

1 **Checklist and practical identification key for the cichlid fishes (Cichliformes: Cichlidae) of**
2 **the La Plata drainage in Bolivia, including three new geographical records**

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10
11 **Abstract:** In comparison with the Bolivian Amazon, the ichthyofauna of the La Plata drainage
12 of Bolivia received relatively little attention historically. Until now, 14 species of cichlid fish
13 have been registered from this area. After an exhaustive review of museum collections
14 (Museo de Historia Natural Noel Kempff Mercado y Colección Boliviana de Fauna), we can
15 report three additional species: *Astronotus crassipinnis* (Heckel, 1840), *Mesonauta festivus*
16 (Heckel, 1840) and *Satanoperca pappaterra* (Heckel, 1840). Four other species, which have
17 been listed in previous publications, can be confirmed for the La Plata drainage of Bolivia
18 based on the examination of voucher specimens: *Aequidens plagiozonatus* Kullander, 1984,
19 *Apistogramma commbrae* (Regan, 1906), *A. trifasciata* (Eigenmann & Kennedy, 1903) and
20 *Crenicichla vittata* Heckel, 1840. As such, 16 of the 17 species can be referenced with voucher
21 specimens in museum collections. We also provide an identification key for the cichlid fish
22 species of the study area.

23
24 **Key words:** Biogeography, freshwater fish, Paraguay river, new report, checklist

25
26 **Resumen:** En comparación con la Amazonía boliviana, la ictiofauna de la Cuenca de la Plata en
27 Bolivia recibió relativamente poca atención históricamente. Hasta el momento, se han
28 registrado 14 especies de peces cíclidos de esta área. Después de una revisión exhaustiva de
29 las colecciones de los museos (Museo de Historia Natural Noel Kempff Mercado y Colección
30 Boliviana de Fauna), podemos informar que se adicionan tres especies: *Astronotus crassipinnis*
31 (Heckel, 1840), *Mesonauta festivus* (Heckel, 1840) y *Satanoperca pappaterra* (Heckel, 1840).
32 Otras cuatro especies, que han sido incluidas en publicaciones anteriores, pueden confirmarse
33 para la Cuenca de La Plata en Bolivia con base en revisiones de especímenes *voucher*:
34 *Aequidens plagiozonatus* Kullander, 1984, *Apistogramma commbrae* (Regan, 1906), *A.*
35 *trifasciata* (Eigenmann & Kennedy, 1903) y *Crenicichla vittata* Heckel, 1840. Como tal, 16 de
36 las 17 especies pueden ser referenciadas con especímenes de lotes en colecciones de los
37 museos. También proporcionamos una clave de identificación para las especies de cíclidos del
38 área de estudio

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40 **Palabras clave:** Biogeografía, Peces de agua dulce, río Paraguay, nuevo reporte, Lista de
41 verificación

42
43 **Introduction**

44 The fish fauna of Bolivia is one of the richest in the world (Sarmiento & Barrera 2004; Carvajal-
45 Vallejos *et al.* 2014; Sarmiento *et al.* 2014). Unfortunately, it remains poorly documented in

46 the scientific literature. This is particularly the case for the Bolivian part of the La Plata basin,
47 which comprises the Paraguay river in the eastern part of the country, and the rivers
48 Pilcomayo and Bermejo in the south (Figure 1). The first accounts on fish in the Bolivian part
49 of the La Plata basin that include cichlids have been made by Haseman in 1909, who collected
50 fish for the Carnegie Museum (USA). All cichlids he reported from Bolivia are from Puerto
51 Suárez (Haseman 1911) in the río Paraguay drainage. The location ‘São Francisco, Bolivia’ in
52 Haseman's (1911) work is actually located in Brazil (‘Rio São Francisco, into Paraguay river,
53 Matto Grosso’; Eigenmann (1911)). In the 1950's, Travassos collected several fish species,
54 including cichlids, in the Paraguay and Otuquis drainages, but did not identify them at species
55 level (Travassos 1957). In 1970, Terrazas Urquidi published a first list of the Bolivian fish
56 species. The sources for his reports on *Apistogramma taeniata*, *A. trifasciata*, *A. corumbae*
57 and *Crenicichla vittata* from the Bolivian río Paraguay drainage remain, however, unclear. In
58 the 1980s, Kullander wrote a series of taxonomic accounts on the cichlid fishes of the río
59 Paraguay drainage (Kullander 1981, 1982c, b, a, 1984, 1987). However, with the exception of
60 the first descriptions of *A. inconspicua* and *Bujurquina oenolaemus*, he did not include Bolivian
61 specimens.

62 Since the 1990's several extensive surveys have been conducted by Bolivian researchers
63 mostly affiliated to the Museo de Historia Natural ‘Noel Kempff Mercado’ (MHNNKM) in Santa
64 Cruz de la Sierra. With the notable exception of the article by Farrell & Cancino (2007), these
65 studies have been published in governmental reports and academic theses which are
66 unfortunately not readily accessible. For most of the species lists published in governmental
67 reports, little metadata (such as sampling sites, dates, information on species identification,
68 pictures, or lists of voucher specimens etc.) is available. Because of these limitations and since
69 the species identification is not verifiable in most cases, we refrain from citing this grey
70 literature in the present study, although we consider its content very valuable.

71 Geographical species records provide the basis of local, regional or national inventories on
72 which biodiversity measures can be estimated, they can be used to study biogeographical
73 patterns or they enable us to monitor changes in biodiversity through time. Regarding this
74 importance, the publication of such records should follow certain standards allowing the
75 verification of species identification. In this study, we report on the species of cichlid fishes
76 from the Bolivian part of the La Plata drainage. We aim not only to report a species list, but
77 also to link records to voucher specimens in museum collections, to provide photographs of
78 new records and to facilitate future identification with an identification key.

79

80 **Study area**

81 The study area includes the Bolivian part of the La Plata drainage in the departments Santa
82 Cruz, Chuquisaca and Tarija. The major sub-drainages in this area are the rivers Paraguay,
83 Pilcomajo and Bermejo.

84

85 **Methods**

86 We report the cichlid species present in the collections of the Colección Boliviana de Fauna
87 and the Museo de Historia Natural ‘Noel Kempff Mercado’ in La Paz and Santa Cruz de la
88 Sierra, respectively. Fish re-identification took place in 2010. Besides a few exceptions, newer
89 collections are therefore not considered in this study. The list of lots in this study should not
90 be considered complete for various reasons (e.g. not being available at the time the

91 examination took place). Fish were identified using the primary taxonomic literature (see
92 references). Many collection numbers in the MHNNKM have been changed in recent years. To
93 avoid confusion, we also provide the old numbers in brackets. Abbreviations: MNKP = Museo
94 de Historia Natural 'Noel Kempff Mercado' (P = peces). CBF = Colección Boliviana de Fauna.
95 To assess the completeness of the species list provided in this study statistically, we estimated
96 rarefaction curves using the rarecurve function of the package vegan v2.5-2 (Oksanen *et al.*
97 2007) in R v3.4.2 (R Development Core Team 2012).

98

99 **Results**

100 ***Aequidens plagiozonatus* Kullander, 1984**

101 *Aequidens plagiozonatus* Kullander, 1984

102 **Type locality.** Brazil, State of Mato Grosso, R. Paraguay system Mun. Itiquira, internal lakes
103 of the Piquiri-Itiquira system, Fazenda Santo Antonio do Paraíso.

104 **Bibliography for the study area**

105 *Aequidens plagiozonatus*; Farrell & Cancino (2007): localities (Río Aguas Calientes).

106 **Examined material. Bolivia: Santa Cruz: Angel Sandoval:** MNKP 4765 (3518), 4, Curiche
107 Tapera, K. Osinaga & P. Coro, 29 Sep 1999.

108 **Identification.** Species most frequently misidentified as members of the genus *Aequidens*
109 belong to genera *Bujurquina*, *Cichlasoma* and *Laetacara*. *Bujurquina* differs from the other
110 genera by having conspicuous lateral and nape bands. *Laetacara* has a dark stripe from the
111 eye to the tip of the snout and a scaled preoperculum (vs. no dark stripe and preoperculum
112 naked). *Cichlasoma* differs from the other genera in having scale rows in the proximal area of
113 the rayed part of the dorsal fin and 6 vertical bars behind the midlateral spot (vs. 5 in
114 *Aequidens*). *Aequidens plagiozonatus* is the only species of its genus to have been reported
115 and confirmed from the upper río Paraguay drainage. It is medium sized and reaches 10.3 cm
116 SL (Kullander 1984). See Figure 2 for general appearance. A detailed description and diagnosis
117 can be found in Kullander (1984).

118

119 ***Apistogramma borellii* (Regan, 1906)**

120 *Heterogramma borellii* Regan, 1906

121 *Heterogramma ritense* Haseman, 1911

122 *Heterogramma rondoni* Miranda Ribeiro, 1918

123 *Apistogramma aequipinnis* Ahl, 1938

124 *Apistogramma reitzigi* Mitsch, 1938

125 **Type locality.** Carandasiñho, Matto Grosso.

126 **Bibliography for the study area**

127 *Heterogramma borellii*; Haseman (1911): locality (Puerto Suarez) and voucher material.

128 *Apistogramma borellii*; Terrazas Urquidi (1970): listing (R. Paraguay).

129 *Apistogramma borellii*; Schindler & Staeck (1993): listing.

