bol.cient.mus.hist.nat. 24 (2), julio-diciembre, 2020. 100-115. ISSN: 0123-3068 (Impreso) ISSN: 2462-8190 (En línea)

BOLETÍN CIENTÍFICO
CENTRO DE MUSEOS
MUSEO DE HISTORIA NATURAL

Pterygoplichthys pardalis (Castelnau, 1855), an introduced species in the Cauca River Basin, Colombia.*

Henry D. Agudelo-Zamora[1], *Daniela De Fex-Wolf*[2] *& Mario A. Zuluaga-Gómez*[3]

Abstract

Aim: We report *Pterygoplichthys pardalis* introduction - a freshwater fish species from the Amazon river basin - in the Cauca river basin and in Salvajina and Calima dams, Colombia. **Scope:** We registered and taxonomically evaluated *P. pardalis* to verify its identification, seeking to avoid the elimination of native morphologically similar species. **Methodology:** Material deposited in some ichthyology collections was examined, evaluating 35 morphometric characters for identification following Armbruster's keys. These results were compared with the available literature for Pterygoplichthys genus. **Conclusions:** This article reports some identification errors, mainly regarding *Pterygoplichthys undecimalis*, which actually correspond to *P. pardalis*. We also suggest two possible mechanisms that explain *P. pardalis* introduction into national basins: i) oversights during ornamental fish species trade and by their buyers, and ii) aquaculture projects that, seeking to "improve" regional economy, not take into consideration characteristics and suitability of the species they seek to promote. Finally, this article alerts about *P. pardalis* introduction in national basins and their possible effects on native species and ecosystems.

Key words: Loricariidae; sailfin catfish; freshwater, introduction

Pterygoplichthys pardalis (Castelnau, 1855), una especie introducida en la Cuenca del río Cauca, Colombia.

Resumen

Objetivo: Reportamos la introducción de *Pterygoplichthys pardalis*- una especie íctica de agua dulce de la cuenca del río Amazonas- en la cuenca del río Cauca y en las represas de Salvajina y Calima, Colombia. **Alcance:** Registramos y evaluamos taxonómicamente a *P. pardalis* para verificar su identificación, evitando que se eliminen especies nativas morfológicamente similares**. Metodología empleada:** Se examinó material depositado en algunas colecciones de ictiología, evaluando 35 caracteres morfométricos para su identificación siguiendo las claves de Armbruster. Estos resultados se compararon con la literatura disponible para el

* 30-VI-2020. FA: 2-IX-2020.

[1] Grupo de Investigación en Peces Neotropicales, Fundación, FUNINDES. Actual address: *Programa de Informática de la Biodiversidad Instituto de Ciencias Naturales, Universidad Nacional de Colombia, Bogotá Colombia. Email*: hdagudelo@gmail.com orcid.org/0000-0001-8571-7235 **Google Scholar**

[2]School of Geography and Planning, Cardiff University, Cardiff, UK. Email: danieladefex@gmail.com orcid.org/0000-0001-6382-2659 **Google Scholar**

[3]Grupo de Investigación en Conservación -BioCon. *Instituto Universitario de la Paz - UNIPAZ Centro de investigaciones Santa Lucia, Barrancabermeja-Santander, Colombia*. Email: mazgo18@uco.edu.co orcid.org/0000-0002-6296-2833

CÓMO CITAR:
AGUDELO-ZAMORA, H.D.; DE FEX, D. & ZULUAGA, M.A., 2020.- *Pterygoplichthys pardalis* (Castelnau, 1855), an introduced species in the Cauca River Basin, Colombia. *Bol. Cient. MusHist. Nat. U. de Caldas,* 24 (2): 100-115. https://doi.org/10.17151/bccm.2020.24.2.7

género *Pterygoplichthys*. **Conclusiones:** Este artículo reporta algunos errores en identificación, principalmente de *Pterygoplichthys undecimalis*, que en realidad corresponden a ejemplares de *P. pardalis*. También sugiere dos posibles mecanismos que explican su introducción en cuencas nacionales: i) descuidos durante el comercio de especies ornamentales de peces y por parte de sus compradores y ii) proyectos de acuicultura que pretenden "mejorar" la economía regional sin considerar las características e idoneidad de las especies que buscan fomentar. Finalmente, este artículo alerta sobre la introducción de *P. pardalis* en cuencas nacionales, y sus posibles efectos sobre especies y ecosistemas nativos.

Palabras clave: Loricariidae, pez diablo, agua dulce, introducción

Introduction

The sailfin fishes are a group of catfish belonging to the Loricariidae family, morphologically characterized by possessing 10 or more dorsal-fin rays, not or diminutive interopercle that is on the hyomandibula when present, and a reduce the number of vertebrae between the dorsal fin and hypural (Armbruster, 1997; Armbruster, 2004; Armbruster & Page, 2006).

Pterygoplichthys genus is composed of 15 valid species endemic of the Neotropical region and distributed in diverse basins like Amazon, Magdalena-Cauca, Maracaibo, Panama, Orinoco, and São Francisco (Armbruster, 1997; Armbruster & Page, 2006). Seven species of the genus are registered to Colombia (DoNascimientoet al., 2017): *P. undecimalis* (Steindachner, 1878) distributed in the Magdalena-Cauca basin and Lower Sinú (Eigenmann, 1922; Fowler, 1942; Miles, 1947; Dahl, 1971; Ortega-Lara et al., 2002; Maldonado-Ocampoet al., 2005), *P. weberi* Armbruster & Page 2006, *Pterygoplichthys multiradiatus* (Hancock, 1828), *Pterygoplichthys lituratus* (Kner, 1854), *Pterygoplichthys gibbiceps* (Kner, 1854), and *P. pardalis* (Castelnau 1855) report to Caquetá River and upper Amazon River drainages (Weber, 1992; Mojica et al., 2005, Bogotá-Gregory & Maldonado-Ocampo, 2006; Armbruster & Page, 2006; Buckup et al., 2007; Maldonado-Ocampoet al., 2008), and *Pterygoplichthys zuliaensis* Weber, 1991 distributed in the Caribbean region (DoNascimientoet al., 2017).

Fish introduction processes are known from the middle ages but gained relevance during the end of the XX century. This activity was especially intense between 1950 and 1985, involving close 45 percent of 1354 introductions registered in different countries' water bodies (Welcomme, 1988). History shows that translocation of living species by human action, whether deliberate or accidental, has been the most important cause of species' natural distribution alteration since the Pleistocene era (Mooney & Cleland, 2001). Mankind migration history is key to understanding many of the oldest animal and plant population introductions. Currently monitoring border systems deficiency and lack of measures to prevent and control them- besides crescent processes

of global economic interdependence, urbanization, agriculture development, and other ecosystem perturbation impacts- accelerate the species introduction process. Besides, it is expected that global climate change effects favor species invasion, exacerbating aquatic environments species introduction vulnerability (Dukes et al., 2009).

