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First record of *Goodea atripinnis* (Cyprinodontiformes: Goodeidae) in the state of Hidalgo (Mexico) and some considerations about its taxonomic position

Primer registro de *Goodea atripinnis* (Cyprinodontiformes: Goodeidae) del estado de Hidalgo (México) y algunas consideraciones acerca de su posición taxonómica

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ABSTRACT

A population of blackfin goodea *Goodea atripinnis* was encountered in the Metztitlán Canyon Biosphere Reserve (Pánuco Basin, Hidalgo, Mexico). This species has a wide distribution across the Pacific Slope of Mexico, including the Lerma-Grande de Santiago basin, Ameca River, Magdalena Lake and the Balsas and Armería basins. Biometric data were used for identification and comparison to those of other putative members of the genus. The taxonomic identification and systematic position of this species are discussed. *Goodea luitpoldii* and *G. gracilis* are confirmed as synonyms with *G. atripinnis*. Comments on conservation implications of this species and their Pánuco Basin populations are given.

Key words: *Goodea atripinnis, Goodea gracilis*, *Goodea luitpoldii*, Central Basin of Mexico, Metztitlán Canyon Biosphere Reserve, Conservation.

RESUMEN

Se encontró una población de *Goodea atripinnis* en la reserva de la biosfera Barranca de Metztitlán (Hidalgo, México). Esta especie tiene una amplia distribución a lo largo de la vertiente Pacífica de México, incluyendo las cuencas de los ríos Lerma-Grande de Santiago, Ameca, Balsas y Armería, así como la del lago Magdalena. Se incluyen los datos biométricos utilizados para la identificación y comparación con los otros supuestos miembros del género. Se discute la identificación taxonómica y la posición sistemática de esta especie. *G. luitpoldii* y *G. gracilis* son confirmados como sinónimos de *G. atripinnis*. Se incluyen comentarios acerca de las implicaciones en la conservación de esta especie y las poblaciones presentes en la cuenca del Pánuco.

Palabras clave: *Goodea atripinnis, Goodea gracilis*, *Goodea luitpoldii*, cuenca central de México, reserva de la biosfera Barranca de Metztitlán, conservación.

The state of Hidalgo is located in east central Mexico, at the intersection of the Mexican Neovolcanic Belt, the central highland plateau (Mesa Central) and the Sierra Madre Oriental. Rivers of Hidalgo, part of the Pánuco, Tuxpan and Cazones basins, flow into the Gulf of Mexico. Fishes in the region are relatively diverse and contain Neotropical and Nearctic species, suggesting that this is a transition zone between the two ecozones (Soria-Barreto *et al.*, 1996). The region is characterized by extreme variation in local ecological systems and a high diversity of flora and fauna, produced by geographic isolation of local populations (Pulido-Flores *et al.*, 2005).

Several studies of parasites (Gutiérrez-Cabrera *et al.*, 2005; Monks *et al.*, 2005), taxonomic descriptions (Álvarez del Villar & Navarro, 1953; Taylor & Miller, 1983) and biology (Ibáñez, 2004; Ibáñez *et al.*, 2008) of fishes from Hidalgo have been carried out, but there are few studies about their geographical distribution

(Soria-Barreto *et al*., 1996; Miranda *et al*., 2008). The knowledge of the distribution of a species is one of the first steps in the proposal of conservation practices and aids in improving management practices. This is particularly relevant to conservation of habitats with special interest from the point of view of biodiversity (e.g. Contreras-Balderas *et al*., 2002; Lozano-Vilano *et al*., 2007; Pinodel-Carpio *et al*., 2010).

During an ongoing study of freshwater fishes and environmental quality of the Metztitlán Canyon Biosphere Reserve (Pánuco Basin), specimens of goodeids belonging to the genus *Goodea* Jordan 1880 were encountered in several localities. The characteristics and importance of this species is discussed herein. We also present evidence to support the synonymy of *G. luitpoldii* (Steindachner 1894) and *G. gracilis* Hubbs & Turner 1939 with *G. atripinnis* Jordan 1880.

