey in males, with slightly yellowish (males) or orange (females) tips, other membranes transparent with slightly greyish tone close to base of fin. Anal fin in most males without, in most females with, narrow blackish anterior outer margin running from base of first spine to its tip and thence to tip of third spine. Soft portion of dorsal and anal fins with inconspicuous rows of hyaline spots in males, absent in females.

Coloration of live specimens. (figs. 4–13) Live coloration of adult male *Apistogramma paulmuelleri* sp. n. is – depending on mood – variable, and some colour patterns are unique within the genus. The species has been presented before by KOSŁOWSKI (2002), and STAECK (2003). Hence only photographs of specimens showing typical colour patterns have been included in this paper to enable accurate identification of the species, and the information given below is restricted to highlighting diagnostic elements of live coloration.

The most striking and unique colour pattern of mature male *Apistogramma paulmuelleri* sp. n. is as follows: combination of bright red and light blue to turquoise line pattern on cheeks, gill covers, preorbital, and, occasionally, adjacent areas on abdomen and breast up to pectoral base; large upright black band-like spot occupying caudal-fin base (figs. 4–5, & 7–12); broad cheek stripe

(figs. 4–6, & 10–12); four narrow abdominal stripes (figs. 5, & 9–13); broad and distinct vertical bars, and frequently five to six dorsal spots (figs. 4–5, & 9–13).

Abdominal stripes regular, composed of irregular-shaped rounded spots (figs. 5, & 11–13). In large males lemon yellow, occasionally sprinkled with red spots, on ventral surface of head between lower jaws and on branchiostegal membranes, laterally adjacent parts of lower jaw and cheek mainly porcelain white except where covered by red and blue line pattern (figs. 4, & 6–9). In aggression dorsal fin with conspicuous light metallic green to blue submarginal stripe, distally bordered by thin blackish or dark grey margin (figs. 4, 7–9, & 12–13). Colour of body greyish in subdominant, dirty yellow in dominant territorial, yellowish brown in aggressive males, some males with metallic blue or greenish sheen on body. Body of mature females light yellowish brown to brownish, bright yellow during brood care. Anal fin of mature males basically bluish with irregular pattern of up to five red streaks from base to outer margin (figs. 7–9). Body of females with six conspicuous vertical bars from dorsal base to a) horizontal from centre of eye to caudal-fin base (bar 1), b) horizontal posterior to upper edge of pectoral-fin base (bars 2 & 3), and c) to lower margin of body (bars 4 to 7) (figs. 10–13). Lateral band in both sexes frequently reduced to narrow zigzag line (figs. 4–5, & 11); comparatively large lateral spots, near-rectangular to squarish, at intersections of lateral band with vertical bars 2 to 6 (exceptionally 7) (figs. 9–10); in aggression, when bars not clearly expressed on dirty yellow body, reverse pattern of four to five lateral spots coinciding with position of lateral band and intervals between vertical bars 2 to 7 (figs. 7–9, & 13). In extreme aggressive lateral threat behaviour reverse-pattern lateral spots extending onto flanks and dorsal base, emphasising the reverse bar pattern (fig. 8); remarkably, these reverse-pattern light vertical bars do not cross abdomen vertically to longitudinal axis of body, but slightly diagonally downwards and backwards. Lateral spots usually clearly expressed by subdominant males during territorial conflict, while dominant aggressor, depending on stage of conflict, exhibits progressively reduced reverse pattern (fig. 9).

Adult specimens with conspicuous black midventral stripe and anal spot, usually more distinct in males. In most specimens small black spot on upper base of pectoral in both sexes (figs. 5–13), but faded in some dominant or highly aggressive individuals (figs. 4 & 9). Body of aggressive breeding females with white chest, series of five to six broad lateral spots at interspaces of vertical bars 2 to 6 or 7 with lateral band (reverse pattern) (fig. 13), series of five to six partially merging dorsal spots along dorsal-fin base (figs. 11 & 13); nape spot, dark pattern on forehead, and distal margins of body scales faint brown to grey, except those in triangle between anal-fin, ventral-fin, and pectoral-fin bases (figs. 10–13). Dominant territorial males in presence of heterospecific intruders pale yellowish or beige with pattern consisting of fairly irregular zigzag lateral band, pale shadows



Fig. 4. *Apistogramma paulmuelleri* sp. n., non-type, male, not preserved, live coloration shortly after capture, dominant, showing typical reduction of black pattern with zigzag lateral band and faded vertical bars.



Fig. 5. *Apistogramma paulmuelleri* sp. n., paratype MUSM 41806, male 39.1 mm SL, live coloration shortly after capture, subdominant, fright coloration (immediately after attack by aggressive dominant male) with typical four abdominal stripes, lateral band reduction, and faded vertical bars.



Fig. 6. *Apistogramma paulmuelleri* sp. n., male, live coloration shortly after capture, portrait showing typical yellow and ivory coloration on lower parts of head.



Fig. 7. *Apistogramma paulmuelleri* sp. n., holotype MUSM 41805, male, 41.2 mm SL, live coloration shortly after capture, high aggression with typical reduced and reversed black pattern during incipient lateral threat.



Fig. 8. *Apistogramma paulmuelleri* sp. n., paratype MUSM 41808, male, 39.1 mm SL, live coloration shortly after capture, high aggression, showing typical reversed black band pattern including abdominal streaks, during advanced lateral threat immediately before attack on opponent.



Fig. 9. *Apistogramma paulmuelleri* sp. n., two males showing typical live colour pattern at beginning of territorial conflict, paratype MUSM 41808 (top, subdominant) and holotype MUSM 41805 (lower right, dominant), shortly after capture and immediately before preservation.



