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The genus *Gymnotus* (Gymnotiformes: Gymnotidae) in Argentina. How bad taxonomy results in poor regulations and no conservation

By J. Casciotta[1,2], A. Almirón[1], S. Sánchez[3], J. Iwaszkiw[4] and M. C. Bruno[5]

[1]*División Zoología Vertebrados, Museo de La Plata, UNLP, La Plata, Argentina;* [2]*Comisión de Investigaciones Científicas de la Provincia de Buenos Aires (CIC), Buenos Aires, Argentina;* [3]*Instituto de Ictiología del Nordeste, Facultad de Ciencias Veterinarias, UNNE, Corrientes, Argentina;* [4]*División Ictiología, Museo Argentino de Ciencias Naturales - Bernardino Rivadavia - (MACN - CONICET), Buenos Aires, Argentina;* [5]*Laboratorio de Ecología Molecular, Centro regional de Estudios Genómicos, Florencio Varela, Argentina*

Summary

Four species of the genus *Gymnotus* are present in Argentina: *G. inaequilabiatus, G. omarorum, G. pantanal,* and *G. sylvius*, the last three species being recorded for the first time in freshwater courses. *Gymnotus omarorum*, *G. pantanal*, and *G. sylvius* together with others of the genus *Brachyhypopomus* are the group of fishes that bear the greatest impact in the trade as live bait for sport fishing in the northeastern region of Argentina. Within this large area, only the provinces of Chaco, Corrientes, and Formosa have regulations for the catch, trade, and sale of species as live bait. Unfortunately, the species covered by legal regulations are *Gymnotus carapo* and *Brachyhypopomus brevirostris*, neither of which occurs in freshwater habitats of Argentina. Comments are included as to how this bad taxonomy affects the regulations and conservation status of these species.

Introduction

The genus G*ymnotus* has a broad distribution range from southern Mexico to the Salado River Basin in Argentina (Albert, 2001). At present, this genus includes 34 species that occur in most freshwater habitats of the lowland Neotropics (Richer-de-Forges et al., 2009).

Historically, three species of *Gymnotus* have been recorded in freshwater environments of Argentina: *G. anguillaris*, *G. carapo*, and *G. inaequilabiatus*. *Gymnotus anguillaris* was recorded from 'off Patagonia' (Albert et al., 1999); however, as this species is distributed in the Orinoco and Amazon basins, its presence in Argentinian freshwaters is rather doubtful. *Gymnotus carapo* is the species with the most recordings in Argentina, but its distribution is restricted to the basins in the north of South America (Albert and Crampton, 2003), and therefore these recordings for Argentina should be considered as misidentifications. Finally, there are few records for *G. inaequilabiatus*, where the type locality is Río de la Plata (Mago-Leccia, 1994; Casciotta et al., 2005; Almirón et al., 2008; Koerber, 2011).

Some *Gymnotus* and *Brachyhypopomus* spp. are collected and sold as live bait for sport fishing in Argentina. A dozen *Brachyhypopomus* cost between U.S.$ 4 to 8, while a dozen *Gymnotus*, depending on specimen size, time of year and intensity of demand, may be sold for about US$30 to 80. Which of the two genera is more exploited as live bait is not known. In the opinion of one of the present authors (S. S.), the commercial trade of *Brachyhypopomus* specimens could be triple that of *Gymnotus*. Unfortunately, the species covered by legal regulations are *Gymnotus carapo* and *Brachyhypopomus brevirostris*, neither of which occurs in freshwater habitats of Argentina (Almirón et al., 2010; this paper).

The aim of this paper is to record the presence of *G. omarorum*, *G. pantanal* and *G. sylvius* in freshwaters of Argentina and offer some considerations on how bad taxonomy affects both the regulations and the conservation status of Gymnotiforms used as live bait.

