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Four new species of *Cyprinodon* from southern Nuevo León, Mexico, with a key to the *C. eximius* complex (Teleostei: Cyprinodontidae)

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Four new species of *Cyprinodon* are described from springs in a previously unreported fossil lake (playa), from Southern Nuevo León, México: Bolsón de Sandia (=Pluvial Lake Sandia). They are distinguished from all others by the following characters: *Cyprinodon longidorsalis*, from Charco La Palma: large dorsal fin, reaching caudal fin when depressed, inserted in advance of pelvic fins; commissural fold wide; fourth ceratobranchial usually with 2 teeth. *Cyprinodon inmemoriam*, now extinct, from La Trinidad: fourth ceratobranchial with 0 to 4 teeth; short maxilla, 0.68 times in anal fin base; postdorsal to postanal length short, 0.8 times in caudal peduncle length; head 3.0 times in SL; anal base 3.3 times in head length; in males, head and body greyish blue, bars obsolete. *Cypinodon veronicae*, from Charco Azul: maxilla short, 0.70-0.77 times in anal fin base; head large, 2.7-2.9 times in SL; in males, 6-7 diffuse dark bars on upper half of body; in females, dorsal fin with irregular ocellus whose black spot is half-moon shaped, smaller than pupil. *Cyprinodon ceciliae*, presumably extinct, from La Presa in San Juan de Avilés: nuptial males with 7-8 well marked black bars, all extending to belly; in females, dorsal fin blackish in the proximal two thirds, ocellus a round black spot usually smaller than pupil, anal frequently with dark spot posteriorly and near the base. The long dorsal fin of *C. longidorsalis* is unique in the genus. Several other characters are shared with other species and are diagnostic only in combination. These species are compared with *C. alvarezi*, their hypothetical closest relative. Descriptions, coloration, results of a discriminant analysis and a key to the *C. eximius* complex are included.

Se describen 4 especies de peces *Cyprinodon* del Sur de Nuevo León, México, localizadas en un lago fósil indescrito que llamamos Bolsón de Sandia (=Pluvial Lake Sandia). Se distinguen entre sí por las siguientes características: *Cyprinodon longidorsalis*, de Charco La Palma: aleta dorsal muy larga, deprimida alcanza la caudal, su orígen delante de las pelvicas; pliegue comisural amplio; cuarto ceratobranquial con 0-2 dientes. *Cyprinodon inmemoriam*, ahora extinto, de La Trinidad: cuarto ceratobranquial, 0-4 dientes; maxila muy corta, 0.68 en la base anal; distancia postdorsal-postanal corta, 0.8 en el pedúnculo caudal; cabeza 3.0 en la longitud patrón; base anal 3.3 en la longitud cefálica; macho: cabeza y cuerpo azul grisáceo, barras obsoletas. *Cyprinodon veronicae*, de Charco Azul: maxila corta, 0.71-0.77 en la base anal; cabeza grande, 2.7-2.9 en longitud patrón; macho: 6-7 barras oscuras laterales difusas, que cubren la mitad dorsal del cuerpo. Hembras: aleta dorsal con ocelo irregular, su lunar negro en media luna, menor que la pupila. *Cyprinodon ceciliae*, de la Presa, San Juan de Avilés: Machos nupciales: 7-8 barras notorias extendidas en el vientre. Hembra: aleta dorsal negruzca en los $^2/_3$ proximales, ocelo central redondo menor que la pupila; anal frecuentemente con lunar negro posterior y cercano a la base. La dorsal deprimida muy larga de *C. longidorsalis* es única en el género. Varias características son compartidas en el grupo y son diagnósticas sólo en combinación. Se comparan con *C. alvarezi*, hipotéticamente su pariente mas cercano. Se incluyen descripciones, coloracion en vivo, además del resultado de un análisis discriminante, con gráficas. Se presentan claves para las especies descritas del complejo *C. eximius*..

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Introduction

Except for Miller (1986), few integrated fish faunal studies are available for the Central Plateau, Nuevo León, México; isolated studies of its species are common. The central plateau is an arid region with both arheic and endorheic basins. Many streams are intermittent and temporary, with no fishes; some springs, however, harbor a few highly endemic forms. Until 1983, only two fish species were known from the Nuevo León portion. Both were cyprinodontids: *Megupsilon aporus* Miller & Walters, 1972 (a monotypic genus) and *Cyprinodon alvarezi* Miller, 1976, both known only from Ojo del Potosí, near Ejido Catarino Rodríguez. One of us (SCB) photographed a nearby playa (bolsón) having several springs, from a commercial flight during 1983. In 1984, three flowing springs were located in the area, and a fourth one in 1988. Each spring had its undescribed endemic pupfish. They belong to the *C. eximius* complex as defined by Miller (1976). The four new species apparently form a monophyletic lineage closely related to *C. alvarezi*. Two of the springs dried up and their respective endemic pupfish species disappeared while being studied and are probably extinct. The other two new endemic species and both Potosí species are strongly endangered by a lowering of the water table caused by agricultural overexploitation of groundwater in the area. We recognized the four new endemic forms as undescribed species, describe them below and discuss their status.

Description of the area

The Valley of Sandia, whose bottom lands, or Llanos de Salas (= Bolsón de Sandia), contain a previously unreported dry lake bed of unknown age, between 99°49' and 100°46'W, 25°00' and 32°25'N (Fig. 1 A); we propose the name Bolsón de Sandia (= Pluvial Lake Sandia) for this lake bed. The valley contains two surface subbasins, rising respectively from NE and SE, forming pluvial fans of intricately anastomosing distributaries, both extending towards the center of the valley (Fig. 2). Going from historical to geological times, numerous dry springs and a large river were present here, but now water is restricted to a few headsprings. The valley is surrounded by low mountains, except for the Sierra Montelongo Pedregoso (Fig. 1 B; 3,200 m asl). Two low canyons are were former tributaries, entering the valley from NW and N: the first is the old outlet from a canyon lying to the SE. The second is composed of two branches, one coming from the Potosí Valley (Fig. 1 C), and the other from the Hediondilla valley (Fig. 1 D). Miller & Walters (1972) erroneously used the name Hediondilla for the Potosí Valley. Other important features are Sierra del Potosí, highest peak 3700 m asl, and Sierra del Orégano, between Potosí and Hediondilla (Fig. 1 F, 2570 m asl). According to SPP (1981), the valley of Sandia is in the municipality of Aramberri, and Hediondilla-Potosí are in Galeana, both in Nuevo León.

