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Speciation Aspects and Man-Made Community Composition Changes in Chihuahuan Desert Fishes

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INTRODUCTION

The fish fauna of the Chihuahuan Desert is composed of 107 native species, according to Miller (this volume), and is of Northern origin for the most part, as demonstrated by the presence of the same or closely related species. This fauna includes the fishes of most interior drainages that once were part of the Rio Bravo (Meek 1903, 1904; Tafall 1946 cited by Tamayo 1962). These interior drainages are the rivers Mimbres, Casas Grandes, Santa María, Carmen, Nazas, Aguanaval, Palomas, Parras, Illescas-Moctezuma, and Hediondilla that lie entirely or mostly within the Chihuahuan Desert; other related interior drainages are the Lagunas Encinillas (=Sauz), Bustillos, and Santiaguillo (Map 1).

SPECIATION ASPECTS

The Chihuahuan isolated basins have an impoverished fauna, usually composed of from one-half to one-fourth the number of fish species found in similar but exterior rivers that have an outlet to the sea or are parts of major drainages. This is demonstrated in Fig. 1, where correlations are found between basin surfaces and species number, also demonstrable for number of genera and families. Similar correlations of area/species number have been studied in plants of the California islands (Johnson et al. 1968), British Isles (Johnson and Raven 1970; Johnson and Simberloff unpubl. data), Galápagos Archipelago (Johnson and Raven 1973), and in fishes of world lakes (Barbour and Brown 1974), either with emphasis on endemics or total species. Such fish-species number is probably a function of habitat diversity, higher in large rivers, although this relation might be modified by the diversity of the regions traversed by the rivers, such as in the Río Salado (66,050 km^2,

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Wauer, R.H., y D.H. Riskind, 1977(1978).
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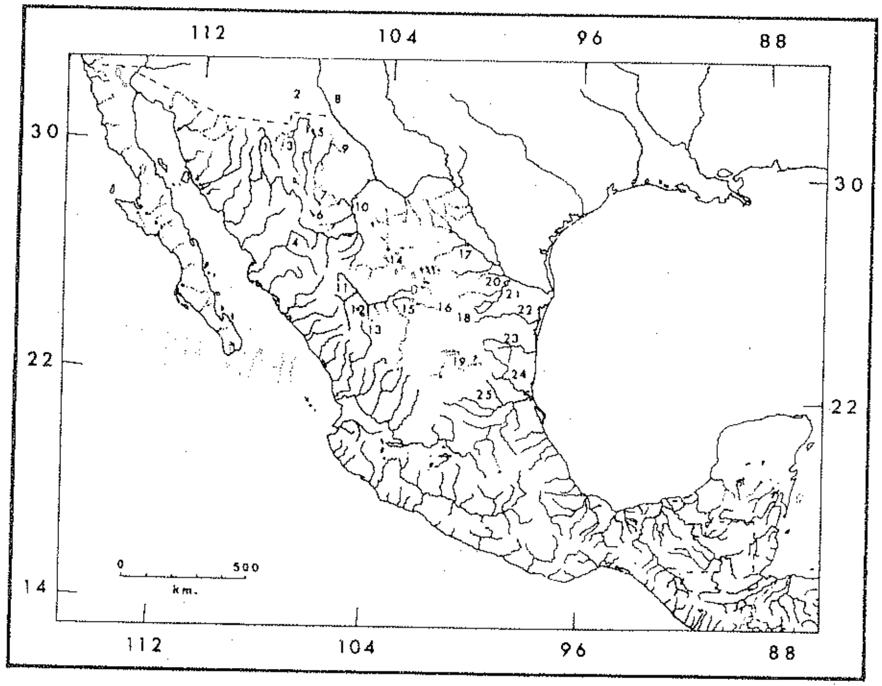


Map 1. Basins mentioned in the text: 1. Río Yaqui, 2. Rio Mimbres, 3. Río Casas Grandes, 4. Río del Fuerte, 5. Río Santa María, 6. Laguna Bustillos, 7. Encinillas, 8. Upper Rio Grande, 9. Río Carmen, 10. Río Conchos, 11. Río Nazas, 12. Laguna Santiaguillo, 13. Río Mezquital, 14. Río Cadena, 15. Río Aguanaval, 16. Parras, 17. Río Salado, 18. Hediondilla, 19. Moctezuma-Illescas, 20. Río Alamo, 21. Río San Juan, 22. Río San Fernando, 23. Río Soto la Marina, 24. Río Tamesí, 25. Río Pánuco.

35 spp.) and the Río Pánuco (66,300 km^2, 43 spp.). Also correlated to the basin area is the number of endemic species, negatively for the smaller basins and changing to positive correlation as the streams get larger, forming a U-shaped line; exterior drainages show positive correlation between size and endemic species number. The high endemism of interior drainages is demonstrable at the species or forms levels, the latter including the sum of species and subspecies and their respective percentages.

Endemic genera are known from very small drainages or springs, probably due to divergence through genetic drift. If a score of endemic points is made, with 3 for genera, 2 for species, and 1 for subspecies, the result is another U-shaped line. The raw data of this correlation appear in Table 1. The endemic genera referred to are: a *Cyprinodon*-like form from Baños de San Diego, Chihuahua (Minckley pers. comm.); *Stypodon* Garman (1881) from Parras, Coahuila; *Megupsilon* Miller and

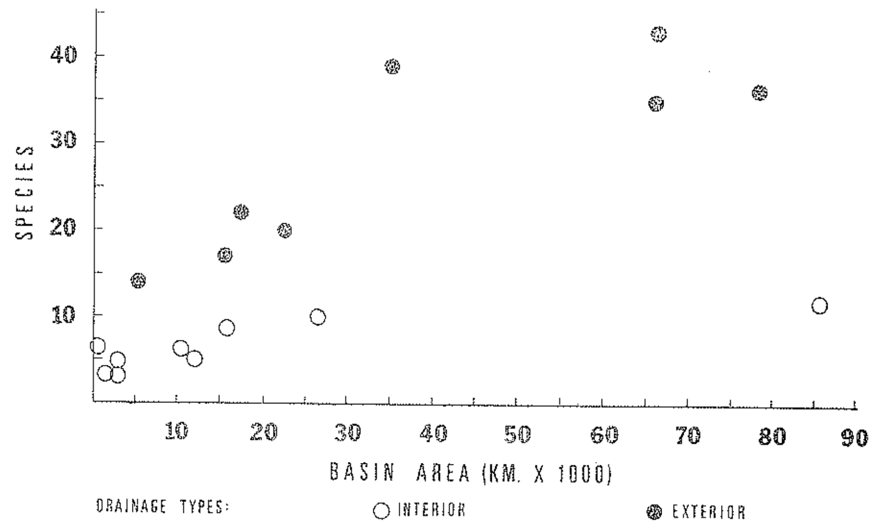


Fig. 1. Correlation diagram of basin area and species number for interior and exterior drainages of the Chihuahuan Desert.

