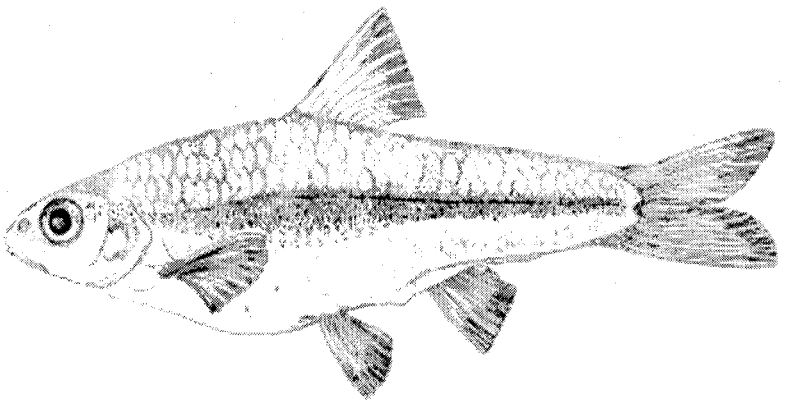
SPECIAL PUBLICATIONS

Museum of Texas Tech University

NUMBER 46 12 May 2003

AQUATIC FAUNA OF THE NORTHERN CHIHUAHUAN DESERT



CONTRIBUTED PAPERS FROM A SPECIAL SESSION WITHIN
THE THIRTY-THIRD ANNUAL SYMPOSIUM OF
THE DESERT FISHES COUNCIL

HELD
17 NOVEMBER 2001
AT
SUL ROSS STATE UNIVERSITY, ALPINE, TEXAS

EDITED BY
GARY P. GARRETT AND NATHAN L. ALLAN

Fish Assemblages of the Río Conchos Basin, México, with Emphasis on Their Conservation and Status

Robert J. Edwards, Gary P. Garrett, and Edie Marsh-Matthews

Abstract

The Chihuahuan Desert region contains a number of unique aquatic environments, but with few exceptions, these have been little studied. We sampled the Río Conchos Basin in 1994 and 1995 to assess the status of the fishes of this region. Most sites showed some degree of human-induced impacts. A number of potentially threatened fishes were either abundant at only a few sites or rare or absent throughout the localities sampled. Comparisons with collections taken during the 1950s indicate that the basic fish fauna is largely intact. However, there appears to be diminished relative abundances of "large river" forms in favor of non-natives (primarily an African cichlid, *Oreochromis aureus*) and "quiet-water" native fishes. This change seems related to decreased flows and regulated flow regimes from dams in the basin.

Resumen

La región del desierto de Chihuahuan contiene un número de ambientes acuáticos únicos, pero con pocas anomalías, éstos se han estudiado poco. Porque muchos de los pescados en la región se piensan para ser amenazados con la extinción o han ido extintos, muestreamos el lavabo de Río Conchos en 1994 y 1995 para evaluar el estatus de los pescados de esta región. La mayoría de los sitios mostraron un cierto grado de impactos humano-inducidos. Un número de pescados potencialmente amenazados eran o abundantes en solamente algunos sitios o raro o ausente a través de los lugares muestreó. Las comparaciones de nuestros datos a las colecciones tomadas durante los años 50 indican que mientras que la fauna básica de los pescados en la región es en gran parte intacta, aparece ser reducciones en formas del "río grande" y aumenta las formas del ambiente introducido de los pescados y de la "reservado-agua". Estos cambios aparecen relacionados a disminuido y los regímenes regulados del flujo.

Introduction

The limited aquatic habitats of the Chihuahuan Desert have undergone substantial anthropogenic modification in the last hundred years, including reduced water quality, diversion of surface water, overdrafting of groundwater, channelization, impoundment, and introduction of non-native species (Miller and Chernoff, 1979; Propst and Stefferud, 1994; TNRCC, 1994; IBWC, 1994; Lee and Wilson, 1997; Edwards et al., 2001). Impacts from these modifications are only now being documented and few baseline data exist concerning the ecological requirements for most of the aquatic species.

Approximately half of the native fishes of the Chihuahuan Desert are threatened with extinction or are extinct (Hubbs, 1990). Documented extinctions from the northern Chihuahuan Desert include Maravillas red shiner (*Cyprinella lutrensis blairi*), phantom shiner (*Notropis orca*), Rio Grande bluntnose shiner (*Notropis simus simus*), and Amistad gambusia (*Gambusia amistadensis*) (Miller et al., 1989; Hubbs, this volume). Some noteworthy extirpations include Rio Grande shiner (*Notropis jemezanus*) from the New Mexico portion of the Rio Grande (Propst et al., 1987) and Rio

Grande silvery minnow (*Hybognathus amarus*), Rio Grande cutthroat trout (*Oncorhynchus clarki virginalis*) and blotched gambusia (*Gambusia senilis*) in Texas (Bestgen and Platania, 1990, 1991; Hubbs et al., 1991) as well as others. The status of a number of fishes in the northern Chihuahuan Desert is poorly understood, particularly for the Mexican portion of their ranges. Endemic species other than fishes also are being lost from this area (Howells and Garrett, 1995; Howells, this volume; Lang et al., this volume).

In this paper, we present data on fish collections from 14 localities in the Río Conchos Basin in 1994 and 1995. We compare our results with a series of collections taken from the basin nearly 40 years earlier, and we comment on the status of several imperiled fishes for which the Río Conchos Basin represents a significant portion of their geographic distribution.

STUDY AREA

The Río Conchos receives its water from a series of tributaries originating in the Sierra Madre Occidental in Chihuahua, Mexico, along with a number of springs, seasonal rains and periodic tropical storms (Tamayo and West, 1964). The climate ranges from subhumid and temperate in the Sierra Madre Occidental to semiarid and warm in the central Plateau and warm and arid in its northern-most reaches; temperatures often exceed 40°C and precipitation averages about 315 mm/year, with greater amounts in the mountain areas and lesser amounts in the central and northern portions of the state (Kelly, 2001). The Mexican state of Chihuahua has over two million people, with 80% living in small to medium sized towns and the remainder centered in the cities of Juarez and Ciudad Chihuahua. Anthropogenic impacts range from deforestation and mining in the Sierra Madre, impoundments on both large and small streams throughout the region, manufacturing in the cities, and agriculture throughout the central Plateau, especially surrounding Ciudad Chihuahua (Comisión Nacional del Agua, 1997). Only the largest cities have wastewater treatment plants and most rural areas lack even basic sewage collection and disinfection facilities (Kelly, 2001). Some major streams (for example, the Río Florido) are severely impacted with high levels of oil, fecal coliform bacteria, discharges from chemical plants, and pollution from agricultural return flows (Comisión Nacional del Agua, 1997). The Río Conchos is the primary source of water for the Rio Grande downstream of Presidio, Texas. The average annual flow of the Rio Grande immediately upstream of its confluence with the Río Conchos is approximately 72 thousand acre-feet (8.9 x 10^7 m^3), whereas the Río Conchos contributes an annual average of 779 thousand acre-feet (9.6 x 10^8 m^3), far exceeding the input from any other tributary of the Rio Grande System (IBWC, 1990; Eaton and Hurlburt, 1992; TNRCC, 1994).