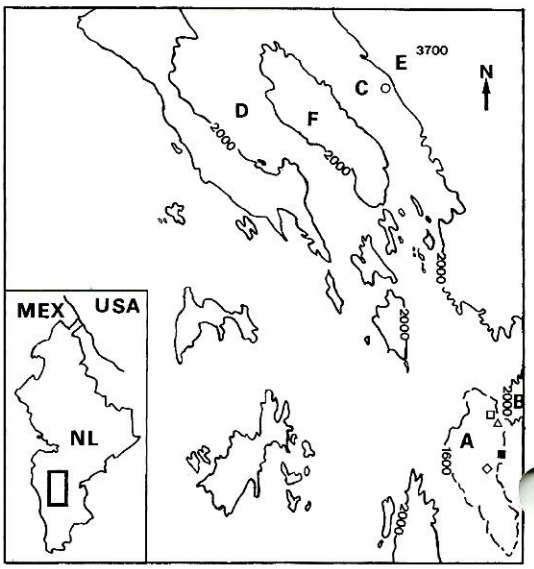


Fig. 1. Map of southern Nuevo León, México, showing the following springs and other landmarks, north to south: El Potosí, La Presa, Charco Azul, La Trinidad (fish gone in 1985, spring dried around 1986), Charco Palma. A, Bolsón de Sandia; B, Sierra Montelongo Pedregoso; C, Potosí valley; D, Hediondilla valley; E, Sierra del Potosí; F, Sierra del Orégano. Inset map shows the state of Nuevo León and the location of study area.

General physiognomy of the area is shown in Figure 2. The following data were extracted from SPP (1981): climate in the floor of Bolsón de Sandia is BSo hx' (Dry; Semi Hot Dry). The Potosí area is BS1kx' (Semi Dry Temperate). Soils at Sandia are sodic-haline; at Potosí they are haline or sodic-haline.

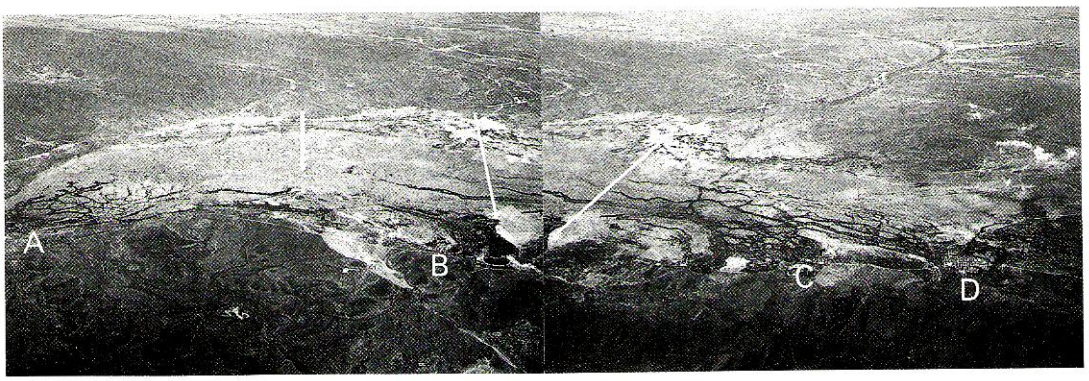


Fig. 2. The dry Bolsón de Sandia (Pluvial Lake Sandia) in 1983, seen on eastern views. Note the shape of the old lake bed, the complex old channels, marked by cedar woods seen as darkstripes. Towns are: A, La Soledad; B, La Trinidad; C, San Juan de Avilés; and D, Sandia. Arrow indicates Charco Palma. The black lines near the center connect common points in both original photographs. Photos SCB.

Vegetation comments are given in the species accounts. This area is at the SE limits of the Chihuahuan Biotic Province (Miller, 1981), and at the western piedmont of the Sierra Madre Oriental Physiographic Province (SPP, 1981).

Material and methods

The type material has been deposited in the following institutions: AMNH, American Museum of Natural History; IPN-ENCB, Instituto Politécnico Nacional; TNHC, University of Texas Natural History Collections; TU, Tulane University Museum of Natural History; UAIC, University of Alabama Ichthyological Collections; UANL, Universidad Autónoma de Nuevo León; UMMZ, University of Michigan Museum of Zoology; UNAM, Universidad Nacional Autónoma de México.

Counts and measurements (in thousandths of SL) follow Miller (1943), and Hubbs & Lagler (1947). We aplied multivariate statistics using discriminant analysis by SPSS (version 83 - ABS6-NOS/BE, 1982). Abbreviations used in descriptions are: SL, standard length; CS, cleared and stained; HL, head length; P2, pelvic fins; the postdorsal-postanal distance measurement is the distance between the bases of the last dorsal and the last anal fin rays. In Material examined, geographical data after locality are presented as country, state, municipality, and region; initials of the collectors were used after the first use of the name in full.

Definition of the group

The four new species form a close assemblage, with a number of characters shared with *C. alvarezi*. The five species have four lachrymal (*C. alvarezi* sometimes has only three) and two mandibular pores. They all have widely overlapping counts of scales, fin rays, gill rakers, and cephalic lateralis pores, except preopercular ones. Head and anterior body of mature males are covered with numerous small tubercles, giving them a rough appearance. All have metallic blue mature males, although shades and color distribution may vary with season and species. The four new species share the following characters: iris of eye with two color rings, the inner golden yellow and the outer pale yellow, distinct from the all blue eye of *C. alvarezi*; each ring covers about half of the iris. Males have a slightly to strongly diamond-shaped body, as do most members of the genus.

Cyprinodon longidorsalis, new species
(Figs. 3a, 4a)

Holotype. UANL 8281, mature male, 40.6 mm SL; Charco la Palma (24°04'N 100°05.3'W), México, Nuevo León, Aramberri, interior basin of Llanos de Salas; M. L. Lozano V., A. J. Contreras B., B. Jensen, P. Barrón R., 17 June 1988.

Paratypes. All from the type locality: UANL 8282, 1: 26.8 mm SL; same data as holotype. -

UANL 8283, 4: 29.0-39.9 mm SL, UNAM IB/CML-P 3235, 2; S. Contreras B., MLLV, AJCB, PBR, 31 October 1987. - UANL 8284, 5: 30.2-35.4 mm SL, UMMZ 215481, 2, UANL 8285, 1: 36.7 mm SL, CS; MLLV, AJCB, PBR; 13 March 1988. - UANL 8286, 2: 44.8-51.4 mm SL; UANL 8317, 1: 37.5 mm SL; CS; SCB, V. Contreras A., C. D. Contreras A.; 20 April 1985. - UANL 9027, 3: 35.5-45.9 mm SL, USNM 308116, 2, IPN P4437, 2; MLLV, AJCB; 20 November 1988. Deposits at each institution contain both male and female.