130 **Examined material. Bolivia: río Paraguay drainage: Santa Cruz: Angel Sandoval:** MNKP 3215
131 (3927), 1, Laguna Mandioré, K. Osinaga, 15 Jul 1998. MNKP 4586 (3504), 12, Hacienda Vista
132 Hermosa, laguna, K. Osinaga & P. Coro, 19 Sep 1999. **Germán Busch:** MNKP 1177 (1643), 4,
133 Puerto Suárez, Laguna Cáceres, San Eugenio, K. Osinaga, R. Coca, V. Fuentes & A. Franco, 19
134 Feb 1996. MNKP 1178 (1646), 1, Puerto Suárez, Laguna Cáceres, K. Osinaga, R. Coca, V.
135 Fuentes & A. Franco, 22 Feb 1996. MNKP 1180 (1667), 2, Laguna Cáceres, K. Osinaga, R. Coca,

136 V. Fuentes & A. Franco, 22 Feb 1996 (lot also contains 1 specimen of *Cichlasoma dimerus*).
137 MNKP 1183 (1671), 3, Puerto Suárez, Laguna Cáceres, Palo Santo, K. Osinaga, R. Coca, V.
138 Fuentes & A. Franco, 22 Feb 1996. MNKP 1217 (2260), 4, Puerto Quijarro, Tamarinero, Canal
139 Tamengo, K. Osinaga, R. Coca, V. Fuentes & A. Franco, 26 Feb 1996. MNKP 1219 (2732), 10,
140 Puerto Quijarro, bahia Cáceres, Canal Tamengo, K. Osinaga, R. Coca, V. Fuentes & A. Franco,
141 26 Feb 1996 (lot also contains 1 specimen of *Cichlasoma dimerus*). MNKP 1222 (4229), 5,
142 Puerto Suarez, Laguna Cáceres, curiche temporal, K. Osinaga, R. Coca, V. Fuentes & A. Franco,
143 19 Feb 1996. MNKP 1393 (1491), 2, Puerto Suárez, Laguan Cáceres, P. Rebolledo, K. Osinaga,
144 V. Fuentes, L. Paniagua & L. Paredes, 9 Aug 1996. MNKP 1401 (1496), 1, Puerto Suárez, río San
145 Lorenzo, P. Rebolledo, K. Osinaga, V. Fuentes, L. Paniagua & L. Paredes, 6 Aug 1996. MNKP
146 1416 (1517), 3, Puerto Suárez, Laguna Cáceres, P. Rebolledo, K. Osinaga, V. Fuentes, L.
147 Paniagua & L. Paredes, 6 Aug 1996. MNKP 1444 (1560), 2, Puerto Quijarro, Laguna Cáceres, P.
148 Rebolledo, K. Osinaga, V. Fuentes, L. Paniagua & L. Paredes, 13 Aug 1996. MNKP 1445 (1566),
149 11, Puerto Suarez, Laguna Cáceres, P. Rebolledo, K. Osinaga, V. Fuentes, L. Paniagua & L.
150 Paredes, 9 Aug 1996. MNKP 1511 (2255), 18, Puerto Quijarro, Tamarinero, Laguna Cáceres, P.
151 Rebolledo, K. Osinaga, L. Paniagua, L. Paredes & V. Fuentes, 13 Aug 1996. MNKP 1518 (2734),
152 5, Puerto Suárez, Laguna Cáceres, P. Rebolledo, K. Osinaga, L. Paniagua, L. Paredes & V.
153 Fuentes, 11 Aug 1996. MNKP 1520 (2743), 1, Puerto Quijarro, Tamarinero, Laguan Cáceres, P.
154 Rebolledo, K. Osinaga, L. Paniagua, L. Paredes & V. Fuentes, 15 Aug 1996. MNKP 2402 (2727),
155 2, Puerto Suarez, Laguna Cáceres, M.A. Parada & R. Yañez, 25 May 1997. MNKP 3882 (3055),
156 7, Puerto Suarez, Laguna Cáceres, K. Osinaga & J. Cardona, 26 Oct 1998. MNKP 3922 (4064),
157 6, río Pimiento, Laguan Cáceres, K. Osinaga & J. Cardona, 28 Oct 1998. MNKP 3932 (4175), 2,
158 Laguna Cáceres, curichi Estancia Verdem, K. Osinaga & J. Cardona, 28 Oct 1998. MNKP 3954
159 (3219), 59, poza sobre el camino a la hacienda Santa Elena (Otuquis), K. Osinaga & J. Cardona,
160 31 Oct 1998 (lot also contains 3 specimens of *A. commbrae*). MNKP 3963 (6153), 4, poza sobre
161 el camino a la hacienda Santa Elena (Otuquis), K. Osinaga & J. Cardona, 31 Oct 1998. MNKP
162 4010 (3886), 10, Bahía Corea, 'Otuquis', K. Osinaga, J. Cardona, A. Justiniano & M. Chavez, 5
163 Nov 1998. MNKP 4041 (3054), 1, El Carmen, Est. Campo en medio camino a 2 km al suroeste,
164 K. Osinaga & J. Cardona, 10 Nov 1998.

165 **Identification.** To date, four species of *Apistogramma* have been reported from the upper río
166 Paraguay drainage: *A. borellii*, *A. commbrae*, *A. inconspicua* and *A. trifasciata* (reports of other
167 species exist, but should be considered questionable). *Apistogramma borellii* differs from *A.*
168 *trifasciata* by the absence of an oblique black stripe between pectoral and anal fin origin and
169 from *A. commbrae* and *A. inconspicua* by having the posteriormost vertical bar and caudal
170 spot separated. Preserved specimen show a series of separated midlateral spots on the flanks.
171 *Apistogramma borellii* is a small species reaching a size of 3.9 cm SL (Kullander 2003).

172

173 ***Apistogramma commbrae* (Regan, 1906)**

174 *Heterogramma commbrae* Regan, 1906

175 *Heterogramma corumbae* Eigenmann & Ward, 1907

176 **Type locality.** Carandasiño, Matto Grosso; Colonia Risso.

177 **Bibliography for the study area**

178 *Apistogramma commbrae*; Farrell & Cancino (2007): locality (Río Tucavaca).

179 *Apistogramma corumbae*; Terrazas Urquidi (1970): listing (R. Paraguay).

180 **Examined material. Bolivia: río Paraguay drainage: Santa Cruz: Angel Sandoval:** MNKP 3216
181 (3927), 1, Laguna Mandioré, K. Osinaga, 15 Jul 1998. MNKP 4591 (3504), 1, Hacienda Vista
182 Hermosa, laguna, K. Osinaga & P. Coco, 20 Sep 1999. **Chiquitos:** MNKP 5270, 13, Candelaria,
183 río Tucavaca, M.E. Farrell, M.Á. Velásquez & P. Hinojosa, 29 Dec 2003. **Germán Busch:** MNKP
184 1488 (1526), 5, Puerto Suarez, Laguna Cáceres, P. Rebolledo, K. Osinaga, V. Fuentes, L.
185 Paniagua & L. Paredes, 13 Aug 1996. MNKP 2949 (1966), 1, Puerto Suarez, Hacienda Arcoiris,
186 Laguna Cáceres, M.A. Parada & V. Fuentes, 1997. MNKP 3954 (3219), 3, poza sobre el camino
187 a la hacienda Santa Elena, K. Osinaga & J. Cardona, 31 Oct 1998 (lot also contains 59 specimens
188 of *C. borellii*). MNKP 3981 (3236), 1, poza camino a Santa Elena a 10 km de hacienda Las
189 Camelias, K. Osinaga & J. Cardona, 1 Nov 1998. MNKP 6599 (3522), 1, río Santo Rosario, K.
190 Osinaga & P. Coro, 1 Oct 1999.

191 **Identification.** *Apistogramma commbrae* differs from *A. trifasciata* by the absence of an
192 oblique black stripe between pectoral and anal fin origin and from *A. borellii* by having the
193 posteriormost vertical bar and caudal spot fused to a tail spot. In *A. commbrae*, the dark
194 midlateral band is clearly fused with the tail spot, while in *A. inconspicua*, the band is
195 somewhat separated from it. Preserved specimen of *A. commbrae* show several typically
196 conspicuous longitudinal stripes along the flanks below the lateral band (less conspicuous or
197 absent in *A. inconspicua*). Additional characters to distinguish *A. commbrae* from *A.*
198 *inconspicua* are: modally 16 dorsal fin spines (vs. 15) and teeth on the posteromedial portion
199 of the pharyngeal tooth plate bicuspid (vs. tricuspid; Kullander, 1982c). It is a small species
200 reaching 32.6 mm SL (Kullander 1982b). See Figure 3 for general appearance. A detailed
201 redescription of *A. commbrae* can be found in Kullander (1982b).

202

203 ***Apistogramma trifasciata* (Eigenmann & Kennedy, 1903)**

204 *Biotodoma trifasciatus* Eigenmann & Kennedy, 1903

205 *Heterogramma trifasciatum masiliense* Haseman, 1911

206 *Apistogramma trifasciatum haraldschultzi* Meinken, 1960

207 **Type locality.** Arroyo Chagalalina [Paraguay].

208 **Bibliography for the study area**

209 *Apistogramma trifasciata*; Terrazas Urquidi (1970): listing (R. Paraguay).

210 *Apistogramma trifasciata*; Schindler & Staeck (1993): listing.

