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TWO NEW FISHES OF THE GENUS *CYPRINODON* FROM THE CUATRO CIENEGAS BASIN, COAHUILA, MEXICO

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THE TOWN of Cuatro Ciénegas de Carranza lies in a small, semi-isolated valley in central Coahuila, México, about 250 airline kilometers south-southeast of the Big Bend region of Texas. This desert basin (see Minckley, in press, Fig. 2), about 30 by 40 kilometers in major dimensions, is nearly enclosed by steeply folded ranges of Cretaceous limestone. The valley floor, of gypsum-limestone substrate, is a little more than 700 meters above sea level, and the major ranges are generally between 1,500 and 2,000 meters high.

Looking south across the arid basin from the main road east of the town, the visitor has no inkling of the large number of springs, marshes, streams, sink holes, and lagunas that support the remarkable aquatic biota of the valley. The region is extraordinarily rich biologically, with high endemism, especially among the snails, crustaceans, and fishes (Hubbs and Miller, 1965; Taylor, 1966; Taylor and Minckley, 1966; Minckley, in press).

The primary purpose of this paper is to make known the two endemic species of pupfishes, genus *Cyprinodon*. Studies of their variability, population genetics, ecology, behavior, and especially of their interspecific hybridization, are in progress by others.

The two new species increase to 14 the number of fishes now recorded from the valley; 5 of them are endemic. Approximately 20 species are known from this area and about half of these are believed to be restricted to it (Taylor and Minckley, 1966: 19).

Cyprinodon bifasciatus, new species

Fig. 1

DIAGNOSIS.—An elongate, rather slender, laterally compressed species of *Cyprinodon* with the dorsal fin anterior in position (both sexes);

without an ocellus on the dorsal (or anal) fin of either juveniles or adults; with rather weak sexual dimorphism; the male with a very narrow terminal black band on the caudal fin, a yellowish eye, and 4 horizontal rows of yellow-orange spots along the sides (axial scale row uppermost); the margin of the caudal fin slightly emarginate (both sexes), with 14 (rarely 13) rays; and typically with two horizontal lateral dark stripes on each side (more pronounced in females and juveniles than in large males).

TYPES.—Holotype, UMMZ 179835, a mature male 44.5 mm. standard length (S.L., Fig. 1), Río Puente Colorado, ca. 11 km. S of Cuatro Ciénegas (Río Mesquites system), Coahuila, México; 6 April 1961 by R. R. Miller, Carl L. Hubbs, W. L. Minckley, and D. R. Tindall. Collected with the holotype were 149 paratopotypes, UMMZ 179836, 10–53 mm. S.L. In addition, the following paratypes were studied: UMMZ 177863, 100, 21–39 mm. S.L., from Escobeda, a hot spring 12 km. S of Cuatro Ciénegas, 11 September 1958, W. L. Minckley; UMMZ 179197, 128, 12–28 mm. S.L., Laguna Churince (Posos Bonitos), 20.3 km. SSW of Cuatro Ciénegas, 19 August 1960, W. L. Minckley et al.; 226, 7–27 mm. S.L. (UMMZ 179879), same locality, 10 April 1961, R. R. Miller and party; UMMZ 179204, 178, 10–49.5 mm. S.L., Posos de la Becerra, 17 km. SW of Cuatro Ciénegas, 20 August 1960, W. L. Minckley et al.; 581, 9–49 mm. S.L. (UMMZ 179830), same locality, 6 April 1961, R. R. Miller and party; UMMZ 179212, 16, 12–31 mm. S.L., Río Mesquites, 9.8 km. S of Cuatro Ciénegas, 21–22 August 1960, W. L. Minckley et. al.; UMMZ 181068, 88, 29–48 mm. S.L., in ciénegas along Río Mesquites, ca. 10 airline km. due S of Cuatro Ciénegas, 8 July 1961, B. A. Branson; UMMZ 179222, 130, 14–36 mm. S.L., Los Hundidos, 6 km. ENE of Tío Candido, 16 km. S, 5 km. E of Cuatro Ciénegas, 23 August 1960, W. L. Minckley and J. E. Craddock; UMMZ 179857, 53, 23–39 mm. S.L., Tierra Blanca, ca. 12 km. WSW of Cuatro Ciénegas, 8 April 1961, Miller, Hubbs, Minckley, and Lugo; UMMZ 186303, 176, 15–54 mm. S.L., 9.7 km. SSW of Cuatro Ciénegas (just S of West Laguna of El Mojarral), 7 April 1966, W. S. Brown and Les Cullum.