Materials and methods

Morphometric and meristic data were taken following Albert et al. (1999) and Albert and Crampton (2003). Total length was measured in millimeters (mm TL). Morphometric data were taken as point-to-point linear distances with digital calipers to the nearest 0.1 mm on the left side of specimens. Measurements are reported as a percentage of total length (TL). Scale, lateral-line pore, and pectoral-fin ray counts were taken directly from the ethanol-preserved and cleared-and-stained specimens under a dissecting microscope. Specimens in which the caudal appendage was obviously damaged or partially regenerated were excluded from measurements of total length. Examined material can be seen in Table 1. Institutional abbreviations are as listed in Ferraris (2007).

Results

Gymnotus inaequilabiatus (Valenciennes, 1839) (Fig. 1a, b).

G. carapo: Ringuelet et al., 1967.

G. carapo: Monasterio de Gonzo, 2003.

Gymnotus inaequilabiatus differs from the other species present in Argentina by being over 600 mm in total length, having 17–20 pectoral-fin rays, and by the color patterns on larger specimens consisting of dots instead of obliquely oriented bands or no markings (Fig. 1b). Morphometric and meristic data of examined material and different character states provided by Albert and Crampton (2003) can be seen in Table 2. *Gymnotus inaequilabiatus* is known as 'morena' and 'carapo'. The material examined herein come from the Paraná and Paraguay river basins (Fig. 2).

Gymnotus omarorum Richer-de-Forges et al., 2009 (Fig. 1c).

G. cf. *carapo*: Casciotta et al., 2003.

G. cf. *inaequilabiatus*: Casciotta et al., 2005.

Gymnotus omarorum can be distinguished from the other species inhabiting freshwaters of Argentina by the presence

Table 1
Collection data of *G. inaequilabiatus*, *G. omarorum*, *G. pantanal*, and *G. sylvius* in this paper

Species	Collection number	Specimens/TL	Locality	Basin
G. inaequilabiatus	MACN-ict 9660	1ex, ca 690 mm	Corrientes Province, Riacho El Carrizal	Río Paraná
	MACN-ict 5979	4 exs., 250.0–555.0 mm	Santa Fe Province, Rosario city	Río Paraná
	MACN-ict 4832	1 ex., 590 mm	Chaco Province, Río de Oro	Río Paraguay
	MACN-ict 1436	1 ex., 570 mm	Jujuy Province, río Lavallen	Río Paraguay
	MACN-ict 9675	1 ex., 99.0 mm	Entre Ríos Province, Pre-Delta National Park, Arroyo La azotea	Río Paraná
G. omarorum	MACN-ict 9656	13 exs., 155.5–256.5 mm	Corrientes Province, Esteros del Riachuelo (27°34′39″S–58°15′23″W)	Río Paraná
	MACN-ict 8033	2 exs., 175.0–189.0 mm	Chaco Province, Resistencia	Río Paraná
	MACN-ict 9676	1 ex., 183.5 mm	Entre Ríos Province, Arroyo Grande	Río Uruguay
G. pantanal	MACN-ict 9655	19 ex., 154.0–256.6 mm	Corrientes Province, Esteros del Riachuelo (27°34′39″S–58°15′23″W).	Río Paraná
G. sylvius	MACN-ict 9654	5 exs., 219.7–348.0 mm	Corrientes Province, Esteros del Riachuelo (27°34′39″S–58°15′23″W)	Río Paraná
	MACN-ict, 4638	1 ex., 340 mm	Corrientes Province, Esteros de Santa Lucía, Manantiales,	Río Paraná
	AI 253	1 ex., 275.0 mm	Misiones Province, Verde creek (25°40′15″S–53°56′00″W)	Río Iguazú
	AI 254	1 ex., (C&S), 186.0 mm	Misiones Province, Arroyo Deseado (25°47′08″S–54°02′21″W)	Río Iguazú