211 **Examined material. Bolivia: río Paraguay drainage: Santa Cruz: Angel Sandoval:** MNKP 3188
212 (3921), 7, Puerto Gonzalo, río Pando, K. Osinaga, 12 Jul 1998. MNKP 3214 (3927), 2, Laguna
213 Mandioré, K. Osinaga, 15 Jul 1998. MNKP 4592 (3504), 1, Hacienda Vista Hermosa, laguna, K.
214 Osinaga & P. Coro, 20 Sep 1999.

215 **Identification.** Differs from all other species of *Apistogramma* by having an oblique black
216 stripe between pectoral and anal fin origin. This stripe is absent in living specimens of at least
217 one population in the Bolivian Amazon (personal observation), but seems to be always present
218 in preserved animals. *Apistogramma trifasciata* is a small species reaching a size of 3.8 cm SL
219 (Kullander 2003). See Figure 4 for general appearance of the species.

220

221 ***Apistogramma* sp. (unidentified juveniles)**

222 **Examined material. Bolivia: río Paraguay drainage: Santa Cruz: Ángel Sandoval:** MNKP 4611
223 (3453), 6, laguna, Hacienda Vista Hermosa, laguna, K. Osinaga & P. Coro, 21 Sep 1999.

224

225 ***Astronotus crassipinnis* (Heckel, 1840)**

226 *Acara crassipinnis* Heckel, 1840

227 **Type locality.** ... Rio-Paraguay ... in Buchten ... bei Villa Maria und Caiçara ... Rio-Guaporè bei
228 Matogrosso, im Rio-negro und im Rio-branco.

229 **Bibliography for the study area**

230 **Examined material. Bolivia: río Paraguay drainage: Santa Cruz: Ángel Sandoval:** MNKP 4810
231 (3600), 1, Santo Rosario, río Santo Rosario, K. Osinaga & P. Coro, 1 Oct 1999. **Germán Busch:**
232 MNKP 1262 (1801), 1, Puerto Suarez, Hacienda Arcoiris, Laguna Cáceres, K. Osinaga, R. Coca,
233 V. Fuentes & A. Franco, 28 Feb 1996. MNKP 1430 (1532), 1, Puerto Suarez, Castrillo, Laguna
234 Cáceres, P. Rebolledo, K. Osinaga, V. Fuentes, L. Paniagua & L. Paredes, 9 Aug 1996. MNKP
235 3874 (3796), 1, Puerto Suarez, río Pimiento, K. Osinaga & J. Cardona, 23 Oct 1998.

236 **Identification.** *Astronotus crassipinnis* can be identified on the basis of the following unique
237 combination of characters: 'African type' lips (see Figure 12 in Kullander (1986)), unpaired fins
238 densely scaled, about 35 scales in the longitudinal row, no ocelli along the dorsal-fin base. This
239 species is the only one of its genus known to occur in the Río Paraguay basin. It is a large
240 species reaching 24 cm SL (Kullander 2003). See Figure 5 for general appearance. More
241 detailed accounts on the appearance of *A. crassipinnis* are provided by Kullander (1981, 1986).

242

243 ***Bujurquina oenolaemus* Kullander 1987**

244 *Bujurquina oenolaemus* Kullander, 1987

245 **Type locality.** Bolivie, dép. Santa Cruz. Rio Aguas Calientes à Aguas Calientes, à 25 km à l'est
246 de Roboré, sur le rail. (Basin du Paraguay).

247 **Bibliography for the study area**

248 *Bujurquina oenolaemus*; Kullander (1987): diagnosis, description, photograph, illustration,
249 locality (Río Aguas Calientes) and voucher specimen.

250 *Bujurquina oenolaemus*; Farrell & Cancino (2007): localities (Río Aguas Calientes) and
251 photography.

252 *Bujurquina oenolaemus*; Sarmiento *et al.* (2014): listing (Río Aguas Calientes).

253 **Examined material. Bolivia: río Paraguay drainage: Santa Cruz: Chiquitos:** MNKP 4692 (3481),
254 11, Aguas Calientes, río Aguas Calientes, K. Osinaga & P. Coro, 26-27 Sep 1999. MNKP 5202
255 (4142), 3, Aguas Calientes, río Aguas Calientes, V. Fuentes & S. Sanguenza, 13 Dec 2000. MNKP
256 5244, 1, Localidad Aguas Calientes, El Playon, nacimiento del río Aguas Calientes, M.E. Farrell,
257 M.Á. Velásquez & P. Hinojosa, 5 Jan 2004. MNKP 5282, 6, punto de union de los ríos Jesus y
258 Aguas Calientes, localidad Aguas Calientes, M.E. Farrell, M.Á. Velásquez & P. Hinojosa, 4 Jan
259 2004. MNKP 5298, 9, Aguas Calientes, balneario El Burriño, río Aguas Calientes, M.E. Farrell,
260 M.Á. Velásquez & G. Huanca, 5 Jul 2004. MNKP 5352, 1, Aguas Calientes, zona El Playón, río
261 Aguas Calientes, M.E. Farrell, M.Á. Velásquez & G. Huanca, 5 Jul 2004. MNKP 5362, 2, Aguas
262 Calientes, punto de union río Aguas Calientes y río Jesus, M.E. Farrell, M.Á. Velásquez & G.
263 Huanca, 5 Jul 2004.

264 **Identification.** Differs from *B. vittata* by having a shorter pectoral fin (29-33 vs. 36-41 % of SL)
265 and a longer head (38-41 vs. 35-38 % of SL). Body with a dark reddish/ wine-coloured hue
266 when alive, brachiostegal membrane reddish. *Bujurquina oenolaemus* is a small species
267 reaching 7.1 cm SL (Hablützel, unpublished data).

268

269 ***Bujurquina vittata* (Heckel, 1840)**

- 270 *Acara vittatus* Heckel, 1840
271 *Aequidens paraguayensis* Eigenmann & Kennedy, 1903
272 **Type locality.** ... Sümpfen um Cujabá, der Hauptstadt in der Provinz Matagrosso [sic].
273 **Bibliography for the study area**
274 *Aequidens paraguayensis*; Haseman (1911): localities (Puerto Suarez) and voucher material.
275 *Aequidens paraguayensis*; Terrazas Urquidi (1970): listing (Río. Pilcomayo and Río.
276 Paraguay).
277 *Bujurquina vittata*; Farell & Cancino (2007): localities (Río Otuquis drainage).
278 **Examined material. Bolivia: río Paraguay drainage: Santa Cruz: Angel Sandoval:** CBF 8679, 1,
279 Pantanal, Río Las Conchas, Estancia Las Conchas, arroyo "submontano" de "aguas negras", con
280 presencia de grandes pozas, rápidos y cataratas, 17° 33' 58.3''S 59° 28' 17.1''W, J. Sarmiento
281 & K. Osinaga, 17 Apr 1999. CBF 8683, 6, Pantanal, Río Las Conchas, Estancia Las Conchas,
282 arroyo "submontano" de "aguas blancas", con alternancia de rápidos y pozas, 17° 33' 58.3''S
283 59° 28' 17.1''W, J. Sarmiento & K. Osinaga, 16 Apr 1999. MNKP 739 (589), 1, San Matías,
284 Estación Cascabel, M.L. Argandoña, 8 Sep 1994. MNKP 742 (535), 2, San Matías, Estancia
285 Cascabel, M.L. Argandoña, 8 Sep 1994. MNKP 3227 (4903), 2, Laguna Mandioré, K. Osinaga,
286 16 Jul 1998. MNKP 4727 (3613), Santo Corazon, río Santo Corazon, K. Osinaga & P. Coro, 28
287 Sep 1999. MNKP 4816 (6600), 3, río Santo Rosario, K. Osinaga & P. Coro, 1 Oct 1999. **Chiquitos:**
288 MNKP 4877 (3355), 1, Carmen Rivero Torrez. río Otuquis, V. Fuentes & S. Sanguenza, 1 Nov
289 1999. MNKP 4867 (4250), 1, río Tucavaca, V. Fuentes & S. Sanguenza. MNKP 5232, 1, Laguna al
290 lado derecho del Camino, 800 m antes de la localidad de Candelaria, M.E. Farell, M.Á.
291 Velásquez & P. Hinojosa, 29 - 30 Dec 2003. MNKP 5328, 1, Localidad Candelaria, río Aguas
292 Calientes, M.E. Farell, M.Á. Velásquez & G. Huanca, 2 Jul 2004. MNKP 5363, 3, Candelaria, río
293 Tucavaca, M.E. Farell, M.Á. Velásquez & G. Huanca, 30 Jun 2004. **Germán Busch:** MNKP 3953
294 (3209), 4, poza en el camino a hacienda Santa Elena, K. Osinaga & J. Cardona, 31 Oct 1998.
295 **Identification.** Differs from *B. oenolaemus* by a longer pectoral fin (36-41 vs. 29-33 % of SL)
296 and a shorter head (35-38 vs. 38-41 % of SL). Body (at least ventral portions of head and flanks)
297 with a yellowish hue when alive, brachyostegal membrane without chromatophores. A brief
298 redescription of *B. vittata* is provided by Kullander (1981). *Bujurquina vittata* is a small species
299 reaching 7.9 cm SL (Hablützel, unpublished data).
300
301 ***Chaetobranchopsis australis* Eigenmann & Ward, 1907**
302 *Chaetobranchopsis australe* Eigenmann & Ward, 1907
303 **Type locality.** Bahia Negra [Paraguay].
304 **Bibliography for the study area**
305 *Chaetobranchopsis australis*; Haseman (1911): locality (Puerto Suarez) and voucher material.
306 *Chaetobranchopsis australis*; Farell & Cancino (2007): locality (Río Tucavaca).
307 **Examined material. Bolivia: río Paraguay drainage: Santa Cruz: Ángel Sandoval:** CBF 8686, 1,
308 Pantanal, Río Las Conchas, Estancia Las Conchas, arroyo "submontano" de "aguas blancas",
309 con alternancia de rápidos y pozas, 17° 33' 58.3''S 59° 28' 17.1''W, J. Sarmiento & K. Osinaga,
310 16 Apr 1999. MNKP 2459 (2175), 1, Hacienda Santa Helena, río Mercedes, R. Coca & Maraz,
311 22 Sep 1997. **Germán Busch:** MNKP 3929 (2997), 1, Puerto Suarez, Estación Verde, Laguna
312 Cáceres, K. Osinaga & J. Cardona, 28 Oct 1998. MNKP 3947 (3033), 22, poza en el camino a la
313 hacienda Santa Elena (Otuquis), K. Osinaga & J. Cardona, 31 Oct 1998.

