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NOTROPIS ORCA AND *NOTROPIS SIMUS*, CYPRINID FISHES FROM THE AMERICAN SOUTHWEST, WITH DESCRIPTION OF A NEW SUBSPECIES

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The bluntnose shiner, *Notropis simus* (Cope), is an endemic cyprinid of the Rio Grande basin, where it was thought to inhabit the Rio Grande proper and the lowermost parts of its major tributaries. Although still common in certain parts of its range throughout the 1940's, the species experienced a precipitous decline in abundance during the 1950's, and by the mid-1960's had apparently disappeared completely (Miller, 1979).

Our interest in this species emanated from the possibility that the so-called "Pecos Shiner", regarded by Koster (1957) as a potentially undescribed species confined to the Pecos River drainage of New Mexico, was conspecific with *N. simus* (original observations by CRG), and the possibility that a specimen collected from the lower Rio Grande in 1975 was indeed *N. simus*. This took on added importance because of increasing evidence that *N. simus* had disappeared from the Rio Grande (Hubbs et al., 1977), and that the Pecos shiner had itself decreased substantially in abundance in recent years.

Despite its considerable range and former abundance, *Notropis simus* has received scant attention from scientists. Knapp (1953), Hubbs (1957a) and Moore (1957) assumed *Notropis orca* Woolman to

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be a junior synonym of *N. simus*, an action perpetuated by Miller (1976) and Gilbert (1978). Although we had no reason to doubt this, preliminary comparison of specimens of *N. simus* with type material of *N. orca* indicated several consistent morphological differences; a closer comparison was clearly in order.

This study was undertaken to resolve the problems indicated above. Our findings lead us to conclude that (a) *Notropis simus* and *Notropis orca* are valid species, whose ranges overlap (or once overlapped) in the upper Rio Grande of western Texas and southern New Mexico (Fig. 1), and (b) the Pecos shiner is a distinct subspecies of *N. simus* (Fig. 1). *N. simus simus* is confined, or was once confined (the last known specimen was collected in 1964, Pl. 3), to the upper Rio Grande, with the most downstream record from El Paso/Juárez, Texas/Mexico. All records of the new subspecies are from the Pecos River of New Mexico. *N. orca* formerly ranged in the Rio Grande, from central New Mexico downstream to its mouth, with only one specimen known to have been collected (in 1975) during the past 30 years. At least four collections (including the type series of *N. orca*) contain both species, and four hybrid specimens have been identified.

METHODS AND MATERIALS

Counts and measurements were taken as per Hubbs and Lagler (1958) with the following additions and clarifications: (a) prepelvic length is measured from the outermost left pelvic-ray base to the tip of the snout; (b) head depth at eye is measured vertically at the center of the pupil; (c) head depth at occiput is the same as head depth of Hubbs and Lagler (1958); (d) anal origin to dorsal origin is the diagonal measurement between the fins; (e) postdorsal- and postpelvic-fin lengths are distances from the caudal base to the origin of the dorsal fin and insertion of the pelvic fin, respectively; (f) dorsal-fin length and anal-fin length are depressed lengths; (g) anterior dorso-lateral scales were counted along the longitudinal row situated ca. three-fourths of the distance up from the lateral line to the mid-dorsal line, as discussed by Gilbert (1964); (h) preoperculo-mandibular pores, infraorbital pores and supraorbital pores were counted according to Illick (1956); (i) vertebral counts include the Weberian vertebrae as four and the urostyle as one; and (j) the first