MATERIALS AND METHODS

We collected fishes from 14 locations (combined into 11 stations) throughout the Río Conchos System of Chihuahua (Figure 1). The Río Parral was not sampled because locals advised us that the waters were too polluted to even safely wade in. Our station designations, specific sampling localities and sampling dates were as follows: Station 1, springs at Ojo Talamantes, 16 km NE of Allende, 6 August 1994; Station 2, the Río Conchos at Valle de Zaragosa, 6 August 1994; Station 3, Río San Pedro S of Satevó at Highway 24 crossing, 6 August 1994; Station 4, Río Santa Isabela, 20 km downstream from Riva Palacio, 7 August 1994; Station 5, Río Santa Isabela immediately upstream from Riva Palacio, 7 August 1994; Station 6, Río Conchos, immediately downstream from Julimes, 5 August 1994; Station 7, a series of three collections at the springs and outflows at San Diego de Alcalá, 24 October 1995; Stations 8a and 8b, Río Chuviscar near San Diego de Alcalá, 4 August 1994 (Station 8a) and 24 October 1995 (Station 8b), respectively, during and after construction of a water pipe to draw water from the stream; Station 9, headwaters of Río Chuviscar, near Highway 160, approximately 15 km S of Namiquipa, 23 October 1995; Station 10, Río Conchos at Cuchillo

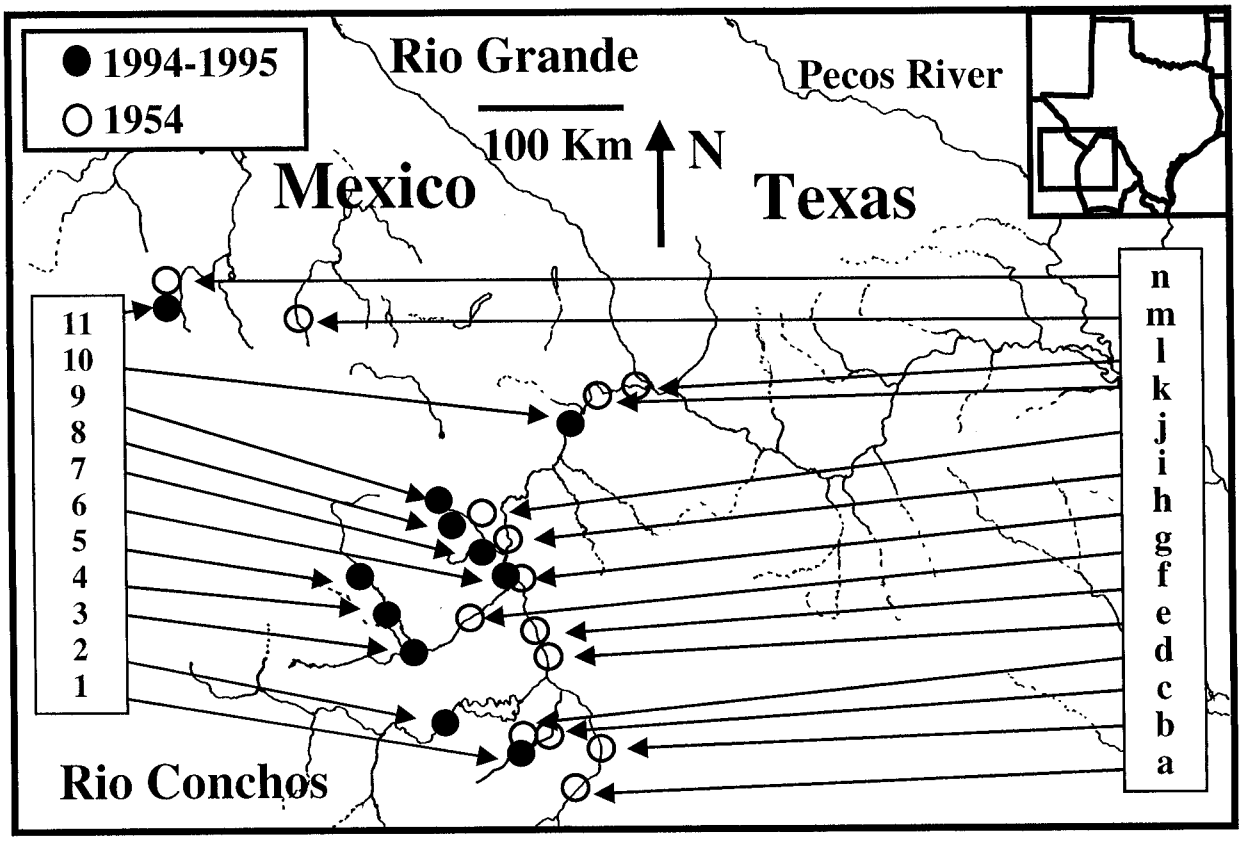


Figure 1. Map of Rio Conchos study area. Numerals indicate most current collection sites and letters indicate comparative historical collection sites. See text for collections localities.

Parado, about 30 km from the confluence with the Rio Grande, 3 August 1994; and, Station 11, springs at Ojo del Arrey, approximately 4 km NE of Angostura, 10 August 1994. The Río Florido was not sampled because it was dry or too seriously polluted throughout much of its course.

We intensively sampled contiguous segments of habitats with seemingly pristine conditions so as to represent, to the greatest degree possible, the natural biota. We selected multiple sampling sites at each location and collected at each site until we detected no additional changes in species occurrence and relative abundances in the sample. In general, all available microhabitats were sampled roughly in proportion to their occurrence. Sites were sampled with seines 3 m (3 mm mesh) to 10 m (6 mm mesh) long or electrofishing in all available habitats. At most sites waters were too shallow for effective electrofishing, and seining was the major method. At each location, all specimens collected were identified and enumerated. A representative subsample of each species (except those not allowed by permit) was retained. Our data are presented as relative abundances to facilitate comparisons. We compared our data to museum collection records (Texas Natural History Collections, The University of Texas at Austin) of a series of collections taken by Clark Hubbs and Victor Springer in June and July 1954 and by Hubbs and Oscar Wiegand in December 1954 from similar areas (and using seines) throughout the Río Conchos basin. We collected in all available habitats within a fewer number of larger sites with generally three to six teams of collectors at each station, whereas the 1954 collectors sampled at a greater number of smaller habitats, in part, because only two people were sampling (C. Hubbs, University of Texas at Austin, pers. comm.). We combined a number of the 1954 sampling stations into a smaller series of stations in order to be more comparable to our collection data. The stations created for the 1954 comparisons (Figure 1) were as follows. Station a, Río Florido, at Highway 45 crossing, 17.6 km ESE of