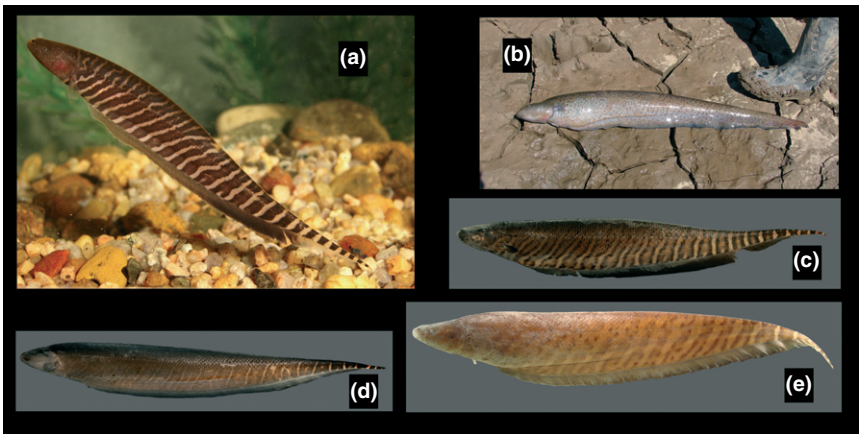

Fig. 1. Color patterns of studied species: (a) *G. inaequilabiatus*, MACN-ict 9675, 99.0 mm TL, Parque Nacional Pre-Delta, Entre Ríos province; (b) *G. inaequilabiatus*, Parque Nacional Pre-Delta, Entre Ríos province, not preserved, ca 1040 mm TL; (c) *G. omarorum*, MACN-ict 9656, 237.6 mm TL, Esteros del Riachuelo, Corrientes province; (d) *G. pantanal*, MACN-ict 9655, 247.0 mm TL, Esteros del Riachuelo, Corrientes; (e) *Gymnotus sylvius*, AI 253, 275.0 mm TL, Arroyo verde, Misiones province

of 14 to 16 pectoral-fin rays, a short head 9.5–12.0% TL, and pale bands not as narrow as in the *G. pantanal*. Morphometric and meristic character states and differences among the examined material herein and data provided by Richer-de-Forges et al. (2009) are given in Table 3. *Gymnotus omarorum* is usually known as 'morena' or 'morena común'. The material examined herein come from the Paraná and Uruguay river basins (Fig. 2).

Gymnotus pantanal Fernandes, et al., 2005 (Fig. 1d).

This species is easily distinguished from the other species in Argentinian fresh-water environments by its distinctive body color pattern consisting of thin, obliquely-oriented pale-pigmentation bands. *Gymnotus pantanal* has 2n chromosomes = 39 for males and 2n = 40 for females, with predominance of subtelocentric and acrocentric chromosomes (Sánchez et al., 2004; Bellafronte da Silva and Pavan Margarido, 2005; Pavan Margarido et al., 2007). Morphometric and meristic data for the specimens examined here and differences provided in the original description can be seen in Table 4. In Argentina *Gymnotus pantanal* is called 'morena brava'. The material examined herein come from the Paraná River Basin (Fig. 2).

Gymnotus sylvius Albert et al., 1999; (Fig. 1e).

G. carapo: Gómez and Somay, 1985.

Gymnotus sylvius can be distinguished from the remaining species of *Gymnotus* inhabiting freshwaters of Argentina by its longer head (12.3–15.4 vs 11.5–12.7% TL in *G. inaequilabiatus*, 8.8–11.0% TL in *G. pantanal*, and 9.5–12.0% TL in *G. omarorum*). Morphometric and meristic characters for *G. sylvius* and differences among the specimens examined herein and those from Albert et al. (1999) and Albert and Crampton (2003) are presented in Table 5. The common name of this species is 'morena', 'mamacha', 'botellona'. The material examined herein comes from the Paraná River Basin and Iguazú River Basin above the Iguazú falls (Fig. 2).

Discussion

The Gymnotiformes are the group of fishes that bear the greatest impact in the trade as live bait for sport fishing in Argentina. Unfortunately, and due to the misidentification of species of the genera *Gymnotus* and *Brachyhypopomus*, the existing regulations only control the capture of *Gymnotus carapo* and *Brachyhypopomus brevirostris*, however these two species are absent from the freshwater environments of Argentina.