Fig. 11. *Apistogramma paulmuelleri* sp. n., non-type, female, not preserved, live coloration shortly after capture, subdominant, showing typical reduction of black pattern with zigzag lateral band and faded vertical bars.



Fig. 13. *Apistogramma paulmuelleri* sp. n. non-type, female, not preserved, live coloration after 1 week in the aquarium, dominant aggressive, typical reversed brood-care colour pattern two days after spawning.



Fig. 10. *Apistogramma paulmuelleri* sp. n., female, not preserved, live coloration shortly after capture, subdominant, fright coloration with typical abdominal stripes, broad lateral spots, and vertical bars.



Fig. 12. *Apistogramma paulmuelleri* sp. n., non-type, female, not preserved, live coloration shortly after capture, mature, dominant, non-aggressive territorial, incipient brood-care coloration, typical change of base colour to creamy yellow.

of six (to seven) vertical bars, six distinct dorsal spots, dark nape spot, intense dark caudal spot, and cheek stripe (fig. 9); in this colour pattern scales above lateral band with significantly darker margins, margins significantly broader below lateral band than above, forming reticulate pattern on vertical bars. Males in courtship display with same pattern as highly aggressive males in lateral threat (figs. 7–8).

Systematic relationships: *Apistogramma paulmuelleri* sp. n. is apparently a member of the *Apistogramma regani* lineage (nomenclature following RÖMER, 2006c) but its systematic position remains uncertain. Among species from the Peruvian Amazon, only *Apistogramma cinilabra*, *A. cruzi*, *A. eunotus*, and two as yet undescribed species, *Apistogramma* sp. “Winkelfleck / angle-spot” and (to a minor extent) *Apistogramma* sp. “peru-

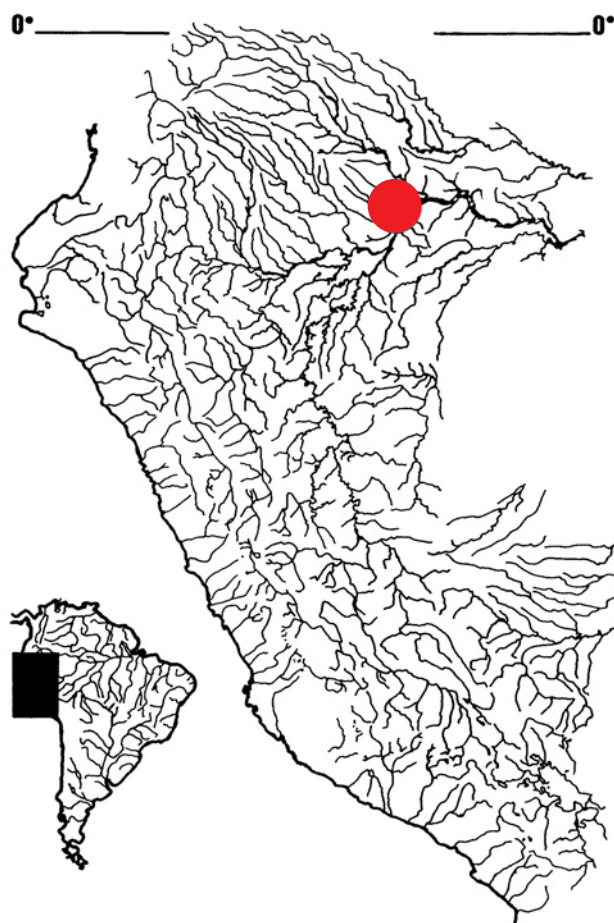


Fig. 14. Map of Peru showing distribution of *Apistogramma paulmuelleri* sp. n., type locality indicated by red dot.

regani” (see RÖMER, 2006), exhibit overall similarity to the species described here. In particular, the bar-like spot pattern on the caudal peduncle, in combination with the abdominal stripes, raises questions, as this specific type of pattern is otherwise known only from *Apistogramma regani* and *A. ortmanni*, which originate either in the central Amazon basin in Brazil (*regani*) or in rivers running to the North from the Guiana Shield (*ortmanni*). At present no precise information on the phylogenetic relationships of this new species is available. Hence a more detailed, putative phylogeny for this species would be largely speculative at the current time and must be postponed pending further study.

Etymology. The species’ name *paulmuelleri* honours the late Professor Emeritus Dr. Paul MÜLLER (10th October 1940 to 30th May 2010), one of the leading biogeographers of recent decades, who made a number of significant contributions to our understanding of the origins of Neotropical cichlids, including the genus *Apistogramma* (MÜLLER 1973, 1981; MÜLLER & WEIMER 1976). Prior to his retirement, Professor MÜLLER was head of department at the Institute for Biogeography at Trier University, where the senior author had the honour and pleasure of cooperating and regularly discussing his own work on *Apistogramma* with him.

Distribution and Ecology. *Apistogramma paulmuelleri* sp. n. has been found exclusively in a section, only a few hundred metres long, of a small forest brook (*quebrada*). On the basis of information from local fishermen, as well as reference material available in MUSM (ORTEGA *et al.*, 2011, 2012; RÖMER *et al.* in prep.) and collected by ourselves, it is apparently endemic to the Loreto (fig. 14).

The small river in which the new species has been found forms part of the Amazon river system, geologically-speaking the Iquitos palaeoarch, incurved within comparatively steep hills (see figs. 15 & 16). All the locations from which material was available are situated east of the Rio Itaya and west of the Amazon River north of Nauta. CHRISTOFFERSEN (*in lit.* 2011) for example, who has regularly collected at different locations in the same area since 2005, also found the species at just two locations close to each other. One of his collection sites is identical with our site F15-P-2011-R. The other is probably very close to our field station F8-P-2011-R, in the same *quebrada* as was sampled by our team.