Fourteen localities along the Metztitlán River were sampled (Collecting permit SGPA/DGVS/060804/06) using a back-pack electrofishing unit (300-600 V, 0.2-2 A) in November 2007 and May 2008 (Fig. 1). Fish were anaesthetized with 2-phenoxyethanol (0.2 $mg \cdot l^{-1}$) before being sexed, measured (total length, in mm) and weighed (g). Preliminary field examination of the goodeids did not permit identification to species. Voucher specimens were euthanized by an overdose of anaesthesia and transported to the laboratory for taxonomic identification and study, where they were measured according to the protocol of Hubbs and Turner (1939). Specimens are deposited temporally in the Zoological Museum of the University of Navarra, Pamplona, Spain (MZNA 145270, 145492, 145493, 145495 and 145501) and they will be deposited in the Colección Nacional de Peces, Instituto de Biología, Universidad Nacional Autónoma de Mexico (CNP-IBH).

Of the 6,905 total fishes that were collected in the survey, only five specimens of *Goodea* were captured in three localities of the upper Metztitlán River (Table 1, Fig. 2). This is the first record of this genus for the state of Hidalgo; the area of its distribution is greatly expanded to the east, more than 170 km from the nearest locality of the genus. This new record, and that of *Girardinichthys viviparus* (Bustamante 1837) in Tecocomulco Lake (Miranda *et al*., 2008), are the easternmost reports of a species of Goodeidae. The family contains approximately 40 species of viviparous fish distributed primarily across the Mesa Central of central Mexico, although several species occupy Atlantic and Pacific systems that drain the margins of the southern high plateau. Ten of these species are endangered and three are extirpated from nature (Espinosa-Pérez *et al*., 1993; Miller *et al*., 1986). Human and industrial impact and habitat degradation are the major threats in its natural environment, along with the general disappearance of the natural environment by urban, agricultural and industrial water exploitation.

According to the William N. Eschmeyer's Catalog of Fishes (Eschmeyer & Fricke, 2009) and the FishBase (Froese & Pauly, 2009) online databases, three valid species of *Goodea* are recognized: *G. luitpoldii*, *G. atripinnis* and *G. gracilis*. The first species is endemic to the Lerma-Grande de Santiago basin, associated with the great lakes of Central Mexico (Hubbs, 1924). The synonymy of this name with *G. atripinnis* is widely accepted by the scientific community and the recognition of *G. luitpoldii* has not been supported in recent studies (*e.g.* Doadrio & Domínguez, 2004; Webb *et al*., 2004; Domínguez-Domínguez *et al*., 2006). An update of the information pertaining to the genus on databases is necessary.

Goodea atripinnis has a wide distribution across the Pacific Slope of Mexico, including the Lerma-Grande de Santiago Basin, Ameca River, Magdalena Lake and the Balsas and Armería Basins and it exploits different habitats in lakes, ponds, springs, outflows and streams (Miller *et al*., 2005; de la Vega-Salazar, 2006). *Goodea gracilis* is distributed in the Atlantic slope of Mexico in the Santa María River, the San Juan del Río, and other tributaries of the Pánuco basin in Querétaro and San Luis Potosí, typically in the headwaters. This species has been identified as vulnerable by the IUCN (Contreras-Balderas & Almada-Villela, 1996) and included in the last revision of imperilled North American freshwaters fishes (Jelks *et al*., 2008), whereas *G. atripinnis* is considered as a tolerant species (de la Vega-Salazar, 2006) and is not included in these Red Lists.

Goodea gracilis was originally considered to be a distinct species; however, the results of subsequent morphometric and molecular analyses conflict on this point (Webb, 1998; Webb et al., 2004). Described by Hubbs and Turner in 1939, *G. gracilis* was distinguished from *G. atripinnis* by three relative measurements: 1) greatest depth 3.3 to 3.7 *vs*. 2.6 to 3.2 in standard length (respectively), 2) least depth about half *vs*. two-thirds length of head and 3) width of mouth usually about 2.5 *vs*. 3.0 in head length. Simply, *G. gracilis* was distinguished from *G. atripinnis* by its slender form. In the specimens of the present study these measurements are not conclusive (Table 1): the greatest depth corresponds to that of *G. gracilis*, the least depth corresponds to *G. atripinnis*, and the width of the mouth is intermediate between those given for the two species. Taking into account the natural distribution of these species, fish captured in the upper Metztilán River should be assigned to *G. gracilis*. However, these taxonomic characters are not sufficient to differentiate between these specimens and *G. atripinnis*.