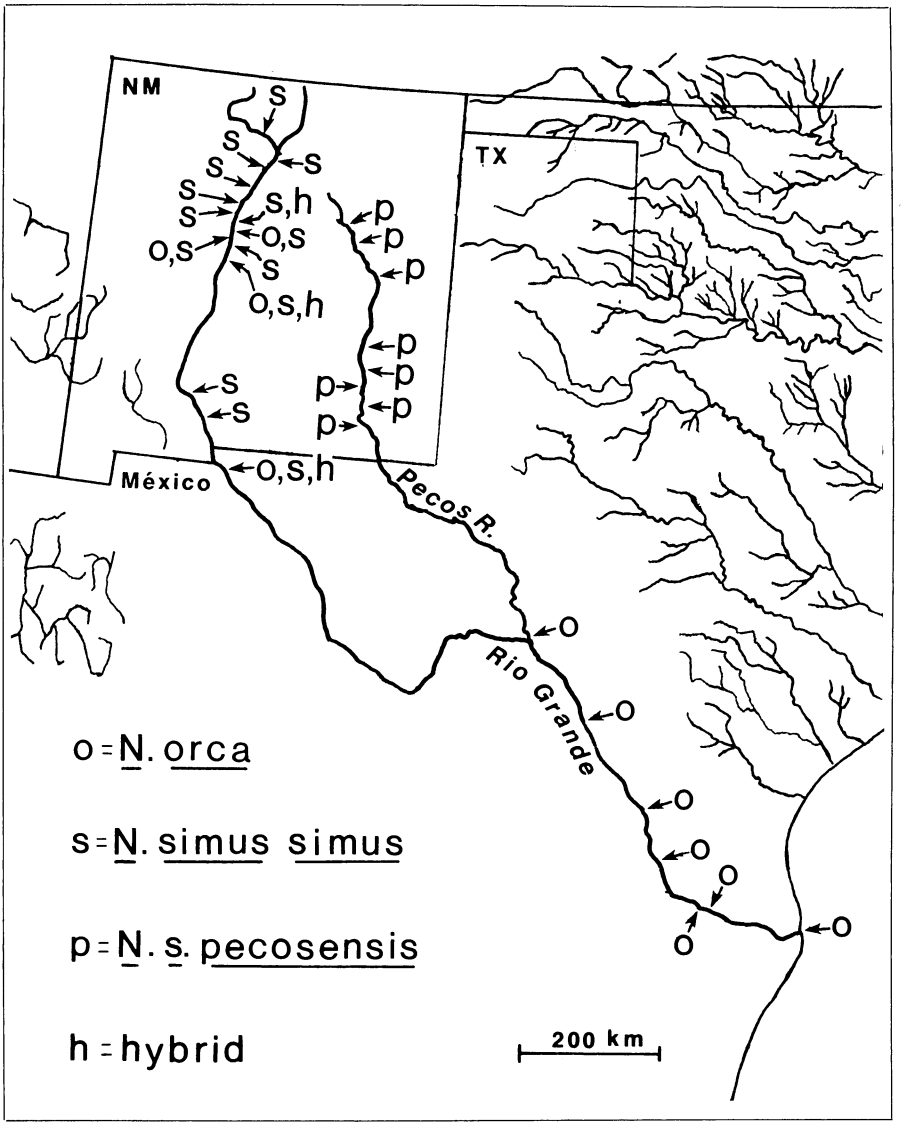

Figure 1. Map of record stations of *Notropis orca* (o), *Notropis simus simus* (s), their hybrids (h), and *Notropis simus pecosensis* (p) from southwestern United States and Mexico. NM = New Mexico; TX = Texas.

caudal vertebra is considered to be that centrum bearing a haemal arch (either fused or not) and lacking pleural ribs.

Principal components analysis (PCA) is used to make multivariate comparisons among several taxa. A priori assignment of specimens to groups is not required by PCA, and thus allows for discovery of groups from the scatter of PCA-scores on combinations of principal component axes (for discussion of PCA and PCA-score formation see Smith, 1973, or Blackith and Reyment, 1971). PCA was performed separately on meristic and morphometric data. The principal components were computed from the correlation matrix of meristic data, and scores calculated from standardized variables. Mensural data were first log transformed (base 10), to correct for allometries, and to standardize the variance of the variables (i.e., remove scaling effect); principal components were then computed from the covariance matrix.

The usual interpretation of resultant components of morphometric data is that the first component (PCI) describes size and the remaining components (e.g., PCII, PCIII, etc.) comprise shape. However, size and shape may confound PCI and PCII (Sprent, 1972; Humphries et al., 1981). The method of Humphries et al. (1981) was used to remove the effect of size from PCII by regression; scores on the resultant sheared-PCII allow us to compare size-free shape among specimens under study, especially when plotted against an estimate of overall size, pooled within-species PCI. The removal of size from PCII does not increase the amount of discrimination in the analysis, it only clarifies the inherent discrimination.

Specimens examined in this study are housed in the following institutions: California Academy of Sciences (CAS); Eastern New Mexico University (ENMU); Florida State Museum, University of Florida (UF); Tulane University (TU); National Museum of Natural History (USNM); Universidad Autónoma de Nuevo León (UANL); University of Michigan Museum of Zoology (UMMZ); and University of New Mexico (UNM).