DESCRIPTION.—The distinctive body form and coloration are illustrated in Figure 1. Note the anterior position of the dorsal fin and the lack of an ocellus on this fin in the female. Unlike most species of the genus, *C. bifasciatus* shows little sexual dimorphism in the position of the dorsal fin (see below). The cleithral process and overlying scapular scale (Miller, 1956: 1–2, fig. 1) are only slightly enlarged and are not thickened, as they are in *C. variegatus*. The first dorsal ray is moder-

ately expanded at the base but is not thickened and spine-like, as it is in *C. variegatus*.

Dorsal rays: 11(34), 12(66), ave. 11.66, the first two usually unbranched (in 74 out of 90; 1 had a single unbranched ray and 5 had 3 unbranched rays); anal rays: 9(2), 10(74), 11(14), ave. 10.13, the first 1 or 2 unbranched; pectoral rays (both fins): 13(33), 14(108), 15(39), ave. 14.03; pelvic rays (both fins): 3(1), 6(13), 7(160), 8(6), ave. 6.94; caudal rays: 13(7), 14(78), ave. 13.92. The holotype has dorsal 12 (first 2 rays unbranched), anal 11 (first ray unbranched), pectorals 14–14, pelvics 7–7, and caudal 14.

Scales in lateral series: 24(1), 25(7), 26(60), 27(22), ave. 26.14; scales between dorsal and pelvic fins: 10(4), 11(85), 12(1), ave. 10.97; scales around caudal peduncle: 12(1), 13(3), 14(6), 15(7), 16(73), ave. 15.64; scales around body: 24(13), 25(12), 26(47), 27(10), 28(8), ave. 25.87. The holotype has 26 lateral scales, 11 from dorsal to pelvic, 16 around caudal peduncle, and 26 around body. The preorbital region is well scaled. The squamation between the bases of the pelvic fins is usually formed of 2 large scales arranged in tandem order, much as in *Floridichthys*; however, 8 of 38 males and females examined for this character have irregularities: either there are 2 basal scales or 2 asymmetrical scales beyond the single, large basal one. The large, rather regularly arranged prepelvic scales usually number 14 to 16 between pelvic origin and isthmus, with a range of 12 to 17. The scale structure is not clearly assignable to either the *macularius* or the *nevadensis* types (Miller, 1943: 5, 7, pls. V–VII), but rather appears to represent a combination of the two. At and near the focus, the scale tends to resemble that of *macularius,* having weak spine-like projections along the circuli, whereas the reticulate *(nevadensis)* pattern is developed between the circuli distally from the focus.

Head pores vary as follows (both sides counted): mandibular, 0(11), 2(169), ave. 1.88; preopercular, 5(1), 6(15), 7(159), 8(5), ave. 6.93; lachrymal, 3(17), 4(163), ave. 3.90. Holotype has 2–2 mandibular, 7–7 preopercular, and 4–4 lachrymal pores. All of the pores are small.

Gill rakers number: 23(5), 24(23), 25(31), 26(22), 27(8), 28(1), ave. 25.09. Vertebrae (including urostyle), determined from radiographs: 25(2), 26(25), 27(73), 28(9), ave. 26.82, typically 11 or 12 precaudal and 14 to 16 caudal. Holotype has 11 + 16 = 27.

In 30 adults (12 from UMMZ 179830 and 18 from UMMZ 179836) there are 6 branchiostegal rays.

Proportional measurements on 39 specimens from the type locality (Puente Colorado), stepped with dividers under appropriate magnifi-

cation, are given below for 21 males (including the holotype), 30.9–51.4 mm. S.L., and 18 females, 29.5–41.3 mm. S.L. Except where sexual dimorphism is marked, the data for the sexes are combined. The range of variation is followed by the value, in parentheses, for the holotype and then the average value of the measurement.

In standard length: head length, 3.2–3.55 (3.25), 3.4; greatest body depth, in males, 2.5–3.1 (2.8), 2.8, and in females, 2.75–3.3, 3.0; caudal peduncle length, 3.4–3.85(3.5), 3.6; predorsal length, 1.9–1.97(1.95), 1.9; postdorsal length, 1.85–2.0(1.95), 1.95; prepelvic length, 1.9–1.97(1.95), 1.9.