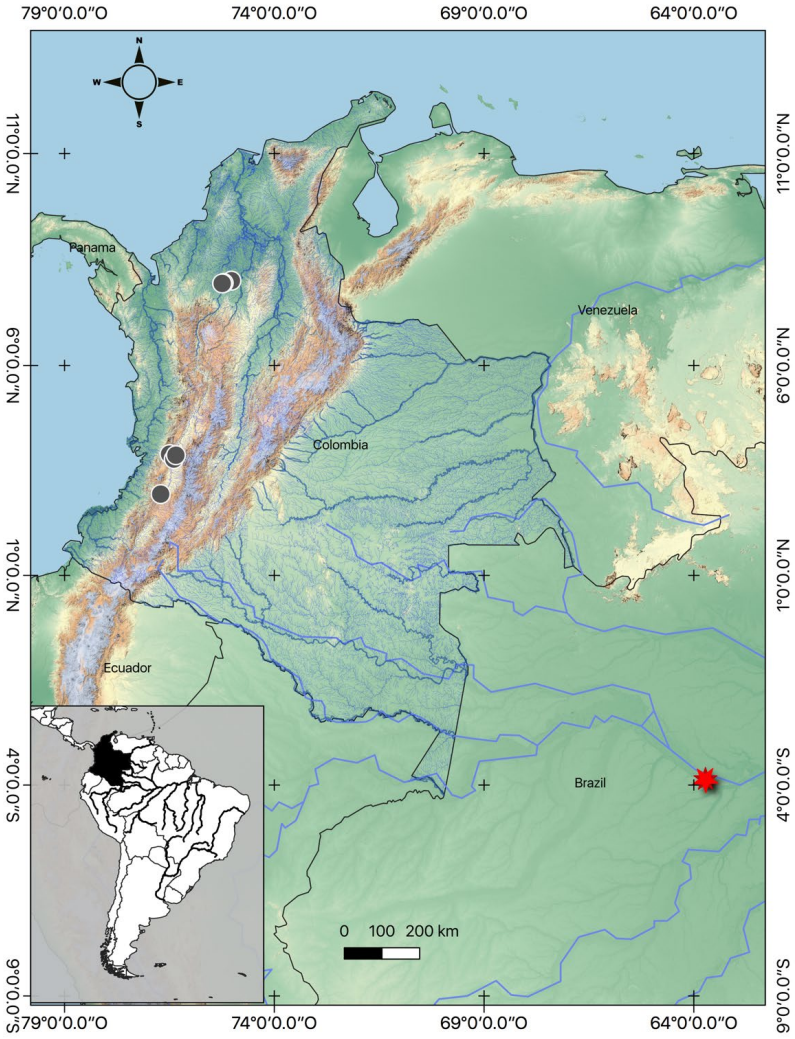

Figure 1. Distribution of *Pterygoplichthys pardalis* in the Cauca River. Red star= Type locality, Black circles = New records.

Pterygoplichthys genus has a history of introductions in many places and has a damaging reputation in countries where it has been introduced, such as Canada (Mendoza et al., 2009), United States (Florida, Hawaii, Nevada, Texas, California), Puerto Rico (Courtenay et al., 1984; Rodríguez-Barreras et al., 2020), Jamaica (Jones, 2008), Philippines (Chavez et al., 2006), Taiwan (Shih-Hsiung et al., 2005, Liang & Shieh, 2005), Singapore (Tan & Tan, 2003), Vietnam (Zworykin & Budaev, 2013), Serbia (Simonović et al., 2010), Costa Rica (Bussing, 2002), and Mexico, where the species are established in Balsas and Mezcala rivers in Michoacan state (Conabio, 2004; Imac, 2005; La Jornada, 2005), Amacuzac River, Morelos (Trujillo-Jiménez, 2003), and Catazajá and Medellín lagoons (Wakida-Kusunoki et al., 2007).

Until now, for freshwater fishes in Colombia, there are not reports for species of *Pterygoplichthys* genus outside their original distribution ranges (Galvis et al., 1997; Salinas-Coy & Agudelo-Córdoba, 2000; Ortega-Lara et al., 2006; Maldonado-Ocampo et al., 2005; Galvis et al., 2007; Maldonado-Ocampo et al., 2008). The aim of this paper is to determine the presence of a non-native species, *Pterygoplichthys pardalis,* through field samples in the Cauca river basin, as well as in the Salvajina and Calima dams (Figure 1), and the Patía river basin based in literature. Some taxonomic details were made, including comments of introduced species of the genus in the Cauca basin and feasible environmental disturbances are described.

Methodology

We examined material deposited in some collections such as the **CIUA:** *Colección Ictiología Universidad de Antioquia*, Medellín, Antioquia – Colombia, and **CP-UCO:** *Colección Peces, Universidad Católica de Oriente*, Rionegro, Antioquia – Colombia (Table 1). We evaluated 35 morphometric characters (Table 2) following Armbruster (2003a), Armbruster & Page (2006). Distances were measured in millimeters using dial calipers and then converted to ratios of standard or head length. Data collected were compared with available published and online *Pterygoplichthys* literature (Armbruster, 1997, 1998, 2002a, 2002b, 2003a, 2003b, 2004; Armbruster & Hardman, 1999; Armbruster & Page, 2006; Page 1994; Weber 1992). Species nomenclature follows Armbruster (2003a, 2004).

Table 1. Specimens revised in collections.

Previous identification	Voucher	Locality	Basin
Hypostomus pardalis	CIUA 429	La Vieja River, Quindio, Colombia	Cauca
Pterygoplichthys undecimalis	CIUA 641	Sonso lagoon, Buga, Valle del Cauca, Colombia	Cauca
Pterygoplichthys undecimalis	CIUA 3349	Sonso lagoon, Buga, Valle del Cauca, Colombia	Cauca
Pterygoplichthys pardalis	CP-UCO 1155	Barrio Chino locality, Caucasia, Antioquia, Colombia	Cauca
Pterygoplichthys undecimalis	IMCN 4328	Calima dam, sector El Remolino, Calima, Valle del Cauca, Colombia	Calima
Pterygoplichthys undecimalis	IMCN 4393	Calima dam, sector Jiguales, Calima, Valle del Cauca, Colombia	Calima
Pterygoplichthys undecimalis	IMCN 3408A	Cauca river, before the confluence with the Risaralda river, Risaralda, Colombia	Cauca
Pterygoplichthys undecimalis	IMCN 3388	Cauca river, before the confluence with the Risaralda river, Risaralda, Colombia	Cauca
Pterygoplichthys undecimalis	IMCN 4461	Salvajina dam, Station 3, Suarez, Cauca, Colombia	Cauca
Pterygoplichthys pardalis	IMCN 4896	Calima dam, sector Rosa de los vientos, Calima, Valle del Cauca, Colombia	Calima
Pterygoplichthys pardalis	IMCN 4913	Calima dam, sector Jiguales, Calima, Valle del Cauca, Colombia	Calima

Table 2. Measurements of the three specimens from CIUA compared with Chavez et al., (2006) data.

