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A Novel Killifish Species (Teleostei: Fundulidae) Discovered in the Upper Río Soto La Marina Basin, Nuevo León, Mexico: Fundulus herminiamatildae

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Abstract: Fundulus herminiamatildae sp. nov. Is endemic from the Marmolejo stream, a head water tributary of Río Soto La Marina basin, in the municipality of Aramberri, Nuevo León, México. Geologically, it is located in the Northeastern province of México, specifically in the Sierra Madre Oriental subprovince. The water temperatura is a determinant and important factor for the species differentiation. Its closest relative is F. philpisteri. Fundulus herminiamatildae is distinguished from other killifishes by a large number of conspicuous and simple lateral bars, body with high profile, and the following proportions in cephalic length: snout (2.52.9, mean 2.7) eye diameter (4.1-4.9, mean 4.5), and Preorbital length (2.7-3.1, mean 2.9).
Keywords: Fundulus herminiamatildae – Mexico – Marmolejo stream – Río Soto La Marina-New species.

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The genus Fundulus Lacèpède, 1803 belongs to the American cyprinodontiform family, Fundulidae (Parenti, 1981), of Gondwanan origin (Nelson, 2006). This genus includes euryhaline and eurythermic species in habiting desertic and semi-desertic areas, springs, rivers, and lagoons of North America, including coastal areas in México. It is composed of approximately 40 species (Miller, 1955; Mayden et al. 1992; Nelson, 1994; García-Ramírez et al. 2006) among which eight are found in Mexico: Fundulus grandis Baird & Girard, 1853 in States of Tamaulipas and Veracruz; F. grandissimus Hubbs, 1936 in North of Yucat an and Quintana Roo, F. persimilis Miller, 1955 Northern of Yucatan; F. lima Vaillant 1894; F. parvipinnis Girard, 1854 Baja California peninsula; F. philpisteri García-Ramírez et al., 2006 in Nuevo Léon; F. similis (Baird & Girard, 1853) in Tamaulipas and F. zebrinus Jordan & Gilbert, 1883 an exotic species in Mexico, found in Chihuahua. Currently, F. grandissimus and F. persimilis, are respectively considered as vulnerable and endangered species in the IUCN Red List of Threatened species (Collette, B, et al. 2015; Jelks, H., et al. 2015) and are under a special protection in México by NOM-059-ECOL-2001 (Norma Official Mexican). In addition, F. philpisteri presents amore alarming status, it is classified as a critically endangered species (Maíz-Tome, L. 2019) due to its fragile habitat and specialization. In México García-Ramírez (1997) reported that the population of Arroyo Marmolejo was different from Fundulus grandis.
The aim of this paper is to provide a morphological description of a new species (F. herminiamatildae) on the basis of specimens from a head water stream (ArroyoMarmolejo) of the Río Soto La Marina basin, in the municipality of Aramberri, Nuevo León, México.

Additionally, we compared morphological caracter soft his new species with those of termal spring (F. philpisteri) and estuarine/fresh water environments (F. grandis) in order to determine diagnostic and description characteristics.

2. Methods

The specimens examined of the genus Fundulus for this study were collected along coastal environments, comprising the Laguna Madre Tamaulipas system, including its associated streams, and in headwater streams of the San Fernando and Soto La Marina river basins, between 1966-2004 (Fig. 1). The examined material was housed at the Fish Collection of the Facultad de Ciencias Biológicas, Universidad Autónoma de Nuevo León (UANL) and several paratypes were deposited indifferent institutions: Museum of Zoology University of Michigan (UMMZ–248753), Tulane Museum of Natural History (TUHC–204176), University of Texas at Austin (TNHC–39831), Escuela Nacional De Ciencias Biológicas, Instituto Politécnico Nacional (IPN–ENCB–P5592), United States National Museum (USNM–391644).

Abbreviations for institutions and collections cited follow Leviton et al. (1985). The examined specimens were catalogued with the acronymous, number of catalog, number of specimens, standard length as minimum and maximum in millimeters, locality, basin, state, country, collector(s), and collecting dates were added.

Thirty-five body measures and 16 meristic characters of the standardized method of Hubbs and Lagler (1958) were considered for the morphometric analysis of the specimens (Fig.4). All the measurements were made on the left side of each specimen using a digital caliper (precision, 0.01 mm). Proportions are expressed in base of the TSL= times in standard length; TCL = times in cephalic length. Count sof the cephalic pores follow Gosline(1949) were considered.