Four species of *Gymnotus* occur in freshwater environments of Argentina. *Gymnotus inaequilabiatus* is found in lotic envi-

Table 2
Morphometric and meristic data for *G. inaequilabiatus*. Differences in character states among material examined herein and those of Albert and Crampton (2003) are given. Standard deviation (SD)

	Material examined n = 7			
	Range	Mean	SD	Albert and Crampton (2003)
Total length (mm)	100-ca 690			
Percentage of TL				
Head length	11.5–12.7	12.1	0.45	–
Body depth	9.6–11.1	10.4	0.45	–
Snout-1st ramus distance	40.5–47.7	42.2	2.53	–
Percentage of HL				
Post-orbital distance	54.4–61.1	58.4	2.77	–
Pre-orbital distance	31.2–37.3	34.2	2.39	–
Interorbital distance	36.8–45.4	40.8	3.38	–
Pectoral-fin length	32.0–46.4	39.3	4.61	–
Pre-anal length	50.8–67.2	60.1	5.15	67.3–90.1
Meristic characters	n = 7			
Chromosomes (2n)	–			–
Color band	26–27			19–24
Pectoral-fin rays	17–20 (mode = 20)			13–16 (mode 15)
Scales above lateral line	8–15 (mode = 14)			6–9 (mode = 6)
Pored lateral-lines scales to 1st ramus	35–52 (mode = 46)			35–37 (mean = 37)
Total pored lateral-line scales	84–170			–
Anal-fin rays	205–348 (mean = 302)			170–260 (mean = 220)
Lateral-line ventral rami	10–49 (mean = 33)			6–11 (mean = 8)
Anal-fin pterygiophore scales	10–19 (mode = 17)			6–7 (mode = 6)

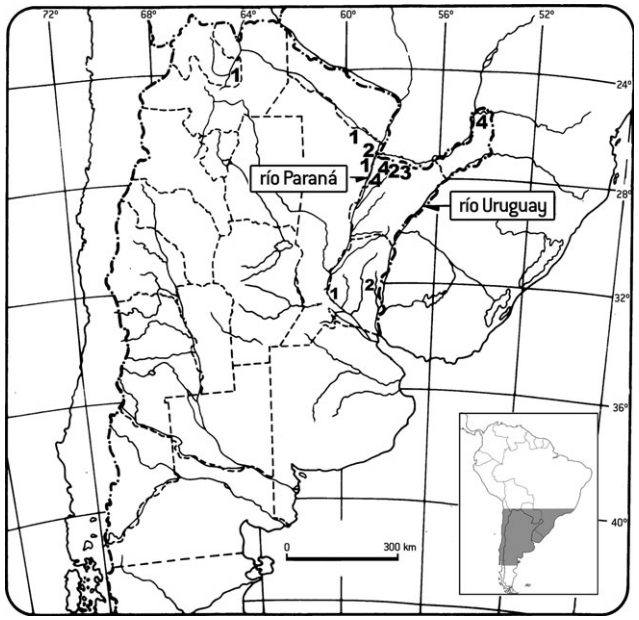

Fig. 2. Geographical distribution of genus *Gymnotus* in Argentina: 1. *G. inaequilabiatus*, 2. *G. omarorum*, 3. *G. pantanal*, and 4. *G. sylvius*

ronments and cannot survive in poorly oxygenated waters, whereas *G. omarorum*, *G. pantanal*, and *G. sylvius* usually inhabit environments such as marshes or ponds with dense floating aquatic vegetation and poorly oxygenated water.

The last three species of *Gymnotus* together with species of the genus *Brachyhypomus* are those most commonly commercialized as live bait for sport fishing in Argentina. This fishing mode is practiced mainly in the Argentine littoral (northeastern region). Of the provinces that make up this vast fishing area, only Chaco, Corrientes, and Formosa have regulations for the catch, trade and sale of species as live bait.