So far assumptions that the species might also occur west and north of the Rio Nanay could not be verified in spite of intensive collecting activities in that area by professionals such as scientists and commercial fishermen, as well as by amateurs. On the other hand, a number of specimens labelled *Apistogramma* sp. “Apache” from at least five other collecting sites have had to be assigned to other species, probably not yet described.

On August 4th 2011 at field-station F8-P-2011-R the water of the approximately 3 to 8 metres wide *quebrada* was clear light brownish and up to a maximum of approximately 80 cm deep. The field station is several hundred metres downstream from the source area of the little stream, where field-station F15-P-2011-R is located.

Together with *Apistogramma paulmuelleri* sp. n. we collected *Laetacara flavilabris* (COPE, 1870) of varying sizes, roughly half-grown specimens of a colour morph of *Crenuchus spilurus* GÜNTHER, 1863, several *Aequidens* sp., three *Cichlasoma* sp., several medium to adult size specimens of two still undetermined species of *Rivulus*, and adult specimens of a species of *Hyphessobrycon*, also not yet identified scientifically. *Crenuchus* represented the most abundant species at this location, followed by *Apistogramma*. Most of the adult specimens of the comparatively rare *Laetacara flavilabris* were in brood-care coloration. This was also the case with all adult female *Apistogramma paulmuelleri* sp. n., which were loam yellow in colour and exhibited the typical black pattern. But we were unable to find females caring for broods at the actual collecting site, perhaps because of the comparatively dense cover on the bottom at the collecting area and the comparatively deep water, which restricted visibility for above-water observation.

Field-station F17-P-2011-R is sited only about 200 metres from the location in question.

The second location (F15-P-2011-R) had been cleared since 2009, as was evident from comparison of photographs taken there by Tom CHRISTOFFERSEN (*in lit.*, 2012) with our own material. The vegetation at the location

Table 3. Biometric data taken from *Apistogramma paulmuelleri* sp. n. type specimens (given in mm; for abbreviations see tables 1 & 4). DNA-No.: provisional LMI storage numbers (for details see text).