For a multivariate approach a canonical discriminant function was realised using SPSS (version10.0) was performed. To carry out this analysis, we examined 20 specimens of Fundulus grandis (Laguna Madre, Tamaulipas), 18 specimens of F. philpisteri (Baño de San Ignacio, Linares, Nuevo León) and 15 from specimens of F. herminiamatildae (new species of Marmolejo stream, Aramberri, Nuevo León).

2.1. Comparative material. Fundulus philpisteri. - Baño de San Ignacio springs, Linares, Nuevo León, México, Río San Fernando: UANL 15031 (26:28-83.7mm); Coll.: S. Contreras-Balderas and grupo de la Universidad Autónoma de Tamaulipas; 7 Sep. 2001; UANL 9031 (1: 63.4 mm); Coll.: S. Contreras-Balderas and A. Contreras-Arquieta; 6 Aug. 1988; UANL 11146 (5:31.6-37.3 mm); Coll.: S. Contreras-Balderas, M. L. Lozano-Vilano, M. E. García-Ramírez, and A. J. Contreras-Balderas, 12 oct. 1992; UANL-16147 (1:
56.1mm); Coll.: M. L. Lozano-Vilano, A. J. Contreras-Balderas, Jorge A. Contreras-Lozano and J. E. LozanoVilano, 23 jul. 2004.

Fundulus grandis. - Río Bravo: UANL 2138 (34:35.2-71.0 mm) Presa Falcón cerca de Nueva Cd. Guerrero, Tamaulipas, México; Coll.: S. Contreras-B. and Gpo. de Fac. de Biología, 29 Jul. 1975; UANL 1523 (4:31.3-48.4mm) Presa Marte R. Gómez, 6 km NNW of Comales; Coll.: S. Contreras-B. and Gpo. FCB, 24 Sep. 1973; UANL 6154 (25:50.6-61.3 mm) Río Bravo en Miguel Alemán; Coll.: S. Contreras-B. and Gpo. FCB, 30 Jul.1982; UANL 6097 (1: 31.6 mm) Río Bravo en Matamoros; Coll. S. Contreras-B. and Gpo.
FCB, 28 Jul. 1982; Coll.: S. Contreras-B., A. Gómez-S., and Gpo. Biol. de Campo, 8 Sep. 1990; UANL 11454 (13:66.5-81.4 mm) Río San Juan bajo puente Carr. México 2km W of Camargo, México; Coll.: A. J.
Contreras-B., P. J. Rodríguez-B.and J. A. Bernal, 1 Apr. 1977; UANL 2126 (1: 35.0 mm) Boca del Río Bravo;
Coll.: S. Contreras-B. and Gpo. FCB., 28 Jul. 1975; UANL 4181 (1: 47) Río Álamo en la desembocadura al Río Bravo, México; Coll.: G. Ruíz-C., H. Cirilo-S., H. Torres-M. and D. J. Castillo-R., 18 Dec. 1981; UANL 6128 (3:21.6-47.0 mm) Río Bravo en Parque Anzaldúas, México; Coll.: S. Contreras-B., S. Contreras-A., A.
Contreras-A. and A. Contreras-A., 29 Jul. 1982. Laguna Madre; UANL 7936 (7: 57.4-83.8 mm) Punta de la
Media Luna (No San Luis Potosí), México; Coll.: A. Gómez-S, C. Rosario-R., and J. Rabago-C, 24 May 1986; UANL 10466 (18:37.2-50.8 mm) Laguna Almagre, México; and UANL 5320 (9:61.7-95.5 mm) Río San Juan en

el Salto, 6 km NE de los Aldabas, Nuevo León, México; Coll.: C.M. Villarreal-T., M. E. Obregón-M. and J. F. Lozano-M., 3 May 1982.

3. Results

FUNDULUS HERMINIAMATILDAE SP.NOV.

(Table I, Fig. 3) Material examined

3.1. Holotype. - UANL-18803, adult male, 88.7 mm SL; Marmolejo stream, Aramberri, Nuevo León, México, Soto La Marina River basin (24° 09' 38.6" N 99°45'15.7" W); Coll.; S. Contreras-Balderas, M. L. Lozano-Vilano, M. E. García-Ramírez, A. J. Contreras-Balderas and T. Rodríguez; 28 Apr. 1992.