In head length: head depth at occiput, 1.0–1.25(1.15), 1.1; head width, 1.4–1.5(1.5), 1.5; greatest body depth, 0.7–0.98(0.75), 0.8; caudal peduncle length, 0.95–1.15(1.05), 1.05; least depth of peduncle in males, 1.7–2.05(1.9), 1.9, and in females, 1.9–2.2, 2.0; bony interorbital width, 2.35–3.3(2.65), 2.8; snout length, 2.75–3.3(3.0), 3.1; orbit length, 2.6–3.3(3.0), 2.9; upper jaw length, 2.6–3.0(2.6), 2.8; mandible length, 3.1–3.65(3.55), 3.3; mouth width, 2.55–3.1(2.7), 2.9; length of depressed dorsal fin, in males, 0.8–1.0(0.9), 0.95, and in females, 1.0–1.5, 1.0; length of depressed anal fin, in males, 1.25–1.35(1.25), 1.3, and in females, 1.3–1.45, 1.4; pectoral length, 1.15–1.35(1.25), 1.2; pelvic length, in males, 1.75–2.1(1.9), 1.9, and in females, 1.9–2.15, 2.0; length of middle caudal rays, 1.1–1.2(1.15), 1.1.

Length of caudal peduncle into predorsal length, 1.75–2.1(1.8), 1.9; length of caudal fin (middle rays) into predorsal length, 1.95–2.2(1.98), 2.0; caudal peduncle, depth into length, 1.65–2.0(1.75), 1.8; pelvic length into caudal peduncle depth, 0.85–1.1(1.0), 0.99.

The intestine is long and much convoluted. In an adult male 45 mm. S.L. from Posos de la Becerra, this structure was approximately 194 mm. (stretched length) or about 4 times the standard length.

The anterior position of the dorsal fin is demonstrated by projecting forward (with a pair of dividers) the distance between the base of the caudal fin and the origin of the dorsal fin (the postdorsal distance) and noting the point reached by the tip of the dividers. In the same 39 fish used in the other measurements, the point reaches in the 21 males from the rostral fold to beyond the tip of the lower jaw, usually to or beyond the front of the upper lip; in the 18 females, the point extends from half way between the orbit and the rostral fold to just short of the tip of the lower jaw, usually about to the rostral fold or the front of the upper lip.

The development of the black terminal caudal band of the male

may be expressed by stepping its width into the eye, giving ratios of 2.4–3.8 (3.2 in holotype), ave. 3.1.

COLORATION.—The life colors of *C. bifasciatus* were recorded for the series from Posos de la Becerra on April 6, when the fish were in breeding condition. Color photographs were also taken of freshly killed males.

In the adult male the dorsal and anal fins are intense chalky blue to iridescent turquoise, dusted with small melanophores on the interradial membranes, and the distal margin (dorsal fin) or posterior half (anal fin) dusky to black. The terminal black band on the dusky caudal fin is very narrow, notably less than one-half the diameter of the eye (see measurements). In living breeding males, the caudal peduncle and proximal half of caudal fin are lemon yellow. Pectoral and pelvic fins clear, becoming dusky to black on margins. Eye intense yellow to yellow-orange, the pupil black and the iris watery blue. Lips purplish. Side of body with horizontal rows of yellow-orange to orange spots along the distal margins of the scales, from the axial row to 5 rows below. Ground color of body chalky blue to pale iridescent blue to silvery; lateral stripes as in the female (see below) but generally less prominent, the abdominal stripe sometimes weak or obsolescent in large fish. The males, unlike those of most species of *Cyprinodon,* lack vertical bars.

In females, the ground color of the body is light-blue to pale-brown or creamy-yellow. There are two prominent, dark brown, horizontal stripes along the axial scale row and on the side of the abdomen, plus a third, fainter one on the upper side. All of the fins are clear; the dorsal lacks the ocellus that is typical of females (and juveniles) of most species of *Cyprinodon.*

In juveniles, the axial lateral stripe is often disrupted into a prominent series of squarish or rectangular blotches, and each lateral stripe is generally more pronounced than in adults, especially larger ones. The disrupted pattern of the axial stripe is also displayed in females, but typically less prominently, and it may even be seen in preserved males, except very large ones. There is no trace of a dorsal (or anal) ocellus in the juvenile.

HABITAT AND HABITS.—This species is largely restricted to headwater warm springs and their outlets and to streams, typically in constantly warm water (26.7 to 34.5° C). Water chemistry is dominated by magnesium sulfate, with a high content of calcium carbonate. The depth may vary from less than a meter to as much as 10 meters; the bottom is of fine, deep silt and marl; and the current is moderate to slight. During

summer, when water temperatures are increased in habitats available to the species, *C. bifasciatus* expands its "winter range" either by actively swimming or by being carried downstream. Unlike other species of the genus, *C. bifasciatus* is very sensitive to thermal changes.