Coll.No.	Status	DNA No.	Sex	SL	TL	TLS	HL	HD	BD	HW	PDL	TDL	PPL	PAL	TAL	Eye	SNL	CHD	POD	IOW	UJL	LJL	CPD	CPL	DFB	AFB	PecL	PeIL	PeISL	LDS	LAS
MTD F 32638	PT	301862	m	41.3	56.3	56.3	14.7	11.3	15.2	6.8	14.2	36.8	16.9	29.3	36.4	4.7	3.0	3.6	0.9	3.4	4.3	4.8	6.9	5.6	24.8	8.0	13.9	15.8	5.0	8.5	7.9
MUSM 41805	HT	301859	m	41.2	56.6	56.6	14.2	12.2	15.8	7.3	14.5	36.9	16.4	28.7	36.4	4.5	3.5	4.0	0.8	3.1	4.0	4.7	6.6	5.4	25.0	8.5	14.2	15.0	5.1	8.7	7.6
MUSM 41809	TPT	301883	m	40.5	54.4	54.4	14.3	12.4	15.5	7.1	14.5	35.7	16.5	28.0	34.9	4.7	3.1	4.0	1.0	2.9	4.1	5.9	6.3	5.7	24.0	8.2	11.8	15.0	6.5	8.6	8.5
MTD F 32636	PT	301885	m	39.6	52.7	52.7	13.0	11.6	14.9	6.8	13.5	34.7	15.5	27.4	34.1	4.4	2.7	3.3	0.9	2.7	3.9	4.9	6.4	5.9	23.6	8.0	11.1	14.1	5.9	8.5	7.6
MTD F 32635	PT	301882	m	39.5	52.5	52.5	13.3	11.3	15.2	7.0	14.2	34.9	15.6	27.8	34.5	4.5	3.2	3.3	0.8	3.1	4.2	5.4	6.3	5.4	23.2	7.8	12.4	15.3	5.2	9.0	8.1
CAS 233863	PT	301884	m	39.4	52.6	52.6	13.7	11.1	15.0	6.9	14.2	35.6	16.4	28.2	35.3	4.8	3.2	3.7	0.9	2.9	4.3	3.9	6.3	5.1	23.7	7.9	11.6	12.6	4.7	9.1	8.0
MUSM 41808	PT	301863	m	39.1	53.2	53.2	12.9	11.9	13.9	7.0	13.1	34.9	16.4	28.3	34.9	4.5	3.1	3.7	1.1	2.8	4.0	5.3	6.0	5.1	23.5	7.4	12.5	12.9	5.4	7.7	7.2
MTD F 32637	PT	301872	m	38.6	51.6	51.6	13.3	11.5	14.4	6.6	13.5	34.4	15.5	27.4	33.7	4.4	2.8	3.3	0.8	2.7	3.7	5.1	6.6	5.0	23.3	7.1	11.9	12.9	5.8	8.1	7.5
MUSM 41810	PT	301871	m	37.2	50.3	50.3	13.2	11.1	13.6	6.8	13.2	33.0	14.6	26.0	32.4	4.3	2.6	2.9	0.8	2.9	3.7	5.0	6.1	5.0	21.6	7.5	11.3	13.7	5.9	8.0	7.5
MUSM 41806	PT	301864	m	37.1	50.4	50.4	12.5	10.5	13.5	6.7	12.6	32.9	15.3	26.3	32.6	4.1	3.4	3.3	0.8	2.6	3.7	4.6	5.6	4.8	21.7	7.1	11.7	13.0	5.3	7.9	7.0
MTD F 32637	PT	301870	m	34.0	46.5	46.5	11.5	9.4	12.8	6.0	12.5	31.0	14.1	24.2	30.4	4.1	2.4	2.7	0.8	2.4	3.5	4.4	5.7	4.4	20.7	6.3	11.6	12.7	5.5	7.2	6.9
MUSM 41810	PT	301873	m	31.8	41.3	41.3	11.4	8.5	11.3	5.5	11.6	28.4	12.5	22.1	27.5	3.9	2.4	2.7	0.7	2.6	3.0	4.3	4.6	4.7	18.5	6.0	9.1	10.6	5.2	5.7	6.0
MTD F 32638	PT	301861	f	32.1	42.9	42.9	10.8	8.5	11.7	6.1	11.1	28.7	13.2	22.6	28.3	3.9	2.5	2.6	0.9	2.4	3.2	3.2	5.0	4.1	19.0	6.2	11.0	8.9	5.1	5.3	6.0
MUSM 41811	PT	301874	m	32.0	43.0	43.0	10.8	9.3	11.6	5.7	11.7	28.9	13.2	22.5	28.4	4.0	2.2	2.7	0.6	2.3	3.4	4.0	4.8	4.3	19.4	6.6	9.3	12.0	5.0	6.2	6.4
CAS 233864	PT	301875	m	32.0	42.5	42.5	11.1	9.5	12.1	5.7	11.6	28.3	13.0	22.3	27.8	4.1	2.1	2.5	0.8	2.3	2.9	4.1	4.9	4.7	18.9	6.1	9.5	10.1	4.4	6.2	6.4
MTD F 32639	PT	301866	m	30.6	40.2	40.2	10.3	8.4	10.9	5.3	11.1	26.8	12.3	21.0	26.5	3.7	2.1	2.3	0.8	2.1	2.8	4.2	4.8	3.9	17.7	6.0	9.7	10.3	4.8	5.6	5.7
MUSM 41807	PT	301860	f	30.2	40.5	40.5	10.3	8.6	11.1	5.3	11.1	26.4	12.2	21.2	26.0	3.9	2.5	2.3	0.8	2.2	2.9	3.5	4.7	4.2	17.1	5.7	10.9	11.5	3.6	5.0	5.4
CAS 233863	PT	301877	f	29.7	38.6	38.6	9.3	8.5	10.4	5.3	10.1	26.2	11.2	19.9	25.8	3.8	2.0	2.4	0.7	2.2	2.4	3.5	4.7	4.0	17.5	6.0	8.9	8.4	4.4	5.0	5.4
MUSM 41811	PT	301880	f	29.1	37.3	37.3	9.5	7.8	10.3	5.0	10.9	25.5	11.2	19.3	24.8	3.9	2.5	2.5	0.7	2.1	2.7	2.9	4.5	3.6	16.5	6.0	8.1	8.9	4.4	5.0	5.3
MTD F 32636	PT	301878	f	28.9	38.2	38.2	9.2	8.4	10.2	5.2	10.3	25.5	11.4	19.8	25.2	3.7	2.1	2.2	0.7	2.1	2.6	2.9	4.4	4.1	17.1	5.6	8.5	9.9	4.3	5.2	5.7
CAS 233864	PT	301879	f	28.5	37.4	37.4	9.6	7.7	9.8	5.1	10.2	25.7	10.9	19.0	24.9	3.5	1.7	2.2	0.6	2.0	2.7	3.3	4.2	4.0	17.4	6.0	7.9	9.0	4.4	5.0	5.5
MTD F 32637	PT	301881	f	28.8	38.2	38.2	9.9	8.4	10.3	5.3	11.0	26.6	11.7	20.7	25.8	3.7	2.4	2.4	0.7	2.1	2.7	4.1	3.8	3.3	17.8	5.8	8.7	9.5	4.8	5.6	5.9
MTD F 32637	PT	301886	m	27.6	36.4	36.4	9.8	8.0	10.0	5.0	9.9	24.0	11.1	18.8	23.9	3.5	2.1	2.1	0.7	2.0	2.7	3.5	4.2	3.4	15.3	5.4	8.4	9.1	4.2	5.0	5.2
MTD F 32643	PT	301876	m	26.4	34.6	34.6	9.1	7.1	9.6	4.7	9.2	22.9	10.5	17.9	22.4	3.4	2.4	1.7	0.5	1.9	2.6	3.4	4.4	3.8	14.7	5.0	8.2	7.5	4.4	5.1	5.1
MUSM 41807	PT	301869	f	25.7	35.1	35.1	9.5	7.0	9.3	4.4	10.1	23.2	10.4	18.0	22.7	3.5	2.2	2.1	0.7	1.8	2.4	3.5	3.8	3.4	15.2	5.2	8.6	8.0	4.1	4.3	5.0
MUSM 41808	PT	301865	m	25.6	34.6	34.6	8.8	7.1	9.0	4.5	9.3	22.2	10.0	17.1	22.0	3.1	1.5	1.7	0.5	2.0	2.2	3.5	3.7	3.3	14.7	5.0	6.8	8.7	4.3	4.8	5.0
MUSM 41806	PT	301867	m	25.1	34.4	34.4	8.8	7.1	8.8	4.5	9.3	22.5	10.2	17.5	22.6	3.4	1.7	1.9	0.5	2.0	2.1	5.5	3.5	3.2	14.8	5.4	6.8	8.4	4.2	4.5	4.9
MUSM 41808	PT	301868	m	23.6	31.4	31.4	8.6	6.9	8.4	4.2	9.0	21.4	10.0	16.7	20.7	3.2	2.0	1.9	0.6	1.8	2.1	3.1	3.8	3.0	13.5	4.8	7.7	7.8	4.9	4.0	4.7

Table 4. Meristic data taken from *Apistogramma paulmuelleri* sp. n. type specimens (SL given in mm; for abbreviations see last column of table). Abbreviations: **DF**=dorsal fin; **CF**=caudal fin; **AF**=anal fin; **PF**=pelvic fin; **PecF**=pectoral fin; **(h)**=hard rays (spines); **(i)**=minor soft rays; **(s)**=soft rays; DNA No.: LMI storage number of DNA sample.