Notropis simus (Cope)
Bluntnose Shiner
Pls. 1-4; Figs. 1-10

DIAGNOSIS.—A species of *Notropis* distinguished from *N. orca* and other congeners by the following combination of traits: pharyngeal

dentition usually 2,4-4,2, occasionally lacking one or both teeth in minor row, rarely 0,4-4,0; anal-fin rays (7)8-10(11), modally 9; total vertebrae 35-38, usually 36 or 37; gill rakers 4-9 on first arch, 10-15 on second arch, and 8-10 on last half arch, sum of three arches 25-30(32); caudal peduncle variable in depth, slender in Rio Grande populations (77-104 per mille SL) and deep in Pecos River populations (90-118 per mille SL); snout blunt and often overhanging upper lip, which includes lower lip; mouth not sharply inclined, less than terminal to subterminal, usually extending to under pupil; eye relatively small, 48-84 per mille SL; lateral-line scales 33-38; caudal fin longer than head; breeding tubercles small, profuse, irregularly distributed over head, and present on upper surface of first nine rays of pectoral fin of breeding males; fins generally immaculate; lacking chromatic breeding colors; a silvery lateral stripe in life, its greatest width greater than orbit diameter; pigment absent from mandibular symphysis; dorsal-fin origin posterior to pelvic-fin insertion, and closer to caudal base than to snout tip; posterior margins of dorsal and anal fins slightly falcate or straight; postero-ventral surface of urohyal bifurcate; posteriorly directed uncinate processes present on first four epibranchials; fifth cartilaginous epibranchial present.

DESCRIPTION.—Variational data on body proportions, anal-fin rays, gill rakers and vertebrae appear in Tables 1-5, and additionally in subspecies accounts.

Body moderately deep and robust, with or without distinct taper posteriorly. Body wide and moderately compressed. Dorsal-fin origin behind pelvic insertion, originating closer to caudal base than to tip of snout. Snout blunt and rounded, often projecting beyond upper lip which includes lower lip; head deep and wide. Mouth not sharply inclined, varying from almost terminal to subterminal; maxilla usually reaches under pupil but may fall short, edge straight or slightly decurved. Anterior lobe of dorsal fin longest, its posterior margin slightly falcate or straight. Anterior rays of anal fin usually subequal to posterior rays in depressed fin. Gut simple with two flexures, type 1 of Kafuku (1958); peritoneum silvery.

Scales thin, with numerous well developed radii in posterior field, and moderately to slightly imbricated; scales of normal shape, not higher than wide. Breast fully scaled, or scales becoming embedded or obsolete.

Breeding males with small profuse tubercles irregularly dis-

TABLE 1

MEASUREMENTS OF *NOTROPIS SIMUS SIMUS*, EXPRESSED IN THOUSANDTHS OF SL.

		Males (N=16)		Females (N=26)		Total (N=66)	
Measurement	Lectotype	Range	$\bar{X}$	Range	$\bar{X}$	Range	$\bar{X}$
Standard length, mm	62.8	30.0–65.2	49.6	30.8–69.4	46.8	24.2–78.5	42.0
Predorsal length	561	513–555	541	520–575	546	511–576	543
Postdorsal length	462	465–514	487	450–510	484	443–514	484
Preanal length	688	640–689	664	654–692	671	631–692	667
Prepelvic length	510	466–509	490	483–517	499	466–517	496
Postpelvic length	540	501–561	533	499–539	520	499–561	523
Head length	241	239–262	253	231–267	255	231–271	255
Postorbital head length	118	105–124	113	100–127	114	100–132	114
Head depth							
at eye	129	118–140	130	113–140	129	113–142	129
at occiput	164	162–180	168	131–191	168	131–191	168
Head width	121	129–160	136	124–163	136	121–163	135
Eye diameter	61	57–73	65	51–78	65	48–81	65
Snout length	65	67–77	72	62–79	71	62–83	71
Upper jaw length	86	81–90	85	74–93	84	74–95	85
Gape width	62	53–74	63	52–86	63	52–86	64
Body depth	226	199–260	223	208–281	232	189–281	227
Dorsal origin-anal origin	245	233–264	249	224–272	252	202–272	248
Body width	103	97–144	120	101–181	127	95–181	122
Caudal peduncle							
least depth	89	81–100	90	78–104	90	78–104	90
length	194	154–210	197	183–222	201	154–234	201
width	45	31–56	40	26–59	41	25–59	40
Dorsal fin base	116	110–150	128	115–138	126	109–150	125
Anal fin base	124	115–157	139	118–150	134	115–157	134
Dorsal fin length	220	221–265	245	197–272	242	197–277	243
Anal fin length	194	198–252	232	197–240	219	194–259	224
Pectoral fin length	221	222–247	232	202–241	219	202–247	223
Pelvic fin length	165	157–182	169	138–182	162	138–182	163

tributed over head, lips, gular and branchiostegal regions, and extending onto breast scales (if present); breeding females may have small tubercles sparsely scattered over head but not on breast. Nuptial tubercles small, but well developed, on upper surface of pectoral fin in breeding males. Tubercles present on first 9 pectoral rays; outermost pectoral ray with irregularly scattered, mostly uniserial tubercles; tubercles best developed on rays 3 to 5, uniserial proximally,