Body measurements related to degree of elongation are variable and reflect principally environmental conditions: fishes living in fast flowing water have a more streamlined, hydrodynamic body (Riddell & Leggett, 1981; Pakkasmaa & Piironen, 2001) than those living in lakes and ponds. A study of the genetic and morphological differentiation (including jaw shape and body depth) of specimens from a stream population of *G. atripinnis* suggested that stochastic factors (seasonal reductions in stream flow, behaviour) were involved in this differentiation (White & Turner,

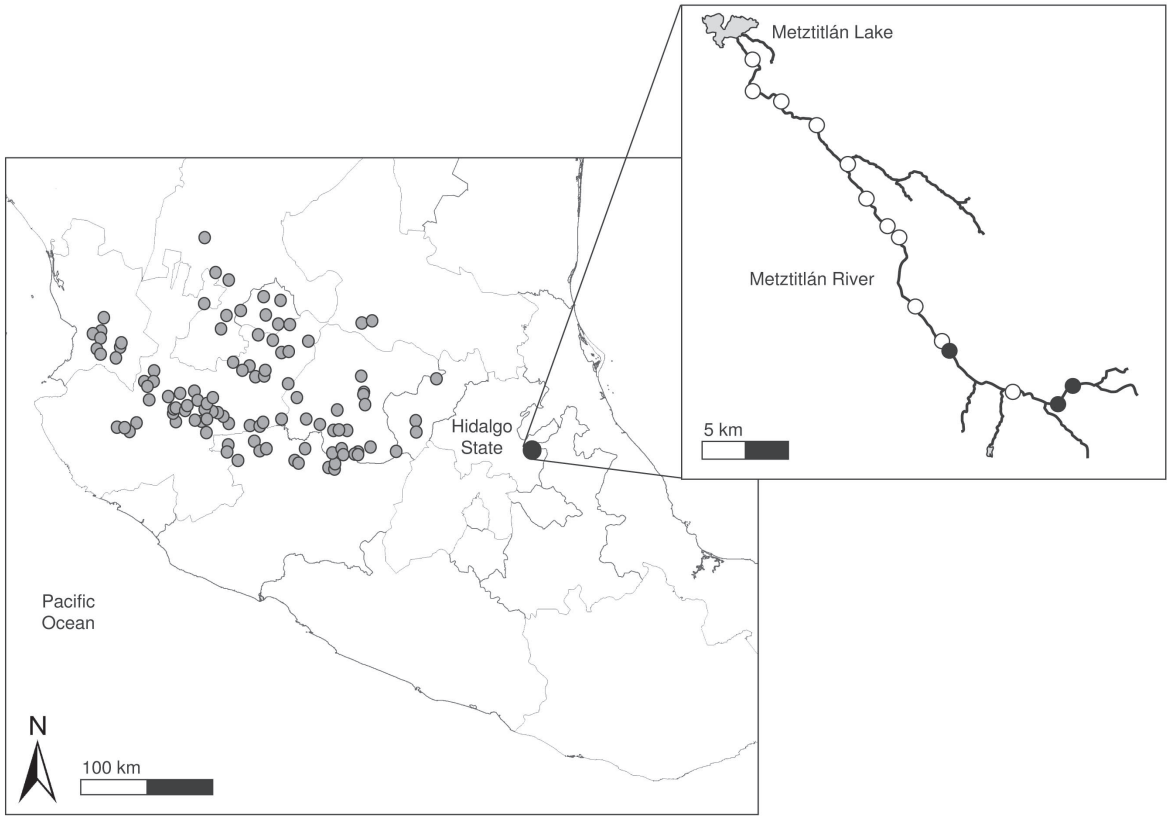

Figure 1. Distribution of *Goodea atripinnis* Jordan 1880 according to Miller *et al*. (2005) (grey circles). In the box, sampling points in the Metztitlán River with non-occurrence (white circles) and occurrence (black circles) of this species.

1984). Thus, biometric characters do not appear to be sufficient to differentiate species of *Goodea*, and some researchers think that the specific status of *G. gracilis* (Webb *et al*., 2004; Miller *et al*., 2005) is inconsistent and consider the genus to be comprised of only a single species, *G. atripinnis*. However, *G. gracilis* is present as a unique species in FishBase and the IUCN Red List, and has been accepted in some recent studies (Doadrio & Domínguez, 2004; Domínguez-Domínguez *et al*., 2006; Jelks *et al*., 2008) as a separate species.