314 **Identification.** *Chaetobranchopsis australis* belongs to the tribe Chaetobranchini, which are
315 specialized filter feeder and have a large number of long gill rakers (around 50 or more on the
316 first gill arch). Most other species of Neotropical cichlids have about 20 or less short gill rakers
317 on the first gill arch. It is the only species of Chaetobranchini known to occur in the La Plata
318 basin. *Chaetobranchopsis australis* is a medium-sized species reaching 12 cm SL (Kullander
319 2003).

320

321 ***Cichla piquiti* Kullander & Ferreira, 2006**

322 *Cichla piquiti* Kullander & Ferreira, 2006

323 **Type locality.** Brazil: Pará: Rio Itacaiúnas at Caldeirão.

324 **Bibliography for the study área**

325 *Cichla piquiti*; Sarmiento *et al.* (2014): listing (Paraguay-Paraná Basin).

326 **Examined material.** None.

327 Identification. The genus *Cichla* can be readily distinguished from other South American
328 cichlids by its large size, the deeply notched dorsal-fin margin, the small scales, the densely
329 scaled unpaired fins and the conspicuous ocellus on the base of the caudal fin. *Cichla piquiti*
330 and *C. kelberi* Kullander & Ferreira, 2006 are the only species of *Cichla* reported from the upper
331 río Paraguay (both introduced). They can readily be distinguished on the number of vertical
332 bands below the dorsal fin: three in *C. piquiti* vs. five in *C. kelberi*. *Cichla piquiti* is a large
333 species reaching 43 cm SL (Kullander & Ferreira 2006).

334

335 ***Cichlasoma dimerus* (Heckel, 1840)**

336 *Acara dimerus* Heckel, 1840

337 *Acara marginatus* Heckel, 1840

338 ?*Heros centralis* Holmberg, 1891

339 **Type locality.** Cujabá-Fluss.

340 **Bibliography for the study area**

341 *Aequidens portalegrensis*; Haseman (1911): localities (Puerto Suarez) and voucher material.

342 *Cichlasoma dimerus*; Kullander (1983): locality (R. San Rafael, 4 km S Roboré) and voucher
343 material.

344 *Cichlasoma boliviense*; Farrell & Cancino (2007): locality (Río Roboré).

345 **Examined material. Bolivia: río Paraguay drainage: Santa Cruz: Angel Sandoval:** CBF 8623, 3,
346 Pantanal, pantano con lagunilla, 17°04'10.5''S 59°28'17.1''W, J. Sarmiento & K. Osinaga, 19
347 Apr 1999. CBF 8651, 11, Pantanal, Lago Santa Elena, J. Sarmiento & K. Osinaga, 20-21 Apr
348 1999. MNKP 736 (537), 2, San Matías, Estancia Cascabel, M.L. Argandoña, 8 Sep 1994. MNKP
349 740 (535), 5, San Matías, Estancia Cascabel, M.L. Argandoña, 8 Sep 1994. MNKP 2416 (2112),
350 1, a 3 km de San Matías, debajo del puente, R. Coca & Maraz, 20 Sep 1997. MNKP 2418 (2156),
351 2, a 3 km de San Matías, debajo del puente, R. Coca, Maraz, 20 Sep 1997. MNKP 2426 (2193),
352 1, a 3 km de San Matías, debajo del puente, R. Coca & Maraz, 20 Sep 1997. MNKP 2441 (2209),
353 1, camino a curiche la Hormiga a 14 km de San Matías, Curichi Patujusal, R. Coca & Maraz, 21
354 Sep 1997. MNKP 3228 (6116), 7, Puerto Gonzalo, Laguna Mandioré, K. Osinaga, 16 Jul 1998.
355 MNKP 3270 (4903), 4, Laguna Mandioré, K. Osinaga, 16 Jul 1998. MNKP 4746 (3518), 4,
356 Curiche Tapera, K. Osinaga & P. Coro, 29 Sep 1999. MNKP 4612 (3453), 1, laguna, Hacienda
357 Vista Hermosa, laguna, K. Osinaga & P. Coro, 21 Sep 1999. MNKP 6147, 1, río Bella Boca, V.
358 Fuentes, 23 Nov 2000. **Chiquitos:** MNKP 4892 (3371), 1, río Bravo, V. Fuentes & S. Sangueza,

359 5 Nov 1999. MNKP 4850 (3410), 5, río Aguas Calientes, V. Fuentes, S. Sangueza, 31 Oct 1999.
360 MNKP 3792, 1, río Esperancita, M. Velasquez & V. Fuentes, 2 Feb 2006. MNKP 5353, 2, río
361 Aguas Calientes, zona El Playón, Aguas Calientes, M.E. Farrell, M.Á. Velásquez & G. Huanca, 5
362 Jul 2004. **Germán Busch:** MNKP 1155 (1537), 1, Puerto Suarez, Laguna Cáceres, Palo Santo, K.
363 Osinaga, R. Coca, V. Fuentes & A. Franco, 19 Feb 1996. MNKP 1156 (1548), 3, Puerto Suarez,
364 Hacienda San Lorenzo, río San Lorenzo, K. Osinaga, R. Coca, V. Fuentes & A. Franco, 29 Feb
365 1996. MNKP 1180 (1667), 1, Puerto Suarez, Laguna Cáceres, K. Osinaga, R. Coca, V. Fuentes &
366 A. Franco, 22 Feb 1999 (lot also contains 2 specimens of *Apistogramma borellii*). MNKP 1195
367 (1739), 1, curiche temporal, Laguna Cáceres, Puerto Suárez, K. Osinaga, R. Coca, V. Fuentes &
368 A. Franco, 19 Feb 1996. MNKP 1218 (2261), 1, Puerto Quijarro, Tamarinero, Canal Tamengo,
369 K. Osinaga, R. Coca, V. Fuentes & A. Franco, 26 Feb 1996. MNKP 1219 (2732), 10, Puerto
370 Quijarro, bahía Cáceres, Canal Tamengo, K. Osinaga, R. Coca, V. Fuentes & A. Franco, 26 Feb
371 1996 (lot also contains 10 specimens of *Apistogramma borellii*). MNKP 1223 (4229), 2, Puerto
372 Suarez, Laguna Cáceres, curiche temporal, K. Osinaga, R. Coca, V. Fuentes & A. Franco, 19 Feb
373 1996. MNKP 1327 (1561), 2, Puerto Suarez, Laguna Cáceres, Hacienda Arcoiris, K. Osinaga, V.
374 Fuentes, A. Justiniano & E. Guzmán, 19 May 1996. MNKP 1394 (1491), 1, Puerto Suárez,
375 Laguan Cáceres, P. Rebolledo, K. Osinaga, V. Fuentes, L. Paniagua & L. Paredes, 9 Aug 1996.
376 MNKP 1427 (1528), 1, Puerto Suarez, Laguna Cáceres, Castrillo, P. Rebolledo, K. Osinaga, V.
377 Fuentes, L. Paniagua & L. Paredes, 9 Aug 1996. MNKP 1429 (1531), 7, Puerto Suarez, Laguna
378 Cáceres, Hacienda Arcoiris, P. Rebolledo, K. Osinaga, V. Fuentes, L. Paniagua & L. Paredes, 4
379 Aug 1996. MNKP 1516 (2255), 1, Puerto Quijarro, Tamarinero, Laguna Cáceres, P. Rebolledo,
380 K. Osinaga, L. Paniagua, L. Paredes & V. Fuentes, 13 Aug 1996. MNKP 2193 (2035), 44, El
381 Carmen, zona de inundación, estancia Campo el Medio, P. Rebolledo, R. Coca, V. Fuentes & G.
382 Soto, May 1997. MNKP 2197 (2051), 1, El Carmen, zona de inundación, estancia Campo el
383 Medio, P. Rebolledo, R. Coca, V. Fuentes & G. Soto, May 1997. MNKP 2293 (2046), 1, Puerto
384 Busch, Isla Santa Rosa, río Paraguay, R. Coca, V. Fuentes & G. Soto, 14 May 1997. MNKP 3902
385 (3017), 7, Puerto Suarez, río Pimiento, K. Osinaga & J. Cardona, 27 Oct 1998. MNKP 3907
386 (3201), 2, Puerto Suarez, Laguna Cáceres, Pto. Arcoiris, río Pimiento, K. Osinaga, J. Cardona,
387 27 Oct 1998. MNKP 3928 (2995), 2, Puerto Suarez, Laguna Cáceres, Est. Verde, K. Osinaga & J.
388 Cardona, 28 Oct 1998. MNKP 3960 (4321), 33, Poza en el camino a Hacienda Santa Elena, río
389 Otuquis drainage, K. Osinaga & J. Cardona, 31 Oct 1998. MNKP 4021 (3018 and 3026), 2, El
390 Carmen, zona de inundación, Estancia Campo el Medio, K. Osinaga & J. Cardona, 9 Nov 1998.
391 MNKP 4037 (3037), 19, El Carmen, Estancia Campo en Medio, curichi a 2 km suroeste, K.
392 Osinaga & J. Cardona, 10 Nov 1998. MNKP 4046 (3261), 18, El Carmen, Estancia Campo en
393 Medio, curichi a 2 km suroeste, K. Osinaga & J. Cardona, 10 Nov 1998. MNKP 4319, 2, Santa
394 Ana, río la Canoa, V. Fuentes, 21 Oct 2000. MNKP 5085 (4327), 2, Sta. Ana, Poza La Banda,
395 Santa Ana, V. Fuentes, 20 Oct 2000. **río Bermejo drainage: Tarija: Arce:** CBF 8605, 4, Río
396 Bermejo, Ciudad de Bermejo: Punto 2, 22°47'S 64°20'W, J. Horton, 27 Dec 1993.
397 **Identification.** As described in Kullander (1983). Most adult or sub-adult specimen of
398 *Cichlasoma boliviense*, a species from adjacent areas in the Amazon, have scale-base spots on
399 the posteroventral parts of the sides, resulting in a mottled pattern, which are absent in *C.*
400 *dimerus*. The two species overlap in measurements and meristics (Kullander 1983), making it
401 virtually impossible to distinguish them by morphology in some cases. However, no specimen
402 with mottled colouration pattern have yet been observed in the La Plata drainage, indicating