Villa Ocampo, 27 June 1954; Río Florido at Espirito Santo, 8 km ESE of Villa Ocampo, 27 June 1954, a tributary of the Río Florido, 24.6 km ESE of Parral, 27 June 1954, and the Río Florido 0.8 km W of Villa Ocampo, 27 June 1954; Station b, Río Florido at Guadalupe, 22.4 km E of Parral, 26 June 1954; Station c, a series of collections at the springs and associated outflows near the Ojo de la Hacienda Delores including the Río Valle de Allende, at Valle de Allende, 27 June 1954, El Ojo de la Hacienda Dolores, 8 km S of Jimenez and 3.2 km SE of Dolores, 30 June 1954, an irrigation ditch draining El Ojo de la Hacienda Dolores, 30 June 1954, El Ojo Almoloya, 3.2 km W of Estacion Troya, 30 June 1954, an irrigation ditch at Highway 45, 1.6 km SE of Bachimba, 1 July 1954, Río Parral, 3.2 km W of Parral and approximately 0.5 km W of the railroad bridge, 26 June 1954, Río Valle de Allende, 1.6 km W of Valle de Allende at the small dam, 30 December 1954, a ditch near El Ojo Almoloya, 2.4 km W of Troya, 31 December 1954 in an irrigation ditch near Ojo Hacienda Dolores at points 3.2 and 6.4 km S of Jimenez, 31 December 1954, El Ojo de La Hacienda Dolores, 8 km S of Jimenez and 3.2 km SE of Dolores, 31 December 1954, and Ojo Hacienda Dolores, 8 km S of Jimenez, 31 December 1954; Station d, Ojo de San Gregorio, 0.5 km W of San Gregorio and 19.2 km ENE of Parral, 31 December 1954; Station e, Río Conchos at Camargo, 25 June 1954, Río Conchos at La Cruz (several different sites), 25 June 1954, Río Conchos, 1.6 km N of Saucillo, 28 June 1954, Río Conchos at highway crossing, 19.2 km SW of Camargo, a tributary of the Río Conchos, 1.6 km E of San Francisco de Condios and 24 km SW of Camargo, both on 28 June 1954; Station f, Río Conchos at Saucillo on the E channel at ford, 25 June 1954; Station g, Río San Pedro, 1.6 km SW of Meoqui, 24 June 1954, Río San Pedro at Meoqui, 30 December 1954; Station h, Río Conchos at Julimes, 24 June 1954; Station j, was the Río San Pedro, 0.4 km SW of confluence with Río Conchos, 24 June 1954, Río Sacramento 1.6 km N of Ciudad Chihuahua, 1 July 1954; Station k, Río Conchos, 32 km W of Rio Grande confluence, 14 June 1954; Station l, Río Conchos, 1 km. upstream of confluence with Rio Grande, 13 June 1954, Río Conchos, 6.4 km W of Rio Grande confluence at Sierras Navas, 14 June 1954; Station m, Río del Carmen at El Carmen, 1 July 1954; Station n, Río Santa Maria at Buenaventura, 2 July 1954.

RESULTS

1994-1995 COLLECTIONS

Our collections yielded 18,371 specimens representing 37 species (Table 1). Streams within the Río Conchos Basin are characterized by a relatively large minnow (Cyprinidae) component that includes *Cyprinella lutrensis, Notropis chihuahua, Notropis braytoni, Notropis jemezanus, Campostoma ornatum, Macrhybopsis aestivalis,* and *Rhinichthys cataractae.* Other typical species were *Scartomyzon austrinus, Ictalurus lupus, Astyanax mexicanus, Cyprinodon eximius,* and *Gambusia senilis.* Several wide-ranging species were found, including *Dorosoma cepedianum, Pimephales promelas, Ictalurus furcatus, Pylodictis olivaris, Gambusia speciosa, Lepomis cyanellus, L. megalotis, L. macrochirus,* and *Micropterus salmoides.* As expected, mainstem localities contained more species and tributary streams contained a subset of the total species complement.

The springs at Ojo de Talamantes (Station 1) and those at Ojo del Arrey (Station 11) were quite different from the other localities sampled. At the former site, an undescribed species of *Gambusia* accounted for over 70% of the fishes captured, while at the latter site, *G. speciosa* and an undescribed species of *Cyprinodon* accounted for more than 95% of the fishes captured. Each of these springs has been substantially modified. The springs at Talamantes have been transformed into an aquatic tourist park and impounded with a low concrete dam and the springs at Ojo del Arrey have been developed into a swimming pool, with a small outflow spring run.

The headwaters of the Río Chuviscar (Station 9), the Río San Pedro (Station 3) and the Río Chuviscar at San Diego de Alcalá (Station 8b) all contained large

Table 1. Relative abundance of species captured in the Rio Conchos basin during 1954 (Stations a - n) and 1994-1995 (Stations 1 - 11). Gambusia speciosa collections in 1954 were referenced as G. affinis. See Figure 1 and text for specific station locations.

Species	Station 1	2	3	4	5	6	7	8a	8b	9	10	11
Lepisosteus osseus	—	—	—	—	—	—	—	—	—	—	—	—
Dorosoma cepedianum	—	—	—	—	—	—	—	—	—	—	—	—
Campostoma ornatum	—	0.53	0.73	1.44	14.42	—	0.75	2.39	—	—	—	—
Codoma ornata	—	—	0.55	33.56	20.29	—	—	—	—	—	—	—
Cyprinella lutrensis	—	13.82	6.69	9.11	—	33.57	3.58	3.24	15.20	0.80	61.90	2.54
Cyprinus carpio	—	—	—	—	—	—	—	—	—	—	0.50	—
Dionda episcopa	0.13	0.12	18.18	8.34	—	—	9.39	3.38	—	—	—	—
Gila pulchra	—	—	—	0.90	6.01	—	—	—	—	—	—	—
Macrhybopsis aestivalis	—	—	—	—	—	—	—	—	—	—	—	—
Notropis braytoni	—	0.19	—	0.54	—	1.33	—	—	—	0.80	0.20	—
Notropis chihuahua	14.40	16.48	7.05	23.36	40.99	0.20	6.11	21.27	4.80	—	2.02	—
Notropis jemezanus	—	13.61	—	—	0.40	1.33	—	—	—	—	—	—
Pimephales promelas	—	33.39	0.79	0.59	2.40	0.10	—	—	0.80	—	4.54	—
Rhinichthys cataractae	—	0.02	—	—	—	—	—	—	—	—	—	—
Carpiodes carpio	—	0.08	—	—	—	0.20	—	—	—	—	10.69	—
Catostomus conchos	—	6.18	0.12	—	—	—	—	—	—	—	—	—
Ictiobus bubalus	—	0.02	0.06	—	—	—	—	—	—	—	—	—
Cycleptus elongatus	—	—	—	—	—	—	—	—	—	—	—	—
Pantosteus jordani	—	—	—	—	—	—	—	—	—	—	—	—
Pantosteus plebius	—	—	—	—	—	—	—	—	—	—	—	—
Scartomyzon austrinus	—	0.42	0.12	—	—	0.61	—	—	—	—	1.31	—
Astyanax mexicanus	6.33	0.73	5.23	2.12	—	—	3.28	0.14	1.60	—	1.31	—
Ameiurus melas	—	—	—	0.09	0.13	—	—	—	—	—	—	0.13
Ictalurus furcatus	—	0.03	—	—	—	—	—	—	—	—	0.91	—
Ictalurus lupus	—	0.14	0.06	—	—	0.10	—	—	—	—	0.10	—
Ictalurus punctatus	—	—	—	0.05	—	0.10	—	—	—	—	0.10	—
Pylodictis olivaris	—	—	—	—	—	0.71	—	—	—	—	0.81	—
Cyprinodon eximius	—	0.56	1.16	0.09	—	—	—	45.21	13.00	—	—	—
Cyprinodon macrolepis	—	—	—	—	—	—	—	—	—	—	—	—
Cyprinodon sp.1	—	—	—	—	—	—	24.74	—	—	—	—	—
Cyprinodon sp.2	—	—	—	—	—	—	—	—	—	—	—	8.81
Fundulus zebrinus	—	—	—	—	—	—	—	—	—	—	0.20	—
Gambusia speciosa	—	—	—	—	—	—	—	—	—	—	—	88.51
Gambusia alvarezi	—	—	—	—	—	—	—	—	—	—	—	—
Gambusia hurtadoi	—	—	—	—	—	—	—	—	—	—	—	—
Gambusia senilis	—	0.10	56.96	17.41	10.95	—	23.99	23.94	62.20	98.39	—	—
Gambusia sp.1	—	—	—	—	—	—	6.11	—	—	—	—	—
Gambusia sp.2	71.87	—	—	—	—	—	—	—	—	—	—	—

Table 1. (cont.)