In contrast to the majority of species of *Cyprinodon,* this species lives an open, active life in competition with a diversity of other fishes, including a characin *(Astyanax fasciatus),* a catfish *(Ictalurus lupus),* largemouth bass *(Micropterus salmoides),* longear sunfish *(Lepomis megalotis),* a darter *(Etheostoma* sp.), and 1 or more species of cichlids (genus *Cichlasoma*). As many as 13 species (representing 8 families) have been found in association with *C. bifasciatus.* The young live on the bottom, where they move about in schools in darter-like fashion; with growth they come to occupy open water. Territorial males are aggressive, even attacking large, predatory fish (W. L. Minckley, pers. comm.).

Relationships.—The immediate relationships of *Cyprinodon bifasciatus* are not readily apparent. In form of body, emarginate shape and nearly fixed number of caudal fin rays, life colors, color pattern, and behavior, this species stands apart from most others of the genus. I believe it represents an early evolutionary stock that developed in the long and well-isolated Cuatro Ciénegas basin—perhaps as long ago as early Pliocene or even late Miocene time. Possibly it was derived from a basal stock along the ancestral line that led also to *Cyprinodon variegatus.* Certain resemblances between the two that may be indicative include a long pectoral fin, numerous gill rakers, generally slab-sided body, long 7-rayed pelvic fins, anterior position of dorsal fin, well-scaled preorbital region, and complete head-pore system. Some of these characters (e.g., gill-raker number) may, of course, have been independently derived.

That it hybridizes in the basin, in man-made habitats, with *Cyprinodon atrorus,* next to be described, does not necessarily mean that the two are intimately related, since experiments (by R. K. Liu, pers. comm.) have shown that distinct species of *Cyprinodon* may be crossed rather readily in the laboratory. I believe that *C. bifasciatus* has occupied the Cuatro Ciénegas bolsón far longer than has *C. atrorus.*

Etymology.—The new species is named *bifasciatus* in reference to the two prominent lateral stripes: one along the midside, from the head to the base of caudal fin; the other from the base of the pectoral fin to the end of the anal fin base.

Cyprinodon atrorus, new species
Fig. 2

DIAGNOSIS.—A species of *Cyprinodon* of typical body form (short and deep), characterized by the following combination of traits: caudal fin of male with a very broad, jet-black terminal band (about as wide as eye); mandibular and lachrymal pores lacking, and usually only 3 to 6 (typically 4) preopercular pores; supraorbital canal system discontinuous (see description); female (and juvenile) with a well-developed ocellus on both dorsal and anal fins; dorsal fin of breeding male yellow to orange; pelvics small, 6-rayed; gill rakers 20 to 25, usually 22 to 24; branchiostegals 5 (1 in 30 had 6).

MATERIAL.—Holotype: UMMZ 130380, an adult male 31 mm. S.L. (Fig. 2) from an unspecified locality (Sta. XV) S of Cuatro Ciénegas, Coahuila, México, 15 August 1939, E. G. Marsh, Jr. Paratopotypes: UMMZ 130381, 575, 15–33 mm., from the same station. Paratypes: UMMZ 130391, 368, 16–32 mm., from another unspecified locality (Sta. XVI) near Cuatro Ciénegas, 28 August 1939, Marsh (6 additional specimens from this series, MCZ 38004, are at Harvard)[1]. Non-types: UMMZ 179846–47, 162, 10.5–35 mm., Laguna San Pablo, about 14 airline km. SSE of Cuatro Ciénegas, 7 April 1961, R. R. Miller, C. L. Hubbs, W. L. Minckley, D. R. Tindall, and José Lugo G.

[1] As discussed by Hubbs and Miller (1965: 64–65), collection XV of Marsh may have come from the vicinity of Río Mesquites and his collection XVI from near what is now called Río Puente Chiquito (see Minckley, in press).

DESCRIPTION.—Body form and coloration are illustrated in Figure 2, which shows the pronounced terminal black band on the caudal fin of the male and the well-developed ocelli on both dorsal and anal fins of the female. The cleithral process and overlying scapular scale are moderately enlarged and thickened. The first dorsal ray is not notably different from the second ray.

Dorsal rays: 10(15), 11(14), 12(1), ave. 10.53, the first two usually unbranched (in 23 of 30; 6 had a single unbranched ray and 1 had 3 unbranched rays); anal rays: 9(1), 10(29), ave. 9.97, the first 1 (usually) or 2 unbranched; pectoral rays (both fins): 12(2), 13(2), 14(23), 15(30), 16(3), ave. 14.50; pelvic rays (both fins): 5(5), 6(47), 7(8), ave. 6.05; caudal rays: 14(4), 15(15), 16(11), ave. 15.23. The holotype has dorsal 10 (first 2 rays unbranched), anal 10 (first ray unbranched), pectorals 12–15, pelvics 6–6, and caudal 15.