Diagnosis. *Cyprinodon longidorsalis* is unique in having: a long depressed dorsal reaching posteriorly from 3/4 of the length of caudal peduncle to caudal base; dorsal origin in front of pelvic fin; 0-2 teeth on fourth ceratobranchial; lips as thick or thicker than pupil diameter, the lower one wide, with a marked fold in the cleft. Male: head and body golden blue, 7-8 bars, the first 3-4 only on dorsum, the others to venter. Female: dorsal fin with central regular ocellus larger than pupil. Additional characters, not unique to the species, are: eye small, 1.5-1.7 times in anal fin base; maxilla 0.88-1.0 times in anal fin base; postdorsal-postanal distance 0.9-1.0 times in caudal peduncle length; head 2.8-3.1 times in SL.

Description. Mature males: compressed diamond-shaped body, deeper than in females; head subconical; eye close to dorsal profile; mouth slighthly upturned, its lower jaw large and strong; both lips as thick or thicker than pupil diameter, the upper smaller and the lower massive. Depressed dorsal fin and its base longer than in any other species of the group, reaching between three fourths of caudal peduncle and caudal base when depressed; first 2 dorsal rays rudimentary, inserted slighthly behind dorsal hump and before pelvic origin. Anal fin base long, its insertion under posterior third of dorsal fin, reaching behind middle of caudal peduncle when depressed (Fig. 5a). Pectoral fin inserted low on body, strong, rounded, reaching behind pelvic origin. Pelvic fin reduced, reaching anus. Females: shallower body, round venter; dorsal posterior, inserted in front of pelvic fin, reaching only to the anterior third of caudal peduncle when depressed. Anal origin under posterior third of dorsal fin, reaching posterior half of caudal peduncle when depressed; pectoral fin not reaching pelvic origin; pelvic fin reaching or not anus. In both sexes: mouth cleft strongly folded; total pores 13, 7 preopercular ones. Measurements are given in Table 1, fin ray and scale counts in Table 2.

Coloration. Nuptial males: head and body bright blue, with golden reflections; sides with 7-8 blackish bars, the anterior 3-4 cover only dorsal half, posterior ones down to venter. Fins creamish, with interradial melanophores giving them a dark appearance; dorsal, anal, and pectoral fins with white margins, not sharply delimited; caudal fin with black border wider than pupil diameter. Females: body dorsum light grayish green, their venter very light brown; sides with 4 blotches corresponding to central areas of bars, and posteriad fused to form a stripe extending to caudal base; dorsal fin with posterior ocellus, its black spot regular in shape, larger than pupil, and excentric, the white portion is narrow, especially at the posterior border of ocellus, nearly in contact with last dorsal ray (Fig. 6a); other fins yellowish to clear.

Habitat and associated species. The spring Charco La Palma is located on the lake bottom approximately 2 km inside the former shoreline; the lake bottom is very dry, with sparse *Acacia* and suculents and dusty soil, with little organic matter. In the spring, water temperatures were 21 °C, clear with muddy bottom easily roiled; algae predominant, with some submerged terrestrials, and formerly with swampy outlet that extended 2-3 m "downstream" SE, now dry. Around the spring there are some shrubs, an orchard and a cattle tank watered by the outlet, which has not been functional since 1988.

Etymology. The specific epithet *longidorsalis* is from the Latin *longus*, long, and *dorsalis*, belonging to the dorsum, in reference to the long dorsal fin. A noun in apposition.

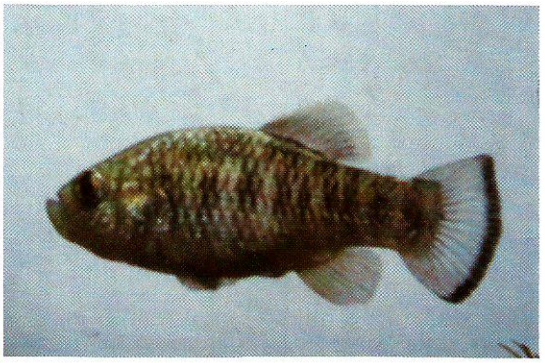
Distribution. Known only from the type locality, Charco la Palma, Municipality of Aramberri, Nuevo León, México.

Conservation status. Endangered (Lozano and Contreras, 1989); special concern (Williams et al., 1989).

a, *C. longidorsalis*, Charco Palma.

b, *C. inmemoriam*, La Trinidad.

c, *C. veronicae*, Charco Azul



d, *C. ceciliae*, La Presa

e, *C. alvarezi*, Potosí

Fig. 3. Live males of five species of *Cyprinodon* from Bolson de Sandia, Nuevo León, México. Photos SCB (a-c, e) and A. J. Contreras B. (d).

Cyprinodon inmemoriam, new species
(Fig. 3b)

Holotype. UANL 8279, mature male, 57.3 mm SL; Ojo La Trinidad (24°06.3'N 100°03.3'W), México, Nuevo León, Aramberri, interior basin of Llanos de Salas, A. J. Contreras B., A. Valdez G., J. M. Torres A., 17 March 1984.

Diagnosis. *Cyprinodon inmemoriam* is distinguished from all its congeners by several unique characters: fourth ceratobranchial with up to 4 teeth, at least on one side; the shortest maxilla, 0.68 times in anal fin base; postdorsal to postanal length short, 0.8 times in caudal peduncle length; head and body greyish blue, bars obsolete. Also, the combination of the following characters: eye 1.2 times in anal base; head 3.0 times in SL; anal base short, 3.3 times in head length; dorsal fin short, reaching anterior third of caudal peduncle.