Menidia beryllina	—	—	—	—	—	2.24	—	—	—	—	6.15	—
Lepomis cyanellus	—	—	0.06	—	—	—	1.34	—	1.60	—	—	—
Lepomis gulosus	—	—	—	—	—	—	0.15	—	—	—	—	—
Lepomis macrochirus	0.54	—	—	—	—	0.10	18.18	—	—	—	—	—
Lepomis megalotis	0.07	13.29	—	1.80	2.00	0.10	1.79	—	—	—	0.10	—
Micropterus salmoides	6.66	—	—	—	—	0.31	—	—	—	—	1.01	—
Etheostoma australe/pottsi	—	—	—	0.27	2.40	—	—	—	—	—	—	—
Aplodinotus grunniens	—	—	—	—	—	—	—	—	—	—	—	—
Oreochromis aureus	—	0.29	2.25	0.32	—	58.98	0.60	0.42	0.80	—	8.17	—
Specimens captured	5,891	1,645	749	2,281	2,217	1,486	249	500	980	671	710	992
Number of species	7	19	15	16	10	15	13	8	8	13	17	17
Percent introduced	0.0	0.3	2.3	0.3	0.0	61.2	0.6	0.4	0.8	0.6	14.8	14.8

	Station							
Species	a	b	c	c1	c2	d	e	f
Lepisosteus osseus	—	—	—	—	—	—	1.13	—
Dorosoma cepedianum	—	—	—	—	—	—	—	—
Campostoma ornatum	6.37	19.11	8.30	—	—	—	—	—
Codoma ornata	8.45	—	0.14	—	—	—	—	—
Cyprinella lutrensis	26.36	3.18	15.11	1.76	1.03	—	4.53	27.18
Cyprinus carpio	—	—	—	—	—	—	—	—
Dionda episcopa	14.48	16.56	7.42	—	0.46	—	18.93	—
Gila pulchra	4.66	—	21.08	—	—	—	—	—
Macrhybopsis aestivalis	—	—	—	—	—	—	—	—
Notropis braytoni	—	—	—	—	—	—	—	—
Notropis chihuahua	6.96	4.46	9.62	1.18	—	—	9.11	11.65
Notropis jemezanus	0.46	—	—	—	—	—	21.90	—
Pimephales promelas	9.22	—	0.23	0.14	—	—	10.52	—
Rhinichthys cataractae	3.61	—	—	—	—	—	—	—
Carpiodes carpio	3.91	—	—	—	—	—	0.33	0.49
Catostomus conchos	4.51	—	—	—	—	—	—	—
Ictiobus bubalus	—	—	—	—	—	—	—	—
Cycleptus elongatus	—	—	—	—	—	—	0.16	—
Pantosteus jordani	—	—	—	—	—	—	—	—
Pantosteus plebius	—	—	—	—	—	—	—	—
Scartomyzon austrinus	—	—	—	—	—	—	0.65	—
Astyanax mexicanus	6.80	—	—	—	5.61	—	10.72	0.49
Ameiurus melas	—	—	—	—	—	—	—	—
Ictalurus furcatus	—	—	—	—	—	—	—	—
Ictalurus lupus	—	—	—	—	—	—	—	—

Table 1. (cont.)

Species	Station a	b	c	c1	c2	d	e	f
Ictalurus punctatus	—	—	—	—	—	—	—	—
Pylodictis olivaris	—	—	—	—	—	—	0.33	—
Cyprinodon eximius	0.30	—	2.00	—	—	—	2.27	14.08
Cyprinodon macrolepis	—	—	—	5.44	—	—	—	—
Cyprinodon sp.1	—	—	—	—	—	—	—	—
Cyprinodon sp.2	—	—	—	—	—	—	—	—
Fundulus zebrinus	—	—	—	—	—	—	—	—
Gambusia speciosa	—	—	—	—	—	—	—	—
Gambusia alvarezi	—	—	—	—	—	120.16	—	—
Gambusia hurtadoi	—	—	—	91.48	—	—	—	—
Gambusia senilis	2.11	56.69	35.38	—	92.91	—	8.10	—
Gambusia sp.1	—	—	—	—	—	—	—	—
Gambusia sp.2	—	—	—	—	—	—	—	—
Menidia beryllina	—	—	—	—	—	—	—	—
Lepomis cyanellus	—	—	—	—	—	—	—	—
Lepomis gulosus	—	—	—	—	—	—	—	—
Lepomis macrochirus	—	—	—	—	—	—	5.99	18.45
Lepomis megalotis	1.81	—	—	—	—	—	1.94	0.97
Micropterus salmoides	—	—	—	—	—	—	3.24	26.70
Etheostoma australe/pottsi	—	—	0.71	—	—	—	0.16	—
Aplodinotus grunniens	—	—	—	—	—	—	—	—
Oreochromis aureus	—	—	—	—	—	—	—	—
Specimens captured	659	157	1,204	2,188	874	496	618	206
Number of species	15	5	10	5	4	1	17	8
Percent introduced	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

Species	Station g	h	i	j	k	l	m	n
Lepisosteus osseus	—	—	—	—	1.22	0.97	—	—
Dorosoma cepedianum	—	—	—	—	—	6.82	—	—
Campostoma ornatum	—	—	1.16	4.85	—	—	21.46	—
Codoma ornata	2.82	—	—	21.36	—	—	—	—
Cyprinella lutrensis	—	0.65	1.16	—	—	16.18	35.62	29.55
Cyprinus carpio	—	—	—	—	4.88	2.34	—	—
Dionda episcopa	6.76	—	—	19.42	—	—	—	—
Gila pulchra	—	—	—	—	—	—	8.15	9.85
Macrhybopsis aestivalis	—	—	—	—	6.10	10.72	—	—
Notropis braytoni	—	18.95	—	—	39.02	28.46	—	—

Table 1. (cont.)

Species	Station g	h	i	j	k	l	m	n
Notropis chihuahua	1.13	21.57	10.47	4.85	—	—	—	—
Notropis jemezanus	—	18.97	—	—	—	11.89	—	—
Pimephales promelas	5.07	—	1.16	4.85	8.54	1.17	0.43	18.94
Rhinichthys cataractae	—	—	—	—	1.22	0.19	—	—
Carpiodes carpio	—	3.27	—	—	2.44	2.14	—	—
Catostomus conchos	—	—	—	—	—	—	0.86	—
Ictiobus bubalus	—	—	—	—	—	—	—	—
Cycleptus elongatus	—	—	—	—	—	0.19	—	—
Pantosteus jordani	—	—	—	—	—	—	25.75	—
Pantosteus plebius	—	—	—	—	—	—	—	29.55
Scartomyzon austrinus	—	—	—	—	1.22	—	—	—
Astyanax mexicanus	2.82	15.68	—	0.97	35.37	4.68	—	—
Ameiurus melas	—	—	—	—	—	—	—	—
Ictalurus furcatus	—	—	—	—	—	1.36	—	—
Ictalurus lupus	—	—	—	—	—	—	—	—
Ictalurus punctatus	—	—	1.16	—	—	—	—	—
Pylodictis olivaris	—	—	—	—	—	0.97	—	—
Cyprinodon eximius	33.24	—	—	—	—	—	7.73	12.12
Cyprinodon macrolepis	—	—	—	—	—	—	—	—
Cyprinodon sp.1	—	—	—	—	—	—	—	—
Cyprinodon sp.2	—	—	—	—	—	—	—	—
Fundulus zebrinus	—	—	—	—	—	—	—	—
Gambusia alvarezi	—	—	—	—	—	—	—	—
Gambusia hurtadoi	—	—	—	—	—	—	—	—
Gambusia senilis	47.89	15.03	52.33	42.72	—	—	—	—
Gambusia sp.1	—	—	—	—	—	—	—	—
Gambusia sp.2	—	—	—	—	—	—	—	—
Menidia beryllina	—	—	—	—	—	—	—	—
Lepomis cyanellus	—	—	—	—	—	1.75	—	—
Lepomis gulosus	—	—	—	—	—	—	—	—
Lepomis macrochirus	—	0.65	3.49	—	—	—	—	—
Lepomis megalotis	—	0.65	3.49	—	—	0.19	—	—
Micropterus salmoides	0.28	4.57	25.58	—	—	—	—	—
Etheostoma australe/pottsi	—	—	—	0.97	—	—	—	—
Aplodinotus grunniens	—	—	—	—	—	0.39	—	—
Oreochromis aureus	—	—	—	—	—	—	—	—
Specimens captured	355	116	111	103	82	513	233	132
Number of species	8	10	9	8	9	18	7	5
Percent introduced	0.0	0.0	0.0	0.0	4.9	2.3	0.0	0.0