Scales in lateral series: 24(3), 25(17), 26(10), ave. 25.23; scales between dorsal and pelvic fins: 10(8), 11(18), 12(4), ave. 10.87; scales around caudal peduncle: 16(29), 17(1), ave. 16.03; scales around body:

26(1), 28(20), 29(2), 30(7), ave. 28.47. The holotype has 25 lateral scales, 11 from dorsal to pelvic, 16 around caudal peduncle, and about 28 around body. The scales on the preorbital region extend dorsally from just below the level of the middle of the pupil to the level of the top of the eye, usually reaching to the middle or the top of the pupil (examination based on the 30 fish measured, see below). The scale structure is of the *C. nevadensis* type (Miller, 1948: pl. II).

Head pores vary as follows (both sides counted): mandibular, 0(60); preopercular, 4(24), 5(2), 6(23), 7(7), 8(4), ave. 5.42; and lachrymal, 0(58), 1(2), ave. 0.03. Holotype has neither mandibular nor lachrymal pores and 6–8 preopercular pores. The supraorbital canal system (Gosline, 1949: pl. 1, fig. 1), studied in 30 adults (UMMZ 130391), was continuous between pores 1 and 3 and 6 and 7 in 27, and between 1 and 4 and 6 and 7 in 3. The following 7 variants occurred: the canal was continuous between 1–4 on one side only in 4, between 5–7 on one side only in 2, and it was closed between 6–7 on one side only in 1. Since the pore system is not well developed in smaller fish, only larger adults were examined for this character. In the holotype, the supraorbital canal is continuous between pores 1–3 and 6–7 on the left side, and between pores 1–4 and 6–7 on the right.

Gill rakers number: 20(1), 21(1), 22(6), 23(11), 24(9), 25(2), ave. 23.07; holotype has 23. Vertebrae (including urostyle), determined from radiographs: 25(1), 26(17), 27(10), ave. 26.32, typically 12 precaudal and 14 caudal. Holotype has 12 + 14 = 26.

The branchiostegals of 30 large adults (15 of each sex) numbered 5 in 29 and 6 in 1.

Proportional measurements of 15 males and 15 females from the series containing the holotype (UMMZ 130380 and 130391), 26.5–31.5 mm. and 26.1–31.1 mm. in S.L., respectively, were stepped and the values expressed as in the preceding species.

In standard length: head length, 2.95–3.25(3.15), 3.1; greatest body depth, 2.5–2.9(2.55), 2.6 for males, and 2.8–3.0, 2.9, for females; caudal peduncle length 4.0–4.6(4.45), 4.3 for males, and 4.4–4.9, 4.6 for females; predorsal length, 1.65–1.8(1.7), 1.75; postdorsal length, 2.0–2.25(2.1), 2.1 for males, and 2.15–2.4, 2.3 for females; prepelvic length, 1.6–1.8(1.75), 1.7.

In head length: head depth at occiput, 1.0–1.25(1.08), 1.1; head width, 1.35–1.5(1.45), 1.4; greatest body depth, 0.7–0.96(0.75), 0.8; caudal peduncle length, 1.3–1.6(1.4), 1.4; least depth of peduncle in males, 1.55–1.85(1.6), 1.7, and in females, 1.9–2.0, 1.94; bony interorbital width, 2.5–3.0(2.75), 2.7; snout length, 3.2–3.55(3.5), 3.4; orbit

length, 3.0–3.5(3.35), 3.3; upper jaw length, 2.6–3.0(2.7), 2.8; mandible length, 3.0–3.4(3.35), 3.2; mouth width, 2.5–3.0(2.75), 2.7; length of depressed dorsal fin, in males, 0.8–1.1(1.0), 0.99, and in females, 1.1–1.25, 1.2; length of depressed anal fin, in males, 1.2–1.35(1.2), 1.3, and in females, 1.45–1.6, 1.5; pectoral length, 1.15–1.5(1.45), 1.4; pelvic length, in males, 2.55–3.2(3.0), 2.9, and in females, 3.0–3.5, 3.3; length of middle caudal rays, 1.4–1.6(1.47), 1.5.

Length of caudal peduncle into predorsal length, in males, 2.4–2.7(2.65), 2.5, and in females, 2.65–3.0, 2.8; length of caudal fin (middle rays) into predorsal length, in males, 2.5–2.95(2.8), 2.7, and in females, 2.85–3.2, 3.1; caudal peduncle depth into length, 1.05–1.35(1.15), 1.2; pelvic length into caudal peduncle depth, 1.45–1.8(1.6), 1.6.