The persons involved in the capture and commercialization of Gymnotiforms are known as 'moreneros'. These people basically distinguish four size classes among *Gymnotus* species: medium-sized, large, 'botellonas', and 'mamachas'. The

Table 3
Morphometric and meristic data for *G. omarorum*. Differences in character states among material examined herein and those of Richer-de-Forges et al. (2009) are given. Standard deviation (SD)

	Material examined n = 12			Richer-de-Forges et al. (2009)
	Range	Mean	SD	
Total length (mm)	157.2–254			
Percentage of TL				
Head length	9.5–12.0	10.6	0.59	–
Body depth	9.8–12.2	10.7	0.67	–
Snout-1st ramus distance	40.9–51.6	47.0	3.26	39.0–45.0 (mean = 42)
Percentage of HL				
Post-orbital distance	56.6–66.0	62.6	2.39	–
Pre-orbital distance	31.3–36.5	34.7	1.46	–
Interorbital distance	31.8–46.3	40.7	4.64	–
Pectoral-fin length	42.6–57.1	48.5	4.32	–
Pre-anal length	73.0–85.3	78.5	4.53	–
Meristic characters	n = 6			
Chromosomes (2n)	–			–
Color band	20–25			–
Pectoral-fin rays	14–16			–
Scales above lateral line	6–8			–
Pored lateral-lines scales to 1st ramus	24–40	34	27–35 (mean = 31)	
Total pored lateral-line scales	80–102			–
Anal-fin rays	207–254	222.5	230–265 (mean = 250)	
Lateral-line ventral rami	4–19	11.5	16–37 (mean = 29)	
Anal-fin pterygiophore scales	8–10	9	7–8 (mean = 7)	

Table 4
Morphometric and meristic data for *G. pantanal*. Differences in character states among material examined herein and those of Fernandes et al. (2005) also given. Standard deviation (SD)

	Material examined n = 18			
	Range	Mean	SD	Fernandes et al. (2005)
Total length (mm)	154.0–256.6			–
Percentage of TL				
Head length	8.8–11.0	9.5	0.56	–
Body depth	7.0–10.0	9.2	0.68	–
Snout-1st ramus distance	48.3–54.2	50.9	1.88	–
Percentage of HL				
Post-orbital distance	58.9–66.6	62.1	1.76	–
Pre-orbital distance	32.5–38.8	34.5	1.51	–
Interorbital distance	36.3–43.4	39.4	1.84	–
Pectoral-fin length	39.3–51.9	46.9	3.70	51.0–56.0 (mean = 53.0)
Pre-anal length	72.9–96.5	86.3	6.37	–
Meristic characters	n = 8			
Chromosomes (2n)	40♀, 39♂			–
Color band	20–25			–
Pectoral-fin rays	17–18			–
Scales above lateral line	7–8			–
Pored lateral-lines scales to 1st ramus	48–57			–
Total pored lateral-line scales	95–111			–
Anal-fin rays	246–275			–
Lateral-line ventral rami	8–19			–
Anal-fin pterygiophore scales	9–11			–

Table 5
Morphometric and meristic data for *G. sylvius*. Differences in character states among material examined herein and those of Albert et al. (1999) also given. Standard deviation (SD)

	Material examined n = 5			Albert et al. (1999); Albert and Crampton (2003)
	Range	Mean	SD	
Total length (mm)	219.7–348.0			
Percentage of TL				
Head length	12.3–15.4	13.4	1.22	–
Body depth	11.7–13.5	12.7	0.64	–
Snout-1st ramus distance	49.4–62.7	54.9	5.29	–
Percentage of HL				
Post-orbital distance	55.9–62.9	60.5	2.49	–
Pre-orbital distance	29.4–37.0	33.7	2.95	–
Interorbital distance	29.1–40.5	36.0	4.29	–
Pectoral-fin length	40.9–43.6	41.8	0.95	–
Pre-anal length	59.8–71.1	65.5	4.49	–
Meristic characters	n = 5			
Chromosomes (2n)	40			–
Color band	20–24			–
Pectoral-fin rays	15–17			–
Scales above lateral line	8			–
Pored lateral-lines scales to 1st ramus	36–43			40–47
Total pored lateral-line scales	94–115			–
Anal-fin rays	215–247			–
Lateral-line ventral rami	7–17			–
Anal-fin pterygiophore scales	8–10			6–8