Walters (1972) from Potosí or Hediondilla, Nuevo León; *Xenoophorus* Hubbs and Turner (1939) from the Illescas-Moctezuma area, San Luis Potosí; *Cualac* Miller (1956) and *Ataeniobius* Hubbs and Turner (1939) both from La Media Luna-Río Verde region, San Luis Potosí (Map 2). They are distinctive forms from springs or basins that are small, old, or both.

The infraspecific variation in Chihuahuan Desert fishes is not well known, except for a few detailed studies, mostly unpublished. One of them is the case of *Notropis lutrensis senso lato*, with interesting geographic variation, exemplified by lateral-line scale count (Table 2). There are several of its subspecies and races in almost all of the former Río Bravo streams, its characters varying widely (Map 3). Percent divergence between the means for 13 characters in 13 populations has been studied, considering the Río San Juan race as the value 0 or as the nearest to the ancestral stock. The mean divergence for races of the Samalayuca complex (Casas Grandes, Carmen, North and South Yaqui, and Saúz, but not the Santa María) is from 42.4 to 83.8%. They share eight anal rays, greenish and yellow breeding males, small breeding tubercles, and high scale counts. The Santa María form, *N. l. santamariae*, diverges 51.0%, and is distinguished by its all-yellow breeding males. The Nazas-Aguanaval races, *N. l. garmani*, diverge 46.2%. The Conchos undescribed subspecies has diverged relatively little, 26.4%. Finally, the Upper Rio Grande and the Pecos races are the least divergent, with 13.0

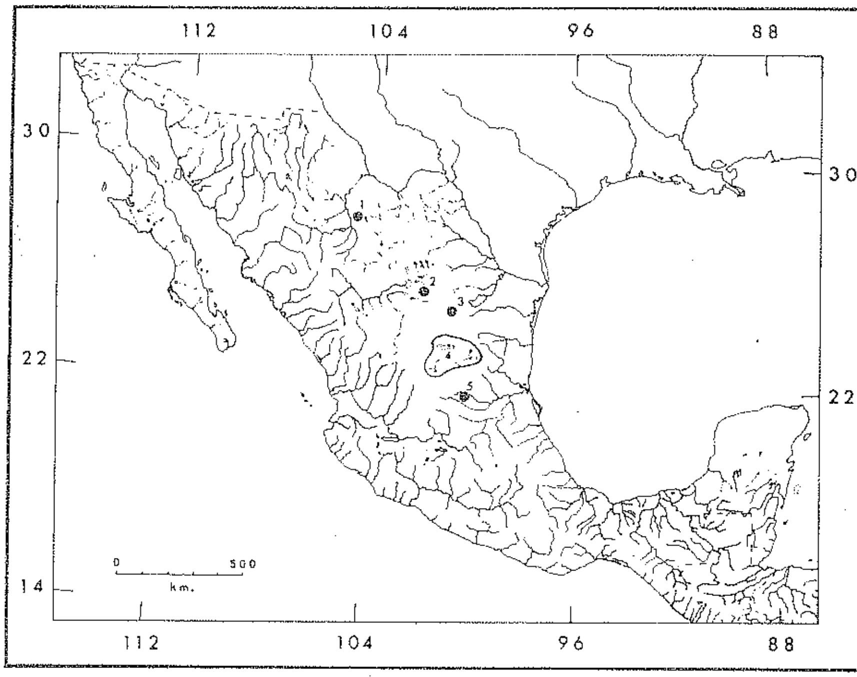
TABLE 1. Correlation between drainage surface, fish richness, and endemism at Chihuahuan and non-Chihuahuan basins.

Type / Basin	Surface km²	Fish Fauna: Total Fam.	Total Gen.	Total spp.	Endemics Gen.	Endemics spp.	Endemics sspp.	Endemism: Forms (1)	Points (2)	Percentage spp.	Percentage Forms
Springs											
Hediondilla (Potosi)	5.5	1	2	2	1	2	-	2	7	100.0	100.0
Media Luna	50	6	6	10	2	6	1	7	19	60.0	70.0
Cuatro Cienegas	600	8	13	18	-	9	4?	13	22	50.0	72.2
Interior											
Parras	400	4	6	7	1	5	1	6	14	71.4	85.7
Santiaguillo	1790	3	3	3	-	2	-	2	4	66.6	66.6
Encinillas (Sauz)	2700	4	5	5	-	2	2	4	6	40.0	80.0
Bustillos	2720	2	3	3	-	-	2	2	2	0	66.6
Santa Maria	10680	3	6	6	-	1	3	4	5	16.6	66.6
Carmen (Patos)	11880	3	5	5	-	1	1	2	3	20.0	40.0
Casas Grandes	16600	4	8	8	-	2	1	3	5	25.0	37.5
Aguanaval	26560	5	7	10	-	4	2	6	10	40.0	60.0
Nazas	85530	6	9	12	-	3	5	8	11	25.0	66.6
Exterior											
Alamo	4381	10	12	14	-	-	-	-	-	0	0
San Fernando	15640	9	13	17	-	-	1	1	1	0	5.9
Tamesi	17690	9	14	23	-	1	4	5	6	4.3	21.7
Soto la Marina	22600	14	16	20	-	1	4	5	6	5.0	25.0
San Juan	35226	12	25	39	-	2	2	4	6	5.1	10.3
Salado	66050	11	20	35	-	2	2	4	6	8.8	11.4
Panuco	66300	16	23	43	1	10	7	17	27	23.3	39.5
Conchos	77090	10	23	36	1?	9	6	15	26	25.0	41.7

(1) Sum of species and subspecies. (2) Values: genus 3, species 2, subspecies 1.