Coll.No.	status	DNA No.	sex	SL	DF (h)	DF (s)	DF (i)	AF (h)	AF (s)	PF (h)	PF (s)	PecF	CF
MTD F 32638	PT	301862	m	41.3	14	7	1	3	7	1	5	12	16
MUSM 41805	HT	301859	m	41.2	14	8	0	3	7	1	5	12	16
MUSM 41809	TPT	301883	m	40.5	15	7	0	3	6	1	5	12	16
MTD F 32636	PT	31885	m	39.6	15	6	1	3	7	1	5	12	16
MTD F 32635	PT	301882	m	39.5	16	6	1	3	7	1	5	12	16
CAS 233863	PT	301884	m	39.4	16	6	1	3	7	1	5	11	16
MUSM 41808	PT	301863	m	39.1	15	7	0	3	6	1	5	12	16
MTD F 32637	PT	301872	m	38.6	15	7	1	3	6	1	5	12	16
MUSM 41810	PT	301871	m	37.2	15	6	1	3	6	1	5	12	16
MUSM 41806	PT	301864	m	37.1	15	6	1	3	6	1	5	12	16
MTD F 32637	PT	301870	m	34.0	15	7	1	3	6	1	5	12	16
MUSM 41810	PT	301873	f	32.1	14	7	1	3	7	1	5	12	16
MTD F 32638	PT	301861	m	32.0	15	7	1	3	6	1	5	12	16
MUSM 41811	PT	301874	m	32.0	15	6	2	3	6	1	5	12	16
CAS 233864	PT	3001875	m	31.8	15	7	0	3	7	1	5	12	16
MTD F 32639	PT	301866	m	30.6	14	7	0	3	7	1	5	12	16
MUSM 41807	PT	301860	f	30.2	15	6	1	3	6	1	5	12	16
CAS 233863	PT	301877	f	29.7	15	7	0	3	6	1	5	12	16
MUSM 41811	PT	301880	f	29.1	16	7	0	3	7	1	5	12	16
MTD F 32636	PT	301878	f	28.9	15	7	1	3	7	1	5	12	16
CAS 233864	PT	3018879	f	28.8	15	7	0	3	6	1	5	11	16
MTD F 32637	PT	301881	f	28.5	15	6	1	3	7	1	5	12	16
MTD F 32637	PT	301886	m	27.6	15	6	0	3	6	1	5	11	16
MTD F 32643	PT	301876	m	26.4	15	7	0	3	6	1	5	12	16
MUSM 41807	PT	301869	f	25.7	14	7	1	3	7	1	5	12	16
MUSM 41808	PT	301865	m	25.6	15	7	0	3	6	1	5	12	16
MUSM 41806	PT	301867	m	25.1	15	7	1	3	7	1	5	12	16
MUSM 41808	PT	301868	m	23.6	15	7	0	3	7	1	5	12	16

was still more or less destroyed at the time of the 2011 collection. There were just a few cultivated plants close to the adjacent road, resulting in a vegetation coverage of less than 30 %. The ecological conditions for fish appeared to be suboptimal in this brook, as the temperature regime had obviously been disturbed by the clearance. Temperature fluctuations are probably more extreme than would normally be expected under natural conditions in a primary- or even secondary-forest brook. Water levels in the *quebrada* may vary seasonally, but this, like most other ecological aspects, has still to be monitored in detail. More detailed ecological research needs to be carried out on this type of environment. All measured data available are given in table 5.

Biology. There are only sparse field data available on the biology of *Apistogramma paulmuelleri* sp. n., restricted to observation of a few females caring for small fry at the

locations investigated on the day of collection in August 2011. One of these females, in full brooding coloration, repeatedly chased a mixed group of about ten *Laetacara flavilabris* and *Aequidens* sp. from her territory, as well as two conspecifics. The attacks were carried out over distances up to a good 25 cm from the obvious centre of the territory, a cave-like structure among some dense, fine palm roots. But based on preliminary aquarium observation of specimens collected together with the type material, *Apistogramma paulmuelleri* sp. n. appears to be a typical representative of the genus. It has repeatedly been bred successfully in captivity by D.P. SOARES and UR. The species exhibits behaviour typically known from other overall monogamous *Apistogramma* species (*cf.* RÖMER, 2000, 2006). But polygamy has also, but less frequently, been observed to occur in captivity (observations by D.P. SOARES & UR). Adult males monopolise resources within large territories, which are guarded highly

Table 5. Water parameter data measured at seven collecting sites for *Apistogramma* (including *Apistogramma paulmuelleri* sp. n.). For methodology of measurements see text.