3.1.1. Paratypes. - UANL-13613 (36: 106.4-30.4 mm SL), same data as holotype, UANL-16160 (29: 87.4-32.0 mm SL) stream at SW of El Porvenir, Nuevo León, México; Coll.: M.L. Lozano-Vilano, A. J. Contreras-Balderas, J. A. Contreras-Lozano, and J. E. Lozano-Vilano; 25 Jul. 2004; UANL-16161 (22: 55.140.1 mm SL) small pond at the SW of El Porvenir; Coll.: M. L. Lozano-Vilano, A. J. Contreras Balderas, J.A. Contreras-Lozano and J.E. Lozano-Vilano; 25 Jul. 2004; UANL 6448 (7: 38-67 mm LP) Río Blanco at 7 Km N of Aramberri; Coll.: Salvador Contreras-B., H. Obregón-B. and A. Contreras-A., 20 Nov.1985; UANL 6447(35:37-86) RíoBlanco 4km from Aramberri; Coll.: S. Contreras-B., H. Obregón-B. and A. Contreras-A., 20 Nov. 1985; UANL 1149 (16:36-83) Río Aramberri, 3km NE of Aramberri; Coll.: F. Jiménez-G., A. Rodríguez, and R. Banda, 7 Aug. 1968; UANL 1133 (145:29-86) 5 km NE of Aramberri; Coll.: S. ContrerasB., D. Molina, and J. A. Martínez, 24 Apr. 1966; UANL 13617 (21:29-79) Arroyo 4 km E of Aramberri; Coll.: S. Contreras-B and Grupo FCB, 13 Dec. 1987; UANL 15696 (41: 72.6-26.9) Arroyo Aramberri; Coll.: M.L. Lozano-V., A. J. Contreras-B., J. A. Contreras-L., and J. E. Lozano-V., 25 Jul. 2004; UANL 16160 (29: 89.1-30.4) Arroyo al SW del Porvenir; Coll.: M. L. Lozano-V., A. J. Contreras-B., J. A. Contreras-L. and J. E. Lozano-V., 25 Jul. 2004; and UANL 16161 (22: 57.3-33.7) Charco al SW del Porvenir; Coll.: M. L. LozanoV., A. J. Contreras-B, J. A. Contreras-L. and J. E. Lozano- V., 25 Jul. 2004.

4. Discussion

4.1. Diagnosis. Fundulus herminiamatildae is distinguished from the other species in northeastern Mexico, using the following combination of characters: 12-17 conspicuous and simple lateral bars, subangular head, thickened body, and slightly convex predorsal profile. Proportions in SL of the new species (Table II) and its comparison with other relatives is as follows: head length of 2.9-3.5 (3.2) (mean is shown in parenthesis), versus 3.0-3.3 (3.2) in F. grandis and 2.8-3.2 (3.0) in F. philpisteri; anal fin origin-hypural length of 2.6-3.0 (2.8) versus 2.6-2.8 (2.6) in F. grandis and 2.7-3.3 (3.0) in F. philpisteri; caudal peduncle short of 3.9-4.2 (4.1) versus 3.4-4.1 (3.8) in F. grandis and 3.9-4.7 (4.2) in F. philpisteri; snout-pelvic origin length of 1.7-2.0 (1.8) versus 1.9-2.1 (2.0) in F. grandis and 1.8-2.2 (1.9) in F. philpisteri; dorsal-anal origin length of 3.7-4.3 (3.9) versus 3.7-4.6 (4.1) in F. grandis and 3.9-4.9 (4.3) F. philpisteri; least depth short of 5.4-6.9 (6.1), versus 5.7- 6.4 (6.2) in F. grandis and 6.0-7.1 (6.6) in F. philpisteri.

Proportions in head length (HL, Table II) of the new species are pelvic-pectoral origin length of 3.5-4.5 (4.1) versus 4.8-5.3 (5.0) in F. grandis and 3.6-5.0 (4.4) in F. philpisteri; the organism is also characterized by big snout of 2.5-2.9 (2.7) versus 3.1-4.0 (3.5) in F. grandis and 2.5-3.4 (3.2) in F. philpisteri; small eyes of 4.1-4.9 (4.5) versus 3.8-4.4 (4.0). In F. grandis and 3.1-4.8 (4.0) in F. philpisteri; preorbital width of 2.7-3.1 (2.9) versus 3.2-3.7 (3.4) in F. grandis and 3.0-3.8 (3.4) in F. philpisteri; anal length depressed to 1.3-1.9(1.5) versus1.3-1.4(1.3) in F. grandis and 1.3-2.1(1.6) in F. philpisteri.