Gambusia senilis populations but with relatively few additional species, a situation that is typical of headwater creeks or degraded and polluted conditions. The species diversity was higher at the Río San Pedro site than the other two localities; however, all were small streams dominated by *G. senilis*.

The lower reaches of Río Conchos tributaries (Stations 4, 5, 7, and 8a) had relatively large numbers of *N. jemezanus, G. senilis*, and usually *Campostoma ornatum*. These sites differed from each other in that the Río Santa Isabella localities also contained large numbers of *Codoma ornata* and our only captures of *Gila pulchra*, whereas the two sites near San Diego de Alcalá had relatively large numbers of *Dionda episcopa* and either *C. eximius* (Station 8a) or an undescribed species of *Cyprinodon* (Station 7). The hot spring outflows at the San Diego de Alcalá location (Station 7) contained our largest collection of *Lepomis macrochirus*, an introduced species accounting for 18% of the fish collected at that site.

The Río Conchos immediately above Presa de Boquilla (Station 2) had relatively large numbers of *C. lutrensis, N. chihuahua, C. ornatum* and *G. senilis* and this area also contained *P. promelas, A. mexicanus, L. cyanellus*, and the introduced *Oreochromis aureus*. Although this area has been impacted greatly by urbanization and influences from the reservoir, introduced species were less abundant than at some of the other localities.

The downstream and middle Río Conchos stations (6 and 10) were heavily impacted by channelization and degraded water quality from agricultural inputs. The collections were dominated by *C. lutrensis*, which accounted for a third to about 60% of the total fish captures at these sites. Also present were the introduced *Menidia beryllina* and some of the more typical Chihuahuan Desert fishes, such as *N. chihuahua, N. braytoni, Scartomyzon austrinus* and several catfish, including *Ictalurus furcatus, I. lupus, I. punctatus*, and *Pylodictis olivaris*. These sites also produced large numbers of the introduced *Oreochromis aureus*, especially the site near Julimes (Station 6), which was dominated by this species.

COMPARISON WITH 1954 DATA

To contrast changes in fish community composition that have occurred in the half-century since the 1954 collections were taken, we summarized collections from Río Conchos stations, Río San Pedro stations and Río Florido stations taken during the 1954 series of collections and our present samples. The high degree of overall similarity in species occurrences indicates that the fish fauna in the Río Conchos basin is still intact (Table 2). Some notable changes have occurred. Introduced fishes have long been known from the Río Conchos. For example, the common carp (*Cyprinus carpio*) was present in the early collections. However, blue tilapia (*Oreochromis aureus*) were not in the system in the 1950s, but are now widely found throughout and dominate the fish assemblages at some localities. There appears to be a change in other elements of the fish assemblages, as well, possibly in response to lessened water flows in the basin. There appears to be a loss of minnow diversity (10 species commonly found in 1954 versus 5 in the present study) and a diminution of species commonly found in large river systems (*Lepisosteus osseus, Notropis braytoni, N. jemezanus, Cycleptus elongatus, Aplodinotus grunniens, Micropterus salmoides, Lepomis macrochirus*, and *L. megalotis)*. In contrast, there appear to have been increases in smaller stream forms such as *Cyprinodon eximius* and *Gambusia senilis* both of which are indicative of diminishing and regulated flows. As these latter two species are of conservation concern, their increased populations in our present collections could be tenuous. Further declines in streamflow could negatively impact these species. The change in the fish communities of the Río Florido is dramatic. The fish assemblage in this stream was quite similar to the mainstem Río Conchos in 1954, but in our survey the river was dry.

Our two samples from the Río Chuviscar (Stations 8a and 8b) in 1994 and 1995, indicate how swiftly noticeable changes can occur in fish assemblages. During our initial sampling, workers were laying a water pipe as part of a system to pump water out of the

Table 2. Comparison of changes in fish communities between 1954 and 1994-1995 for selected streams in the Rio Conchos basin. An asterisk (*) indicates that the stream was dry.

	Río Conchos		Río San Pedro		Río Florido	
Species	1954	1994-95	1954	1994-95	1954	1994-95
Lepisosteus osseus	0.60	—	—	—	—	*
Dorosoma cepedianum	1.02	—	—	—	—	*
Campostoma ornatum	—	1.04	0.39	14.42	8.97	*
Codoma ornata	—	0.18	1.46	20.29	8.64	*
Cyprinella lutrensis	9.47	3.31	0.39	—	22.69	*
Cyprinus carpio	0.81	—	—	—	—	*
Dionda episcopa	6.21	7.23	3.51	—	13.58	*
Gila pulchra	—	—	—	6.01	3.30	*
Macrhybopsis aestivalis	1.78	—	—	—	—	*
Notropis braytoni	9.10	—	—	—	—	*
Notropis chihuahua	8.79	14.24	4.07	40.99	5.99	*
Notropis jemezanus	15.21	—	—	0.40	0.35	*
Pimephales promelas	9.77	0.26	3.02	2.40	8.38	*
Rhinichthys cataractae	0.12	—	—	—	2.21	*
Carpiodes carpio	1.12	—	—	—	2.40	*
Catostomus conchos	—	0.04	—	—	2.84	*
Cycleptus elongatus	0.24	—	—	—	—	*
Ictiobus bubalus	—	0.02	—	—	—	*
Scartomyzon austrinus	0.43	0.04	—	—	—	*
Astyanax mexicanus	7.74	3.90	1.46	—	4.97	*
Ameiurus melas	—	—	—	0.13	—	*
Ictalurus furcatus	0.28	—	—	—	—	*
Ictalurus lupus	—	0.02	—	—	—	*
Ictalurus punctatus	—	—	0.39	—	—	*
Pylodictis olivaris	0.40	—	—	—	—	*
Cyprinodon eximius	1.67	15.46	17.25	—	0.18	*
Gambusia speciosa	1.42	—	—	—	—	*
Gambusia senilis	4.19	26.97	57.06	10.95	13.62	*
Gambusia sp.2	—	23.96	—	—	—	*
Lepomis cyanellus	0.32	0.02	—	—	—	*
Lepomis macrochirus	9.89	0.18	1.16	—	—	*
Lepomis megalotis	2.58	0.02	1.16	2.00	1.88	*
Micropterus salmoides	6.57	2.22	8.67	—	—	*
Etheostoma australe/pottsi	0.23	—	—	2.40	—	*
Aplodinotus grunniens	0.04	—	—	—	—	*
Oreochromis aureus	—	0.89	—	—	—	*
Number of collections	13	3	3	1	5	*
Number of species	26	19	13	10	15	0

stream. A year later, the pump had been installed and the stream was visibly altered, showing numerous effects of the construction activity. Relative abundances of *C. ornatum, D. episcopa, N. chihuahua*, and *C. eximius* were lower and those for *C. lutrensis* and *G. senilis* were notably higher during the second visit. *Pimephales promelas, A. mexicanus, L. cyanellus* and *O. aureus* also had somewhat increased relative abundances following the perturbation. The species showing increased relative abundances are characteristic of either highly degraded areas or small headwater streams and generally are considered to be more tolerant of extreme environmental conditions.