TABLE 2. Frequency distribution of lateral line scales in subspecies and races of *Notropis lutrensis* from the Rio Grande basin and range.

ssp. or race; river	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	n	x
forlonensis; Pánuco	1		1	5	20	56	61	8	2												154	33.3
intergrades; Soto la M.				1	11	22	5	1													40	32.8
lutrensis:																						
San Fernando			1	2	8	31	56	37	24	8	2										169	34.1
Rio Grande																						
San Juan			2	2	9	22	40	6													81	33.2
NE Coahuila				2	6	13	18	8	1												48	33.3
Pecos					9	22	26	6	1												64	33.3
Big Bend							3	4													7	
Upper Rio Grande					1	5	20	19	7	1											53	34.3
ssp.; Conchos					4	21	34	25	14	1											115	34.1
garmani; Nazas						2	9	49	34	25	11	3	1								134	35.8
ssp.; Encinillas								3	8	4	11	9	7	3	2	2		1			50	38.3
formosus:																						
Carmen								1	16	11	9	6	3								53	36.9
Casas Grandes								4	6	9	10	14	14	10	10	12	6	2	3	3	103	40.1
North Yaqui								3	9	10	10	6	4	5	2	1					50	38.0
South Yaqui							4	8	12	5	1										30	35.5
santamariae; Santa María							11	36	48	30	20	6	3						1		158	36.1

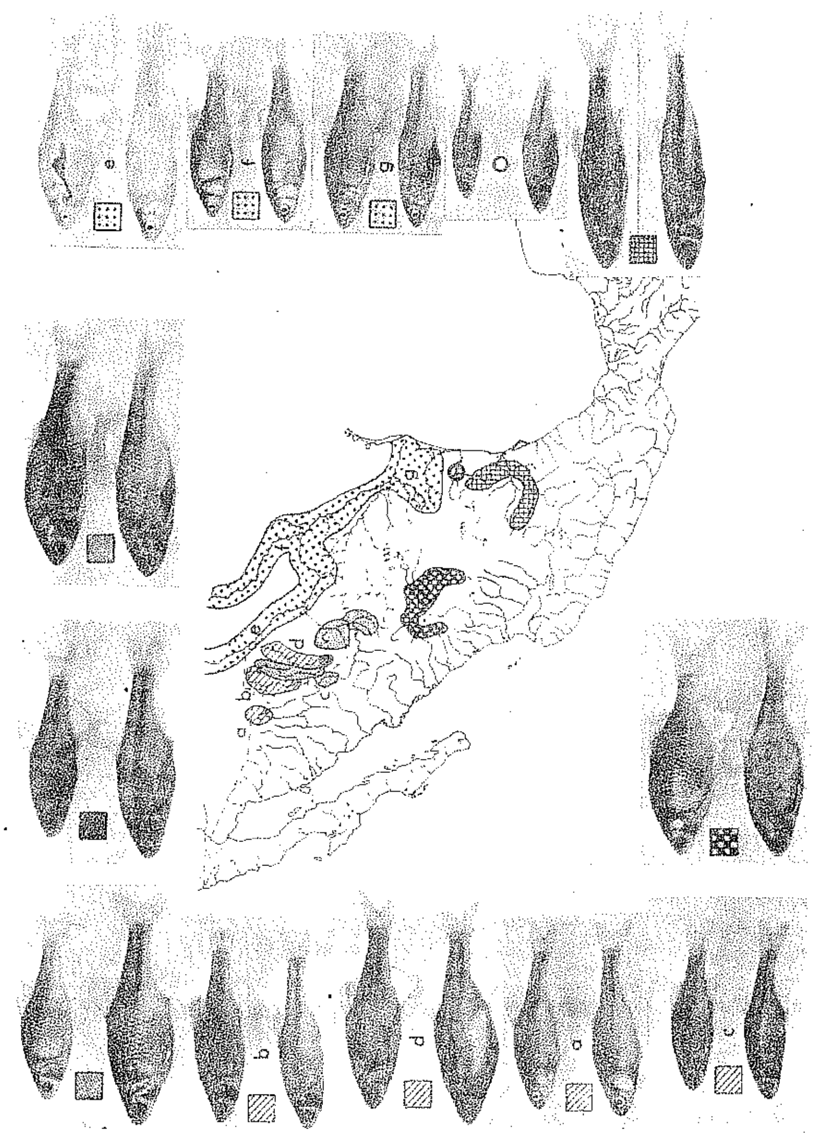


Map 2. Localities of the Chihuahuan Desert with endemic fish genera and their survival status: 1. *Cyprinodon*-like sp., undescribed, San Diego, Chohuahua; 2. *Stypodon*, Parras, extinct; 3. *Megupsilon*, Hediondilla, endangered; 4. *Xenoophorus*, Illescas-Moctezuma; 5. *Cualac* and *Ataeniobius*, La Media Luna, endangered.

and 10.2%, respectively. The character matrix of the data given appears in Table 3.

If we assume such values are a function of time, and represent a level of separation from the main river, then the Upper Rio Grande and Pecos races are the most recent and keep their link to the main populations downstream. The Conchos form differs little more, inhabiting a sub-basin intermittently connected to the main Rio Bravo, a condition that allows divergence to arise, but not to proceed too far, subject to the mobility of the species. Next and older, comes the Nazas-Aguanaval complex, and the oldest is the Samalayuca complex. Thus, the desert advance in Mexico is from north and west to south and east. The former connections of the basins, flow direction, and desert advance appear on Map 4. Species-groups that seem worth studying to test this scheme are the *Gila nigrescens* complex and the *Cyprinodon eximius* complex, widely represented in the region.