The intestine is long and much convoluted, though evidently not as long as in *C. bifasciatus*. In an adult male 30 mm. S.L., from the type locality, this structure was approximately 85 mm. (stretched length) or about 3 times the standard length.

The position of the dorsal fin is expressed as in the preceding species. In the 14 males measured (UMMZ 130391), the point reaches from between the anterior half of the pupil to the posterior half of the rostrum, usually from the front of the eye to the front of the orbit (in the holotype it falls near front of pupil); in the 15 females measured it falls from just behind the orbit to just before the middle of the pupil, usually from the posterior rim of the orbit to the middle of the pupil.

The size of the broad black terminal caudal band of the male may be expressed by stepping its width into the eye, giving ratios of 1.0–1.3 (1.01 in holotype), ave. 1.14.

VARIANTS.—The series from Laguna San Pablo, collected in 1961, are designated non-types because of certain characteristics that might indicate introgression of genes from *C. bifasciatus* due to past hybridization with that species.

The development of the ocelli on the dorsal and anal fins of females and juveniles is quite variable. Whereas these markings are consistently well developed in the two type series, in the 103 juveniles and females from San Pablo both ocelli are well developed in only 38, the anal ocellus is moderate to weak in 46 (including 10 adults), there is only a trace of this ocellus in 7 (1 adult), and 12 fish (1 adult) have no anal ocellus. *C. bifasciatus* consistently lacks an ocellus on either fin.

The dorsal fin is also more anterior in position than it is in the type series. Using dividers as previously described results were as follows: in 20 males (19–32.5 mm. in S.L.), they fell from the front of the eye (in 1) almost to the tip of the snout, usually from the front of the orbit

to the tip of the rostrum; in 20 females(20–34 mm. S.L.), they reached from just behind the pupil (in 1) to the tip of the rostrum (1), usually from about the middle of the pupil to the anterior margin of the orbit.

The following meristic data might also indicate variation toward *C. bifasciatus*: (1) caudal rays 13–16, usually 14 or 15 (ave. 14.60) rather than usually 15 or 16 (ave. 15.23) in the types. The fewer number approaches the typical count of 14 in *C. bifasciatus;* (2) scales around body average 26.73 versus 28.47 (25.87 in *bifasciatus*).

Until a careful analysis is made of variation in existing populations of *C. atrorus,* the significance of these traits will remain uncertain.

Coloration.—The life colors of spawning males were noted in the field and laboratory (outdoor ponds at Tempe, Arizona). The dorsal fin is milky yellow with a deep orange cast, its base milky yellowish-orange; usually it has a very thin black margin, especially in old males. The anal fin is milky white with a yellow to orange cast, the fin jet black on the posterior ¼ to ⅕ and often on the posterior half. Pectorals brilliant-yellow to yellowish-orange, with a thin black margin. Pelvics bright lemon-yellow. Caudal fin yellow to orange, with a broad velvet-black, terminal band; a lighter area is usually evident before the terminal band. Body brilliant blue over predorsal region and on sides down to pectoral fins and posteriorly to or beyond the dorsal origin—in sexually active males to caudal fin base and down the sides over the darker vertical bars; these bars, numbering 7 to 9, are separated by silvery interspaces. Eye with a striking iridescent blue spot before or above the pupil. Belly white; the chin, gular region, cheeks, and breast suffused with golden yellow in the most sexually active males. The head has an overall yellowish cast.

As usual in *Cyprinodon,* the females lack the bright colors of the males. They are gray-brown to black dorsally, and laterally this pigment includes about a third of the side and perhaps half of the caudal peduncle. The lower sides and venter are white, with 5 to 9 dark, irregular blotches on the side, centering on the lateral line, continuing dorsally into the dark dorsum and extending variably downward into the white ventral region. The dorsal and anal fins are clear, or light gray, with distinct, black ocelli near their posterior proximal margins. The pectoral, pelvic, and caudal fins lack pigment. Juveniles are indistinguishable from females.

Habitat and Habits.—*Cyprinodon atrorus* lives in shallow, saline marshy pools that warm and cool rapidly and support a dense growth of blue-green algae and other microphytes over a soft, calcareous bottom. Generally there is no current, and water depth is usually less than

20 cm. (Minckley and Itzkowitz, 1967). These habitats are generally peripheral to those favored by *C. bifasciatus* and are characterized by marked variations in temperature, size, and water chemistry. *C. atrorus,* like most members of the genus *Cyprinodon,* has successfully adapted itself to such highly variable habitats.