According to Webb (1998), Webb *et al*. (2004) and Miller *et al*. (2005), and considering that these relative measures are not consistent characters for the differentiation of goodeids at the species level, the specimens from Metztitlán River are assigned to *G. atripinnis*, *G. gracilis* being a junior synonym of the former. However, a thorough revision of this genus is necessary, if possible including specimens from all known localities for evaluation using molecular techniques. As well, taking into account the different consideration of the IUCN Red List and Jelks *et al*. (2008) of these putative species, the correct determination of these taxa would have serious consequences in the conservation and management policies in a Biosphere Reserve such as Metztitlán Canyon. Finally, it should be noted that no species of *Goodea* is included in the Norma Oficial Mexicana (NOM-059-ECOL-2001; NOM, 2001) , the Mexican federal government's list of native species that are recognized as being in risk of extinction. A thorough study of the genus would provide a scientific basis for the status of the species in this list.

Goodea atripinnis Jordan, 1880 (Figure 2)

G. luitpoldii (Steindachner 1894).

G. gracilis Hubbs and Turner 1939.

Diagnosis. Dorsal fin with 12 to 15 rays. First six anal fin rays of male with comprising an anterior lobe; head length less than body depth. Secondary teeth are bifid and compressed longitudinally. Snout is triangular and elongated in a lateral view.

Description. Based on five studied specimens, original descriptions of *G. atripinnis*, *G. luitpoldii* and *G. gracilis*, and anatomical description of Kobelkowsky (2005). Body elongate, considerably compressed, and the dorsum nearly straight, little elevated. Caudal peduncle deep, about half length of head length in adult. Depth of body variable, 2.6 to 3.7 in the standard length (Hubbs & Turner, 1939). Intestine is elongate, with about 12 transverse segments.

Eye moderate (25 to 30% of head length) directed partly downwards, somewhat longer than snout. Head short and depressed,

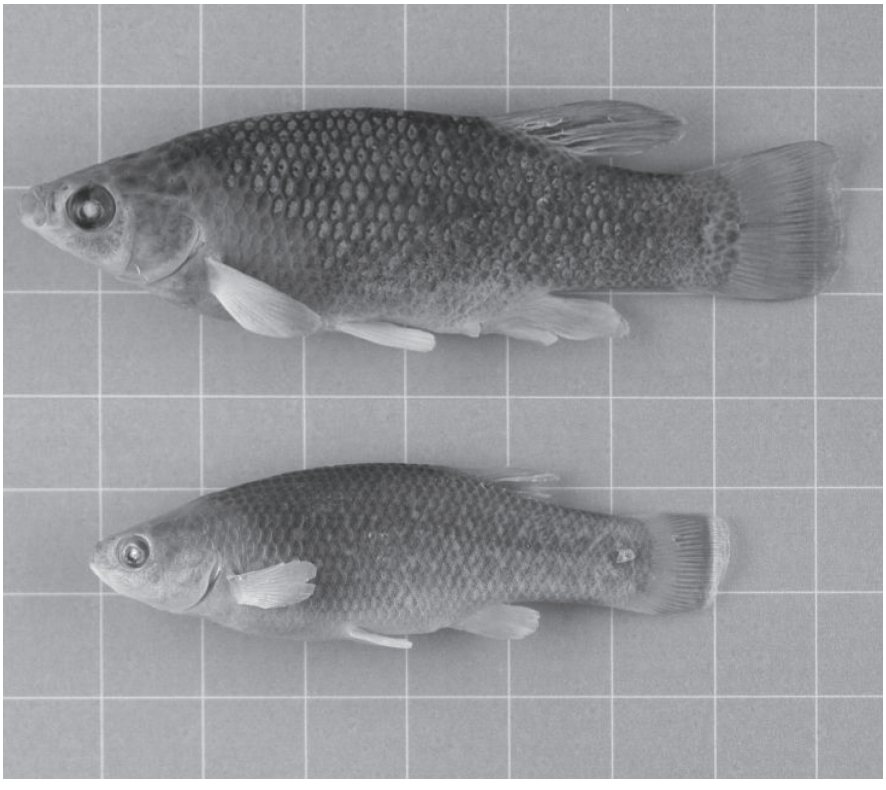

Figure 2. Specimens of *Goodea atripinnis* Jordan 1880 on 1 cm grid. CHE 145492, male (upper; 70 mm SL) and MZNA 145493 female (55 mm SL) captured in the Metztitlán River (Hidalgo, Mexico).

triangular and rather pointed in a lateral view. Interorbital space is broad. Mouth moderately wide with a nearly vertical gape.