Another case studied that points to a complementary scheme of stream captures, rather than former river connections, is *Codoma or-*

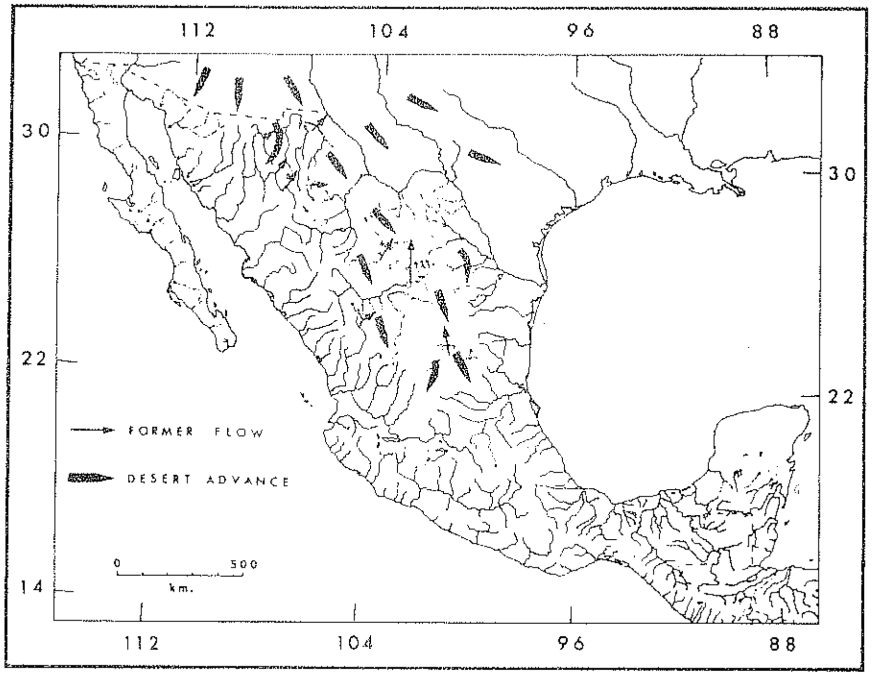


Map 3. *Notropis lutrensis* sspp. and races in the Rio Bravo Basin and Range, showing physiognomy and distribution.

TABLE 3. Character matrix of percentage divergence between means of different populations from the presumed ancestral stock in *Notropis lutrensis* from the Rio Grande basin and range to the Rio Panuco, Mexico: Meristics.

	Populations												
Characters	1	2	3	4	5	6	7	8	9	10	11	12	13
A	0	0	0	0	0	0	100.0	0	0	0	0	0	0
B	9.1	0	9.1	18.2	0	9.1	100.0	90.9	63.6	72.7	90.9	90.9	81.8
C	0	54.0	20.0	0	13.3	46.7	66.7	13.3	54.0	100.0	80.2	46.7	73.4
D	100.0	66.7	33.3	66.7	33.3	66.7	66.7	33.3	0	66.7	0	66.7	66.7
E	1.5	7.3	13.1	1.5	1.5	13.1	37.7	74.0	53.7	100.0	69.6	33.4	42.1
F	1.5	1.5	16.2	4.4	11.8	30.9	66.2	76.4	45.6	100.0	41.2	36.8	39.7
G	15.8	11.9	14.9	0	14.9	28.5	33.7	59.4	55.4	100.0	39.6	45.5	45.5
H	21.4	16.7	14.3	2.4	19.0	26.2	40.5	57.1	71.4	100.0	52.4	28.6	42.8
I	11.6	6.7	15.0	6.7	11.6	30.7	32.4	73.5	43.4	100.0	31.7	58.4	47.4
J	21.1	21.1	9.6	13.4	21.1	28.8	17.3	67.2	46.1	100.0	32.6	36.5	38.4
K	16.7	20.9	8.3	4.2	20.9	25.0	16.7	62.6	41.7	100.0	33.4	25.0	41.7
L	22.2	25.9	11.1	14.8	27.2	37.0	22.2	74.0	51.8	100.0	29.6	44.4	44.4
M	0	0	0	0	0	0	0	50.0	50.0	50.0	50.0	50.0	100.0
Sum	220.9	232.7	164.9	132.3	169.6	342.7	601.1	731.7	576.7	1089.4	551.2	562.9	663.9
$\bar{x}$	17.0	17.9	12.7	10.2	13.0	26.4	46.2	56.3	44.4	83.8	42.4	43.3	51.1

Populations: 1 Panuco, 2 Soto la Marina, 3 San Fernando, 4 Pecos, 5 Upper Rio Grande, 6 Conchos, 7 Nazas 8 Encinillas, 9 Carmen, 10 Casas Grandes, 11 North Yaqui, 12 South Yaqui, 13 Santa Maria.
Characters: A Dorsal, B Anal, C Pectoral, D Pelvic, E Lateral Line, F Predorsals, G Total Circumcorporal, H Dorsal Circumcorporal, I Ventral Circumcorporal, J Total Circumpeduncular, K Dorsal Circumpenduncular, L Ventral Circumpeduncular, M Color. Values are percent difference of the mean from 0 (for San Juan stock).



Map 4. Former flow of rivers and direction of desert advance in the Chihuahuan Province.

nata. Pending a report on the validity of the genus (Contreras and Minckley unpubl. data), the most appropriate name of the species is used here. This species is known from six basin populations: the Upper Yaqui, the Upper and a Lower Conchos races, Nazas, Mezquital, and a few specimens are known from the Upper Rio del Fuerte but they have not been analyzed. The Lower Conchos race seems to be the ancestral form, the Yaqui, Nazas, and Upper Conchos (and maybe the del Fuerte also) depart from it respectively 24.8, 51.6, and 81.3%. The Mezquital race diverges 86.9% in the same direction as the Nazas form, but more extremely, as shown by the signs of divergence (Table 4). Most characters analyzed, exemplified by lateral line and total circumcorporal scale counts, show a Y-shaped cline, with the Lower Conchos race at the angle of the Y (Table 5). This scheme seems possible only through stream captures, of which only one has been documented, the loss of the Guadiana Valley from the Río Nazas to the Río Mezquital (Albritton 1958). This same pattern and the characteristic one of relict distributions modeled by Darlington (1957:485) caused by differential survival should not be confused. Any one of them should be looked for in *Pimephales promelas* and *Dionda episcopa* races and in several others.

TABLE 4. Character matrix of differences between means of meristic characters for different populations from the presumed ancestral stock in *Codoma ornata* from the Rio Grande basin and range, northern Mexico.