field station	GPS position	date	time	water type	T [°C]	pH	O ₂ [mg/l]	µS [cm]	Source
a) near F15-P-2011-R	app. 04°23' S / 73°34' W	2005.10.24	08.05 am	?	26.9	5.1	n. d.	14	Christoffersen
b) few hundred metres W from a)	? (not available)	2006.10.19	11.48 am	?	29.2	4.7	n. d.	70	Christoffersen
c) about 30 min. walk W from a)	? (not available)	2005.10.24	09.46 am	?	26.2	5.0	n. d.	6	Christoffersen
probably F8-P-2011-R	app. 04°24' S / 73°34' W	2009.10.03	11.43 am	clear	30.2	5.3	n. d.	10	Christoffersen
F08-P-2011-R	04°24' S / 73°34' W	2011.08.04	01.10 pm	clear & white	25.2	5.0	1.7	116	LMI
F15-P-2011-R	04°23' S / 73°34' W	2011.08.12	01.31 pm	clear	27.2	4.5	4.0	149	LMI
F17-P-2011-R	04°23' S / 73°34' W	2011.08.12	03.05 pm	clear	29.5	5.6	5.1	85	LMI

aggressively against any potential conspecific male competitor. Only one mature female is usually accepted within the territorial boundaries. Maintenance in captivity has turned out to be comparatively easy, in spite of the fact that the species is sensitive to organic waste in the water. In particular, changes in water-chemistry parameters, such as rapidly increasing levels of nitrate or phosphate, lead to unexpected losses in the laboratory. In the wild the species has been collected only in the headwaters of a small *quebrada*, and habitat may have led to strict adaptation to extremely clear water. This observation may indicate potential risks for the species in the field. More detailed studies of the behaviour, and especially of the reproductive biology of this new species, are in progress.

Discussion

Apistogramma paulmuelleri sp. n. appears to be less polychromatic than other species from the Amazon basin in Loreto. *Apistogramma paulmuelleri* sp. n. exhibits basic cichlid morphology without any special fin ornamentation such as prolongation of dorsal-fin membranes or caudal-fin streamers, large jaws with hypertrophied lips, or other morphological modifications. Many species within the genus exhibit a completely different basic morphological appearance and cannot be mistaken for *Apistogramma paulmuelleri* sp. n.: all species closely related to *Apistogramma cacatuoides* HOEDEMAN, 1951, and all members of the *Apistogramma steindachneri* lineage as well as those of the *Apistogramma agassizii* lineage (nomenclature following RÖMER 2006) exhibit either a modified fin shape (forked or lanceolate) or different body morphology (compare images in RÖMER 2000, 2006; RÖMER & HAHN 2008; RÖMER *et al.* 2012).

This leaves only species of the *Apistogramma regani* lineage for consideration, as most of these share a rounded caudal fin, dorsal fin without extensions, and overall body shape with *Apistogramma paulmuelleri* sp. n.. But within this lineage all species of the *Apistogramma*

macmasteri complex exhibit marked modifications of the dorsal and / or caudal fins (extended fin lappets / prolonged streamers), those of the *Apistogramma caetei* complex lack abdominal stripes and exhibit a round spot on the centre of the caudal base, and those of the *Apistogramma commbrae* and *Apistogramma linkei* supercomplexes have either a smaller or a double spot on the caudal base, and/or in several species lack abdominal stripes, and therefore cannot be mistaken for the species described here.

Hence at first sight *Apistogramma paulmuelleri* sp. n. can be mistaken only for one of the species closely related to *Apistogramma regani* KULLANDER, 1980 from the Amazon headwaters, most of them already described by KULLANDER (1980, 1986).

Within the *Apistogramma regani* supercomplex, most species of the *Apistogramma taeniata* and *Apistogramma urteagai* complexes can be easily differentiated from *Apistogramma paulmuelleri* sp. n. by lacking abdominal stripes and exhibiting a significantly smaller caudal spot [*A. acensis* STAECK, 2003 (figs. 17–19); *A. moae* KULLANDER, 1986; *A. taeniata* (GÜNTHER, 1862); *A. urteagai* KULLANDER, 1986; and still undescribed *A. sp.* “Araguaia”, *A. sp.* “Mitú”; *A. sp.* “Candeias”, *A. sp.* “Xipamanu” (all listed in RÖMER 2006)].

Thus only a number of species of the *Apistogramma regani* complex *sensu stricto*, including *Apistogramma cinilabra* RÖMER *et al.*, 2011, can be mistaken for *Apistogramma paulmuelleri* sp. n., as it shares its overall morphology with *Apistogramma cinilabra*, *A. cruzi* KULLANDER, 1986, *A. eunotus* KULLANDER, 1981, *A. gosseii* KULLANDER, 1982, *A. ortmanni* (EIGENMANN, 1912), *A. pleurotaenia* (REGAN, 1909), *A. regani* KULLANDER, 1980, and the undescribed species *A. sp.* “Gelbwangen/ yellow-cheeks”. Several images of these species have already been published by RÖMER (2000, 2006) and RÖMER *et al.* (2011). But closer comparison reveals significant diagnostic differences between the new species and members of the *Apistogramma regani* complex.

Apart from the different coloration of the lips, the significantly longer caudal peduncle (on average, length about 81 % of depth) clearly differentiates *Apistogramma paulmuelleri* sp. n. from the overall comparable *Apistogramma cinilabra* (CPL only about 59 % of CPD).



Fig. 15. View of the habitat of *Apistogramma paulmuelleri* sp. n. (F15-P-2011-R) west of the Iquitos–Nauta road, August 12th 2011, at about 1.30 p.m. local time.



Fig. 16. View of the type habitat of *Apistogramma paulmuelleri* sp. n. (F8-P-2011-R) east of the Iquitos–Nauta road, August 4th 2011, at about 1.30 p.m. local time.

Apistogramma pleurotaenia is only known from the holotype, a bleached female of 27.6 mm SL. On the basis of the original description and comments by KULLANDER (1982) and KOSLOWSKI (2003), the species is differentiated from *Apistogramma paulmuelleri* sp. n. by possessing four anal-fin spines, a continuous lateral band, and abdominal dashes, and by lacking abdominal stripes. The value of anal-fin spine counts is highly doubtful in this case ($n=1!$), as single specimens with counts other (in most cases higher) than three have subsequently been reported from several other species of *Apistogramma* (RÖMER 2000, 2006; RÖMER *et al.*, 2012). Hence the identity of *A. pleurotaenia* will probably remain unresolved in the future, as any correlation of freshly-collected material with the species' holotype will be purely hypothetical.