403 that *C. boliviense* is indeed restricted to the Amazon. *Cichlasoma dimerus* is a medium-sized
404 species reaching 11.7 cm SL (Kullander 1983).

405

406 ***Crenicichla lepidota* Heckel, 1840**

407 *Crenicichla lepidota* Heckel, 1840

408 *Crenicichla edithae* Ploeg, 1991

409 **Type locality.** Rio-Guaporè.

410 **Bibliography for the study area**

411 *Crenicichla lepidota*; Haseman (1911): locality (Puerto Suarez) and voucher material.

412 *Crenicichla lepidota*; Terrazas Urquidi (1970): listing (R. Bermejo and R. Paraguay).

413 *Crenicichla lepidota*; Farell & Cancino (2007): localities (Río Otuquis drainage).

414 *Crenicichla lepidota*; Varella (2011): bibliography.

415 **Examined material. Bolivia: río Paraguay drainage: Santa Cruz: Angel Sandoval:** CBF 8652, 1,

416 Pantanal, Lago Santa Elena, Paraguay drainage, J. Sarmiento & K. Osinaga, 20-21 Apr 1999.

417 CBF 8680, 1, Pantanal, Río Las Conchas, Estancia Las Conchas, arroyo "submontano" de "aguas

418 negras", con presencia de grandes pozas, rápidos y cataratas, 17° 33' 58.3''S 59° 28' 17.1''W,

419 J. Sarmiento & K. Osinaga, 17 Apr 1999. MNKP 2417 (2113), 2, río a 3 km de San Matías, debajo

420 del puente, R. Coca & Maraz, 20 Sep 1997. MNKP 2420 (2158), 10, río a 3 km de San Matías,

421 debajo del puente, R. Coca & Maraz, 20 Sep 1997. MNKP 2425 (2187), 1, río a 3 km de San

422 Matías, debajo del puente, R. Coca & Maraz, 20 Sep 1997. MNKP 2435 (2169), 2, Curichi

423 Patujusal, camino a la curiche La Hormiga, 14 km a San Matías, R. Coca & Maraz, 21 Sep 1997.

424 MNKP 4716 (3490), 1, Santo Corazón, río Santo Corazón, K. Osinaga & P. Coro, 28 Sep 1999.

425 MNKP 4747 (3519), 2, Curiche Tapera, K. Osinaga & P. Coro, 29 Sep 1999. MNKP 4105 (3611),

426 1, pantano, viejo cauce de río, J. Sarmiento, K. Osinaga, F. Osorio & R. Bueno, 23 Apr 1999.

427 MNKP 4587 (3506), 1, Area de Manejo Integral San Matías, laguna, Hacienda Vista Hermosa,

428 K. Osinaga & P. Coro, 20 Sep 1999. MNKP 3139 (3924), 2, río Pando, Puerto Gonzalo & K.

429 Osinaga, 11 Julio 1998. MNKP 3223 (4151), 1, Laguna Uberaba, K. Osinaga, 4 Jul 1998. MNKP

430 4105 (3641), 6, Área de Manejo Integral San Matías, Hacienda Pantano Caribe, río Caribe, K.

431 Osinaga & P. Coro, 24 Sep 1999. MNKP 4680 (3643), 4, Area de Manejo Integral San Matías,

432 Hacienda Pantano Caribe, río Caribe, K. Osinaga & P. Coro, 27 Sep 1999. MNKP 4570 (3664),

433 4, laguna, Hacienda Vista Hermosa, K. Osinaga & P. Coro, 19 Sep 1999. MNKP 4645 (3870), 5,

434 Area de Manejo Integral San Matías, Hacienda Pantano Caribe, río Caribe, K. Osinaga & P.

435 Coro, 27 Sep 1999. MNKP 3223 (4187), 1, Laguna Mandioré, K. Osinaga, 15 Jul 1998. **Chiquitos:**

436 MNKP 4762 (3622), 7, Aguas Calientes, río Aguas Calientes, K. Osinaga & P. Coro, 26-27 Sep

437 1999. MNKP 4864 (4123), 2, ?, V. Fuentes & S. Sanguenza, Nov 1999. MNKP 5256, 1, laguna al

438 lado del camino, 800 m antes de llegar a Candelaria, M.E. Farell, M.Á. Velásquez & P. Hinojosa,

439 30 Dec 2003. MNKP 5269, 31, Candelaria, río Tucavaca, M.E. Farell, M.Á. Velásquez & P.

440 Hinojosa, 29 Dec 2003 (lot also contains 1 specimen of *C. semifasciata*). MNKP 5296, 1,

441 Candelaria, río Aguas Calientes, M.E. Farell, M.Á. Velásquez & G. Huanca, 2 Jul 2004. MNKP

442 5305, 5, laguna al lado derecho del camino, 800 m antes de llegar a la localidad de Candelaria,

443 M.E. Farell, M.Á. Velásquez & G. Huanca, 1 Jul 2004. **Germán Busch:** MNKP 1182 (1670), 1,

444 Puerto Suarez, Palo Santo, Laguna Cáceres, K. Osinaga, R. Coca, V. Fuentes & A. Franco, 21 Feb

445 1996. MNKP 1403 (1498), 5, Puerto Quijarro, Tamarinero, Laguna Cáceres, P. Rebolledo, K.

446 Osinaga, V. Fuentes, L. Paniagua & L. Paredes, 15 Aug 1996. MNKP 1404 (1499), 1, Puerto

447 Quijarro, Tamarinero, Laguna Cáceres, P. Rebolledo, K. Osinaga, V. Fuentes, L. Paniagua & L.

448 Paredes, 13 Aug 1996. MNKP 1422 (1521), 1, Puerto Quijarro, Tamarinero, Laguna Cáceres, P.
449 Rebolledo, K. Osinaga, V. Fuentes, L. Paniagua & L. Paredes, 8 Aug 1996. MNKP 1424 (1524),
450 1, Puerto Suarez, Laguna Cáceres, zona de la Bamba antigua, P. Rebolledo, K. Osinaga, V.
451 Fuentes, L. Paniagua & L. Paredes, 11 Aug 1996. MNKP 1484 (1729), 1, Puerto Suarez, Laguna
452 Cáceres, P. Rebolledo, K. Osinaga, L. Paniagua, L. Paredes & V. Fuentes, 9 Aug 1996. MNKP
453 1425 (1525), 4, Puerto Quijarro, Tamarinero, Laguna Cáceres, P. Rebolledo, K. Osinaga, V.
454 Fuentes, L. Paniagua & L. Paredes, 13 Aug 1996. MNKP 1526, 5, Puerto Quijarro, Laguna
455 Cáceres, P. Rebolledo, K. Osinaga, V. Fuentes, L. Paniagua, L. Paredes, 13 de Ago 1996. MNKP
456 2206 (2083), 3, El Carmen, zona de inundación, Estancia Campo el Medio, P. Rebolledo, R.
457 Coca, V. Fuentes & G. Soto, May 1997. MNKP 3945 (3011), 6, poza en el camino Hacienda
458 Santa Elena, K. Osinaga & J. Cardona, 31 Oct 1998. MNKP 3973 (3036), 4, Camino a Hacienda
459 Santa Elena, K. Osinaga & J. Cardona, 1 Nov 1998. MNKP 3900 (2987), 2, Puerto Suarez, río
460 Jordano Pimiento, K. Osinaga & J. Cardona, 27 Oct 1998. MNKP 3993 (3000), 4, Otuquis, Bahía
461 Corea, K. Osinaga, J. Cardona, A. Justiniano & M. Chavez, 5 Nov 1998.