Measurement	***P. pardalis* from Cauca river**				***P. pardalis* from Laguna Bay**			
	N	**Range**	**Mean**	**SD**	**N**	**Range**	**Mean**	**SD**
SL (mm)	3	209.89–252.54	229.45	21.5	97	76.1–422.9	225.3	95.4
Predorsal L	3	82.48–103.91	89.71	12.3	97	20.3–47.3	41.4	3.8
Head L	3	58.3–75.05	63.93	9.6	97	26.7–35.1	30.9	1.8
Head dorsal L	3	19.05–28.02	22.11	5.1	97	6.7–40.5	11.8	3.4
Cleithral W	3	51.74–61.49	55.60	5.2	97	20.2–32.7	25.3	2.6
Head pectoral L	3	51.26–65.41	56.46	7.8	97	18.9–32.5	25.5	2.7
Thorax L	3	45.91–55.09	50.46	4.6	97	16.8–27.9	22.6	2.4
Pectoral spine L	3	64.51–81.7	71.60	9.0	97	3.2–35.4	28.8	4.1
Abdominal L	3	46.73–57.51	51.47	5.5	97	15.9–28.9	22.1	2.2
Pelvic spine L	3	39.93–59.37	48.66	9.9	97	11.8–26.3	21.2	2.8
Postanal L	3	78.44–102.54	91.06	12.1	97	21.1–37.7	32.5	2.7
Anal fin spine L	3	33.54–44.18	37.99	5.5	97	7.8–19.6	14.4	2.5

Measurement	*P. pardalis* from Cauca river				*P. pardalis* from Laguna Bay			
	N	Range	Mean	SD	N	Range	Mean	SD
Dorsal pectoral D	3	55.36–68.7	59.84	7.7	97	2.5–29.0	23	3.1
Dorsal spine L	3	48.33–62.91	54.14	7.7	97	13.4–30.8	21.9	3.4
Dorsal pelvic D	3	44.55–57.92	49.21	7.6	97	14.0–27.2	20.6	2.5
Dorsal fin base L	3	62.66–86.89	71.84	13.1	97	3.2–39.3	32.7	3.6
Dorsal adipose D	3	35.36–37.83	36.51	1.2	97	10.9–19.8	15.3	1.5
Adipose spine L	3	14.79–19.58	16.58	2.6	97	4.1–9.9	6.8	1.2
Dorsal Adipose caudal D	3	33.08–37.49	35.02	2.3	97	7.8–14.7	11.8	1.6
Caudal peduncle Dp	3	30.9–40.7	35.80	4.9	97	8.3–13.2	11	1
Ventral adipose caudal D	3	19.55–25.1	21.75	2.9	97	13.1–21.4	17	1.5
Adipose anal D	3	45.26–62.78	52.30	9.3	97	16.3–25.2	21.1	1.7
Dorsal anal D	3	26.72–36.54	30.09	5.6	97	9.7–15.1	12.6	1.2
Pelvic dorsal D	3	59.38–83.65	69.19	12.8	97	21.7–33.0	27.6	2.7
Head eye L	3	19.55–34.91	26.69	7.7	97	25.9–71.3	40.4	7.8
Orbit Dia	3	6.87–7.38	7.16	0.3	97	7.3–23.1	13.8	4.3
Snout L	3	32.17–40.48	36.01	4.2	97	26.4–57.2	47.3	5.1
Internares W	3	10.3–16.83	12.98	3.4	97	1.8–39.3	27.6	3.9
Interorbital W	3	27.57–33.69	29.65	3.5	97	38.9–68.3	52.2	6
Head Dp	3	39.1–52.2	43.65	7.4	97	37.7–86.7	56.4	7.6
Mouth L	3	26.3–30.51	27.84	2.3	97	18.9–45.7	34.9	5.3
Mouth W	3	18.09–21.7	19.63	1.9	97	24.0–44.0	34.7	4.6
Barbel L	3	8.52–9.83	9.10	0.7	97	6.9–22.3	12.6	2.7
Dentary tooth cup L	3	7.23–8.65	8.08	0.8	97	6.9–18.1	11.8	1.9
Premaxillary tooth cup L	3	7.48–7.11	06.79	0.3	97	5.0–20.1	10.6	2.2

Results and Discussion

Pterygoplichthys undecimalis is the only valid species distributed in the Magdalena-Cauca river basin according to Ortega-Lara et al., (2006), Maldonado-Ocampo et al., (2005, 2008), Lasso et al., (2011) and DoNascimiento et al., (2017) (Figure 2b). Recently we captured one specimen of *Pterygoplichthys pardalis* (CP-UCO 1155) from the lower Cauca River basin, in *Barrio Chino* locality, a small town near Caucasia Municipality, in the Antioquia department (Figure 3). Additionally, we examined the material of this genus deposited in the CIUA collection from the upper Cauca river basin collected in La Vieja river (CIUA 429). We identify specimens

belonging to *P. pardalis* that were misidentified as *Hypostomus pardalis*, indicating a species introduction in the Cauca river basin (from Salvajina dam to Nechí river) and in the Calima dam. Recently Moncayo-Fernández et al., (2017) indicated that *P. undecimalis* was transplanted in the Patía river basin. However, we suggested that this is a misidentification as it currently corresponds to a *P. pardalis* exemplar. A similar introduction has been previously reported for *Loricariichthys brunneus* (Hancock 1828) in the Cauca river basin (Ortega-Lara et al., 2006).