Table 1. Comparison of morphometric character variation in five species of *Cyprinodon* from Bolson de Sandia (values in brackets are means). H, Holotype; N, Number of paratypes; SL, Standard length; HL, Head length; PRDL, Predorsal length; PODL, Postdorsal length; MW, Mouth width; EW, Eye width; PW, Pupil width; IOW, Interorbital width; SNO, Snout; POHL, Postorbital head length; UJL, Upper jaw length; DFB, Dorsal fin base; DDFL, Depressed dorsal fin length; DFO/AFO, Dorsal fin origin/anal fin origin; PDFB/AFO, Postdorsal fin base/anal fin origin; DFO/PAFB, Dorsal fin origin/postanal fin base; PDFB/PAFB, Postdorsal fin base/postanal fin base; DFO/P1FO, Dorsal fin origin/pelvic fin origin; PDFB/HB, Postdorsal fin base/hypural base; AFB, Anal fin base; SNO/AFO, Snout/anal fin origin; DAFL, Depressed anal fin length; AFO/HB, Anal fin origin/hypural base; CPL, Caudal penduncle length; AFO/P2FO, Anal fin origin/pelvic fin origin; BP, Body depth; CPD, Caudal peduncle origin; P1FB, Pectoral fin base; SNO/P1FO, Snout/pectoral fin origin; P1FL, Pectoral fin length; P2FL, Pelvic fin length; SNO/P2FO, Snout fin origin/pelvic fin origin; P1FO/P2FO, Pectoral fin origin/pelvic fin origin; P2FO/PDFB, Pelvic fin origin/postdorsal fin base; CB, Caudal band.

Character	*C. longidorsalis*			*C. inmemoriam*		*C. veronicae*			*C. ceciliae*			*C. alvarezi*	
	H	N=10 ♂	N=10 ♀	H	N=1 ♂	H	N=25 ♂	N=25 ♀	H	N=25 ♂	N=25 ♀	N=25 ♂	N=25 ♀
SL	40.6	32.7-51.4 (39.1)	26.8-44.8 (33.8)	57.3		44.2	33.9-47.4 (39.2)	35.5-40.8 (37.6)	52.0	33.6-52.0 (44.8)	29.5-44.2 (36.2)	33.9-51.0 (41.9)	35.8-48.9 (39.5)
HL	320	320-356 (339)	322-348 (335)	332		346	341-372 (352)	342-366 (355)	327	310-349 (333)	321-348 (336)	317-353 (334)	313-349 (334)
PRDL	530	530-568 (548)	552-601 (585)	590		604	573-609 (595)	581-633 (604)	561	543-615 (579)	565-618 (591)	561-606 (584)	567-606 (591)
PODL	541	494-570 (529)	440-499 (476)	522		498	470-518 (493)	452-505 (473)	535	495-542 (517)	438-494 (464)	476-529 (510)	454-494 (475)
MW	113	113-136 (116)	99-125 (109)	124		113	110-124 (117)	106-129 (119)	113	91-123 (109)	90-123 (104)	98-129 (110)	92-120 (105)
EW	81	79-87 (82)	78-93 (86)	82		90	84-105 (92)	86-106 (97)	79	77-94 (84)	84-102 (92)	77-95 (86)	85-95 (90)
PW	44	35-44 (39)	36-52 (42)	37		36	36-49 (42)	40-49 (44)	31	31-43 (36)	34-50 (41)	32-55 (40)	37-46 (41)
IOW	111	106-132 (113)	96-123 (109)	126		120	108-132 (119)	116-139 (127)	113	107-128 (116)	97-118 (108)	105-127 (115)	118-137 (127)
SNO	101	101-123 (107)	86-132 (99)	112		109	100-116 (107)	95-112 (105)	92	89-114 (100)	84-106 (95)	92-125 (106)	92-114 (101)
POHL	158	155-175 (163)	152-174 (162)	167		167	156-181 (166)	152-180 (165)	165	147-170 (159)	145-170 (157)	143-165 (155)	142-172 (153)
UJL	133	123-144 (131)	119-141 (123)	148		140	136-149 (141)	131-150 (142)	136	123-148 (133)	111-140 (128)	122-144 (134)	121-147 (135)
DFB	261	220-276 (245)	172-222 (197)	218		204	187-226 (210)	173-213 (193)	236	184-258 (228)	160-199 (184)	183-227 (208)	170-209 (183)
DDFL	411	345-420 (379)	280-315 (294)	333		314	298-352 (321)	263-306 (279)	363	325-397 (358)	253-294 (278)	293-356 (330)	257-304 (276)
DFO/AFO	468	404-525 (437)	318-384 (348)	471		432	375-440 (415)	351-404 (371)	443	405-484 (442)	335-373 (353)	412-450 (424)	340-378 (354)
PDFB/AFO	352	316-397 (336)	256-304 (277)	366		328	301-336 (316)	270-314 (287)	344	306-367 (337)	261-297 (277)	310-352 (331)	261-297 (278)