TABLE 2

FREQUENCY DISTRIBUTION OF ANAL FIN RAYS IN *NOTROPIS ORCA* AND *N. SIMUS*

	Anal Fin Rays							
Taxon	7	8	9	10	11	12	N	Mean
N. orca	1	73*	8				82	8.1
N. s. simus		30	458*	121	4	1	614	9.2
N. s. pecosensis	1	26*	57	4			88	8.7

*Value of holotype or lectotype

TABLE 3

FREQUENCY DISTRIBUTIONS OF GILL-RAKER COUNTS IN *NOTROPIS ORCA* AND *N. SIMUS*

	Gill Rakers, First Arch												
Taxon	4	5	6	7	8	9	10	11	12	13	14	N	Mean
N. orca					3	26	24*	3			1	57	9.6
N. s. simus	3	2	22	25*	25	5						82	7.0
N. s. pecosensis	2	3	13*	22	5	3						48	6.7

	Gill Rakers, Second Arch												
Taxon	10	11	12	13	14	15	16	17				N	Mean
N. orca				3	17	27*	13	2				62	14.9
N. s. simus	3	23	40*	26	9							101	12.1
N. s. pecosensis	2	12	23	38*	12	1						88	12.6

	Gill Rakers, Last Arch												
Taxon	7	8	9	10	11	12						N	Mean
N. orca				17	22*	6						45	10.8
N. s. simus	4	22*	31	5								62	8.6
N. s. pecosensis		3	8*	4								15	9.1

*Value of holotype or lectotype

biserial mesially to bifurcation of each ray with 4-8 tubercles per segment, and uniserial distally to tip; well developed tubercles on thickened interradial membranes between first and tenth element in pectoral fin. Occasional breeding female with a few small irregularly disposed tubercles on upper surface of pectoral fin.

Small melanophores sparsely and irregularly scattered over head; heart-shaped subcutaneous pigment associated with brain and pineal

TABLE 4

FREQUENCY DISTRIBUTIONS OF VERTEBRAL COUNTS IN *NOTROPIS ORCA* AND *N. SIMUS*

	Precaudal Vertebrae						
Taxon	13	14	15	16	17	N	Mean
N. orca		5	60*	16	1	82	15.2
N. s. simus	1	71	27*			99	14.3
N. s. pecosensis	13	40*	9			62	13.9
	Caudal Vertebrae						
Taxon	17	18	19	20	21	N	Mean
N. orca	1	22	47*	11	1	82	18.9
N. s. simus	2	38*	51	8		99	18.7
N. s. pecosensis	13*	38	11			62	18.0
	Total Vertebrae						
Taxon	35	36	37	38	39	N	Mean
N. orca			9	62*	11	82	38.0
N. s. simus		25	69*	12		106	36.9
N. s. pecosensis	13*	42	7			62	35.9

*Value of holotype or lectotype

organ more distinct than superficial flecks of pigment; melanophores extending anteriorly between nares and over tip of snout, often disappearing above lips in Rio Grande populations; flecks of pigment present under rostral flap. Lips varying from unpigmented to pigmented; if pigmented, upper jaw with more pigment flecks near symphysis of maxillae, and fading laterally; mandible with less pigment than upper jaw, lacking pigment at symphysis and flecks present adjacent to symphysis. Gular and branchiostegal regions immaculate; pigment spots sparsely present above lateral side of upper lip and below nares and anterior region of orbit; dense concentration of small melanophores in infraorbital region, roughly extending from anterior midpoint of pupil to posterior midpoint of pupil; a few scattered, but larger, melanophores usually present on upper third of opercle and preopercle; lower regions of opercular series lacking melanophores and sometimes appearing silvery.

In preservation individuals are fairly pallid; side of body either pallid or with silvery stripe, its width greater than diameter of orbit; a wide dusky lateral stripe of diffuse melanophores, originating at

TABLE 5

MEASUREMENT OF *NOTROPIS SIMUS PECOSENSIS*, EXPRESSED IN THOUSANDTHS OF SL.