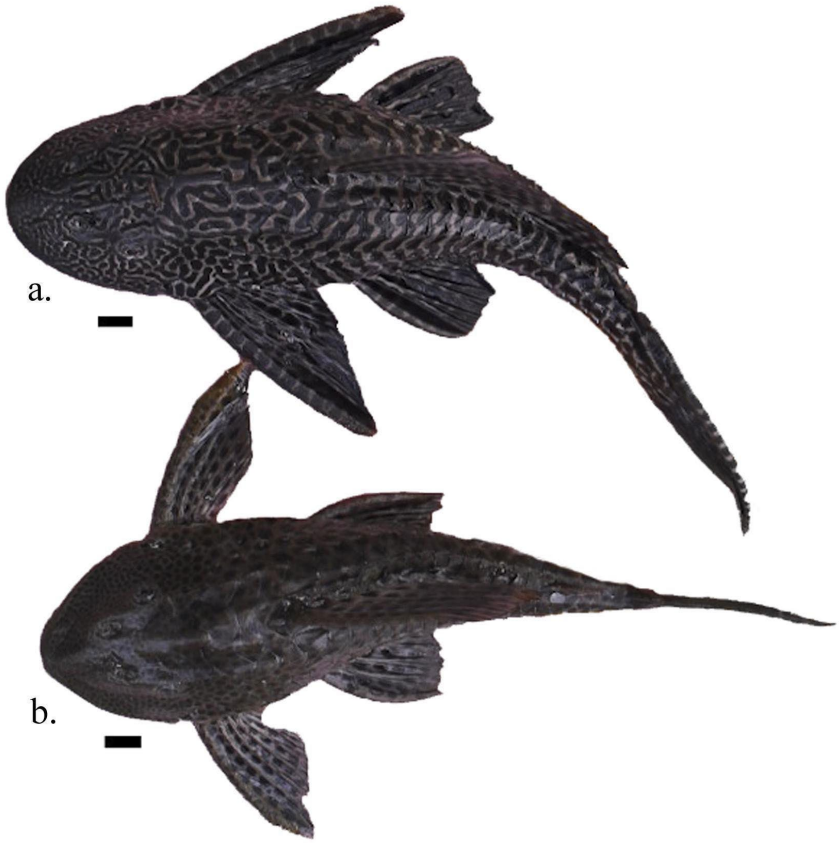

Figure 2. Specimens of non-native a) *Pterygoplichthys pardalis* and native b) *P. undecimalis* (*in vivo*) from Videles wetland in the upper Cauca river, Cauca Valley department. The bar represents one centimeter. Collected and photographed by N. Santos and P. Bonilla.

Despite the *Pterygoplichthys pardalis* introduction evidence, there are no records of their introduction or transplantation in Colombia (Alvarado & Gutiérrez, 2002; Gutiérrez, 2006; Mancera-Rodríguez & Álvarez-León, 2008; Gutiérrez et al., 2012; Baptiste et al., 2010; Álvarez-León et al., 2002). In other places (such as USA, Puerto

Rico or Mexico), there have been reported negative environmental impacts associated with *P. pardalis* introduction such as coastline instability, trophic chain alterations, commercial fisheries pressures (Amador Del Angel et al., 2014), and for other species of aquatic vertebrates, such as the manatee (Nico et al., 2009a), pelicans (*Pelecanus occidentalis*) (Bunkley-Williams et al., 1994), egg predation of other fishes (Chaichana & Jongphadungkiet, 2012).

Figure 3. *Pterygoplichthys pardalis* (*in vivo*) from lower Cauca River. CP-UCO 1155. SL 191,48 mm. Collected and photo by M. A. Zuluaga.

Individuals found in this study have the typical mechanisms of all translocated or introduced populations studied in other countries (Leprieur et al., 2008), suggesting two possible mechanisms for their release: i) carelessness during the ornamental fishes trade, like, for example, when people released them into natural water bodies, due to specimens grow overpassing aquaria capacity or when people become bored with them (Mendoza et al., 2009), or by ii) aquaculture projects looking to "improve" region's economy. For instance, it has been reported that the Calima dam population was moved by a fisherman (Figure 5), who introduce a few hundred specimens of *P. pardalis* from Sonso Lagoon in the Cauca river (near Buga municipality), where *P. pardalis* is wrongly sold as Merluza fillets (*Brotula* spp.) (Copescal, 1986; Fuller et al., 1999; Nico & Martin, 2001; Vidthayanon, 2005; Page & Robins, 2006; Nico et al., 2009b).

Species introduction is not a recent activity in the world. According to residents surveys, reports of Rivera et al., (2004), and photographic report dating since 1998, the introduction was made at least twenty years ago or more. Recently, in the Ibague

fish market (Tolima department), we identified a significant number of *P. pardalis* for sale (Figure 6). The seller expressed that there is a great demand for this species and explained that the fish came from the upper Cauca River. Active trade of this species indicated that their introduction is not recent. This was also supported by Ortega-Lara (pers. comm.) in the Sonso Lagoon and Acevedo et al., (2010) in Videles wetlands, Calima and Salvajina dams (Figure 7). In the Ibague fish market is possible to observe sexually mature females specimens with eggs, probably indicating that species have active reproduction, where the high number of individuals offered for sale would be a result of a significant population.

Figure 4. Pterygoplichthys pardalis from upper Cauca river. CIUA 429 (1–3). SL 209,89 mm. Collected by L. Ochoa-Orrego and A. Montoya-López. Photo by D. De Fex-Wolf.

Figure 5. *Pterygoplihthys pardalis* fishery in Calima dam with transplanted specimens from Sonso lagoon in the Cauca Valley department. Photo by N. Santos and P. Bonilla.

Observations presented here are based on photographs (Santos & Bonilla com. pers.) as, unfortunately, we do not obtain samples of *Pterygoplichthys undecimalis* (Figure 2). We use photographs to take measurements with *ImageJ 1.43u* for Mac (http://imagej.nih.gov/ij/). A comparison showed that *P. pardalis* has larger pectoral fins than *P. undecimalis* and the pectoral fins of *P. pardalis* reach and exceed more than half the length of the pelvic fins, but in *P. undecimalis* the pectorals fin reach the pelvic fin but do not extend for half of their length (Figure 4). Also, *P. pardalis* has a longer snout tip. The pelvic fins of *P. undecimalis* are longer than those of *P. pardalis,* and the first spine of the pectoral and pelvic fins in *P. undecimalis* is wider than in *P. pardalis.* The color pattern is also very different: *P. pardalis* has vermiculation on the body and first ray of the pectoral fin but *P. undecimalis* have circular spots (see Steindachner 1978:Table VIII). It is interesting to note that despite long time *P. pardalis* presence in the region and their high demand and consumption, this non-native species had not been correctly identified or declared as introduced by any corporation or research institute in the country.

An issue with the taxonomy of this genus refers to the diagnosed characters (Armbruster 2004). This is a disadvantage for species identification in the field, especially due to

taxonomist specialized lack in these groups. *Pterygoplichthys pardalis* is still confused with our native species, *P. undecimalis*, as in some fishing identification manuals, (Rivera et al., 2004), field guides (Castaño, 2010), and the first catalog of inland fishery resources of Colombia (Carvajal-Quintero et al., 2010), or most recently, in Botero-Botero et al., (2019). To help separate them, we present some differences between these two species previously mentioned (see Figure 2).

Figure 6. *Pterygoplihthys pardalis* in Ibague fish market, Tolima Department. Note the quantity of fish including several females with eggs. Photo by L. Jara and O. Castillo.