Few other fishes live with this species. Not infrequently it is the sole fish in its ecological niche, and only two species have been collected with it. These are *Lucania interioris* Hubbs and Miller (1965) and *Gambusia marshi* Minckley and Craddock (in Minckley, 1962). Like the *Lucania, C. atrorus* dives into bottom vegetation (e.g., beds of *Chara*) when alarmed; or it may escape by swimming into shallow, weed-choked channels.

RELATIONSHIPS.—The very broad terminal black band on the caudal fin of the mature male is a distinctive mark of this species. It is approached in this feature by *Cyprinodon eximius* Girard, of the Río de Sauz basin, Río Conchos, and certain Texas tributaries of the Río Grande, and by *C. latifasciatus* Garman of the Parras basin, Coahuila (see Miller, 1964). Another trait shared with *C. eximius* is the yellow to orange dorsal fin of the breeding male, and both *C. atrorus* and *C. latifasciatus* have 5 branchiostegals. Not enough is known, however, about the number and variability of branchiostegal rays in *Cyprinodon* to appraise the significance of this character. The basic number is 6, with the rays arranged in three groups as follows: 1 broad ray attached to the epihyal, 3 narrower ones inserted posteriorly on the ceratohyal, and 2 slender ones attached to the anterior part of the ceratohyal. When there are only 5 branchiostegals, one of the latter two rays is lacking. Possession of 6 branchiostegals is evidently the generalized condition in cyprinodontoids (McAllister, 1968: 127–128). The reduction to 5, like the reduced size and number of rays of the pelvic fins, has probably occurred independently several times.

C. atrorus differs from *C. latifasciatus* in many features, including: (1) male with vertical bars rather than horizontal stripes; (2) female with ocelli on both dorsal and anal fins (none in *latifasciatus*); (3) no lachrymal pores; (4) reduced preopercular pores, typically 4 or 6 rather than 7; and (5) pectoral fin shorter, not extending to or beyond origin of pelvics. From *C. eximius* the new species differs in: (1) the more numerous gill rakers, 20–25 versus 11–18; (2) lacking lachrymal pores (usually 4 in *eximius*) and reduced preopercular pores (usually 7 in *eximius*); (3) having usually 14 or 15 rather than 16 or 17 caudal rays; and (4) the absence of a checkered pattern of prominent black spots and

dashes characteristic of the basal half to two-thirds of the male caudal fin of *eximius*.

Probably *C. atrorus* was derived from *C. eximius*, or from a form that was the common ancestor of both species, at a time more recent than was the origin of *C. bifasciatus* described above.

ETYMOLOGY.—The name *atrorus* is from the Latin *ater*, black, and *ora*, border (with nominative suffix *-us*), in reference to the conspicuous black terminal band on the caudal fin of the male.

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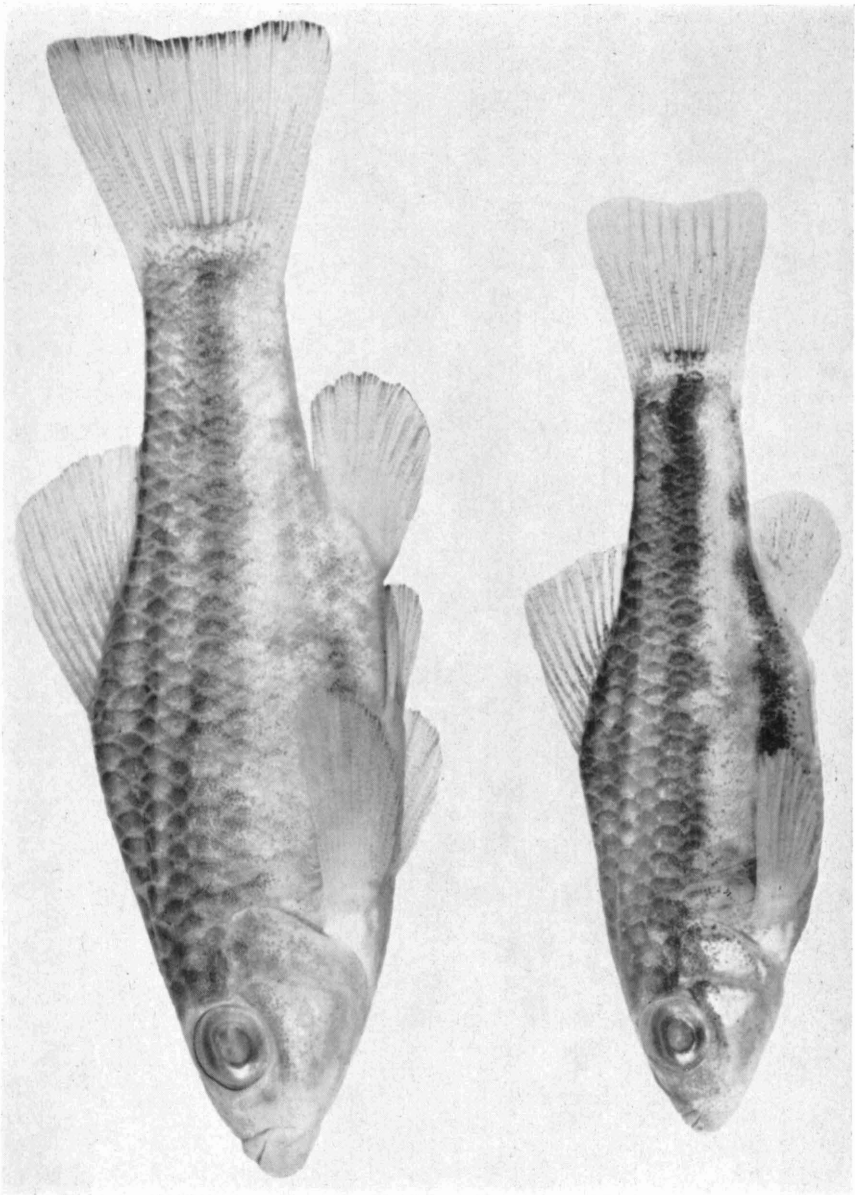