Measurement	♀ Holotype	Males (N=28) Range	Males (N=28) $\bar{X}$	Females (N=52) Range	Females (N=52) $\bar{X}$	Total (N=88) Range	Total (N=88) $\bar{X}$
Standard length, mm	48.8	29.2–50.3	41.7	28.1–53.4	43.4	23.9–53.4	41.7
Predorsal length	533	503–543	529	504–552	537	503–552	534
Postdorsal length	494	473–520	498	462–515	492	462–520	494
Preanal length	697	633–694	664	638–698	674	627–698	669
Prepelvic length	502	470–509	485	458–517	491	458–517	489
Postpelvic length	531	499–541	525	496–545	523	494–545	524
Head length	275	243–273	258	243–280	259	234–280	259
Postorbital head length	131	110–131	117	103–135	117	103–135	117
Head depth							
at eye	143	117–146	131	121–145	132	117–146	132
at occiput	180	158–181	168	162–193	174	157–193	172
Head width	137	117–149	135	121–156	140	117–156	138
Eye diameter	66	61–84	69	64–78	69	61–84	69
Snout length	74	64–78	71	59–82	70	59–82	71
Upper jaw length	96	76–97	87	73–101	89	73–101	88
Gape width	74	48–72	63	55–74	65	48–74	64
Body depth	238	205–267	228	217–273	244	205–273	237
Dorsal origin-anal origin	266	235–284	254	221–290	259	221–290	256
Body width	125	89–148	114	121–156	140	89–162	123
Caudal peduncle							
least depth	105	90–118	105	93–117	104	90–118	105
length	207	201–235	215	189–248	211	189–248	213
width	41	31–48	38	27–47	37	27–48	38
Dorsal fin base	127	94–131	115	86–129	115	86–131	115
Anal fin base	113	92–139	120	98–130	116	92–142	118
Dorsal fin length	229	207–253	233	210–271	236	207–271	235
Anal fin length	184	172–221	208	173–230	199	172–230	201
Pectoral fin length	236	213–260	238	201–275	227	201–275	232
Pelvic fin length	170	134–175	160	115–181	164	115–188	163

upper half of pectoral girdle and extending to caudal base, intersecting lateral line anteriorly and at caudal base, lying on or to three scales above lateral line at mid-body; melanophores sometimes forming definite streak within lateral stripe extending posteriorly from about pelvic-fin insertion to caudal base; above lateral stripe, scales have a tendency to be outlined in Pecos River populations; pre- and postdorsal stripes ranging from indistinct to dusky with concentrations of small melanophores.

Pelvic and anal fins immaculate; dorsal and pectoral fins with flecks of pigment extending outward along rays; caudal fin variable in pigmentation, some specimens with small flecks of pigment extending outwardly along margins of or on rays, more highly pigmented individuals with a dense concentration of large melanophores on median rays in crotch of caudal musculature, which extend onto fin and may form a small chevron or irregularly-shaped spot.

Notropis simus simus (Cope)
Pls. 1-3; Figs. 1-10

Alburnops simus Cope, in Cope and Yarrow, 1875:649-650, Pl. 31, Figs. 2,2a (original description; Rio Grande at San Ildefonso, ca. 40 km NW of Santa Fe, New Mexico).

Cliola sima, Jordan and Gilbert, 1883:170 (after Cope).

Notropis simus, Evermann and Kendall, 1894:100-101 (in part; characters of syntypes). Jordan and Evermann, 1896:267 (after Cope). Knapp, 1953:56,62, Fig. 86 (chars. in key; distr.). Hubbs, 1957a:6 (in part; listed), 1957b:93 (in part; distr.). Koster, 1957:52, 66-67 (in part; descr.; distinctive chars.; size; Rio Grande; use as bait). Moore, 1957:117,127 (in part; key; chars.; distr.). Hubbs, 1958:6 (in part; distr.), 1961:6 (in part; distr.). Moore, 1968:73,82 (in part; key; chars.; distr.). Eddy, 1969:130, Fig. 307 (in part; chars. in key; range). Alvarez, 1970:60,62 (in part; recognized *N. simus orca* as the Mexican form; chars. in key). Hubbs, 1972:3 (in part; distr.). Hubbs and Echelle, 1972:150-152, 162-163 (in part; listed from upper Rio Grande basin; "Texas-Mexico affinity"; potentially endangered; "morphologically distinct races" in Rio Grande, Rio Conchos, Pecos R.; recorded from Rio Conchos without reference to voucher specimens). Hubbs, 1976:3 (in part; distr.; endangered). Miller, 1976:11 (in part; synonymy; comparison between types of *orca* and *simus*). Hubbs et al., 1977:91,96 (in part; possibly extinct in U.S. waters; comments on former occurrence). Gilbert, 1978:16,27,67,80 (in part; syntypes listed with SL, range and some counts; synonymy). Hatch, 1978:E29-30, fig. (in part; descr., from Koster, 1957; range, possibly incl. Pecos R.; status in New Mexico; endangered species; proposals on conserv.). Miller, 1978:370,376,378 (in part; listed; Rio Grande; assigned to Chihuahuan Fish Province; endangered species). Deacon et al.,

1979:35 (in part; range; endangered species). Hatch, 1979:E27-28, fig. (in part; descr., from Koster, 1957; range; endangered species; conservation). Miller, 1979:1 sheet (in part; endangered species; status; distr.; habitat; conserv.; refs.). Gilbert, 1980:310 (in part; distr. mapped; Pecos R. included; comments on syst.; habitat; factors of decline).