STATUS OF SPECIES

A number of fishes inhabiting the Chihuahuan Desert region have been proposed for listing as endangered or threatened species of the U.S. or Mexico. Based on our results we provide additional observations on the status of some of these species.

The Mexican stoneroller (*Campostoma ornatum*) occurs in numerous localities in the Big Bend region of Texas and northwestern Mexico, including the ríos Conchos, del Fuerte, Casas Grandes, del Carmen, Yaqui, Papigóchic, Sonora, Nazas, Piaxtla and Trujillo (Burr, 1976). Although it occurs throughout the Río Conchos basin, we only found it abundant in the Río Santa Isabella. Some populations are seemingly ephemeral, particularly in highly impacted habitats such as Río Chuviscar. In 1994, this species had a relative abundance of 2.4%, but in 1995 no specimens were obtained. Contreras-B. (1977) reported it extirpated from the Río Chihuahua (= Chuviscar) and the Río Conchos at Camargo, citing the loss of well-oxygenated, clear, moving water flowing over sand and gravel bottoms due to lowered water tables, siltation and sewage effluent. Our Río Conchos sample at Julimes was downstream of Camargo and we did not obtain *C. ornatum*. However, our Río Conchos sample at Valle de Zaragosa is upstream of Camargo and there we obtained 31 specimens. Our collections support a threatened status for this species and agree with many of the designations and reasons for this status given by various governmental agencies and researchers (Miller, 1972; Williams et al., 1989; Hubbs et al., 1991; Texas Organization for Endangered Species, 1995; CONABIO, 1997).

The Chihuahua shiner (*Notropis chihuahua)* is listed as Threatened by the Texas Parks and Wildlife Department, Miller (1972), Hubbs et al. (1991) and the Texas Organization for Endangered Species (1995). Our findings agree with Burr's (1980) assessment that the species occurs sporadically in Texas in the Big Bend region of the Rio Grande, but is currently abundant in tributaries of the Río Conchos. Previous findings from studies in the Big Bend region of the Rio Grande range from absence of the species (Platania, 1990; IBWC, 1994) to a relative abundance of less than approximately 1% (Hubbs and Wauer, 1973; Hubbs et al., 1977; Bestgen and Platania, 1988).

The Rio Grande shiner (*Notropis jemezanus)* is listed as Rare by Mexico (CONABIO, 1997), Threatened by the Texas Organization for Endangered Species (1995), Threatened by Hubbs et al. (1991) and Special Concern by Williams et al. (1989). The historic range included the Rio Grande, Pecos River (New Mexico and Texas), and ríos Conchos, San Juan and Salado drainages of Mexico (Gilbert, 1980). Hubbs (1940) noted that the species was "characteristic of the Rio Grande and its tributaries in New Mexico, Texas and northeastern Mexico" and Treviño-Robinson (1959) found the species throughout the middle Rio Grande of the Texas-Mexico borderlands, almost to the mouth of the Rio Grande during her studies in the 1950s. However, the range of *N. jemezanus* in the Rio Grande and Pecos River has declined dramatically, (Edwards and Contreras-B., 1991; Hubbs et al., 1991; Edwards et al., 2001). This species is part of a mainstream Rio Grande-Río Conchos faunal assemblage that is not dependent on tributaries (Hubbs et al., 1977). It is typically found in large, open rivers over sand and gravel (Gilbert, 1980) where current flows keep the substrate clean from accumulated silt. Our collections support the Threatened status designation given this species by Hubbs et al. (1991).

The headwater catfish (*Ictalurus lupus*) is listed as Rare by Mexico (CONABIO, 1997), Watch List by the Texas Organization for Endangered Species (1995), and Special Concern by Williams et al. (1989) and Hubbs et al. (1991). In our study we found this little known species only in the Río San Pedro and the Río Conchos at Cuchillo Parado, Julimes and Zaragosa, where it was always in low abundance. These results support the Rare (and Watch List) status designations previously given to this species.

Hubbs et al. (1991) listed the undescribed Chihuahua catfish (*Ictalurus* sp.) as Special Concern. Very little is known about this very cryptic and rare species and none were obtained in our collections. It occurred historically in the Rio Grande basin of New Mexico and Texas, the Río Conchos basin in Chihuahua and the Río San Fernando in Tamaulipas. The absence of this species in our samples may indicate that the species is in greater danger of extinction than generally understood.

The Conchos pupfish (*Cyprinodon eximius*) is listed as Threatened by the Texas Parks and Wildlife Department, the Texas Organization for Endangered Species (1995), Williams et al. (1989), Hubbs et al. (1991), and Mexico (CONABIO, 1997). Historically this species was widely distributed, occurring in the upper Río Conchos and Río Sauz in Chihuahua and Alamito, Terlingua and Tornillo creeks and Devils River in Texas (Miller, 1976, 1981; Hubbs and Echelle, 1973; Minckley, 1980; Hubbs et al., 1991). The population in Dolan Creek, a tributary of the Devils River, was extirpated in 1958 and successfully reestablished in 1979 (Garrett, 1980; Hubbs and Garrett, 1990; Garrett et al., 1992). In our surveys, the species was abundant in the Río Chuviscar and occurred in low numbers in headwater streams and tributaries of the Río Conchos. The population in the Rio Sauz Basin may have been extirpated (Echelle et al., this volume).

The blotched gambusia (*Gambusia senilis)* is listed as Threatened by Miller (1972), Mexico (CONABIO, 1997), and Texas Parks and Wildlife Department, Special Concern by Williams et al. (1989) and Extirpated in Texas by Hubbs et al. (1991) and the Texas Organization for Endangered Species (1995). The historic range of the blotched gambusia includes the Río Conchos Basin and Devils River (Hubbs, 1958; Guillory, 1980). Although Hubbs and Springer (1957) reported its range as the Río Conchos downstream as far as Julimes, our collections at Julimes contained no *G. senilis*. However, an abundant population was present farther downstream in the Río Chuviscar and the species almost completely dominates the fish community in the headwaters northwest of Ciudad Chihuahua. In general, we found *G. senilis* abundant and widely distributed in our Mexican samples. The Texas population was isolated by Amistad Reservoir and ultimately eliminated (Hubbs and Echelle, 1973; Hubbs et al., 1991). The Rio Grande Fishes Recovery Team has recommended reestablishment of the Texas population in Devils River State Natural Area from stocks in the Río Chuviscar. A Threatened status seems appropriate for the existing populations of this species.

DISCUSSION

Desert ecosystems are easily perturbed and often slow to recover. Entrenchment of streams from erosion due to overgrazing and deforestation (Ohmart and Anderson, 1982), introductions of exotic species, and extinction of native species may all cause permanent damage to these systems. While other perturbations such as pollution, reduced groundwater, and dam construction are theoretically recoverable, the return to a pristine state is unlikely.