462 **Identification.** A redescription of *C. lepidota* is provided by Kullander (1982) and Varella
463 (2011). It differs from *C. semifasciata* by a less depressed head and a longer and more slender
464 snout and from *C. vittata* by lower longitudinal scale count (34-51 vs. about 79-90 E1 scales).
465 *Crenicichla ploegi* and *C. semicincta* are similar and parapatric species. The form can be
466 distinguished from *C. lepidota* by a higher scale count (58-71 E1 scales) and the colour pattern
467 (Varella *et al.* 2018). The latter differs from *C. lepidota* by lacking a ring of iridescent scales
468 around the lateral spot and having this spot elongated and nearly integrated in the midlateral
469 longitudinal band. *Crenicichla semicincta*, however, has not been reported from the La Plata
470 system and appears to be restricted to the upper río Madera drainage. The species is medium-
471 sized reaching 18.9 mm SL (Varella 2011).

472

473 ***Crenicichla semifasciata* (Heckel, 1840)**

474 *Batrachops semifascaiatus* Heckel, 1840

475 *Acharnes chacoensis* Holmberg, 1891

476 *Boggiania ocellata* Perugia, 1897

477 *Crenicichla simoni* Haseman, 1911

478 **Type locality.** ... Flusse Paraguay bei Caiçara.

479 **Bibliography for the study area**

480 *Crenicichla simoni*; Haseman (1911): locality (Puerto Suarez) and voucher material.

481 *Batrachops ocellatus*; Terrazas Urquidi (1970): listing (R. Paraguay).

482 *Batrachops semifascaiatus*; Terrazas Urquidi (1970): listing (R. Paraguay).

483 *Crenicichla semifasciata*; Farell & Cancino (2007): locality (Río Tucavaca).

484 **Examined material. Bolivia: río Paraguay drainage: Santa Cruz: Chiquitos:** MNKP 5269, 1,
485 Candelaria, río Tucavaca, M.E. Farell, M.Á. Velásquez & P. Hinojosa, 29 Dec 2003 (lot also
486 contains 31 specimens of *C. lepidota*). **Germán Busch:** MNKP 1216 (2259), 1, Puerto Quijarro,
487 Tamarinero, Canal Tamengo, K. Osinaga, R. Coca, V. Fuentes & A. Franco, 26 Feb 1996. MNKP
488 1220 (2733), 1, Puerto Suarez, Laguna Cáceres, Palo Santo, K. Osinaga, R. Coca, V. Fuentes &
489 A. Franco, 23 Feb 1996.

490 **Identification.** Differs from all other *Crenicichla* species in the Paraguay-Paraná drainage by a
491 wider head and a shorter and broader snout. In terms of coloration it differs from the other
492 species by having the base of the scales pigmented, giving the sides a finely reticulated

493 appearance. *Crenicichla semifasciata* is a medium-sized species reaching 18.5 cm SL (Varella
494 2011).

495

496 ***Crenicichla vittata* Heckel, 1840**

497 *Crenicichla vittata* Heckel, 1840

498 **Type locality.** ... Flusse Cuyaba; ... Flusse Paraguay.

499 **Bibliography for the study area**

500 *Crenicichla vittata*; Terrazas Urquidi (1970): listing (R. Paraguay).

501 **Examined material. Bolivia: río Paraguay drainage: Santa Cruz: Chiquitos:** MNKP 4853 (3348)

502 río Aguas Calientes, V. Fuentes & S. Sangueza, 1 Nov 1999. **Germán Busch:** MNKP 1130 (1384),

503 1, Puerto Suarez, San Eugenio, Laguna Cáceres, K. Osinaga, R. Coca, V. Fuentes & A. Franco,

504 19 Feb 1996.

505 **Identification.** *Crenicichla vittata* is straightforward to identify as it is the only *Crenicichla*

506 species in the Upper Río Paraguay basin with about 83-95 scales in the longitudinal row

507 (Kullander 1981; Ploeg 1991). Other species of *Crenicichla* known from other drainage systems

508 with a similar scale count lack a suborbital stripe (Ploeg 1991). Differs from *C. semifasciata* by

509 a less depressed head and a longer and slenderer snout and from *C. lepidota* by higher

510 longitudinal scale count (about 83-95 vs. about 34-45). It is a large species reaching a size of

511 29.4 cm SL (Varella 2011). See figure 6 for general appearance. A brief redescription of *C.*

512 *vittata* is provided by Kullander (1981).

513

514 ***Crenicichla* sp. (unidentified juveniles)**

515 **Examined material. Bolivia: río Paraguay drainage: Santa Cruz: Ángel Sandoval:** MNKP 4780

516 (3570), many juveniles, Bahia Jesus.

517

518 ***Gymnogeophagus balzanii* (Perugia, 1891)**

519 *Geophagus balzanii* Perugia, 1891

520 *Geophagus duodecimspinosus* Boulenger, 1895

521 *Gymnogeophagus cyanopterus* Miranda Ribeiro, 1918

522 **Type locality.** Villa Maria (Matto Grosso), Rio Paraguay a 15°.

523 **Bibliography for the study area**

524 *Geophagus balzanii*; Haseman (1911): locality (Puerto Suarez) and voucher material.

525 *Gymnogeophagus balzanii*; Farell & Cancino (2007): locality (Río Tucavaca).

526 **Examined material. Bolivia: río Paraguay drainage: Santa Cruz: Ángel Sandoval:** MNKP 4797

527 (3522), 4, Santo Rosario, río Santo Rosario, K. Osinaga & P. Coro, 1 Oct 1999. **Chiquitos:** MNKP

528 5313, 1, Candelaria, río Tucavaca, M.E. Farell, M.Á. Velásquez & G. Huanca, 30 Jun 2004.

529 **Identification.** *Gymnogeophagus balzanii* differs from similar species in the study area by

530 having the dorsal fin scaled and lacking a caudal spot. Males develop a conspicuous nuptial

531 bulb on the forehead during the reproductive season. It is the only species of

532 *Gymnogeophagus* known to occur in the upper reaches of the río Paraguay drainage. It is a

533 medium-sized species reaching 12 cm SL (Kullander 2003).

534

535 ***Laetacara dorsigera* (Heckel, 1840)**

536 *Acara dorsiger* Heckel, 1840

537 **Type locality.** Sümpfe in der Nähe des Paraguay-Flusses bei Villa Maria.

538 **Bibliography for the study area**

539 *Acara dorsigera*; Haseman (1911): locality (Puerto Suarez) and voucher material.

540 **Examined material. Bolivia: río Paraguay drainage: Santa Cruz: Ángel Sandoval:** CBF 8630,
541 48, Pantanal, pantano con lagunilla, 17° 04' 10.5''S 59° 28' 17.1''W, J. Sarmiento & K. Osinaga,
542 19 Apr 1999. CBF 8650, 16, Pantanal, Lago Santa Elena, J. Sarmiento & K. Osinaga, 120-21 Apr
543 1999. MNKP 735 (589), 2, San Matías, Estación Cascabel, M.L. Argandoña, 8 Sep 1994. MNKP
544 741 (535), 3, San Matías, Estancia Cascabal, M.L. Argandoña, 8 Sep 1994. MNKP 2422 (2160),
545 2, San Matías debajo del puente, R. Coca & Maraz, 20 Sep 1997. MNKP 3229 (6116), 2, Puerto
546 Gonzalo, Laguna Mandioré, K. Osinaga, 16 Jul 1998. MNKP 4623 (3453), 1, laguna, Hacienda
547 Vista Hermosa, laguna, K. Osinaga & P. Coro, 21 Sep 1999.

548 **Identification.** As described in Ottoni & Costa (2009). *Laetacara* species can be distinguished
549 from similar cichlid genera by the presence of scales on the preoperculum (Kullander 1986).
550 *Laetacara dorsigera* is a small species reaching 4.0 cm SL (Ottoni 2018).

551

552 ***Mesonauta festivus* (Heckel, 1840)**

553 *Heros festivus* Heckel, 1840

554 **Type locality.** Fluss Guaporè und dessen nahe gelegenen Moräste.

555 **Bibliography for the study area**

556 **Examined material. Bolivia: río Paraguay drainage: Santa Cruz: Ángel Sandoval:** MNKP 2414
557 (1984, 2 and 2155, 1), 3, San Matías a 3 km bajo el puente, R. Coca & Maraz, 20 Sep 1997.
558 MNKP 3514 (4547), 1, Area de Manejo Integrado San Matías, Bahía Jesús, K. Osinaga & P. Coro,
559 30 Sep 1999. MNKP 3254 (3933), 3, Laguna Mandioré, K. Osinaga, 16 Jul 1998. MNKP 5204
560 (4689), 3, Laguna La Selva, V. Fuentes, 17 Dec 2000.

561 **Identification.** The genus *Mesonauta* can easily be distinguished from other cichlid genera by
562 the presence of a conspicuous black stripe from the lower jaw to the rayed part of the dorsal
563 fin. Further characteristics are the disciform body, the long pelvic spine (reaching beyond the
564 origin of the anal fin) and the high number of anal fin spines (VII-XI; Kullander & Silfvergrip
565 1991). It is a small species reaching 8 cm SL (Kullander & Silfvergrip 1991). No other species of
566 *Mesonauta* have been reported from the Río Paraguay basin. See Figure 7 for general
567 appearance of the species.

568

569 ***Satanoperca pappaterra* (Heckel, 1840)**

570 *Geophagus pappaterra* Heckel, 1840

571 **Type locality.** Rio-Guapore.