Hybopsis simus, Jordan, Evermann and Clark, 1930:135 (listed; type locality).

MATERIAL.—The lectotype, USNM 16982, is an adult, 62.8 mm SL, collected in Rio Grande at San Ildefonso, Santa Fe Co., New Mexico, in Aug. 1874, by H. C. Yarrow and E. D. Cope. Taken with the lectotype are paralectotypes, USNM 227343 (69), 33.1-63.9 mm.

Additional material is as follows:

New Mexico.—UNM 1400 (13), 48.6-57.1 mm, Chama R. about 7 km E Abiquiu, Rio Arriba Co., 15 April 1949. TU 35683 (1), 65.2 mm, Rio Grande, 7 km N of Peña Blanca, Sandoval Co., 28 July 1964. UF 25141 (ex UNM 1396), (2), 61.1-67.4 mm, 0.5 km above Angostura diversion dam, Sandoval Co., 25 Oct. 1947. UMMZ 133238 (2), 33.8-36.8 mm, Rio Grande just above bridge at Bernalillo, Sandoval Co., 12 April 1941. UF 25139 (ex UNM 1387b), (8), 30.0-49.8 mm, UNM 1387b (372), 18.0-59.2mm, Rio Grande just N of Valencia Co. line, Bernalillo Co., 9 June 1939. UMMZ 120055 (1), 28.4 mm, pit and irrigation ditch connected to Rio Grande, 3 km N Albuquerque, Bernalillo Co., 28 March 1937. UMMZ 120060 (1), 32.5 mm, small borrow pit 4 km S of Alameda on Rio Grande, Bernalillo Co., 6 March 1937. UMMZ 125064 (80), 27.1-53.3 mm, Isleta diversion dam, 24 km S of Albuquerque, Bernalillo Co., 31 Aug. 1939. UMMZ 131134 (4), 26.2-49.3 mm, Isleta irrigation ditch, Bernalillo Co., 29 Jan. 1940. UNM 1403 (77), 21.1-63.8 mm, Rio Grande 6 km below Isleta, Bernalillo Co., 29 Oct. 1944. UMMZ 133232 (4), 36.2-78.5 mm, Rio Grande just below Alameda, Bernalillo Co., 12 April 1941. UMMZ 94890 (6), 16-47.5 mm, Rio Grande at Los Lunas, Valencia Co., 20 Sept. 1926. UMMZ 120051 (2), 24.2-34.7 mm, pit on E side of Rio Grande, 60 m from river, 6 km N of Belen, Valencia Co., 21 Feb. 1937. UNM 1405 (16), 27.9-69.4 mm, Rio Grande near bridge at Bernardo, Socorro Co., 19 June 1939. UNM 1402 (2), 57.4-58.2 mm, Rio Grande at Leasburg dam, Dona Ana Co., 31 Oct. 1944. UMMZ 124733 (1), 33.3

mm, Rio Grande W of Las Cruces on US Hwy 80, Dona Ana Co., 29 June 1938.

Mexico.—UMMZ 207683 (3), 42.0-48.4 mm (formerly IU 4843, part of type series of *N. orca*), Rio Grande at Juárez, Chihuahua, 1891.

DIAGNOSIS.—A subspecies of *Notropis simus* with breast scales becoming deeply embedded or obsolete in adults; body tapering posteriorly to slender caudal peduncle, 77-104 per mille SL, mean 90; anal-fin rays 9 or 10, rarely 8; caudal and total vertebrae, modally 19 and 37, respectively; attaining a larger overall size, adults to 80 mm SL; pharyngeal dentition 2,4-4,2 but often reduced; upper jaw usually extending under pupil, occasionally falling short; small melanophores forming an indistinct dusky lateral stripe, usually lacking a pigment streak and caudal-fin spot; overall lighter pigmentation, scales above lateral stripe not outlined.