Anthropogenic changes in the Río Conchos basin have been going on since the mid-1800s (Miller, 1961, 1977) but the effects have been compounded over time and are now becoming dramatic. Our survey indicates detrimental impacts on the fish assemblages of the Río Conchos in the past 40 years. In the early part of the 20th century it was apparent that water was becoming a major problem in Chihuahua as extensive irrigation projects were initiated (Tamayo and West, 1964). Brand (1937) noted for northwestern Chihuahua that "the increasing use of spring and river water for irrigation on the haciendas and colonias of the region has contributed markedly to the lessened flow of the rivers in their lower courses." At least 30 springs have gone dry in Chihuahua and Coahuila and river discharges of the Río Nazas, Bolson Mayrán, Río Aguanaval, Bolson Viesca, Río de Nadadores, Río Saltillo, Río Salinas, Río del Carmen and the middle Rio Grande are reduced (Contreras-B. and Lozano-V., 1994). Under these conditions of decreased flow, droughts are even more devastating because of increased groundwater pumping for agricultural and municipal use. Such extreme conditions favor more tolerant species often at the expense of less widespread species. Tributary creeks tend to be impacted more severely, yet these areas are critical to the breeding and rearing of young of many of the indigenous species including *C. ornatum* and *N. chihuahua* in the Rio Grande (Hubbs and Wauer, 1973).

One factor noticed during our collections in the Río Conchos Basin was the great efforts toward modernization of the infrastructure in Chihuahua including its highways and municipal facilities. Few areas have escaped this leap toward modernization. However, the magnitude of change for the natural aquatic sys-

tems is sometimes quite dramatic. Many springs, especially those located near human habitation, have been modified or are being modified into swimming areas or spas. In the larger municipalities there is a reasonably strong message of water conservation, but the surrounding countryside shows many signs of increasing use of water consumptive measures such as flood irrigation and spray-water delivery systems.

The Río Conchos Basin has been impacted by centuries of human habitation. Exploitation of limited resources, particularly groundwater pumping, has degraded that environment, caused extirpation and extinction of species and, ultimately, loss of habitat and ecosystems (Smith and Miller, 1985). We suspect that the fish assemblages of this region are indicators of the overall integrity of the ecosystem. The few remaining relatively pristine localities need careful management if they are to be preserved.

ACKNOWLEDGMENTS

We appreciate the able assistance of Nora Valdes and the Valdes family, T. Castillo, D. Cobb, W. Cobb, L. Garcia, L. Garrett, J. Hernandez, V. Hodges, C. Hubbs, J. Marquart, D. Riskind, A. Sudyka, D. VanMeter, B. Wienecke, and D. Wilson in helping with the logistics for this study and with the field collections. We thank the government of Mexico for providing us with our collecting permit. Partial funding was provided by the U.S. Fish and Wildlife Service and the Texas Parks and Wildlife Department and we thank them for their contributions. We thank J. Ortega for translating our abstract into Spanish. Finally, this manuscript benefited greatly from suggestions of anonymous reviewers.

LITERATURE CITED

Bestgen, K. R. and S. P. Platania. 1988. The ichthyofauna and aquatic habitats of the Rio Grande from the New Mexico-Texas border to Big Bend National Park. Final Report to the U.S. Fish and Wildlife Service, Office of Endangered Species, Albuquerque, New Mexico. 55 pp.

_____. 1990. Extirpation of *Notropis simus simus* (Cope) and *Notropis orca* Woolman (Pisces: Cyprinidae) from the Rio Grande in New Mexico, with notes on their life history. Occasional Papers, Museum of Southwestern Biology, 6:1-8.

_____. 1991. Status and conservation of the Rio Grande silvery minnow, *Hybognathus amarus*. The Southwestern Naturalist, 36:225-232.

Brand D. D. 1937. The natural landscape of northwestern Chihuahua. University of New Mexico Bulletin Geological Series, 5:1-74.

Burr, B. M. 1976. A review of the Mexican stoneroller, *Campostoma ornatum* Girard (Pisces: Cyprinidae). Transactions of the San Diego Society of Natural History, 18:127-144.

_____. 1980. *Notropis chihuahua* Woolman. Pp. 251, *in* Atlas of North American Freshwater Fishes (D. S. Lee et al., eds.), North Carolina State Museum of Natural History, Raleigh.

Burr, B. M. and R. L. Mayden. 1981. Systematics, distribution and life history notes on *Notropis chihuahua* (Pisces: Cyprinidae). Copeia, 1981:255-265.

CONABIO (Comisión Nacional para el Conocimiento y Uso de la Biodiversidad). 1997. Oficio No. DOO.750,- 1415/97), la revisión de la NOM-ECOL-059-1994, Norma Oficial Mexicana NOM-ECOL-059-1994, que determina las especies y subespecies del flora y fauna silvestres terrestres y acuaticas en peligro de extincion, amnazadas raras y las sujetas a proteccion especial y que establece especificaciones para su proteccion, Publicada en el D.O.F. de fecha 16 de mayo de 1994.

Comisión Nacional del Agua (CNA). 1997. Programa Hidráulico de Gran Visión del Estado de Chihuahua 1996 – 2020. Subdirección General de Programación Gerencia Regional Norte Gerencia Estatal de Chihuahua, Contrato SGC-GRN-CHIH-96-82A, 923 pp. + 30 appendices.

Contreras-B., S. 1977. Speciation aspects and man-made community composition changes in Chihuahuan Desert fishes. Pp. 405-432, *in* Transactions of the Symposium on the Biological Resources of the Chihuahuan Desert Region, United States and Mexico (R. H. Wauer and D. H. Riskind, eds.), National Park Transaction and Proceedings Series, Department of the Interior, Washington, D.C.

Contreras-B., S. and M. L. Lozano-V. 1994. Water, endangered fishes, and development perspectives in arid lands of Mexico. Conservation Biology, 8:379-387.

Eaton, D. J. and D. Hurlburt. 1992. Challenges in the binational management of water resources in the Rio Grande/Río Bravo. Austin: U.S.-Mexican Policy Studies Program, Lyndon B. Johnson School of Public Affairs, The University of Texas at Austin. U.S.-Mexican Policy Report No. 2.

Edwards, R. J. and S. Contreras-B. 1991. Historical changes in the ichthyofauna of the lower Rio Grande (Río Bravo del Norte), Texas and Mexico. The Southwestern Naturalist, 36:201-212.

Edwards, R. J., G. P. Garrett, and E. Marsh-Matthews. 2002. An ecological analysis of fish communities inhabiting the Rio Conchos basin. (Análisis ecológico de las comunidades de peces que habitan la cuenca del Río Conchos.) In: Libro Jubilar en Honor al Dr. Salvador Contreras-Balderas (Maria de Lourdes Lozano-Vilano, ed.), pp. 43-61.

Garrett, G. P. 1980. Update on some of the protected and endangered fishes of Texas. Proceedings of the Desert Fishes Council, 11:34-36.

Garrett, G. P., R. J. Edwards, and A. H. Price. 1992. Distribution and status of the Devils River minnow, *Dionda diaboli*. The Southwestern Naturalist, 37:259-267.

Gilbert, C. R. 1980. *Notropis jemezanus* (Cope), Rio Grande shiner. Pp. 279, *in* Atlas of North American Freshwater Fishes (D. S. Lee et al., eds.), North Carolina State Museum of Natural History, Raleigh.

Guillory, V. 1980. *Gambusia senilis* Girard, Blotched gambusia. Pp. 546, *in* Atlas of North American Freshwater Fishes (D. S. Lee et al., eds.), North Carolina State Museum of Natural History, Raleigh.

Howells, R. G. and G. P. Garrett. 1995. Freshwater mussel surveys of Rio Grande tributaries in Chihuahua, Mexico. Triannual Unionid Report, 8:10.