Teeth of even outer row uniformly bifid, with truncated lobes; long and slender, much compressed longitudinally, rather strongly curved backward; about 40 in each jaw, more or less regularly alternating; very loosely attached to the extremely narrow, weak, and poorly joined jaws (Hubbs & Turner, 1939). Gill-rakers on first branchial arch relatively long, number about 39 to 45.

Dorsal fin with 12 to 15 rays, modally 13, pectoral fin with 14 to 16, modally 15, pelvic fin with six rays, anal fin with 13 to 16, modally 16, anal of male with six of these rays comprising anterior lobe, the gonopodium, separated by notch from remainder of fin (Kobelkowsky, 2005), and caudal fin with18 to 21 rays, modally 19. Origin of dorsal fin slightly behind that of anal (rarely on the same vertical) in females and low males, usually directly over anal origin in well-developed males. Dorsal fin rounded and elongated. Posterior margin of caudal fin weakly rounded. Vertical fins dark, becoming deep dusky in adults; pectoral pale dusky; pelvic clear, mottled, or uniformly dark.

Scales rather large, 38 (35 to 40) in a longitudinal series, and 13 (12 to 16) in a transverse row. Sides with brown spots and blotches thickly set on a cream background. Larger adults are almost uniform, deep purplish brown to dusky green, except on yellowish belly. Young with relatively few blotches, mostly vertically elongate, scattered over sides. The blotches disappear in matures, however, the colour pattern of the adults in both sexes consists of longitudinal stripes between the scale rows (Kobelkowsky, 2005).

Distribution. Central Mexico: Lerma and Grande de Santiago basin and former parts of this system, including the Ameca River drainage and endorheic Magdalena Lake, Balsas River and Armería basins and independent Pacific tributaries in Nayarit, and immediately adjacent waters in Jalisco and Michoacán, Santa María and San Juan del Río Rivers in the Atlantic slope, and the upper tributaries of the Pánuco basin in Querétaro and San Luis Potosí (Miller *et al*., 2005) and upper Metztitlán River, Hidalgo.

Specimens examined. One specimen MZNA 145270: Metztitlán River in Padre Nuestro (Hidalgo, Mexico); 20º20'18''N, 98º36'37''W; coll. Vilches & Miranda (44 mm SL); One specimen MZNA 145492: Metztitlán River in El Xúchil (Hidalgo, Mexico); 20º16'31''N, 98º30'05''W; coll. Galicia & Miranda (70 mm SL); three specimens MZNA 145493-145495-145501: Metztitlán River in El Chilar (Hidalgo, Mexico); 20º17'51''N, 98º27'57''W; coll. Galicia & Miranda (55-108 mm SL).

Table 1. Records of *Goodea atripinnis* captured in Metztitlán River (Hidalgo, Mexico), relative body measurements and comparison with relative lengths used by Hubbs & Turner (1939) to distinguish *G. atripinnis* and *G. gracilis*. SL, standard length; GD, greatest depth respect to standard length; LD, least depth respect to head length; WM, width of mouth respect to head length.

code	Locality	Coordinates		Altitude (m)	Date	SL	GD	LD	WM
		Latitude	Longitude						
145270	Padre Nuestro	20º20'18''N	98º36'37''W	1452	11/09/07	44	3.3	0.63	2.5
145492	El Xúchil	20º16'31''N	98º30'05''W	1632	04/29/08	70	3.3	0.69	2.6
145493	El Chilar	20º17'51''N	98º27'57''W	1694	04/29/08	55	3.2	0.68	2.6
145495	El Chilar	20º17'51''N	98º27'57''W	1694	04/29/08	43	3.5	0.61	2.8
145501	El Chilar	20º17'51''N	98º27'57''W	1694	04/29/08	108	3.5	0.61	3.0
	Goodea of Metztitlán (average)						3.3	0.64	2.7
	G. atripinnis (according to Hubbs & Turner (1939))						2.6-3.2	0.67	3.0
	G. gracilis (according to Hubbs & Turner (1939))						3.3-3.7	0.50	2.5

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