DESCRIPTION.—Variational data on body proportions and selected meristic variables appear in Tables 1-4. Values of lectotype designated by asterisks, number of counts or specimens indicated parenthetically. Dorsal-fin rays 7(2), 8*(64), 9(1). Pectoral-fin rays: left side 14*(11), 15(46), 16(9); right side 14*(15), 15(39), 16(12). Pelvic-fin rays: left side 7(6), 8*(59), 9(2); right side 7(2), 8*(63), 9(2). Lateral line, complete and slightly decurved anteriorly, scales 34(4), 35*(19), 36(26), 37(15), 38(1). Body circumferential scales: total 23(1), 27(2), 28(4), 29(7), 30(19), 31(10), 32*(14), 33(2), 34(3), 35(1); above lateral line 11(1), 14(6), 15*(34), 16(18), 17(5); below lateral line 10(1), 11(4), 12(10), 13(24), 14(14), 15*(9), 16(1), 17(1). Caudal-peduncle circumferential scales: total 13(2), 14(25), 15*(20), 16(17); above lateral line 6(3), 7*(61); below lateral line 5(26), 6*(21), 7(17). Anterior dorsolateral scales 15(2), 16(6), 17*(16), 18(17), 19(12), 20(11), 21(1). Scale rows from dorsal-fin origin to lateral line 4(1), 6*(39), 7(25). Scale rows from anal-fin origin to lateral line 3(1), 4(57), 5*(7). Preoperculo-mandibular pores: left side 9(4), 10*(36), 11(13); right side 9(2), 10*(39), 11(10), 12(1). Infraorbital pores: left side 13(14), 14*(25), 15(11), 16(1); right side 13(11), 14*(32), 15(8). Supraorbital pores: left side 8*(39), 9(12); right side 8*(33), 9(18). Pharyngeal-arch dentition 2,4-4,2(20), 1,4-4,2(1), 1,4-4,1*(4), 1,4-4,0(1), 0,4-4,1(1), 0,4-4,0(2).

Scales of usual shape, wider than high, with well developed radii

in posterior field. Breast scales becoming obsolete or deeply embedded; breast usually appears naked in adults.

RANGE AND STATUS.—*Notropis simus simus* is known only from the upper Rio Grande basin of Texas and New Mexico; from El Paso, Texas, and Juárez, Mexico, to the vicinity of Abiquiu in the Chama River of New Mexico (Fig. 1). It was last collected in 1964 at Peña Blanca, New Mexico.

HYBRIDIZATION.—This subspecies of *N. simus* is known to hybridize with *N. orca* (see below).

Notropis simus pecosensis Gilbert and Chernoff
new subspecies
Pl. 4; Figs. 1,2,6-10

Notropis simus, Evermann and Kendall, 1894:100-101 (in part; ref. to 6 spec., USNM 36795, presumably from Pecos R.). Knapp, 1953:56,62, Fig. 86 (chars. in key; distr.; first def. publ. record for Pecos R.). Eddy, 1969:130 (in part; chars. in key; range); Hubbs and Echelle, 1972:150-152,162-163 (in part; listed from upper Rio Grande basin; potentially endangered; "morphologically distinct races" in Rio Grande, Rio Conchos, Pecos River). Hatch, 1978: E29-30, fig. (in part; range possibly incl. Pecos R., after Koster, 1957). Gilbert, 1980:310 (in part; distr. mapped; comments on syst.; habitat; factors of decline).

Notropis shumardi, Hatch, 1978:E25-26, fig. (descr. based on Pecos shiner of Koster, 1957; distr. in Pecos River).

Notropis cf. *shumardi*, Hatch, 1979:E25-26, fig. (descr. based on Pecos shiner of Koster, 1957; distr. in Pecos River; conservation status).

Notropis sp., Koster, 1957:66-67 (referred to "Pecos shiner", distinctive chars., distr. in Pecos River).

MATERIAL.—The holotype, UMMZ 207686, is an adult female, 48.8 mm SL, collected in Pecos River about 7 km NE of Roswell, Chaves Co., New Mexico, on 3 Sept. 1944, by W. J. Koster and R. Lindberg. Taken with holotype are paratopotypes: UF 25144 (10), 37.3-53.2 mm; UMMZ 207687 (49), 29.0-53.6 mm; UNM 2631 (758), 18.0-53.2 mm.

Additional paratypes are as follows:

New Mexico.—ENMU NM-CH74-28 (20), 23.9-51.4 mm, Pecos River, US Hwy 70 NE Roswell, Chaves Co., 1974. UF 25140 (ex UNM 1388), (10), 41.3-51.3 mm, Pecos River at Fort Sumner, De Baca Co., 26 Aug. 1939. CAS-SU 53958 (1), 49.8 mm, Pecos River 1 km N Santa Rosa, Guadalupe Co., 26 Sept. 1940. UF 25142 (ex UNM 1416), (15), 37.9-53.4 mm, Pecos River just above Santa Rosa, Guadalupe Co., 21 Aug. 1959. UF 25145 (ex UNM 2969), (5), 36.8-46.5 mm, Pecos River 4 km below Santa Rosa, Guadalupe Co., 18 May 1963.