	Yaqui	Upper Conchos	Nazas	Mezquital
Rays:				
Dorsal	0. =	0 =	0 =	100.0 -
Anal	83.3 +	83.3 +	100.0 +	91.7 -
Pectorals	10.0 +	100.0 +	40.0 +	90.0 -
Pelvics	36.4 +	54.5 +	45.5 +	100.0 +
Scales:				
Lateral line	26.8 -	100.0 +	19.5 -	24.4 -
Predorsal	87.3 -	50.0 +	72.7 -	100.0 -
Total circumcorporal	21.2 -	100.0 +	51.5 -	84.8 -
Predorsal circumcorporal	38.9 -	100.0 +	50.0 -	88.9 -
Ventral circumcorporal	5.9 -	100.0 +	52.9 -	70.6 -
Total circumpeduncular	6.7 +	100.0 +	53.3 -	93.3 -
Dorsal circumpenduncular	0 =	87.5 +	62.5 -	100.0 -
Ventral curcumpeduncular	0 =	100.0 +	71.4 =	100.0 -
Sum	297.5	975.3	619.3	1043.7
$\bar{x}$	24.79	81.28	51.61	86.90

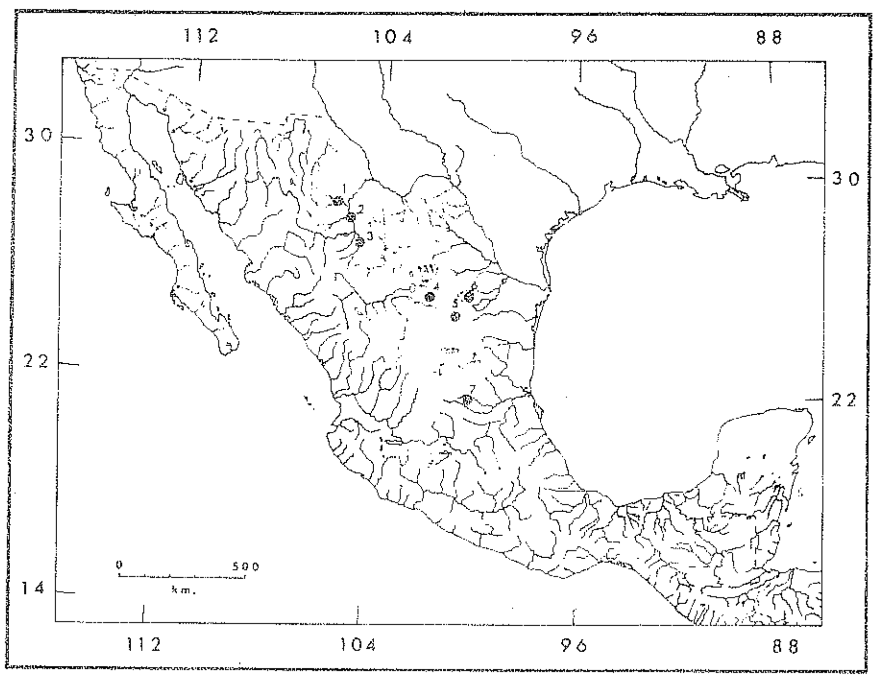
TABLE 5. Frequency distribution of scale counts in five races of *Codoma ornata* from northwestern Mexico.

	Lateral line scales																	
	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	n	$\bar{x}$
Yaqui	1		3	7	41	51	22	10	5								140	36.8
Upper Conchos						1	2	9	11	22	14	17	11	9	3	2	101	42.0
Lower Conchos		1		8	8	21	23	14	6	4	3	2					90	37.9
Nazas				4	33	47	20	6	3	1	1						115	37.1
Mezquital			3	11	36	37	31	8	2								128	36.9

	Total circumcorporal scales																	
	25	26	27	28	29	30	31	32	33	34	35	36	37	38	39	40	n	$\bar{x}$
Yaqui		1	3	11	21	25	22	24	17	8	7	1					140	31.0
Upper Conchos								7	11	18	20	21	17	4	1	2	101	35.0
Lower Conchos			1	4	3	11	22	21	16	6	3	2		1			90	31.7
Nazas			4	16	22	28	27	2	5	1							115	30.0
Mezquital	2	9	22	30	24	13	11	10	5	2							128	28.9

Dealing with the Great Basin, Hubbs and Miller (1948) confirmed the paleohydrological data with fish zoogeography. In the Chihuahuan Desert, the ichthyological evidence is used almost exclusively because of the scarcity of Pleistocene studies. Care should be taken in drawing conclusions from variational data, because variation in fishes may be modified by basin size (the extreme development of endemic genera), age (the probable time levels in speciation of *N. lutrensis*), and community size (unpublished data on one extralimital species pair shows to high variability in one form living in a 5-species community, and consistency for the other one living in a 12-species group). From the data available, small, old basins and simple communities favor stronger differences, and large, young basins and complex communities favor smaller divergences. These inductive statements need ample support before firm conclusions may be reached.

After the work of Miller (1977) and personal estimates, there are 17 species and at least 20 subspecies still undescribed in Chihuahuan fishes. The only published zoogeographical study is that of Smith (1966) on *Pantosteus plebeius*. Only those species described after 1957 are



Map 5. Localities of the Chihuahuan Desert where fish community composition changes have been detected in the last 25-100 years: 1. Chihuahua City, 2. Delicias, 3. Jiménez, 4. Parras, 5. Hediondilla, 6. Monterrey, and 7. La Media Luna.

TABLE 6. Vanishing fish fauna of the Rio Chihuahua, Chihuahua City, Mexico, between 1856 and 1968

	1856 1859	1892 1894	1961	1964	1968
Native Species					
Astyanax mexicanus	=	X	X	=	R
Campostoma ornatum	X	X	X		
Gila pulchra	X	X	X		
Pimephales promelas	=	X	X	X	X
Codoma ornata	X	=	X	X	
Notropis chihuahua	=	X	X		
Notropis lutrensis ssp.	=	X	X		
Dionda episcopa ssp.	=	X	X		
Cyprinodon eximius	X	X	X		
Gambusia senilis	X	X	X	X	X
Etheostoma australe	X	X	X		
Etheostoma pottsi	X	X	X		
Totals	12	12	12	4	3
Exotic ?					
Lepomis macrochirus				X	X
Total				1	1

Key: X Collected, R Rare, = Probably present.

known from good variational data. Considering this situation, the scientific, cultural, aesthetic, and perhaps practical values of the desert fishes, as well as the growing concern of world scientists about environmental degeneration even in the less fragile temperate regions, testified by the abundant literature on the subject, it is upsetting to witness a number of these species vanishing, becoming endangered, or even extinct, due to man's actions.