Furthermore, when misidentifying *Pterygoplichthys pardalis* as *P. undecimalis*, some researchers and local fishermen usually confuse *Pterygoplichthys* with *Hypostomus hondae* or *Hemiancistrus wilsoni*; both species are widely found in the Magdalena-Cauca river basin. In some cases, *P. pardalis* has been called "the real C*oroncoro*" (*el original Coroncoro*). These taxonomic problems are so extensive that in La Pintada town (Antioquia department), some officials of regional autonomous corporations were fostering the species destruction, without a proper and clear determination of which morphotype or species needs to be eliminated, this led fishermen of the region to exterminate all species of loricariids present in their catches (Agudelo-Zamora pers. obs). To avoid this, we follow Weber (1992) and Armbruster (2002b) keys together with Loricariidae specialist confirmation. Due to these species have slight regional differences, these have been extensively hybridized (Sabaj-Pérez, 2011), and until now there is not a taxonomic revision of the genus to assist in the correct species

identification. In this regard, Chavez et al., (2006) reported these small variations in meristic counts and morphometric measurements for the species, that we also found in our data.

Figure 7. *Pterygoplihthys pardalis* and *Oreochromis niloticus* fishery (both non-native species) in the Videles wetlands, Cauca Valley Department. Photo by N. Santos and P. Bonilla.

In Colombia, ecosystem impacts caused by *P. pardalis* are not yet evaluated. Baptiste, et al., (2010) proposed guidelines for the categorization of all aquatic organisms introduced in the country. However, in other countries, some introduced species impact has been studied. One example of this was provided by Amador Del Angel et al., (2014:12), Hubilla et al., (2007), and Chaichana & Jongphadungkiet, (2012), who indicates that *Pterygoplichthys* has had negative impacts on freshwater biodiversity, causing higher water turbidity, consuming bivalves and gastropods and reducing others fishes amount. Also, Nico et al., (2009a) showed that *Pterygoplichthys* could cause damage to the manatee (*Trichechus manatus latirostris*) in Florida (more detail see Nico et al., 2009a), Yossa et al., (1998) and Samat et al., (2008) suggested that *P. pardalis* was more efficiently adapted to exploit benthic food resources than *Prochilodus nigricans* with a higher assimilation rate to convert food into biomass and thus growing faster.

There is an urgent need for a comprehensive study evaluating *P. pardalis* environmental impacts in Colombia. Leprieur et al., (2008) explained that about 20% of known

extinctions are directly caused by invasive species. The anterior approach is highly relevant in Colombia several native species with similar food requirements are at risk (Yossa & Araujo-Lima, 1998), including *P. undecimalis*, *Hypostomus hondae* (Regan 1912), *Panaque cochliodon* (Steindachner 1879), *Prochilodus magdalenae* Steindachner 1879 and *Ichthyoelephas longirostris* (Steindachner 1879), which are important commercial fisheries species, as well as vulnerable species according to the Red Data Book (*P. cochliodon* and *I. longirostris*) (Maldonado-Ocampo et al., 2005; Mojica et al., 2012).

Author participation

HAZ conception, document write, individuals sampling and registration in CP-UCO, manuscript review, and final edition.
DDFW data collection and processing, photo registry contributions in the text, and final edition.
MAZ individuals collection, processing, and registration in CP-UCO, photographs and document contributions, and final edition.

Acknowledgment

We thank Jonathan W. Armbruster for kindly confirming the species identity. To Donald Taphorn for sharing the photos with JWA and the English review of this manuscript. To Luis Jara and Otto Castillo for the fish market photo, to Armando Ortega-Lara, and Gian Carlo Sanchez for Sonso Lagoon data, to Paula Bonilla and Natalia Santos for Calima and Salvajina reservoirs data and photos. We are grateful to Maria I. Rios (CP-UCO), Luz F. Jimenez (CIUA), and Raul Rios (IMCN) for collections access and to Luz E. Ochoa (USP- Brazil) for their contributions for the final document.

References

Acevedo, J., Bonilla, P. A., & Santos-Rivera, N. (2010). Estandarización e implementación de una metodología de marcaje en juveniles de bocachico (*Prochilodus magdalenae*) para realizar seguimiento a las jornadas de repoblamiento en la madrevieja videles. Convenio De Asociación No. 170 De 2008 CVC – FUNINDES.

Alvarado, H., & Gutiérrez, F. (2002). Especies hidrobiológicas continentales introducidas y trasplantadas y su distribución en Colombia. Ministerio del Medio Ambiente, Convención Ramsar, CVS, CVC. 170 pp.

Álvarez-León, R., Gutiérrez-Bonilla, F., & Rodríguez-Forero, A., (2002). Los peces dulceacuícolas introducidos y trasplantados en Colombia: Antecedentes, efectos y perspectivas. 55–62 Pp. En: Mojica, J. I. et al. (Eds.). Libro Rojo de peces dulceacuícolas de Colombia. La serie Libros Rojos de Especies Amenazadas de Colombia. Instituto de Ciencias Naturales Universidad Nacional de Colombia, Ministerio del Medio Ambiente, Bogotá, Colombia.

Armbruster, J., (1997). Phylogenetic Relationships of the Sucker-Mouth Armored Catfishes (Loricariidae) with Particular Emphasis on Ancistrinae, Hypostominae and Neoplecostominae Ph.D. Dissertation, University of Illinois, Urbana-Champaign, 433 pp.

Armbruster, J., (1998). Review of the loricariid catfish genus *Aphanotorulus* and redescription of A. unicolor (Teleostei: Siluriformes). *Ichthyological Exploration of Freshwaters*, 8(3), 253-262.

Armbruster, J., (2002a). Hypancistrus inspector: A new species of suckermouth armored catfish (Loricariidae, Ancistrinae). *Copeia*, 2002, 86-92

Armbruster, J., (2002b). A key to the genera of Loricariidae. Retrieved from http://george.cosam.auburn.edu/usr/key_to_loricariidae/key.html (accessed 4 July 2004)

Armbruster, J., (2003a). *Peckoltia sabaji*, a new species from the Guiana Shield (Siluriformes: Loricariidae). *Zootaxa*, 344, 1–12

Armbruster, J., (2003b). The species of the *Hypostomus cochliodon* group (Siluriformes: Loricariidae). *Zootaxa*, 249, 1–60.

Armbruster, J., (2004). Phylogenetic relationships of the suckermouth armoured catfishes (Loricariidae) with emphasis on the Hypostominae and the Ancistrinae. *Zoological Journal of the Linnean Society*, 141,1–80.

Armbruster, J., & Page, L. M., (2006). Redescription of Pterygoplichthys punctatus and description of a new species of *Pterygoplichthys* (Siluriformes: Loricariidae). *Neotropical Ichthyology*, 4(4), 401–409.