Hubbs, C. 1958. *Gambusia senilis* from the Devil's River, Texas, an addition to the fish fauna of the United States. Copeia, 1958:239.

_____. 1990. Declining fishes of the Chihuahuan Desert. Pp. 89-96, *in* Third Symposium on Resources of the Chihuahuan Desert Region, United States and Mexico (A. M. Powell, R. R. Hollander, J. C. Barlow, W. B. McGillivray, and D. J. Schmidly (eds.), Chihuahuan Desert Research Institute, Alpine, Texas.

Hubbs, C. and A. A. Echelle. 1973. Endangered non-game fishes in the Upper Rio Grande Basin. Pp. 147-167, *in* Endangered Vertebrates in the Southwest (W. C. Huey, ed.), New Mexico Department of Game and Fish, Santa Fe.

Hubbs, C., R. J. Edwards, and G. P. Garrett. 1991. An annotated checklist of the freshwater fishes of Texas, with keys to identification of species. Texas Journal of Science, Supplement, 43:1-56.

Hubbs, C. and G. P. Garrett. 1990. Reestablishment of *Cyprinodon eximius* (Cyprinodontidae) and status of *Dionda diaboli* (Cyprinidae) in the vicinity of Dolan Creek, Val Verde Co., Texas. The Southwestern Naturalist, 35:446-478.

Hubbs, C., R. R. Miller, R. J. Edwards, K. W. Thompson, E. Marsh, G. P. Garrett, G. L. Powell, D. J. Morris, and R. W. Zerr. 1977. Fishes inhabiting the Rio Grande between New Mexico and the Pecos confluence. Pp. 91-97, *in* Importance, Preservation and Management of Riparian Habitat: A symposium (R. R. Johnson and D. A. Jones, eds.), USDA Forest Service, General Technical Report, RM-43.

Hubbs, C. and V. G. Springer. 1957. A revision of the *Gambusia nobilis* species group, with descriptions of three new species, and notes on their evolution. Texas Journal of Science, 9:279-327.

Hubbs, C. and R. Wauer. 1973. Seasonal changes in the fish fauna of Tornillo Creek, Brewster County, Texas. The Southwestern Naturalist, 17:375-379.

Hubbs, C. L. 1940. Fishes from the Big Bend region of Texas. Transactions of the Texas Academy of Science, 23:3-12.

IBWC (International Boundary and Water Commission). 1990. Flow of the Rio Grande and related data. Water Bulletin No. 61, El Paso, Texas.

_____. 1994. Binational study regarding the presence of toxic substances in the Rio Grande/Río Bravo and its tributaries along the boundary portion between the United States and Mexico. Final Report, September 1994, 250 pp.

Kelly, M. E. 2001. The Río Conchos: A preliminary overview. Texas Center for Policy Studies, Austin, Texas, 27 pp.

Lee, R. W. and J. T. Wilson. 1997. Trace elements and organic compounds associated with riverbed sediments in the Rio Grande/Río Bravo basin, Mexico and Texas. U.S. Geological Survey Fact Sheet, FS-098-97, 6 pp.

Miller, R. R. 1961. Man and the changing fish fauna of the American Southwest. Papers of the Michigan Academy of Science, Arts, and Letters, 46:365-404.

_____. 1972. Threatened freshwater fishes of the United States. Transactions of the American Fisheries Society, 101:239-252.

_____. 1976. Four new pupfishes of the genus *Cyprinodon* from Mexico, with a key to the *C. eximius* complex. Bulletin of the Southern California Academy of Science, 75:68-75.

_____. 1977. Composition and derivation of the native fish fauna of the Chihuahuan Desert region. Pp. 365-382, *in* Transactions of the Symposium on the Biological Resources of the Chihuahuan Desert Region, United States and Mexico, (R. H. Wauer and D. H. Riskind, eds.), National Park Transaction and Proceedings Series, Department of the Interior, Washington, D.C.

_____. 1981. Coevolution of deserts and pupfishes (Genus *Cyprinodon*) in the American Southwest. Pp. 39-94, *in* Fishes in North American Deserts (R. J. Naiman and D. L. Soltz, eds.), John Wiley and Sons, New York.

Miller, R. R. and Chernoff, B. 1979. Status of populations of the endangered Chihuahua chub, *Gila nigrescens*, in New Mexico and Mexico. Proceedings of the Desert Fishes Council, 11:74-84.

Miller, R. R., J. D. Williams, and J. E. Williams. 1989. Extinctions of North American fishes during the past century. Fisheries 14, 22-39.

Minckley, W. L. 1980. *Cyprinodon eximius* Girard, Conchos pupfish. Pp. 496 *in* Atlas of North American Freshwater Fishes (D. S. Lee et al., eds.), North Carolina State Museum of Natural History, Raleigh.

Ohmart, R. D. and B. W. Anderson. 1982. North American desert riparian ecosystems. Pp. 433-466, *in* Reference Handbook on the Deserts of North America (G. L. Bender, ed.), Greenwood Press, Westport, Conneticut.

Platania, S. P. 1990. The ichthyofauna of the Rio Grande drainage, Texas and Mexico, from Boquillas to San Ygnacio. Final Report to the U.S. Fish and Wildlife Service, Office of Endangered Species, Albuquerque, New Mexico.

Propst, D. L., G. L. Burton, and B. H. Pridgeon. 1987. Fishes of the Rio Grande between Elephant Butte and Caballo reservoirs, New Mexico. The Southwestern Naturalist, 32:408-411.

Propst, D. L. and J. A. Stefferud. 1994. Distribution and status of the Chihuahua chub (Teleostei: Cyprinidae: *Gila nigrescens*), with notes on its ecology and associated species. The Southwestern Naturalist, 39:224-234.

Smith, M. L. and R. R. Miller, R.R. 1985. Conservation of desert spring habitats and their endemic fauna in northern Chihuahua, Mexico. Proceedings of the Desert Fishes Council, 13:54-63.

Tamayo, J. L. and R. C. West. 1964. The hydrography of Middle America. Pp. 1-570, *in* Handbook of Middle American Indians, Vol. I. Natural Environment and Early Cultures (R. Wauchope and R. C. West, eds.), University of Texas Press, Austin.

TNRCC (Texas Natural Resource Conservation Commission). 1994. Regional Assessment of Water Quality in the Rio Grande Basin including the Pecos River, the Devils River, the Arroyo Colorado and the Lower Laguna Madre. Texas Natural Resource Conservation Commission, AS-34, 377 pp. + appendices.

Texas Organization for Endangered Species. 1995. Endangered, threatened, and watch list of vertebrates of Texas. Texas Organization for Endangered Species Publication, 10:1-22.

Treviño-Robinson, D. 1959. The ichthyofauna of the Rio Grande, Texas and Mexico. Copeia, 1959:253-256.

Williams, J. E., J. E. Johnson, D. A. Hendrickson, S. Contreras-B., J. D. Williams, M. Navarro-M., D. E. McAllister, and J. E. Deacon. 1989. Fishes of North America endangered, threatened or of special concern: 1989. Fisheries, 14:2-20.

Addresses of authors:

ROBERT J. EDWARDS

Department of Biology
The University of Texas-Pan American
Edinburg, Texas 78539
e-mail: redwards@panam.edu

EDIE MARSH-MATTHEWS

Department of Zoology
The University of Oklahoma
Norman, Oklahoma 73019
e-mail: emarsh@ou.edu

GARY P. GARRETT

HOH Fisheries Science Center
Texas Parks and Wildlife Department
Ingram, Texas 78025
e-mail: gary.garrett@tpwd.state.tx.us