DOCUMENTARY EVIDENCE OF FISH COMMUNITY COMPOSITION CHANGES

Following the procedure of Miller (1961), Minckley and Deacon (1968), and my former paper on disappearing communities of fishes peripheral to the Chihuahuan Desert (Contreras 1975), a decrease of the native fish fauna can be documented for seven Chihuahuan localities (Map 5).

Río Chihuahua, Chihuahua City, Chihuahua

The fish fauna of the Río Chihuahua is known from the work of Girard (1856, 1859), Woolman (1892, 1894), and Meek (1902). A total of 12 native species was known until 1901; by 1964 only 3 were collected and another was probably present; in 1968 only 3 remained with 1 of them rare (Table 6). *Lepomis macrochirus* probably has been introduced at this locality, since it was known there only after 1964. *Etheostoma australe* and *E. pottsi* are considered endangered. Sources of disruption are channelization, damming of the river, and siltation (possibly agricultural).

Río Conchos at Camargo (= Santa Rosalia), Chihuahua

This fish fauna has been known since 1901 (Meek 1902), when 16 native species were known and probably 2 more were present. In 1964 only eight remained, plus one exotic. Both endangered endemics, the *Etheostoma* spp., no longer lived there (Table 7). Agricultural use has lowered the flow of water, although flash floods still are a menace. The river, formerly more or less clear, is now murky.

Río Conchos at Jimenez, Chihuahua

The fishes of Río Conchos at Jiménez were first collected also in 1901 (Meek 1902), with 15 known and 3 probable species present. In 1964, there were probably 12, confirmed in 1968. Besides the *Etheostoma* endemics, *Catostomus conchos* Meek (1902) has only been seen three times since 1903 (Miller, this volume). No exotics are known here yet (Table 8). Ecological disruption is similar to that found at Camargo.

TABLE 7. Vanishing fish fauna of the Rio Conchos at Camargo (Santa Rosalia), Mexico, between 1904 and 1964.

	1901	1964
Native species		
Lepisosteus osseus	X	
Astyanax mexicanus	X	X
Campostoma ornatum	X	
Rhinichthys cataractae	X	X
Pimephales promelas	X	
Notropis chihuahua	X	X
Notropis lutrensis ssp.	X	X
Notropis braytoni	X	
Pantosteus plebeius	=	X
Moxostoma austrinum	X	X
Carpiodes carpio elongatus	X	X
Pilodyctis olivaris	X	
Cyprinodon eximius	X	
Gambusia senilis	X	
Micropterus salmoides	=	X
Lepomis megalotis occidentalis	X	
Etheostoma australe	X	
Etheostoma pottsi	X	
Totals	18	8
Exotic		
Cyprinus carpio		X
Total		1

Key: X Collected, = Probably present.

TABLE 8. Vanishing fish fauna of the Rio Conchos at Jimenez, Chihuahua, Mexico, between 1901 and 1968.

	1901	1964	1968
Native species			
Astyanax mexicanus	X	X	X
Campostoma ornatum	X	X	X
Gila pulchra	=	=	X
Pimephales promelas	X	X	X
Codoma ornata	X		
Notropis braytoni	X		
Notropis chihuahua	X	X	X
Notropis lutrensis ssp.	X	X	X
Dionda episcopa ssp.	X	X	X
Catostomus conchos	X		
Carpiodes carpio elongatus	X		
Ictalurus punctatus	=	=	X
Pilodyctis olivaris	=	=	X
Cyprinodon eximius	X	X	X
Gambusia senilis	X	X	X
Lepomis megalotis occidentalis	X	=	X
Etheostoma australe	X		
Etheostoma pottsi	X		
Totals	18	12	12

Key: X Collected, = Probably present.

Parras Basin, Coahuila

This place of endemism has been treated by Miller (1961, 1964) and Contreras (1969), but the historical changes have not been tabulated yet. In 1880, six species were known there, by 1895 another endemic was described, with one more endemic discovered in 1968. In 1903 two endemics were alive (Miller 1964). In 1953, C. L. Hubbs and party could find only one species of native and one exotic fish. The situation recurred in 1964, but a thorough exploration in 1968 resulted in the discovery of another species of *Gila* and a population of *Astyanax*, and, unfortunately, four exotics. In 1973 one more exotic, the destructive *Gambusia affinis speciosa*, was collected, perhaps as the result of mosquito control measures. The three remaining native fishes are rare and endangered. These changes appear in Table 9.

Potosi, Hediondilla, Nuevo León

This interior basin, composed of a big spring and its distributaries, is inhabited by a recently described endemic genus, *Megupsilon aporus* Miller and Walters (1972), and an undescribed species of *Cyprinodon*. The first collection of the *Cyprinodon* was made in 1948, and in 1961 the new genus was collected, along with the exotic golden carp that seemed not to compete with or harm the natives. The spring was enlarged in the 1950s, probably to the unplanned benefit of both natives. However, early in 1974 black bass were introduced, and subsequently the natives have almost disappeared (Table 10).

Río Santa Catarina, Monterrey, Nuevo León

This river, usually a nearly dry bed with flash floods during the rainy season, flows through the city of Monterrey. Its fishes are known from Girard (1856, 1859) when 10 species were taken or must have been present. In 1903 only eight native species remained (Meek 1904); seven remained in the 1940s and six in 1967-68, when an undetermined number of tropicals was introduced in the stream in a publicity event, although only two were collected a few days later. In 1968, the native *Xiphophorus couchianus* and the exotic *X. v. variatus* were collected in a river bed spring, actively breeding. By 1972 massive hybridization was obvious, and in 1973 only hybrids remained in the spring, and guppies were present in the river (Table 11). Urban development, tropical fish hobbyists, and water depletion for municipal supplies have contributed to the disappearance of the native fishes.

Media Luna, Rioverde, San Luis Potosí

This interesting area of fish endemism, or its neighborhood, was first visited by W. L. Tower in 1903 (Meek 1904). He collected five species and five more probably were present. In 1956, four were rare

TABLE 9. Vanishing fish fauna of the Parras Basin, Coahuila, Mexico, between 1880 and 1973.