The canonical discriminant analysis showed that the three species compared here can be separate completely (Fig. 2). A total of 35 morphometric variables on 15 specimens of F. herminiamatildae, 18 of F. philpisteri, and 20 of F. grandis were compared and analyzed through discriminant analysis. The Wilk's Lambda values changed from 0.001 to 0.056, which was interpreted as firm discrimination among the compared species.

Canonical functions 1 (F1) and 2 (F2) explained 75.2% and 24.8% of variance ($p<0.000$) respectively.

4. 1. 1. Description. The physiognomy of the Holotype is shown in figure 3 and its morphometric characters are presented in tables I and table II with comparison of more distinctive features in proportional measures in the three species. The characters observed in both the sexes include wide preorbital 2.7-3.1(2.9) times of the head length (the average is shown in parenthesis); small eyes of 4.1-4.9 (4.5) times of the head length, located closer to the snout tan the operculum, snout projected up ward, dorsal fin inserted slightly in front of the anal origin, reaching three-fourths of the caudal peduncle, flattened occipital region, rounded anal dorsal, pectoral, and pelvic fins.

The following characteristics were observed among males: thickened body, with body depth higher tan the females; nuptial tubers above the dorsal and ventral zone; dorsal, anal, pectoral, and caudal fins; long dorsal and anal fins projected three-fourths over the caudal peduncle; and pectoral fins extended until or beyond the anus.

The females possesse longated body; short pelvic fins, not reaching the anus; and dorsal fin extended to the half of the caudal peduncle.

The meristic data are as follows (holotype in parenthesis): fin rays: dorsal 9-11(11); anal 9-11(11); pectorals 15-19 (18); pelvics 5-7 (7); and caudal 18-20(18). Scales: lateral Line 35-38 (37); dorsal to anal 1215(13); dorsal-pelvic insertion13-15(13); predorsals 21-24(21); around caudal peduncle 21-27(22); around the body 31-37(35); gill rakers 9-12 (9); and head pores: mandibulars 5(5); cephalic8-9(9), lachrymals 4(4); and Preoperculars 7(7).

4.1.1. 1. Coloration. Live coloration.- Mature males with body and posterior part of dorsal fin olive with white spots; pectorals, pelvics and anal fins orange, anal with white spots, caudal yellowish or olive with white spots, body side with 13-17 conspicuous dark bars (juveniles with bars more evident).

Mature females with head bluish, body yellow is hand ventral región cornsilk, sides with13-17 conspicuous dark bars; all fins oranges.

4.1.2. Preserved specimens.- Males body well-pigmented in the dorsal región with dark-brown head; orange ventral region) body and dorsal fin, anal and caudal with colorless spots; 13-17 simple and double conspicuous lateral bars (better marked in juveniles than in adults).

Females: melanophores in the anterior part of the body and head.

4.1. 2. 2. Sexual dimorphism. Males have deeper bodies and generally longer fins tan females. Nuptial tubercles presents in body and fins. Females as in the other members of the species flock had a membranous bag extended to the third or fourth anal radius.

4.1. 2. 2. 2. Habitat and associates. The Marmolejo área is located 11 km downstream the river of the city hall of Aramberri, Nuevo León, in the physiogeographical subprovince of plains and hills (SPP, 1985). The average altitude of the área is 930 masl. The local fish assemblage of F. herminiamatildae sp. nv. Comprises Xiphophorus xiphidium and Cyprinella sp. The hábitat consist of cold mountain streams with rocky bottoms and riparian vegetation composed by syxamore trees (Platanus occidentalis) and mule fat (Baccharis salicifolia).

4.1.3. Etymology. The scientific name of herminiamatildae is patronymic for Herminia Ramírez and Matilde García, parents of the main author, who were important pillars in the profesional and personal growth of the author, and who have a great respect for nature.

4. 1.3.1 Distribution. Fundulus herminiamatildae sp. nov. is endemic to the surrounding área of Aramberri, in the upper Soto La Marina River basin, Nuevo León, México (24°09’38.6”Nand 99°45’15.7”W).

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