Character	*C. longidorsalis*			*C. inmemoriam*		*C. veronicae*			*C. ceciliae*			*C. alvarezi*	
	H	N=10 ♂	N=10 ♀	H	N=1 ♂	H	N=25 ♂	N=25 ♀	H	N=25 ♂	N=25 ♀	N=25 ♂	N=25 ♀
DFO/PAFO	458	401-496 (436)	334-384 (355)	461		403	327-420 (395)	333-385 (353)	435	386-444 (423)	330-366 (348)	366-438 (407)	340-380 (354)
PDFB/PAFB	259	248-305 (263)	201-234 (216)	304		262	241-268 (250)	201-249 (222)	271	232-289 (263)	204-227 (213)	234-284 (265)	211-241 (225)
DFO/P1FO	384	342-438 (374)	312-363 (340)	447		420	378-422 (397)	352-402 (372)	438	363-447 (414)	326-408 (364)	377-419 (400)	340-393 (364)
PDFB/HB	286	269-292 (279)	254-301 (284)	314		301	270-308 (296)	270-298 (283)	288	271-314 (290)	260-295 (275)	283-325 (302)	267-305 (290)
AFB	138	113-138 (123)	99-125 (117)	101		104	91-113 (105)	91-119 (104)	115	107-129 (117)	104-126 (114)	110-136 (117)	96-113 (103)
SNO/AFO	722	692-737 (714)	686-732 (701)	724		715	715-748 (727)	693-740 (719)	677	677-739 (715)	690-740 (710)	670-728 (699)	673-709 (694)
DAFL	251	237-259 (246)	199-242 (218)	215		260	193-238 (216)	194-229 (212)	215	209-238 (224)	192-240 (219)	221-259 (240)	193-230 (212)
AFO/HB	377	356-400 (379)	314-376 (355)	391		362	333-370 (353)	331-367 (341)	394	348-394 (370)	322-369 (348)	361-411 (382)	331-361 (349)
CPL	246	242-277 (260)	213-257 (237)	253		247	231-267 (249)	223-257 (238)	283	229-283 (258)	201-264 (233)	254-288 (267)	231-260 (242)
AFO/P2FO	160	122-160 (141)	104-149 (124)	138		142	141-169 (152)	131-164 (147)	146	109-176 (153)	111-166 (147)	136-162 (147)	130-161 (145)
BP	458	401-522 (429)	306-403 (352)	480		475	408-476 (443)	368-445 (405)	478	423-509 (465)	359-412 (380)	403-479 (445)	364-427 (396)
CPD	217	201-244 (215)	169-197 (183)	230		197	186-215 (198)	173-199 (184)	210	194-226 (210)	166-192 (180)	188-234 (207)	179-198 (187)
P1FB	98	87-99 (93)	76-88 (85)	94		88	83-91 (88)	80-93 (86)	92	81-101 (91)	76-92 (84)	92-107 (98)	84-98 (90)
SNO/P1FO	347	347-412 (367)	336-389 (361)	368		369	360-401 (374)	362-391 (375)	335	320-399 (356)	339-388 (358)	341-389 (360)	341-372 (357)
P1FL	227	206-233 (223)	192-229 (213)	237		201	201-237 (219)	200-229 (210)	225	200-253 (211)	182-219 (204)	198-248 (227)	198-235 (209)
P2FL	103	83-110 (96)	75-93 (83)	96		90	78-98 (88)	80-109 (88)	86	74-103 (91)	73-90 (82)	97-112 (102)	80-100 (91)
SNO/P2FO	579	541-607 (582)	551-609 (583)	599		604	580-607 (597)	571-625 (601)	560	560-622 (582)	577-607 (580)	545-600 (576)	562-605 (584)
P1FO/P2FO	241	228-251 (244)	237-272 (259)	256		265	242-280 (261)	241-296 (269)	263	240-278 (256)	229-288 (262)	231-288 (253)	251-279 (262)
P2FO/PDFB	438	384-449 (403)	308-392 (344)	428		407	377-457 (407)	361-407 (382)	436	378-458 (426)	348-394 (369)	383-445 (412)	356-397 (375)
CB	66	45-73 (56)	—	35		43	33-48 (42)	—	44	35-59 (48)	—	33-76 (62)	—

Description. Only one adult male known, as no other material could be collected before the spring dried and the species became extinct. Body high and strongly compressed. Head subconical. Eye diameter subequal to snout length. Distance between upper margin of eye and head dorsal profile about equal to 0.75 times eye diameter. Lower jaw large and strong, although less so than in *C. longidorsalis*; mouth cleft upturned. Cephalic pores 13, 7 preopercular ones. Dorsal fin small with a short base, its origin behind dorsal hump and slighthly behind pelvic origin, reaching anterior third of caudal peduncle when depressed. Anal fin origin under posterior third of dorsal base, reaching to mid caudal peduncle length when depressed (Fig. 5b). Pectoral fin low, strong and round, covering pelvic fin origin. Pelvics fin reduced, reaching anus. Measurements are given in Table 1, fin ray and scale counts in Table 2.

Life coloration. Head and body greyish blue; bars obsolete. Fins translucent pale yellow, with some interradial melanophores that gave a gray appearance. Dorsal and anal with white margin. Pectoral with a black narrow border; pelvic yellow, without melanophores. Caudal whitish, with a black distal bar, wider than pupil diameter. No females collected.

Habitat and associated species. Ojo La Trinidad was in the Bolsón de Sandia, approximately 1600 m asl, near the piedmont of Sierra Montelongo Pedregoso, and at the middle eastern edge of Pluvial Lake Sandia. The area is semiarid, with a few scattered *Acacia*, and common succulents. Around the former spring, there were small clumps of local cedar (*Cupressus* sp.), and grass. Housing has developed around the spring increasing the impact. Water was colorless, 19 °C; bottom was muddy, with some porous rocks in the banks. There were no other fishes, but an undescribed endemic crayfish (*Cambarellus* sp.) was also collected. Both species are probably extinct. Several explorations of the area did not lead to the discovery of another population.

Etymology. The specific name *inmemoriam*, used as a sustantive in apposition, is a latin expression meaning remember after death, in reference to the species being described after its extinction.

Distribution. Formerly extant and endemic to Ojo de Agua La Trinidad, municipality of Aramberri, Nuevo León, México.

Conservation status. Probably extinct, since only one population was known. No captive stock.

Table 2. Counts in five species of *Cyprinodon* from Bolsón de Sandia. H, Holotype; P, Paratype. Values in brackets are modes. * indicates that half of the population has 25 and other half 26.

	C. longidorsalis		*C. inmemoriam*	*C. veronicae*		*C. ceciliae*		*C. alvarezi.*
	H	P	H	H	P	H	P	
	N=20		N=1	N=50		N=50		N=5(
Rays								
Dorsal	12	12(12)	11	11	11(11)12	12	11(12)13	11(11)12
Anal	11	11(11)12	11	11	10(11)12	11	11(11)12	10(11)11
Pectoral	16	14(15)16	16	15	13(15)16	15	15(15)16	15(16)16
Pelvic	6	5 (6) 6	6	6	5 (6) 7	6	5 (6) 6	6 (6) 7
Caudal	16	15(16)18	17	18	11(16)18	16	14(16)19	14(16)18
Scales								
Lateral	25	25-26 *	25	25	24(25)26	25	24(25)26	24(25)26
Dorsal to anal	11	11(11)12	10	10	10(10)11	11	10(11)12	10(10)12
Dorsal to pelvic	13	12(13)13	12	12	11(11)12	12	11(12)13	10(11)13
Predorsal	16	16(17)18	16	16	15(16)18	16	15(16)18	15(16)18
Around caudal peduncle	16	15(16)16	15	15	13(15)16	15	13(15)16	14(16)16
Gill rakers	16	16(16)19	16	16	15(16)19	16	15(16)18	16(17)20

a, *C. longidorsalis*, Charco La Palma.

b, *C. veronicae*, Charco Azul.

c, *C. ceciliae*, La Presa.

d, *C. alvarezi*, Potosí.

Fig. 4. Live females of four species of *Cyprinodon* from Bolsón de Sandia. Photos SCB (b, c) and A. J. Contreras B. (a, d.).