Armbruster, J., & Hardman, M., (1999). Redescription of *Pseudorinelepis genibarbis* (Loricariidae: Hypostominae) with comments on behavior as it relates to air-holding. *Ichthyological Exploration of Freshwaters*, 10, 53–61.

Amador Del Ángel L.E., Guevara Carrió, E. Del C., Brito Pérez, R., & Endañú Huerta, E., (2014). Aspectos biológicos e impacto socio-económico de los plecos del género Pterygoplichthys y dos cíclidos no nativos en el sistema f1uvio lagunar deltaico Río Palizada, en el Área Natural Protegida Laguna de Términos, Campeche. Universidad Autónoma del Carmen. Centro de Investigación de Ciencias Ambientales. Facultad de Ciencias Naturales. Informe final SNIB-CONABIO Ficha técnica pez diablo Pterygopllchthys pardalis, proyecto No. GN004 México D. F

Baptiste, M. P., Castaño, N., Cárdenas, D., Gutiérrez F. P., Gil, D.L., & Lasso, C. A., (Eds.) (2010). Análisis de riesgo y propuesta de categorización de especies introducidas para Colombia. Instituto de Investigación de Recursos Biológicos Alexander von Humboldt Bogotá, D.C., Colombia. 200 p.

Bogotá-Gregory, J.D. & Maldonado-Ocampo, J.A., (2006). Peces de la zona hidrogeográfica de la Amazonia, Colombia. *Biota colombiana*, 7(1), 55–94.

Botero-Botero, A., Botello, J.C., Navarrete, A.M., Murillo, O., Herrera, J.C., Ortega, L.F., Córdoba, D., Guapacha, S., Sánchez, G.C., & Ortega-Lara, A., (2019). Conocimiento y conservación de la Nutria neotropical y los peces del Alto río Cauca en el Valle del Cauca. Corporación Autónoma Regional del Valle del Cauca-CVC. Fundación FUNINDES. Fundación BIODESS. Santiago de Cali, Colombia. 32 pp.

Buckup, P., Menezes, N., & Ghazzi, M., (2007). Catálogo das espécies de peixes de água doce do Brasil. Rio de Janeiro, Brazil: Museu Nacional. 195 p.

Bunkley-Williams, L., Williams Jr, E. H., Lilyestrom, C. G., Corujo-Flores, I., Zerbi, A. J., Aliaume, C., & Churchill, T. N., (1994). The South American sailfin armored catfish, *Liposarcus multiradiatus* (Hancock), a new exotic established in Puerto Rican fresh waters. *Caribbean Journal of Science*, 30, 90–94.

Bussing, W. A., (2002). Freshwater fishes of Costa Rica. San José, Costa Rica: Editorial de la Universidad de Costa Rica.

Castaño, G. (2010). Peces. Pp. 345–353. En: Infante-Betancour, J. & Tiboche-Garcia, A. (Eds.). Flora y Fauna de los Humedales y Bosques de la zona plana del Municipio de Andalucía. Serie Biodiversidad para la sociedad No 1. Bogota: Yoluka ONG. Fundación de Investigación en Biodiversidad y Conservación. 373 p.

Carvajal-Quintero, J. D. Hernández-Serna, A. & Jiménez-Segura, L. F., (2010). *Pterygoplichthys undecimalis* (Siluriformes: Loricariidae) Capitulo 7. Pp. 386–387 En: Lasso, C.A. et al., (Eds). I. Catálogo de los recursos pesqueros continentales de Colombia. Serie Editorial Recursos Hidrobiológicos y Pesqueros Continentales de Colombia, Instituto de Investigación de Recursos Biológicos Alexander von Humboldt (IAvH), Bogotá, Colombia.

Chaichana, R. & Jongphadungkiet, S., (2012). Assessment of the invasive catfish *Pterygoplichthys pardalis* (Castelnau, 1855) in Thailand: ecological impacts and biological control alternatives, *Tropical Zoology*, 25(4), 173–182. https://doi.org/10.1080/03946975.2012.738494

Chavez, J. M., De La Paz, R. M., Manohar, S. K., Pagulayan, R. C., & Vi, J. R. C., (2006). New Philippine record of South American sailfin catfishes (Pisces: Loricariidae). *Zootaxa*, 1109, 57–68. https://doi.org/10.11646/zootaxa.1109.1.6

Courtenay JR, W. R., Hensley, D. A., Taylor, J. N., & Mccann, J. A., (1984). Distribution of exotic fishes in the continental United States. In: Courtenay Jr, W. R. and J. R. Stauffer Jr, editors. editors. Distribution, biology, and management of exotic fishes. Johns Hopkins University Press. Baltimore, Maryland, 41–77.

(CONABIO) Comisión Nacional Para El Uso Y Conocimiento De La Biodiversidad., (2004). Especies Invasoras. Peces. Retrieved from http://www.conabio.gob.mx/conocimiento/info_especies/especies_invasoras/doctos/peces.html (Accessed 6 July 2005).

(COPESCAL) Comisión De Pesca Continental Para América Latina. (1986). Introducción de especies ícticas y conservación de los recursos genéticos de América Latina. COPESCAL Doc. Ocas., (3), 12 p.

Dahl, G., (1971). Los peces del norte de Colombia. Ministerio de Agricultura, Instituto de Desarrollo de los Recursos Naturales Renovables (Inderena). Talleres Litografía Arco. Bogotá, 391 p.

Donascimiento, C., Herrera-Collazos, E. E., Herrera-R, G. A., Ortega-Lara, A., Villa-Navarro, F. A., Usma Oviedo, J. S., Maldonado-Ocampo, J. A., (2017). Checklist of the freshwater fishes of Colombia: a Darwin Core alternative to the updating problem. *ZooKeys*, 708, 25–138. https://doi.org/10.3897/zookeys.708.13897

Dukes, J. S., Pontius, J., Orwig, D., Garnas, J. R., Rodgers, V. L., Brazee, N., Cooke, B. et al., (2009). Responses of insect pests, pathogens, and invasive plant species to climate change in the forests of northeastern North America: What can we predict?. *Canadian journal of forest research*, 39(2), 231–248.

Eigenmann, C., (1922). The fishes of western South America, Part I. The fresh-water fishes of northwestern South America, including Colombia, Panama, and the Pacific slopes of Ecuador and Peru, together with an appendix upon the fishes of the Rio Meta in Colombia. *Mem. Carnegie Mus*. v. 9 (núm. 1), 1–346, Pls. 1–38.

Fowler, H., (1942). Lista de peces de Colombia. *Revista de la Academia Colombiana de Ciencias Exactas, Físicas y Naturales*, 5(17), 128–138.