572 **Bibliography for the study area**

573 **Examined material. Bolivia: río Paraguay drainage: Santa Cruz: Ángel Sandoval:** MNKP 725
574 (532), 1, San Matías, Estancia Cascabel, M.L. Argandoña, 8 Sep 1994. **Germán Busch:** MNKP
575 5203 (4147), 1, Laguna La Selva, V. Fuentes, 17 Dec 2000.

576 **Identification.** No unambiguous diagnostic characters are currently known for *Satanoperca*
577 *pappaterra* to separate it from *S. jurupari*. However, the species has frequently been reported
578 from the study area and is the only species of its genus occurring in the La Plata basin. From
579 other geophagine cichlid genera, *Satanoperca* can be distinguished by the absence of scales
580 on the dorsal fin and the lack of a suborbital stripe. *Satanoperca pappaterra* is a medium-sized
581 species reaching 17.4 cm SL (Kullander 2003). See Figure 8 for general appearance of the
582 species.

583

584 **Key to species of the La Plata drainage in Bolivia and the upper río Paraguay in Brazil:**

585 1a. – Low number of short gill rakers (about 20 or less on first gill arch) 2

586 1b. – High number of long gill rakers (about 50 or more on first gill arch)

587 ***Chaetobranchopsis australis***

588 2a. – Anal fin with 6 or less spines 5

589 2b. – Anal fin with 7 or more spines ***Mesonauta festivus***

590 3a. – Dorsal fin naked..... 6

591 3b. – Dorsal fin with scales (at least some close to its base) 4

592 4a. – Caudal spot present..... 5

593 4b. – No caudal spot..... ***Gymnogeophagus balzanii***

594 5a. – Scales very small (more than 70 E1 scales) ***Cichla piquiti*** (introduced)

595 5b. – Scales small (about 40 E1 scales) ***Astronotus crassipinnis***

596 5c. – Scales large (23-24 E1 scales) ***Cichlasoma dimerus***

597 6a. – Body moderately deep, typical cichlid shape 7

598 6b. – Body elongated, almost cylindrical ***Crenicichla*** 14

599 7a. – Predorsal scales irregular 10

600 7b. – Predorsal scales in a more or less regular row..... 8

601 8a. – Preoperculum with 3-4 scales ***Laetacara dorsigera***

602 8b. – Preoperculum naked (rarely with one scale) 9

603 9a. – Nape band and dark lateral band from eye to the posterior part of the dorsal fin

604 ***Bujurquina*** 16

605 9b. – No nape band and no conspicuous lateral band ***Aequidens plagiozonatus***

606 10a. – Suborbital stripe present ***Apistogramma*** 11

607 10b. – Suborbital stripe absent ***Satanoperca pappaterra***

608 11a. – Oblique black stripe between pectoral and anal fin origin ***Apistogramma trifasciata***

609 11b. – No such stripe present 12

610 12a. – Posteriormost vertical bar fused with the spot on the caudal peduncle..... 13

611 12b. – Posteriormost vertical bar and caudal spot separated; preserved specimens with a

612 series of separated spots along the flanks; posterior anguloarticularpore

613 absent..... ***Apistogramma borellii***

614 13a. – Abdominal bands prominent; dark midlateral band clearly fused with caudal spot

615 forming a tail spot ***Apistogramma commbrae***

616 13b. – Abdominal bands typically weak; dark midlateral band somewhat separated from

617 caudal spot ***Apistogramma inconspicua***

618 14a. – Wide head and short and broad snout (as typical for the former genus *Batrachops*);

619 scales with a dark base, giving the flanks a reticulated appearance ... ***Crenicichla semifascaita***

620 14b. – Moderately wide head and short long and moderately broad; scales without dark base

621 15

622 15a. – 34-51 E1 scales ***Crenicichla lepidota***

623 15b. – 58-71 E1 scales ***Crenicichla ploegi***

624 15c. – 79-90 E1 scales..... ***Crenicichla vittata***

625 16a. – Pectoral fin short (29-33 % of SL); head long (38-41 % of SL); brachyostegal membrane

626 reddish in living specimen..... ***Bujurquina oenolaemus***

627 16b. – Pectoral fin long (36-41 % of SL); head short (35-38 % of SL); brachyostegal membrane
628 without chromatophores *Bujurquina vittata*

629

630 Discussion

631 The examination of 749 specimens in 162 museum lots revealed 16 species of cichlid fishes.
632 Virtually all records stem from the upper río Paraguay and only one lot (*Cichlasoma dimerus*)
633 has been collected in the río Bermejo drainage. We can also report only one literature report
634 from the Bermejo river (*Chaetobranchus* sp.; Sarmiento *et al.* (2019)) and río Pilcomayo
635 (*Bujurquina vittata*; Terrazas Urquidi (1970)).

636

637 Species considered not to occur in the La Plata drainage of Bolivia

638 Sarmiento & Barrera (1997) and Sarmiento *et al.* (2019) reported *Acaronia* sp. from the río
639 Pilcomayo basin. According to the CBF catalog, these specimens are from the río Bermejo.
640 These samples could not be located in the collection and the occurrence of this Amazonian
641 species so far south as the río Bermejo is highly questionable.

642 Terrazas Urquidi (1970) listed *Apistogramma taeniatum* (= *A. taeniata*) and *Aequidens*
643 *tetramerus* for the Bolivian part of the río Paraguay drainage, but did not provide any further
644 information about specimen, preventing verification. The former species is restricted to the
645 lower río Tapajós drainage in Brazil (Kullander 2003) and its report is certainly based on a
646 misidentification. *Aequidens tetramerus* s.l. occurs in the upper río Madera (Kullander 1986;
647 Hablützel & Pantel 2017), but has not been reported from the La Plata drainage elsewhere,
648 making this report dubious.

649 While the occurrence of *Chaetobranchopsis australis* is certain for the río Paraguay drainage
650 in Bolivia, the report of *Chaetobranchopsis* sp. from the río Bermejo drainage (Sarmiento *et*
651 *al.* 2019) appears odd. We have no knowledge of the possible occurrence of this species from
652 the Argentinian section of the río Bermejo and it seems that the species is restricted to the río
653 Paraguay drainage (possibly including the río Pilcomayo). We have not seen any specimens
654 from the río Bermejo and think this report should be considered with caution.

655

656 Identification issues

657 Discrimination between *Cichlasoma boliviensis* and *Cichlasoma dimerus* was based on
658 sampling location, rather than diagnostic morphological traits. Subadults and adults of the
659 former species typically (but not always) show a specific pattern of spots on the
660 posteroventral portion of the flanks, giving them a mottled appearance. This colouration has
661 never been reported from the La Plata basin, even though a large number of specimens have
662 been screened. It appears reasonable to assume that the two species are allopatric and the
663 watershed corresponds to the distribution boundary.

664 Juveniles that do not show the diagnostic characters of their respective species were only
665 identified at genus level. This applies in particular to species of the genus *Apistogramma*,
666 which might be impossible to distinguish morphologically at juvenile stages.

667

668 The taxonomic status of *Crenicichla ocellata*

669 *Crenicichla ocellata* (Perugia, 1897) has been reported for the Bolivian part of the La Plata
670 basin by Terrazas Urquidi (1970). This name, has been considered a synonym of *C.*
671 *semifasciata* by several taxonomists (Ploeg 1991; Kullander 2003; Varella 2011). The Catalog

672 of Fishes (Fricke *et al.* 2018), however, lists *C. ocellata* as a valid species with reference to
673 several recent taxonomic studies. These publications, however, do not treat *C. ocellata* in the
674 main text, but merely list the holotype among the examined material (e.g. Piálek *et al.* 2010,
675 2015; Casciotta *et al.* 2013; Říčan *et al.* 2017). In one publication, these authors list *C. ocellata*
676 under its original name *Boggiania ocellata* (Piálek *et al.* 2010), indicating that the authors did
677 not intend to recognize *B. ocellata* as a distinct species, but used its original name to indicate
678 the holotype. However, other researchers subsequently started to list *C. ocellata* as a valid
679 species (Koerber *et al.* 2017). Because no argument for or against the synonymy of *B. ocellata*
680 in *C. semifasciata* is provided in recent taxonomic studies, we follow the authors that treat
681 this taxonomic question explicitly or implicitly (Ploeg 1991; Kullander 2003; Varella 2011) and
682 continue to consider *B. ocellata* as a synonym of *C. semifasciata*.

683

684 **Completeness of the list**

685 Most of the cichlid species that have been reported from the La Plata drainage in adjacent
686 areas in Argentina, Brazil and Paraguay could be confirmed for Bolivia. One notable exception
687 is *Apistogramma inconspicua*, which is, within the río Paraguay drainage, still only known from
688 three specimen collected by Haseman in 1909 at a single location in Brazil (Est. Mato Grosso,
689 R. Paraguay system, Cáceres; Kullander, 1982c). At least one of these specimens has, however,
690 the lateral band continuous with the tail spot, which is characteristic for *A. commbrae*. A more
691 detailed examination of these specimens is therefore necessary to confirm the presence of *A.*
692 *inconspicua* in the río Paraguay drainage.

693 The introduced Amazonian *Cichla piquiti* has first been reported from the río Paraguay
694 drainage in Bolivia by Sarmiento *et al.* (2014). Marques & Resende (2005) reported on *Cichla*
695 cf. *monoculus* just north of Corumbá, a Brazilian city close to the Bolivian border. According to
696 Kullander & Ferreira (2006) this introduced population belongs to *Cichla piquiti*. The
697 occurrence of this species in Bolivia therefore appears possible, but unfortunately, no Bolivian
698 specimens were accessible for examination.