Cyprinodon veronicae, new species
(Figs. 3c, 4b)

Holotype. UANL 8291, mature male, 44.2 mm SL; Ojo de Agua Charco Azul = Barreno (24°09.8'N 100°03.7'W), México, Nuevo León, Aramberri, interior basin of Llanos de Salas. S. Contreras B. and Facultad de Ciencias Biológ-s group, 26 February 1984.

Paratypes. All from type locality: UANL 8292, 163: 25.3-50.8 mm SL, UANL 8293, 8: 35.1-47.1 mm SL, CS, UNAM (IB/CML) P-3236, 2, TNHC 17463, 2, TU 157271, 2, UAIC 9349.01, 2, USNM 308115, 2, AMNH 47838, 2, UMMZ 215483, 2, IPN P4435, 2; same data as holotype. - UANL 8294, 23: 21.5-36.1 mm SL; SCB, VCA, 20 April 1985.- UANL 8295, 35: 13.8-38.0 mm SL; SCB, FCB group, 25 October 1985.- UANL 8296, 5: 32.2-43.1 mm SL; MLLV, AJCB, PBR; 13 March 1988. Deposits in each institution contain both male and female.

Diagnosis. *Cyprinodon veronicae* is distinguished from all its congeners by several unique characters: maxilla short, 0.70-0.77 times in anal fin base; head large, 2.7-2.9 times in SL; male with 6-7 diffuse dark bars along sides, covering only upper half of body; female with an irregular ocellus on dorsal fin, its black spot half-moon shaped, smaller than pupil. Also the following combination of characters; eye 1.0-1.2 times in anal fin base; postdorsal-postanal 0.9-1.1 times in caudal peduncle length; anal fin usually smaller than in all other species, 3.0-3.9 times in head lengh; no teeth on fourth ceratobranquial; dorsal fin inserted behind pelvic origin; nuptial males violaceous blue.

Description. Mature males: body strongly compressed, deep, with diamond shaped body, higher than in females. Head large, subconical; snout nearly flat; eye large, its distance from dorsal profile less than pupil diameter. Lower jaw not too strong, as wide as a pupil diameter; mouth large and upturned; dorsal fin, slighthly ahead

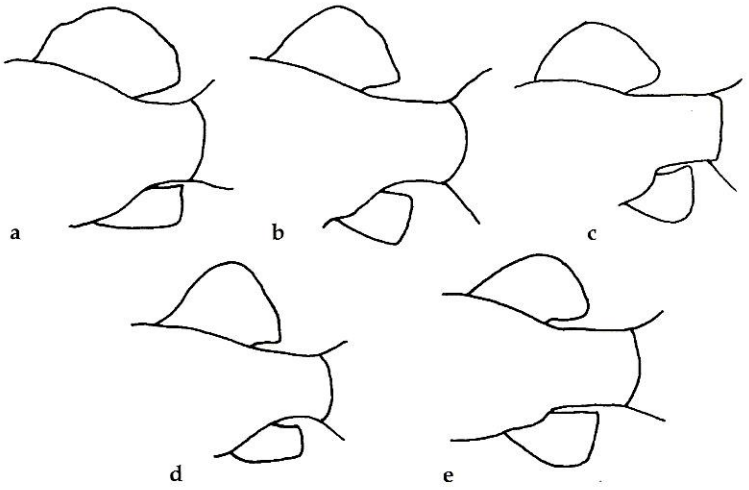


Fig. 5. Outline of the posterior part of body of males of five species of *Cyprinodon* from Bolsón de Sandia: **a,** *C. longidorsalis*; **b,** *C. inmemoriam*; **c,** *C. veronicae*; **d,** *C. ceciliae*; **e,** *C. alvarezi*.

of pelvic origin, covering the anterior third of the caudal peduncle when depressed; anal fin inserted nearly under the posterior end of dorsal fin base, reaching half the caudal peduncle length when depressed (Fig. 5c). Pectoral fin inserted low, rounded, reaching or nearly reaching vertical of dorsal origin; pelvic fin reduced, extending to or near anus. Females: body high, and round venter; upper margin of eye near dorsal profile. Dorsal posterior, inserted in front of pelvic origin, reaching to more than half of caudal peduncle length when depressed. Anal origin under posterior extremity of dorsal fin base, reaching more than half of caudal pecuncle when depressed; pectoral fin not reaching pelvic origin; pelvic fin reaching or not anus. In both sexes: cephalic pores 13-15, 7-9 preopercular ones. Measurements are given in Table 1, and fin rays and scale counts in Table 2.

Coloration. Males: head and anterodorsal body violaceous blue. Each scale with violet blue center, yellowish intermediate area and black margin, giving scalation a reticulate appearance. Body with 6-7 poorly marked bars extending down to midbody; dorsal and anal fins white with bluish margins, some melanophores on interradial membranes near the base. Paired fins yellow, pectoral with black border. Caudal basally white, its interradial membranes with dark melanophores, also a distal black bar, equal to or wider than pupil diameter. Females: head and body yellowish brown, sides with 6-9 large and darker spots. Dorsal fin with an imperfect ocellus, black spot half-moon-shaped, smaller than pupil, its surrounding white area extends to the posterior edge of the fin (Fig. 6b).

Habitat and associated species. The springs at Ojo Charco Azul (=Barreno) are part of the Bolsón de Sandia complex. It is at 1600 m asl, and at the foot of the Sierra Montelongo Pedregoso. The sierra is arid, vegetation mostly cacti and other succulents; a dense woody area of cedar (*Cupressus* sp.) is around the springs, except on eastern side. Originally the water was cristal clear, at 19-20 °C; recently, after depletion, the water is brown. Aquatic vegetation: *Ceratophyllum, Potamogeton, Typha, Eleocharis, Lemna, Utricularia, Scirpus* and *Chara*. The bottom loamy or muddy. There is also a crayfish, *Cambarellus* sp.

Etymology. The specific epithet *veronicae* is dedicated to Verónica Contreras Arquieta, for her participation in the original collecting trip.

Distribution. Endemic to the springs Charco Azul (= Barreno), 27 km SW La Ascensión, municipality of Aramberri, Nuevo León, México.

Conservation status. Endangered (Lozano and Contreras, 1989); special concern (Williams et al., 1989).