Fuller, P.L., Nico, L.G., & Williams, J.D., (1999). Nonindigenous Fishes Introduced into Inland Waters of the United States. *American Fisheries Society* Special Publication 27.

Galvis, G., Mojica, J., & Camargo, M., (1997). Peces del Catatumbo. Asociación Cravo Norte, Santa fé de Bogotá, D.C., 188 p.

Galvis, G., Sánchez-D, P., Mesa-S, L., López-P, Y., Gutiérrez-E, M. A., Gutiérrez-C, A., Leiva, M., & Castellanos, C., (2007). Peces de

la amazonia colombiana con énfasis en especies de interés ornamental. Instituto Colombiano de Desarrollo Rural (INCODER), Universidad Nacional de Colombia y Instituto SINCHI, Bogotá, Colombia. 489 p.

Gutiérrez, F., (2006). Estado de conocimiento de especies invasoras. Propuesta de lineamientos para el control de los impactos. Instituto de Investigación de Recursos Biológicos Alexander von Humboldt, Bogotá, D.C. - Colombia. 156 p.

Gutiérrez, F D. P., Lasso, C. A., Baptiste, M. P., Sánchez-Duarte, P., & Díaz, A. M., (Eds.). (2012). VI. Catálogo de la biodiversidad acuática exótica y trasplantada en Colombia: moluscos, crustáceos, peces, anfibios, reptiles y aves. Serie Editorial Recursos Hidrobiológicos y Pesqueros Continentales de Colombia. Instituto de Investigación de los Recursos Biológicos Alexander von Humboldt (IAvH). Bogotá, D.C. Colombia, 335 p.

Hubilla, M., Kis, F., & Primavera, J., (2007). Janitor Fish *Pterygoplichthys disjunctivus* in the Agusan Marsh: a Threat to Freshwater Biodiversity. *Journal of Environmental Science and Management*, 10(1), 10–23.

(IMAC) Iniciativa Mexicana Para El Aprendizaje Y La Conservación., (2005). Invade pez de acuario lagunas de Tabasco. Retrieved from http://www.imacmexico.org/ev_es.php?ID=18220_201&ID2=DO_TOPIC (Accessed 6 July 2005).

Jones, A. D., (2008). Suckermouth catfish (*Pterygoplichthys pardalis*). Aliens of Xamayca 1(4):1. Retrieved from http://www.jamaicachm.org.jm/Article/PDF /October2008.pdf

Lasso, C.A., Agudelo-Córdoba, E., Jiménez-Segura, L., Ramírez-Gil, H., Morales-Betancourt, M., Ajiaco-Martínez, R.E., Gutiérrez, F.D.P., Usma Oviedo, J.S., Muñoz Torres, S.E., & Sanabria Ochoa, A.I., (2011). I. Catálogo de los recursos pesqueros continentales de Colombia. Serie Editorial Recursos Hidrobiológicos y Pesqueros Continentales de Colombia, Instituto de Investigación de Recursos Biológicos Alexander von Humboldt (IAvH), Bogotá, Colombia.

La Jornada., (2005). Sin control, la proliferación del pez diablo en la Presa Infiernillo. Retrieved from http://www.jornada.unam.mx/2005/mar05/050321/michoacan/10n1soc.html (Accessed 16 April 2005).

Leprieur, F., Beauchard, O., Blanchet, S., Oberdorff, T., & Brosse, S., (2008). Fish invasions in the world's river systems: When natural processes are blurred by human activities. *PLoS Biol*, 6(2), e28. https://doi.org/10.1371/journal.pbio.0060028

Liang, S., Wu, H., & Shieh, B., (2005). Size structure, reproductive phenology, and sex ratio of an exotic armored catfish (*Liposarcus multiradiatus*) in the Kaoping River of southern Taiwan. *Zoological Studies*, 44(2), 252–259.

Maldonado-Ocampo, J. A., Ortega-Lara, A., Usma Oviedo, J. S., Galvis, G., Villa-Navarro, F., Vásquez, L., Prada-Pedreros, S., & Rodríguez, C. A., (2005). Peces de los Andes de Colombia. Guía de campo. Instituto de Investigación de Recursos Biológicos "Alexander von Humboldt," Bogotá, Colombia, 346 p.

Maldonado-Ocampo, J. A., Vari, R. P., & Usma. J. S., (2008). Checklist of the freshwater fishes from Colombia. *Biota Colombiana*, 9(2), 143–237.

Mancera-Rodríguez, N. J., & Álvarez-León, R., (2008). Comercio de peces ornamentales en Colombia The Trade of Ornamental Fishes in Colombia. *Acta biol. Colomb*, 13(1), 23–52.

Mendoza, R.E. J.P., Fisher, W., Courtenay, C., Ramírez-Martínez, A., Orbe-Mendoza, C., Escalera-Gallardo, P., Álvarez-Torres, P., Koleff-Osorio & Contreras-Balderas, S., (2009). Armored Catfish (Loricariidae) Trinational Risk Assessment. Pp. 25–37. In: Mendoza, R.E., Cudmore, B., Orr, R., Balderas, S.C., Courtenay, W.R., Osorio, P.K., Mandrak, N., Torres, P.A., Damian, M.A., Gallardo, C.E., Sanguines, A.G., Greene, G., Lee, D., Orbe-Mendoza, A., Martinez, C.R., & Arana, O.S., (2009). Trinational Risk Assessment Guidelines for Aquatic Alien Invasive Species. Commission for Environmental Cooperation. 393, rue St-Jacques Ouest, Bureau 200, Montréal (Québec), Canada. ISBN 978-2-923358-48-1.

Miles, C., (1947). Los peces del Río Magdalena. Ministerio de la Economía Nacional, Sección de Piscicultura, Pesca y Caza, Bogotá, Colombia, 214 p.

Mooney, H. A., & Cleland, E. E., (2001). The evolutionary impact of invasive species. *Proceedings of the National Academy of Sciences of the United States of America*, 98(10), 5446–5451. https://doi.org/10.1073/pnas.091093398

Mojica, J. I., Usma, J. S., Álvarez-León, R., & Lasso, C. A., (Eds). (2012). Libro rojo de peces dulceacuícolas de Colombia 2012. Instituto de Investigación de Recursos Biológicos Alexander von Humboldt, Instituto de Ciencias Naturales de la Universidad Nacional de Colombia, WWF Colombia y Universidad de Manizales. Bogotá, D. C., Colombia, 319 pp.