Apistogramma gossei and *Apistogramma ortmanni* (fig. 20) are sufficiently differentiated from *Apistogramma paulmuelleri* sp. n. by more slender body and more pointed head, an immaculate caudal fin, a round or squarish spot occupying only half to two thirds of the caudal-fin base, and a significantly broader lateral band. *A. sp.* “Gelbwangen / yellow-cheeks” from the area around Manaus (Brazil) exhibits a more regular, broader lateral band than *Apistogramma paulmuelleri* sp. n., and in most specimens a smaller, oval caudal-peduncle spot, and lacks comparable abdominal stripes and stripe pattern on the caudal fin (see RÖMER 2000). *Apistogramma regani*

can be distinguished from *Apistogramma paulmuelleri* sp. n. by a significantly more slender body, an on average lower dorsal fin, more intense, zebra-like, blackish vertical bars at rightangles to the longitudinal body axis, a straight vertical bar 7 (versus Y-shaped), and in life by a completely different aggressive pattern and always lacking the black spot on the upper base of the pectoral fin. *Apistogramma cinilabra* exhibits a higher body, a broader lateral band never reduced to zigzag form, straight vertical bars at right-angles to the body axis, a broader mid-ventral stripe in females, ash grey lips, and a different pattern in highly aggressive lateral threat, and thus again should not be mistaken for *Apistogramma paulmuelleri* sp. n.

Nowadays there are good arguments that, in the case of many species, high variability in coloration may give females the opportunity to select the “optimal partner” for reproduction (overviews e.g. in BARLOW, 2000). Polychromatism in males may thus be induced by female mate choice, as reported from other species (see also ENGELKING *et al.*, 2010; RÖMER & BEISENHERZ, 2005). In the case of *Apistogramma* the decisive role of coloration, colour pattern, and colour morphs in mate choice has been tested and demonstrated by various authors (ENGELKING *et al.*, 2010; READY *et al.* 2006; RÖMER, 2001; RÖMER & BEISENHERZ, 2005, 2006), leading to the theory that colour morphs of *Apistogramma* may represent dis-



Fig. 17. For comparison: *Apistogramma acrensis*, male, live coloration in the aquarium, dominant, showing differentiating black pattern.



Fig. 18. For comparison: *Apistogramma acrensis*, male, live coloration in the aquarium, subdominant, showing typical and diagnostic band pattern.



Fig. 19. For comparison: *Apistogramma acrensis*, paratype NMW 94888, male, showing typical dark pattern.



Fig. 20. For comparison: *Apistogramma ortmanni*, holotype FMNH 53801 (originally stored under CMC 2306), male, 64 mm SL, typical dark pattern still visible in spite of being partially faded.

tinct species. This was not known to KULLANDER (1980, 1981, 1986) when revising Peruvian *Apistogramma*. He used exclusively preserved material from locations within the upper Amazon basin and situated more than 1400 kilometres from one another (cf. KULLANDER, 1980, 1981, 1986). RÖMER *et al.* (2012) have already surmised that voucher specimens of *Apistogramma cruzi* and *A. eunotus* may in fact represent different genotypic clusters or potentially species (cf. also RÖMER *et al.*, 2010, 2011). The types of both originate from more than one location and may be polyspecific (for details see KULLANDER, 1986; RÖMER *et al.* 2012), which creates some difficulties in the differentiation of these taxa from the species described here. Both species are overall similar to *Apistogramma paulmuelleri* sp. n. and might be mistaken for that species. But *Apistogramma paulmuelleri* sp. n. may be distinguished from *A. eunotus* by the fact that, even in the largest specimens, the vertical bars are never split as is the case in adult *Apistogramma eunotus* (see KULLANDER 1981, 1986). *Apistogramma cruzi* never exhibits the extensive, band-like, large spot, occupying the whole caudal-fin base, seen in *Apistogramma paulmuelleri* sp. n., but has a more or less upright rectangular caudal-peduncle spot that may be split horizontally in roughly the middle of the caudal-fin base.

On the basis of current knowledge, *Apistogramma paulmuelleri* sp. n. seems to be geographically isolated

from other *Apistogramma* species and endemic to the drainage of a single nameless *quebrada*, a left-bank tributary of the Amazon. This river basically contains black water, as do most of its tributaries. As far as we know at present, apparently only one species of the genus *Apistogramma* inhabits these tributaries, namely the one described here. Several other locations inspected in the same area brought to light several other dwarf cichlids, but after carefully reviewing our preserved and live material, we are confident that the species described here has not yet been detected at any of these field stations.

A review of descriptions and literature dealing with the species of the genus *Apistogramma*, and recent findings by RÖMER *et al.* (2011) on the distribution of different *Apistogramma* species from Loreto, suggests that the Peruvian lowland and adjacent areas are probably home to a lot more species than previously thought. In fact the area around Iquitos has been the target of a variety of hobbyist and professional researchers for more than around 50 years now. Several professional collectors and exporters of tropical wildlife, including all taxonomic groups, have exploited all parts of Peru and especially Loreto for decades. But even so there are large numbers of new taxa, even in higher systematic groups such as mammals, birds, reptiles, and—of course—fishes, still being discovered regularly, even close to the major cities within this area (TOMPSON, 2010).

Table 6. *Apistogramma* species reported from Peru up to the end of 2012, with remarks on their current status.