FIG. 1. *Cyprinodon bifasciatus*, n. sp. Above, male holotype, 44.5 mm. S.L., UMMZ 179835. Below, female paratotype, 36.0 mm. S.L., UMMZ 179836. Photograph by W. L. Cristanelli.

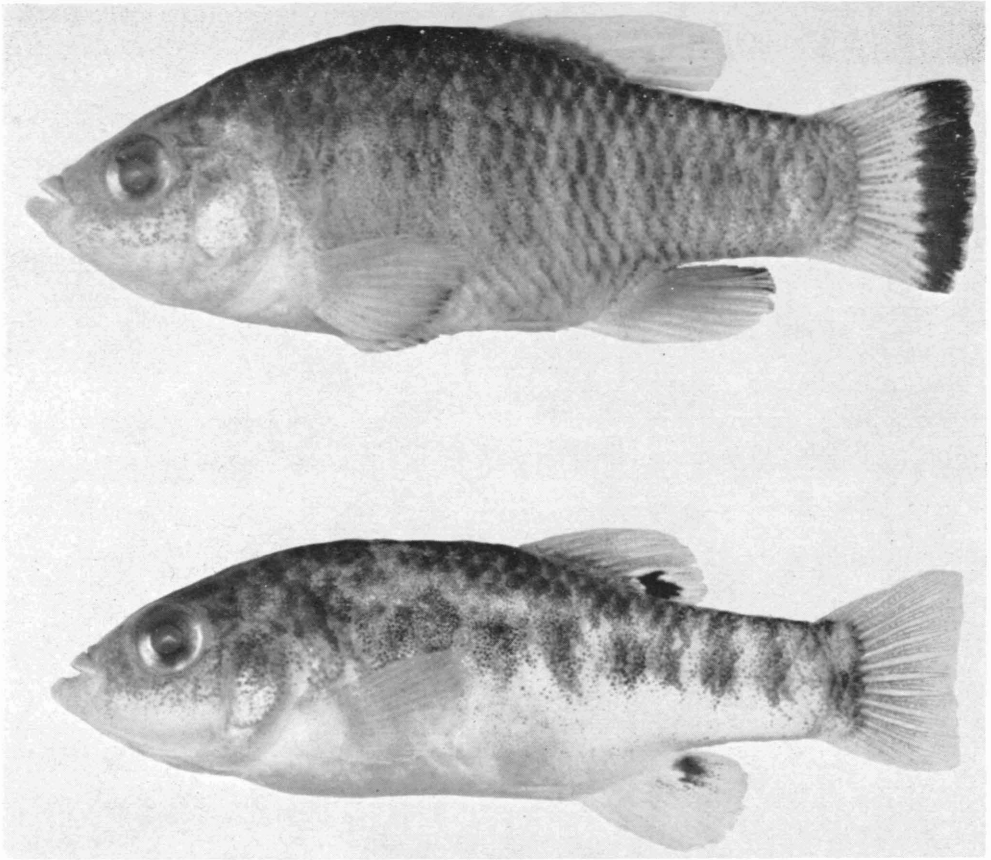

FIG. 2. *Cyprinodon atrorus,* n. sp. Above, male holotype, 31 mm. S.L., UMMZ 130380. Below, female paratype, 30 mm. S.L., UMMZ 130391. Photograph by Photographic Services, University of Michigan, slightly retouched.