	1880	1895	1903	1953	1964	1968	1973
Native species							
Astyanax mexicanus	X	=	=	=	=	X	S
Gila sp. A	=	=	=	=	=	X	S
Gila sp. B	X	=	=	X	X	R	S
Stypodon signifer	X	=	X				
Notropis lutrensis garmani	X						
Dionda episcopa punctifer	X						
Cyprinodon latifasciatus	X	=	X				
Characodon lateralis	=	X					
Totals	8	6	5	3	3	3	3
Exotic species							
Cyprinus carpio				X	X	X	=
Carassius auratus						X	=
Xiphophorus, hybrids						X	X
Poecilia reticulata						X	X
Gambusia speciosa							X
Totals				1	1	4	5

Key: X Collected, R Rare, = Probably present, S Seen.

TABLE 10. Endangered fish fauna of the Spring Potosi, La Hediondilla Basin, Nuevo Leon, Mexico.

	1948	1961	1968	1972	1974
Native species					
Megupsilon aporus	=	X	X	X	R
Cyprinodon sp.	X	X	X	X	R
Exotics					
Carassius auratus		X	X	X	X
Micropterus salmoides					X

Key: X Collected, R Rare, = Probably present.

(Miller 1956), increasing to 5 rare in 1968. No exotics were known here until 1972, when Robert R. Miller and his group collected the unwelcome *Tilapia aurea* and *Gambusia panuco*. At least seven species are endemic to this big spring or the Upper Rio Verde; only the ubiquitous *Astyanax* and perhaps *Ictalurus mexicanus* and *Cichlasoma labridens* are not yet considered endangered, except that the impact of the exotics is not yet apparent. The recent development to pump water from the main laguna can only harm the native biota. The changes appear in Table 12.

ECOLOGICAL COMMENTS ON THE RARE OR ENDANGERED FISHES OF THE CHIHUAHUAN DESERT

Considering the fishes listed in Tables 6 to 13, and without an attempt to conflict but to complement data given by Miller (this volume), several species have been shown as being affected by environmental changes, ranging from local disappearance to becoming rare, vanishing, endangered, or even extinct. As far as is known, these fishes have wide ecological similarities. The following list includes general statements on fish ecological preferences.

Family Lepisosteidae

Lepisosteus osseus (Lacépède). Surface feeding, carnivorous fish. Prefers quiet, turbid, warm waters in large rivers. Rare in the Mexican Plateau, common elsewhere in eastern North America.

Family Characidae

Astyanax mexicanus (Filippi). Ubiquitous omnivore, preferring animal matter. It was wide ecological tolerance and is usually abundant, hence its disappearance from some localities is not understood. It occurs from the Río Bravo and Central Texas southward an undefined distance.

Family Cyprinidae

Campostoma ornatum Girard. Herbivorous, bottom feeder, prefers gravel or rocky bottoms, in clear, cool water. Usually common. Endemic around the Sierra Tarahumara and east to the Big Bend area.

C. anomalum pullum. As former species.

Gila pulchra Girard. Probably carnivorous, feeds near bottom or midwater. Prefers clear cool, moving waters and sandy bottoms.

Gila sp. B. As former species. Endemic in western side of Parras basin. Endangered.

Pimephales promelas Jordan. Herbivorous, bottom feeder, on sandy to gravelly streams, with clear, cool waters.

Codoma ornata Girard. Probably omnivorous, otherwise as former species.

Notropis braytoni Jordan and Evermann. Insectivorous, midwater to bottom, on gravelly places, in cool, moving waters.

TABLE 11. Vanishing fish fauna of the Rio Santa Catarina, Monterrey, Nuevo Leon, Mexico, between 1856 and 1973.

	1856 1859	1884	1903	1942	1967 1968	1970	1972	1973
Native species								
Astyanax mexicanus	=	=	X	=	X			
Campostoma anomalum pullum	X	=	=	X				
Notropis l. lutrensis	X	X						
Dionda episcopa	X	X	X	X	X			
Moxostoma congestum albidum	X							
Poecilia mexicana	=	=	X	X	X			
Xiphophorus couchianus	X	=	X	=	=	H	H	
Gambusia a. speciosa	=	=	X	=	X			
Lepomis megalotis	=	=	X					
Cichlasoma c. cyanoguttatus	=	=	X	X	X			
Totals	10	9	8	7	6	1	1	
Exotic species								
Puntius conchonius					X			
Xiphophorus v. variatus					X	H	H	H
Poecilia reticulata							X	X
Totals					2	1	2	2

Key: X Collected, = Probably present, H Hybrids (*X. couchianus* x *X. variatus*).

TABLE 12. Vanishing fish fauna of La Media Luna region, Rioverde, San Luis Potosi, Mexico, between 1903 and 1972.

	1903	1956	1968	1972
Native species				
Ictalurus mexicanus	X	R	S	
Astyanax mexicanus	X	X	X	
Dionda sp. A	=	=	R	
Dionda sp. B	X	R	R	
Ataeniobius toweri	X	R	R	
Cichlasoma bartoni	X	X	X	
Cichlasoma labridens	=	X	X	
Cualac tessellatus	=	R	R	
Cichlasoma sp.	=	=	X	
Cichlasoma sp.	=	=	R	
Totals	10	10	10	
Exotics				
Tilapia aureum (1)				X
Gambusia panuco (1)				X
Totals				2

Key: X Collected, = Probably present, R Rare, S Seen.

TABLE 13. Fishes of the Chihuahuan Desert impacted upon by environmental changes at: 1 Rio Chihuahua, 2 Camargo, 3 Jimenez, from Chihuahua State; 4 Parras Coahuila, and 5 Monterrey, Nuevo Leon.

Species	1	2	3	4	5
Lepisosteus osseus		X			
Campostoma ornatum	X	X			
Campostoma anomalum pullum					X
Gila pulchra	X				
Gila sp. B				X	
Pimephales promelas		X			
Stypodon signifer				E	
Codoma ornata	X		X		
Notropis braytoni		X	X		
Notropis chihuahua	X				
Notropis lutrensis ssp.	X				
Notropis lutrensis garmani				X	
Dionda episcopa punctifer				E	
Dionda episcopa sspp.	X				X
Carpiodes carpio elongatus			X		
Catostomus conchos			X		
Moxostoma congestum albidum					X
Pilodyctis olivaris		X			
Cyprinodon eximius	X	X			
Cyprinodon latifasciatus				E	
Gambusia a. speciosa					X
Gambusia senilis		X			
Poecilia mexicana					X
Xiphophorus couchianus					X
Characodon lateralis				E	
Etheostoma australe	X	X	X		
Etheostoma pottsi	X	X	X		
Cichlasoma cyanoguttatus cyanoguttatus					X
Lepomis megalotis		X			X

Key: X Impacted species, E Extinct

N. chihuahua Woolman. As former species.

N. lutrensis ssp. Insectivorous, prefers midwater, on gravel or rubble that may be covered by fine silt layer, and in rather cool pools with good vegetation. Endemic of Río Conchos. Usually common.