	Apistogramma	author(s)	described	status in Peru
1.	<i>agassizii</i>	STEINDACHNER	1875	# / c w / u ⁽¹⁾
2.	<i>allpahuayo</i>	RÖMER <i>et al.</i>	2012	# / c l / u ^(2,lv)
3.	<i>atahualpa</i>	RÖMER	1997	# / c l / v
4.	<i>baenschi</i>	RÖMER <i>et al.</i>	2004	# / l / v (q)
5.	<i>barlowi</i>	RÖMER & HAHN	2008	# / c l / q
6.	<i>bitaeniata</i>	PELLEGRIN	1936	# / c w / (1)
7.	<i>cacatuoides</i>	HOEDEMAN	1951	# / c / (1) ⁽²⁾
8.	<i>cinilabra</i>	RÖMER <i>et al.</i>	2011	# / l / h ⁽³⁾
9.	<i>cruzi</i>	KULLANDER	1986	# / wq / q ⁽⁴⁾
10.	<i>eremnopyge</i>	READY & KULLANDER	2004	# / c l / q ^(2,6)
11.	<i>eunotus</i>	KULLANDER	1981	# / c / q ⁽⁴⁾
12.	<i>huascar</i>	RÖMER <i>et al.</i>	2006	# / l / q ⁽²⁾
13.	<i>luelingi</i>	KULLANDER	1976	# / c / u ⁽¹⁾
14.	<i>martini</i>	RÖMER <i>et al.</i>	2004	# / l / u ^(2,6)
15.	<i>nijsseni</i>	KULLANDER	1979	# / l / v ⁽²⁾
16.	<i>norberti</i>	STAECK	1991	# / l / v ⁽²⁾
17.	<i>panduro</i>	RÖMER	1997	# / l / v ⁽²⁾
18.	<i>pantalone</i>	RÖMER <i>et al.</i>	2006	# / l / q
19.	<i>paulmuelleri</i> sp. n.	RÖMER <i>et al.</i>	2013	# / l / v ⁽³⁾
20.	<i>payaminonis</i>	KULLANDER	1996	? / l / q ⁽⁵⁾
21.	<i>rositae</i>	RÖMER <i>et al.</i>	2006	# / l / v ^(2,6)
22.	<i>rubrolineata</i>	HEIN <i>et al.</i>	2002	# / l / q
23.	<i>urteagai</i>	KULLANDER	1996	# / c / q

Current status of species in Peru: # (confirmed); ? (not confirmed); Distribution: c (common); w (widespread); l (local); Population status: v (vulnerable); e (endangered); h (highly endangered); q (questionable); u (not in danger). ⁽¹⁾ different local populations may have species status; ⁽²⁾ local populations outside protected nature reserves may be under threat by human activities; ⁽³⁾ extremely restricted distribution, only one collection site known at present; ⁽⁴⁾ the identity of this species is uncertain. See main text; ⁽⁵⁾ the status of some specimens collected close to the Ecuadorian border in October 2012 is still not confirmed; ⁽⁶⁾ based on information provided by commercial and local fishermen; ⁽⁷⁾ status and collection site need to be confirmed. **Important note:** The comments on species status are based on actual field experience and need to be confirmed by future field research.

The fact that there are so many species within a comparatively small geographic area raises questions about the ecological background of species diversity patterns in the Loreto area. At present there is no definitive answer to the question of why so many species have evolved in the northern territory of Peru. But, taking a closer look at the distribution pattern of the *Apistogramma* species of

this area as an example, we can perhaps obtain a preliminary impression of the evolutionary background.

The Amazon lowlands are an area of seemingly more or less uniform geo-morphology. Only relatively few vertical elements such as palaeoarches, hills, and comparable geological structures determine or disturb the form of the central and upper Amazon basin. Relief dynamic in general is fairly low, and the difference in altitude in the Amazon basin between the upfolding of the Andean mountains and the Atlantic Ocean is less than 400 metres over a distance of roughly 3000 km. As far as is known, *Apistogramma* have not yet been found at altitudes significantly higher than 300 metres within this area, in spite of the fact that they may, as observed during one of our field trips in 2012, inhabit small fast-flowing rivulets in hilly areas. KULLANDER (1986) mentions only one comparable location in the Ecuadorian Rio Payamino system at an altitude of approximately 330 metres above sea level, where Steward collected *Apistogramma payaminonis* KULLANDER, 1986 in a fast-flowing river. But on the other hand the more or less periodic flooding of the Amazon lowlands may significantly contribute to the diversification of species. Floods may be responsible for the translocation of subpopulations of fishes to other areas, where they may be isolated for varying periods of time after the floods have subsided and evolve away from other populations in this isolation. As we know from the aquarium hobby, *Apistogramma* in general exhibit high morphological and chromatic plasticity, which may lead to rapid shifting of the gene pool under such conditions. Depending on the period of isolation, resumed contact with original populations may lead either to recombination into a single population or, depending on the degree of divergence, to co-existence of the new morphs, genotypic clusters, or species. The species of the genus *Apistogramma* may potentially turn out to be equally good models for this type of evolutionary scenario as the well-known Darwin's finches used for the purpose by GRANT & GRANT (1997, 2008 a,b), GRANT & WEINER (2008) and SATO *et al.* (1999).

Conservation status. At present the conservation status of *Apistogramma paulmuelleri* sp. n. is uncertain. The abundance of the species was fairly low compared to that of *Apistogramma* at other locations investigated by the research group in Peru, as well as to *Apistogramma* densities in general observed previously at other locations in the upper and middle Rio Negro system in Brazil (RÖMER, 1992, 1993, 1994, 1998, 2000, 2001). *Apistogramma paulmuelleri* sp. n. may not be vulnerable at present, as it has been collected in at least two locations. But progressive deforestation at the type locality and along the road from Iquitos to Náuta, as well as along main river channels in Amazonia Occidental, may put this (and other) endemic species of the District of Loreto at risk in the near future. This is already the case in species of other systematic groups such as birds and mammals (see TOMPSON, 2010). Hence the distribution and population size of this species should be monitored on a regular basis.

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