first two size classes generally correspond to *G. omarorum,* and the last two to *G. sylvius*. Small-sized specimens, also commercialized, may correspond to any of these three species. The 'moreneros' avoid collecting *G. pantanal* because this is a highly aggressive species that 'bites' the others and may kill its congeners.

In the north of Corrientes province, along the Paraná River Basin, large *Gymnotus* specimens are the preferred live bait, because the goal of sport fishermen is catching large fish such as *Salminus brasiliensis, Pseudoplatystoma corruscans*, *P. reticulatum*, and *Zungaru jahu*. In the south of this province, large *Gymnotus* specimens are also used in sport boat fishing to obtain the large-sized species, but smaller *Brachyhypopomus* spp. individuals (the species remains unknown) are used as bait for smaller fishes such as *Luciopimelodus pati* and *Pimelodus albicans*. For shore fishing, given that the probability of catching large-sized fishes is low, fishermen generally use the smaller *Brachyhypopomus* as live bait specimens, which are also less expensive.

In order to understand the dimensions of the inadequate exploitation of this resource, we consider data provided by diverse official provincial organisms for the year 2005. In that year in Chaco province, 64 752 specimens of Gymnotiformes were commercialized according to collection permit records, and another 46 200 individuals were estimated to have been sold without the corresponding permits. In Corrientes province, the total was 49 800 specimens with collection permits, and an estimated 179 460 without permits. Lastly, in Formosa province, where intensity of collection is much higher, officially recorded captures were 647 316, with an additional 168 000 specimens sold without official permits. For these three provinces alone, the numbers add up to a total of 1 155 528 specimens of 'morenas' commercialized in a year, with a 32% disparity between declared and undeclared individuals. It is also worth noting that in other provinces where these Gymnotiformes and other species are also commercialized as live bait, such as Misiones, Entre Ríos, Santa Fe and Buenos Aires, there are no official records or any controls over this trade.

Underestimation of species richness and/or misidentification of species in a given environment will not only present an inaccurate picture of its biodiversity and community structure, but also result in inadequate policies and regulations concerning the protection of natural resources (Bortolus, 2008). How can the impact of fishing for 'morenas' as live bait be measured if their biodiversity is misidentified and underestimated? Thus, the conservation status of these Gymnotiformes used as live bait is uncertain, and their future looks unpromising.

Laws that regulate sport fishing for some emblematic species such *Salminus brasiliensis*, *Pseudoplatystoma corruscans*, *P. reticulatum*, and *Zungaro jahu*, explicitly state the number of specimens that can be extracted, minimum capture size, and closed seasons for each species. However, none of these factors is regulated for those species used as live bait, thus giving rise to questions still unanswered: (i) Which species of *Brachyhypopomus* are sold as live bait?; (ii) Is greater fishing pressure exerted on some species compared to others?; (iii) What is the population status of these species?; (iv) What is the reproductive potential of *Gymnotus* and *Brachyhypopomus*, and what is their relative abundance?

The demand is growing for Gymnotiformes and other species as live bait for sport fishing, with no control measures to regulate this resource. Short-term studies are urgent as a requisite to implement management strategies for the conservation of these species; their immediate future is uncertain, troubling, and also compromises the fish biodiversity.

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Author's address: J. Casciotta, División Zoología Vertebrados, Museo de La Plata, UNLP, Argentina.
E-mail: jrcas@fcnym.unlp.edu.ar