N. l. garmani Jordan. As former species. Endemic to the Nazas-Aguanaval complex. Formerly known near or at Parras, but now extinct there.

Dionda episcopa sspp. Herbivorous, swims near bottom of shallow streams, in clear, cool, moving waters. Several recognizable endemic subspecies in the Chihuahuan Desert and elsewhere in eastern North America.

Dionda sp., Contreras and Verduzco (unpubl. data). Small predator, prefers thermal springs and outlets. Endemic. La Media Luna-Río Verde complex.

Dionda sp. (Hubbs and Miller, unpl. data). Herbivorous, swims near bottom, mostly in small streams with clear waters on gravel. Endemic. La Media Luna-Río Verde complex.

Family CATOSTOMIDAE

Carpiodes carpio elongatus Meek. Bottom feeder, prefers large rivers with deep channel.

Catostomus conchos Meek. Possibly extinct. Endemic. Río Conchos.

Moxostoma congestum albidum Girard. Bottom feeder. Middle sized streams, on gravel or rubble; in clear, cool, moving waters.

Family ICTALURIDAE

Pilodyctis olivaris (Rafinesque). Scavenger or carnivorous. Large rivers.

Family CYPRINODONTIDAE

Cyprinodon eximius Girard. Herbivorous, bottom feeder, on sandy to gravelly streams, in clear, shallow waters. Endemic. Río Conchos.

Cyprinodon sp. (Miller unpubl. data). Herbivorous, swims near bottom, usually in deep, open waters in a clear spring. Endemic. La Hediondilla, Nuevo León. Endangered.

Megupsilon aporus Miller and Walters. Insectivorous, swims in dense patches of *Ceratophyllum*. Endemic. La Hediondilla, Nuevo León. Endangered.

Cualac tessellatus Miller. May be herbivorous, swims near bottom. Endemic. La Media Luna. Endangered.

Family GOODEIDAE

Ataeniobius toweri (Meek). Herbivorous. Prefers midwater in shallows, or close to shore. Endemic. La Media Luna. Endangered.

Family PERCIDAE

Etheostoma australe Jordan. Bottom insectivorous, on sandy or gravelly shallow streams, with fast, cool waters. A rare species that may be common locally. Endemic. Río Conchos. Endangered.

E. pottsi (Girard). As former species.

Family CICHLIDAE

Cichlasoma cyanoguttatum (Baird and Girard). Rather omnivorous, prefering detritus. Bottom, on almost any substrate. Rare only in the Río Conchos.

Cichlasoma sp. Bottom, mollusk eater; warm, clear, moving water; on silt. Endemic. La Media Luna region. Endangered.

Family CENTRARCHIDAE

Lepomis megalotis occidentalis (Meek). Predator of small arthropods; bottom, on gravel and rubble; in clear, moving waters.

This partial list shows that most of the fishes of the Chihuahuan Desert that are reducing their distribution primarily prefer the well-oxygenated, clear, moving water, running over sand and gravel, and are bottom forms. Several of them are herbivorous, mainly algae eaters, a kind of food that disappears with turbid waters.

REASONS FOR DECLINE OF FISH COMMUNITIES

1. Agricultural development results in a lowering of the water table, increasing aridity, and hence siltation of the reduced streams; also, the attendant dam building results in higher water temperatures, reducing the oxygen capacity of water.
2. Towns provide untreated sewage, saltier than the already saline desert waters in these highly evaporative areas, and industrial development results in a rise of pollution from untreated residual waters. The rivers, scarce, become heavily loaded with silt and often heavily polluted; their current is scantier and becomes intermittent, with muddy pools; the water temperature rises and its diel cycle fluctuates extremely.
3. Many fish culturists are indiscriminate in planting exotic fishes or do not follow biological and ecological principles. Most of these situations are not favorable to the native fishes nor to the human beings that depend on the same waters.
4. The fishes of the relatively simple desert communities have little or no adaptation to predators or competitors, failing to survive if forced to live with the usually aggressive exotic species that are usually more resistant. Such is the situation of *Megupsilon aporus* and *Cyprinodon* sp. that was once abundant at Hediondilla (Potosí), Nuevo León. These species successfully coexisted with the exotic *Carassius auratus*. However, their lack of fear of other fishes makes them succumb to a newly introduced exotic, the strong predator *Micropterus salmoides*. It is possible that these natives may not long survive.

ORIGIN OF THE ECOLOGICAL DEFICIENCIES IN DEVELOPMENT

If we look for the causes of the lack of integral ecological planning of development in the Chihuahuan Desert, it is obvious that the main one is the insufficient knowledge of its biota, beginning at the taxonomic level and continuing at the ecological, resource, and use levels. Standard developers have no biological data and no idea how to use them efficiently, nor do they have good advisors. Thus, there will be no ecologically sound development. There is an urgent need for biological research and influential ecologists. Moreover, ecologically oriented politicians and planners are needed so that the biota of the Chihuahuan Desert, or any other, may be wisely used for the benefit of mankind.

In concluding, the fish fauna of the Chihuahuan Desert is a living resource worth protection; it represents a set of values: scientific, cultural, aesthetic, and practical. Studying its ways we may learn about its past and present, its dynamics, its possibilities of being useful, how to predict its future, and perhaps learn to survive in the desert. Lowering the water table increases the cost of its use, contributes to dry springs, wells, and rivers, and destroys natural resources. Pollution makes unusable the already scarce water. This phenomenon endangers fish life and human communities. We need to design a system of development that includes preservation of such fauna. We can no longer permit the destruction of aquatic habitats and life, considering that we share the same basic resource. It can be safely said that species destruction is thoughtless, useless, and fruitless, and is the result of gross ignorance that needs to be cured.

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