699 Survey of the fish species in the Brazilian part of the Pantanal resulted in a cichlid species list
700 that is almost identical to the one presented here (Menezes *et al.* 2000; Marcelino Polaz *et al.*
701 2014). Only *Bujurquina oenolaemus*, which is endemic to the río Aguas Calientes in Bolivia,
702 was not recorded from Brazil. Menezes *et al.* (2000) and Varella (2011) reported on additional
703 undescribed species of *Crenicichla*, whose distribution, however, may be restricted to the
704 headwaters of the río Paraguay in Brazil. In 2018, one species was formally described as
705 *Crenicichla ploegi* Varella, Loeb, Lima & Kullander, 2018 (Varella *et al.* 2018).

706 Our rarefaction analysis shows that the curve is flattening out (Figure 9), indicating that a large
707 sampling effort has to be conducted to find additional species. We conclude that the species
708 lists for the Bolivian La Plata basin is complete or at least almost complete and provides a
709 sound basis for identification purposes, biodiversity inventories and ecological studies.

710

711 **Conclusions**

712 We report the occurrence of 17 species of cichlids in the Bolivian part of the La Plata drainage.
713 Of those, 16 are documented with voucher specimens. The presence of the 17th species (*Cichla*
714 *piquiti*) appears reliably due to multiple reports of this species in neighbouring areas in Brazil.
715 Our rarefaction analysis supports the notion that sampling was exhaustive and that this

716 species list is complete or at least almost complete. The diagnostic characters mentioned in
717 the text and the dichotomous key should enable reliable identification of cichlids in the field.

718

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724

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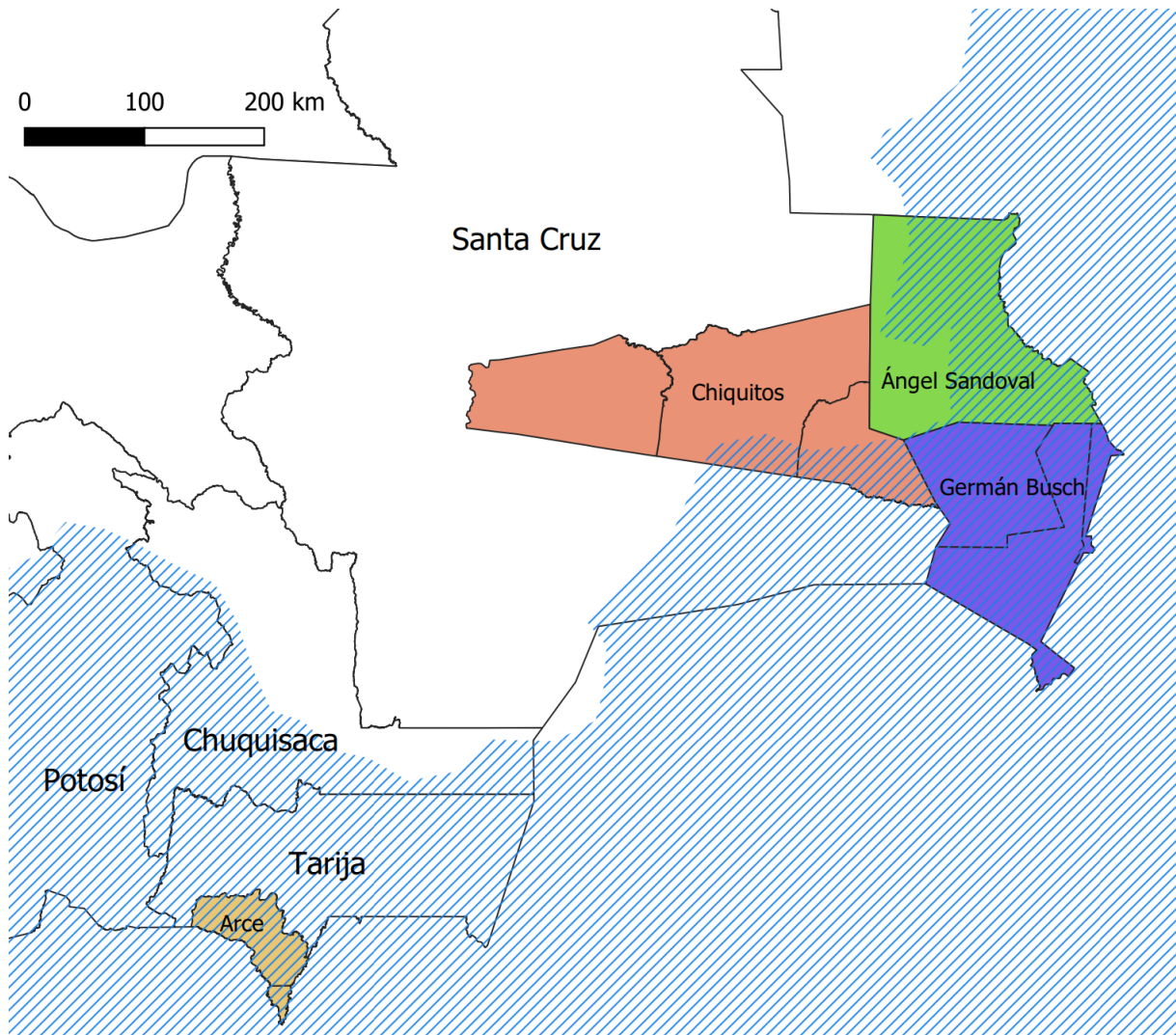
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- 839



840
841 Figure 1: Map of the study area. The blue shaded area indicates the La Plata drainage,
842 covering the Tarija department and parts of Santa Cruz, Chuquisaca and Potosí. Lots in
843 museum collections have been reported to be from the provinces Arce (Tarija), Chiquitos,
844 Ángel Sandoval and Germán Busch (all Santa Cruz).
845



846
847 Fig. 2: *Aequidens plagiozonatus* from the curiche Tapera, río Paraguay drainage, Angel
848 Sandoval, Santa Cruz, Bolivia (MNKP 6598 (3518)).
849



850
851 Fig. 3: *Apistogramma combrae* (female) from the río Tucavaca at Candelaria, Chiquitos,
852 Santa Cruz, Bolivia (MNKP 5270).
853



854
855 Fig. 4: *Apistogramma trifasciata* (male) from the río Paraguay drainage in Bolivia (CBF 6321;
856 exact locality unknown).

857



858

859 Fig. 5: *Astronotus crassipinnis* from río Santo Rosaria at Santo Rosario, río Paraguay drainage,
860 Angel Sandoval, Santa Cruz, Bolivia (MNKP 4810).

861



862

863 Fig. 6: *Crenicichla vittata* from the río Aguas Calientes, río Paraguay drainage, Chiquitos,
864 Santa Cruz, Bolivia (MNKP 3348; tail is bent to the left).

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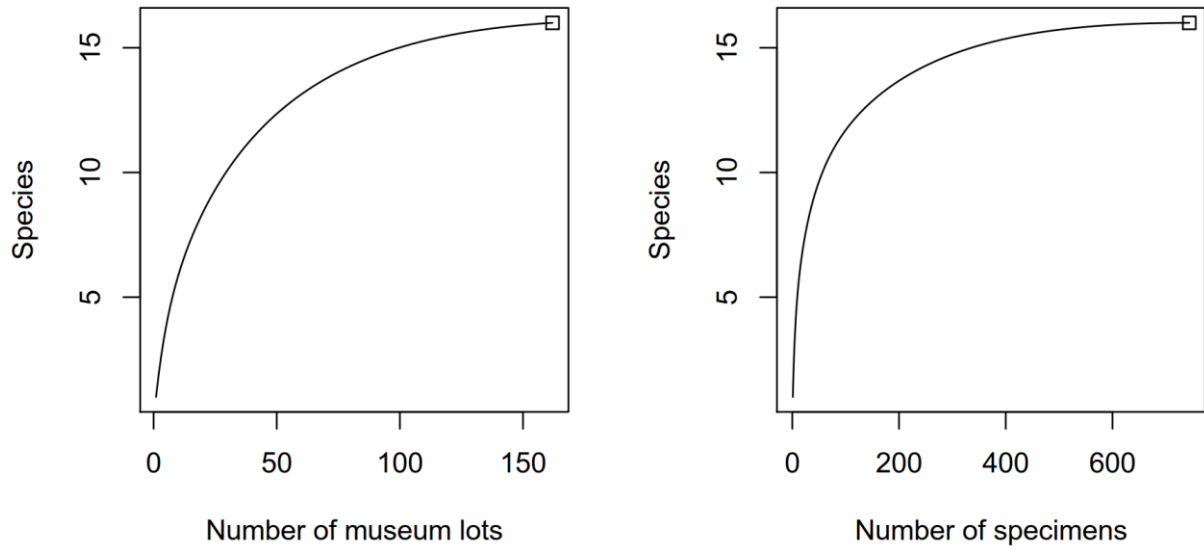
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Fig. 7: *Mesonauta festivus* from San Matias, debajo del puente, río Paraguay drainage, Angel Sandoval, Santa Cruz, Bolivia (MNKP 2414 (1984 or 2155)).



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873

Fig. 8: *Satanoperca pappaterra* from Laguna La Selva, río Paraguay drainage, Germán Busch, Santa Cruz, Bolivia (MNKP 5203).



874
875 Fig. 9: Rarefaction curves to visualize completeness of species sampling. On the left, museum
876 lots were considered as individual species reports, while on the right the analysis was
877 repeated at the level of individual voucher specimens.
878
879

880