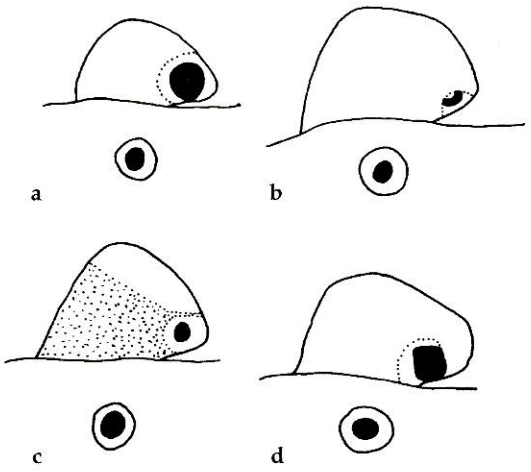


Fig. 6. Dorsal fin outline of females of four species of *Cyprinodon* from Bolsón de Sandia: **a,** *C. longidorsalis*, large regular ocellus; **b,** *C. veronicae*, small imperfect ocellus; **c,** *C. ceciliae*, small regular ocellus; **d,** *C. alvarezi*, imperfect excentric large ocellus. All scaled in proportion to the eye, drawn under each dorsal for comparison.

Cyprinodon ceciliae, new species
(Figs. 3d, 4c)

Holotype. UANL 8287, mature male, 52.0 mm SL; Ojo de Agua La Presa, en San Juan de Avilés, (24°11'87"N 100°04'34"W), México, Aramberri, Nuevo León, Interior basin of Llanos de Salas; M. L. Lozano V., A. J. Contreras B., B. Jensen, P. Barrón R., 17 June 1988.

Paratypes. All from type locality: UANL 8288, 24: 33.3-52.0 mm SL, TU 157270, 2, UAIC 9350. 1, 2, TNHC 17462, 2, IPN P4434, 2; same data as holotype. - UANL 8289, 19: 29.5-47.7 mm SL, USNM 308114, 2, UNAM-IB/CML-P 3237, 2, AMNH 47837, 2, UMMZ 215483, 2, UANL 8290, 4: 32.3-39.7 mm SL, CS; MLLV, AJCB, PBR, 13 March 1988. Desposits in each institution contain both male and female.

Diagnosis. *Cyprinodon ceciliae* is distinguished from all its congeners by its unique coloration: nuptial males violaceous blue, with 7-8 well marked black bars, all extending to venter; dorsal fin of females blackish in the proximal two thirds, ocellus with round black spot usually smaller than pupil; anal frequently with a posterior dark spot near base. Also, a combination of the following characters: eye diameter 1.2-1.6 times and maxilla 0.83-1.2 times in anal base, similiar to *C. longidorsalis*; postdorsal-postanal distance 0.9-1.0 times in caudal peduncle length; fourth ceratobranchial without teeth; anal base large, 2.5-3.2 times in head length; head length 2.8-3.2 times in SL.

Description. Mature males: body subrhomboid, compressed, higher than in females. Head subconical, with a slight depression over the eye and before nuchal area; eye small, upper border nearly in dorsal profile of the head. Jaw large and strong. Dorsal fin origin behind dorsal hump, slighthly behind level of pelvic origin, reaching behind the anterior third of caudal peduncle when depressed. Anal fin origin under posterior third of dorsal base, reaching over middle of caudal peduncle when depressed (Fig. 5d). Pectoral fin round, not reaching to dorsal origin. Females: high body, and bulging belly. Eye large, its upper border near the dorsal profile. Dorsal posterior, inserted behind pelvic origin, reaching beyond midlength of caudal peduncle when depressed. Anal origin under posterior half of dorsal fin base, reaching midlength of caudal peduncle when depressed; pectoral fin covers pelvic origin; pelvic fin not reaching anus. In both sexes: total cephalic pores 13, 7 preopercular pores.

Coloration. Mature males with body and head violaceous blue, specially in scale centers, which have black borders, giving a reticulate appearance. Body with 7-8 well defined black bars, extending to venter. Dorsal and anal fins white, both with blue borders. Pectoral fin yellow, with black margins. These three fins with dark membranes due to interradial melanophores. Pelvic fin yellow. Caudal fin mostly white, with terminal black bar wider than pupil diameter. Females greenish yellow on head and body. Venter slighthly golden. Sides with 8-10 dark spots. All fins greenish yellow; dorsal with numerous small melanophores in the lower two thirds, giving a blackish appearance, ocellus a round black spot usualy smaller than pupil; white area wide, extending to posterior margin of fin (Fig. 6c); most females also with a small anal spot.

Habitat and associated species. The Ojo de Agua La Presa, at the SW edge of San Juan de Avilés, Bolsón de Sandia, lays around 1600 m above sea level, and at the piedmont of Sierra

Montelongo-Pedregoso. The area is arid, with little vegetation, often succulents, there is also thick shrubby growth around; the area is dusty, with poor soils and some cultivated fields nearby. Water is clear, bottom muddy. Aquatic vegetation: *Chara* and *Scirpus*; banks shrubby or meadowlike. Habitat was shared with an undescribed endemic crayfish, *Cambarellus* sp.

Etymology. The specific epithet *ceciliae* is dedicated to Cecilia Contreras Lozano, collaborator in the collecting trip when the species was discovered.

Distribution. *Cyprinodon ceciliae* was endemic, when extant, in the Ojo de Agua La Presa, SW edge of San Juan de Avilés, Aramberri, Nuevo León, México.

Conservation status. Endangered (Lozano and Contreras, 1989); special concern (Williams et al., 1989). The spring nearly dried during the winter of 1991. Several attempts to find specimens when some water returned in early 1992 failed. The species is presumably extint, because no other population is known.

Comparison

Species of the *C. alvarezi* complex are compared in Tables 1-2 and Figures 3-8. Figures 7-8 are canonical discriminant function clusters that show the populations are well defined, with 100 % separation for all samples (N = 25 each sex), except *C. longidorsalis* (N= 10) and *C. inmemoriam* (N = 1). Clusters of males of *C. longidorsalis* and *C. veronicae*, and females *C. veronicae* and *C. ceciliae* are nearly in contact, but there is no overlap. It is interesting that the reciprocal comparisons show these same populations to be the most divergent. We concluded that they represent close species of a monophyletic lineage that includes *C. alvarezi*. Some characters shared and useful in diagnosis are: *C. veronicae* and *C. ceciliae* have no teeth on fourth ceratobranchial; *C. inmemoriam* and *C. veronicae* have similar ratio between eye diameter and anal base, 1.0 to 1.2; *C. longidorsalis* and *C. ceciliae* have similar ratio between maxillary and anal base, 0.83-1.2; finally, ratio between anal fin base and head length 3.0 to 3.9 in *C. inmemoriam* and *C. veronicae*; all except *C. longidorsalis* have