Mojica J. I., Galvis, G., Arbeláez, F., Santos, M., Vejarano, S., Prieto-Piraquive, E., Arce, M., Sánchez-Duarte, P., Castellanos, C., Gutiérrez, A., Duque, S. R., Lobón-Cerviá, J., & Granado-Lorencio, C., (2005). Peces de la cuenca del río Amazonas en Colombia: Región de Leticia. *Biota Colombiana*, 6(2), 191–210

Moncayo-Fernández, A., Mejía-Egas, O., & Ramírez-Chaves, H. E., (2017). *Pterygoplichthys undecimalis* (Siluriformes: Loricariidae): una especie trasplantada en la cuenca del río Patía, vertiente Pacífico, Colombia. *Biota Colombiana*, 18(1), 243–250. https://doi.org/10.21068/c2017.v18n01a15

Nico, L., Loftus, W., & Reid, J., (2009a). Interactions between non-native armored suckermouth catfish (Loricariidae: *Pterygoplichthys*) and native Florida manatee (Trichechus manatus latirostris) in artesian springs. *Aquatic Invasions*, 4(3), 511–519. https://doi.org/10.3391/ai.2009.4.3.13

Nico L., Jelks, H., & Tuten, T., (2009b). Non-Native Suckermouth Armored Catfishes in Florida: Description of Nest Borrows and Burrow Colonies with Assessment of Shoreline Conditions. *Aquatic Nuisance Species*, 9(1), 1–30. Retrieved from http://oai.dtic.mil/oai/oai?verb=getRecord&metadataPrefix=html&identifier=ADA501422

Nico, L. G., & Martin, R. T., (2001). The South American suckermouth armored catfish *Pterygoplichthys anisitsi* (Pisces: Loricariidae) in Texas, with comments on foreign fish introductions in the American Southwest. *Southwestern Naturalist*, 46, 98–104.

Ortega-Lara, A., Aguiño, A., Sánchez, G. C., (2002). Los peces del Alto Cauca: Caracterización de la ictiofauna nativa de los principales ríos de la cuenca alta del río Cauca en el departamento del Cauca. Primera Parte. Fundación para la Investigación y el Desarrollo Sostenible, FUNINDES y Corporación Autónoma Regional del Cauca - CRC, Popayán, Colombia, 142 p.

Ortega-Lara A., Usma, J. S., Bonilla, P. A., & Santos, N. L., (2006). Peces de la cuenca alta del río Cauca, Colombia. *Biota Colombiana*, 7(1), 39–54

Page, L. M., (1994). Identification of sailfin catfishes introduced to Florida. *Florida Scientist*, 57(4), 171–172.

Page, L. M., & Robins, R. H., (2006). Identification of sailfin catfishes (Teleostei: Loricariidae) in southeastern Asia. *The Raffles Bulletin of Zoology*, 54, 455–457.

Rivera, M. C., Hoyos, S., Galeano, R. E., (2004). Manual y Guía Técnica Pesquera para La Ciénaga Colombia En El Municipio De Caucasia. Fundación Montañas. Antioquia.

Rodríguez-Barreras, R., Zapata-Arroyo, C., Falcón L., W., & Lourdes Olmeda, M., (2020). An island invaded by exotics: a review of freshwater fish in Puerto Rico, Neotropical Biodiversity, 6(1), 42–59, https://doi.org/10.1080/23766808.2020.1729303

Sabaj-Pérez, M. H., (2011). Status of Neotropical catfish taxonomy and systematics with emphasis on recent discoveries. Ponencia magistral XI Congreso Colombiano de Ictiología.

Samat, A., Shukor, M. N., Mazlan, A.G., Arshard, A., & Fatimah, M. Y., (2008). Length-weight Relationship and Condition Factor of *Pterygoplichthys pardalis* (Pisces: Loricariidae) in Malaysia Peninsula. *Research Journal of Fisheries and Hydrobiology*, 2008, 3(2), 48–53.

Salinas-Coy, Y., & Agudelo-Córdoba, E., (2000). Peces de importancia económica en la cuenca amazónica colombiana. Instituto Amazónico de Investigaciones Científicas-SINCHI. Scipto. Bogotá. Colombia. 140 p.

Shih-Hsiung, L., Hsiao-Ping, W., & Bao-Sen, S., (2005). Size Structure, Reproductive Phenology, and Sex Ratio of an Exotic Armored Catfish (*Liposarcus multiradiatus*) in the Kaoping River of Southern Taiwan. *Zoological Studies*, 44(2), 252–259.

Simonović, P., Nikolić, V., & Grujić, S., (2010). Amazon Sailfin Catfish *Pterygoplichthys pardalis* (Castellnnau, 1855) (Loricariidae, Siluriformes), a new fish species recorded in the Serbian section of the Danube River. *Biotechnology & Biotechnological Equipment*, 24(sup1), 655–660. https://doi.org/10.1080/13102818.2010.10817916

Steindachner, F., (1878). Zur Fischfauna des Magdalenen-Stromes. Anzeiger der Kaiserlichen Akademie der Wissenschaften, Wien, Mathematisch-Naturwissenschaftliche Classe v. 15 (no. 12) (for 9 May 1878), 88–91.

Tan, B. C., & Tan, K. S., (2003). Singapore. In: Pallewatta, N., J. K. Reaser, and A. T. Gutierrez, editors. Invasive alien species in South-Southeast Asia. National reports and directory of resources. Global Invasive Species Programme. Cape Town, South Africa. 85–90.

Trujillo-Jiménez, P., (2003). Biodiversidad acuática del río Amacuzac, Morelos, México. CONABIO Informe Final del Proyecto S150. Retrieved from http://www.conabio.gob.mx/institucion/proyectos/resultados/InfS150.pdf (Accessed 1 January 2005).

Vidthayanon, C., (2005). Aquatic alien species in Thailand (Part1): Biodiversity. In International mechanisms for the control and responsible use of alien species in aquatic ecosystems, Report of an Ad Hoc Expert Consultation. Xishuangbanna, People's Republic of China, 27–30 August 2003, ed. D. M.

Wakida–Kusunoki, A. T., Ruiz–Carus, R., & Amador Del Ángel, E., (2007). Amazon sailfin catfish, *Pterygoplichthys pardalis* (Castelnau, 1855) (Loricariidae) another exotic species established in Southeastern Mexico. *The Southwestern Naturalist*, 52(1), 141–144.

Weber, C., (1992). Révision du genre Pterygoplichthys sensu lato (Pisces, Siluriformes, Loricariidae). *Revue Française d'Aquariologie*, 19, 1–36.

Welcomme, R. L. (1988). International introductions of inland aquatic species. FAO Fishery Technical Paper 294, 1–328.

Yossa, M.I., & Araujo-Lima, C., (1998). Detritivory in two Amazonian fish species. *Journal of Fish Biology*, 1998, 52(6), 1141–1153

Zworykin, D. D., & Budaev, S. V., (2013). Non-indigenous armoured catfish in Vietnam: invasion and systematics. *Ichthyol Res*, 60, 327–333.