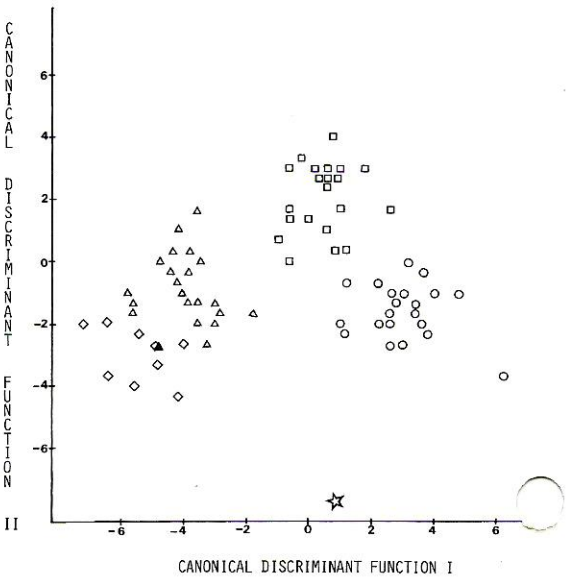


Fig. 7. Graphic representation of canonical discriminant functions analysis of five species (males only) of *Cyprinodon* from Bolsón de Sandia, using 37 morphometric characters. ◇ *C. longidorsalis*; ☆ *C. inmemoriam*; Δ *C. veronicae*; □ *C. ceciliae*; ○ *C. alvarezi*.

depressed dorsal that covers only anterior third of caudal peduncle length, and dorsal insertion behind pelvic origin. Their relationships to other members of the *C. eximius* complex, and to the remainder of the genus (that also has several undescribed forms) are currently under study using both morphological and electrophoretic data by Anthony E. and Alice Echelle and us.

Identification key to the species of the *Cyprinodon eximius* complex (modified from Miller, 1976)

1. - Distal black bar on caudal fin of nuptial males equal to or wider than pupil. 2
   - Distal black bar on caudal of nuptial males narrower than pupil. 6

2. - Pelvic fin length shorter than mandible length. 7
   - Pelvic fin length equal to or longer than mandible length. 3

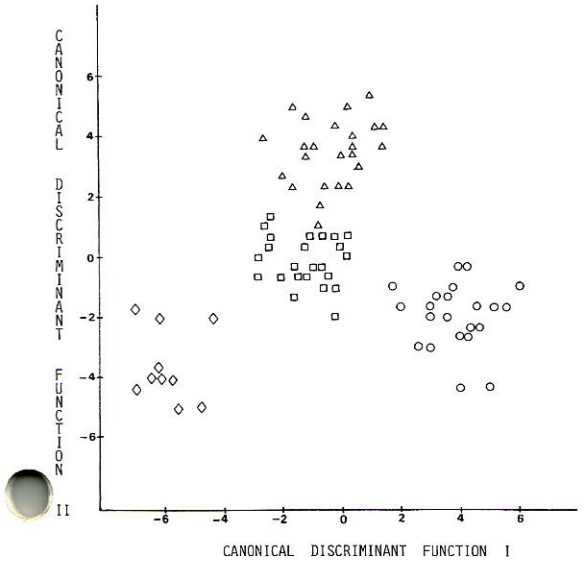


Fig. 8. Graphic representation of canonical discriminant functions analysis of four species (females only) of *Cyprinodon* Bolsón de Sandia, using 36 morphometric characters. ◇ *C. longidorsalis*; Δ *C. veronicae*; □ *C. ceciliae*; ○ *C. alvarezi*.

3. - Caudal fin of nuptial males with conspicuous dark markings in basal ½ to ⅔ of interradial membranes, usually in 3 vertical series. Caudal distal black bar immediately preceded by a narrow clear band. Rio Conchos Basin, Chihuahua.
..... *C. eximius*
- Not as above.
..... 4

4. - Gill rakers 12-17. Mandibular pores 0-2. Scales around caudal peduncle 20 (uncommonly 16). Rio Nazas, Santiaguillo and Río Aguanaval basins, Durango.
..... *C. nazas*
- Gill rakers 20-28. Mandibular pores absent. Scales around caudal peduncle 16 (rarely 15 or 17).
..... 5

5. - Dorsal fin ocellus lacking in both sexes. Lachrymal pores typically 3 (2-4). Dorsal fin of nuptial male not yellow or orange. Body with dark lateral stripe from behind eye to caudal base set off above by a narrow silvery stripe (turquoise in life?), and below by a broad yellowish stripe. Parras Basin, Coahuila. Extinct.
..... *C. latifasciatus*
- Ocellus present on dorsal fin on both sexes. Lachrymal pores lacking. Dorsal fin of nuptial male yellow or orange. Body of male with 7-9 broad vertical bars. Cuatro Ciénegas Basin, Coahuila.
..... *C. atrorus*

6. - Scales in lateral series 23 or 24. Gill rakers 17-22. Dorsal fin of nuptial male yellow. Vertebrae usually 25. Ojo Hacienda Dolores, Chihuahua.
..... *C. macrolepis*
- Scales in lateral series typically 25. Gill rakers 12-15. Dorsal fin of nuptial male not yellow. Vertebrae 26-27. Río Mezquital Basin, Durango.
..... *C. meeki*

7. - Fourth ceratobranchial usually with teeth (may be absent on one side). Female dorsal fin ocellus with spot larger than pupil.
..... 8
- Fourth ceratobranchial usually without teeth. Female dorsal fin spot equal to or smaller than pupil.
..... 10

8. - Male with dorsal fin large, reaching from ¾ of caudal peduncle length to caudal base. Dorsal base 3.6-4.5 times in SL. Cleft of lower lip with a marked fold. Charco La Palma, Aramberri, Nuevo León.
..... *C. longidorsalis*
- Male with short dorsal fin, reaching between ⅓ to ½ of caudal peduncle length. Dorsal base 3.9-5.4 (mostly 4.4 or more) times in SL. Cleft not strongly folded.
..... 9

9. - Depressed dorsal fin of male reaching to ½ of caudal peduncle length; maxila 0.8-1.2 times in anal base. El Potosí, Nuevo León.
..... *C. alvarezi*
- Depressed dorsal fin reaching to ⅓ of caudal peduncle length; maxilla 0.68 times in anal base. Ojo de Agua La Trinidad, Aramberri, Nuevo León. Extinct.
..... *C. inmemoriam*