Other material: USNM 36795 (7), 35.4-46.8 mm, Pecos River, Texas (?).

DIAGNOSIS.—A subspecies of *Notropis simus* with breast fully scaled, scales not becoming embedded or obsolete; relatively deep caudal peduncle, 90-118 per mille SL, mean 104; anal-fin rays 8 or 9; reduced number of caudal and total vertebrae, modally 18 and 36, respectively; attaining a smaller overall length, adults less than 60 mm SL; pharyngeal dentition 2,4-4,2, rarely 1,4-4,2; upper jaw usually extending under pupil; larger melanophores forming dusky lateral stripe and streak, sometimes ending in an irregularly shaped caudal spot; overall darker pigmentation; melanophores usually present on front of snout above lips; dusky lateral stripe lying on or up to two scale rows above lateral line at mid-body.

DESCRIPTION.—Variational data on body proportions and selected meristic variables appear in Tables 2-5. Values of holotype indicated by asterisks, number of counts or specimens indicated parenthetically. Dorsal-fin rays 7(5), 8*(82), 9(1). Pectoral-fin rays: left side 13(1), 14*(30), 15(45), 16(10), 18(1); right side 13(7), 14(32), 15*(42), 16(6). Pelvic-fin rays: left side 6(1), 7(4), 8*(82), 9(1); right side 7(3), 8*(85). Lateral line, complete and slightly decurved anteriorly, scales 33(1), 34*(18), 35(35), 36(24), 37(9). Body circumferential scales: total 26*(12), 27(10), 28(18), 29(28), 30(11), 31(7), 32(2); above lateral line 12(1), 13*(13), 14(23), 15(49), 16(2); below lateral line 10(1), 11*(29), 12(29), 13(22), 14(5), 15(2). Caudal-peduncle circumferential scales: total, 13(2), 14(50), 15*(24), 16(9), 17(3); above lateral line, 6(2), 7*(78), 8(7), 9(1); below lateral line, 5(55), 6*(24), 7(9). Anterior dorso-lateral scales 15(17), 16*(37), 17(17), 18(8), 19(7), 22(1). Scale rows from dorsal-fin origin to lateral line 5(1), 6*(74), 7(13). Scale rows from

anal-fin origin to lateral line 3(16), 4*(71), 5(1). Preoperculo-mandibular pores: left side 8(1), 9(5), 10*(23), 11(4), 12(1); right side 8(1), 9(4), 10*(25), 11(3), 12(1). Infraorbital pores: left side 12(2), 13(8), 14*(17), 15(6); right side 12(3), 13(7), 14*(20), 15(4). Supraorbital pores: left side 7(1), 8*(26), 9(3), 10(1); right side 8*(25), 9(4), 10(2). Pharyngeal arch dentition 2,4-4,2*(21), 1,4-4,2(3).

REMARKS.—Although *pecosensis* is similar to *N. orca* for several characteristics (e.g., caudal-peduncle depth) and intermediate with respect to *N. simus* and *N. orca* for several others (e.g., caudal-peduncle length; see Tables 1-5), we align *pecosensis* with *N. simus* because of similarities in their pharyngeal arches, dentaries, maxillae and premaxillae (see Figs. 2,8-10). The robust pharyngeal arch of *N. s. pecosensis* (not figured) is the same as or has a slightly broader ala than *N. s. simus*, but both of these taxa differ markedly from *N. orca*, which has a relatively slender arch (Fig. 2). Other characters such as number of vertebrae and gill rakers also support this assignment.

RANGE AND STATUS.—*Notropis simus pecosensis* is only known from the Pecos River drainage of eastern New Mexico (Fig. 1), where it is now restricted to the region between just south of Santa Rosa to Carlsbad. Populations are apparently dependent upon large flows of water (Hatch, 1979). Formal listing as endangered has been submitted for consideration in fiscal year 1982 (J. Johnson, pers. comm.).

ETYMOLOGY.—We name this subspecies for the Pecos River, to which it is restricted.

Notropis orca Woolman
Phantom Shiner
Pl. 5; Figs. 1-5, 8-10

Notropis orca Woolman, 1894:56 (orig. descr.; Rio Grande at El Paso, Texas). Jordan and Evermann, 1896:254,289 (descr.). Regan, 1906-08:155-156 (chars. in key; no evidence specimens examined). De Buen, 1940:16 (listed), 1947:269,313 (listed; Rio Bravo Province). Alvarez, 1950:54 (chars. in key; distr.).

Orcella orca, Jordan and Evermann, 1896:254,289 (*Orcella* n. subgen.

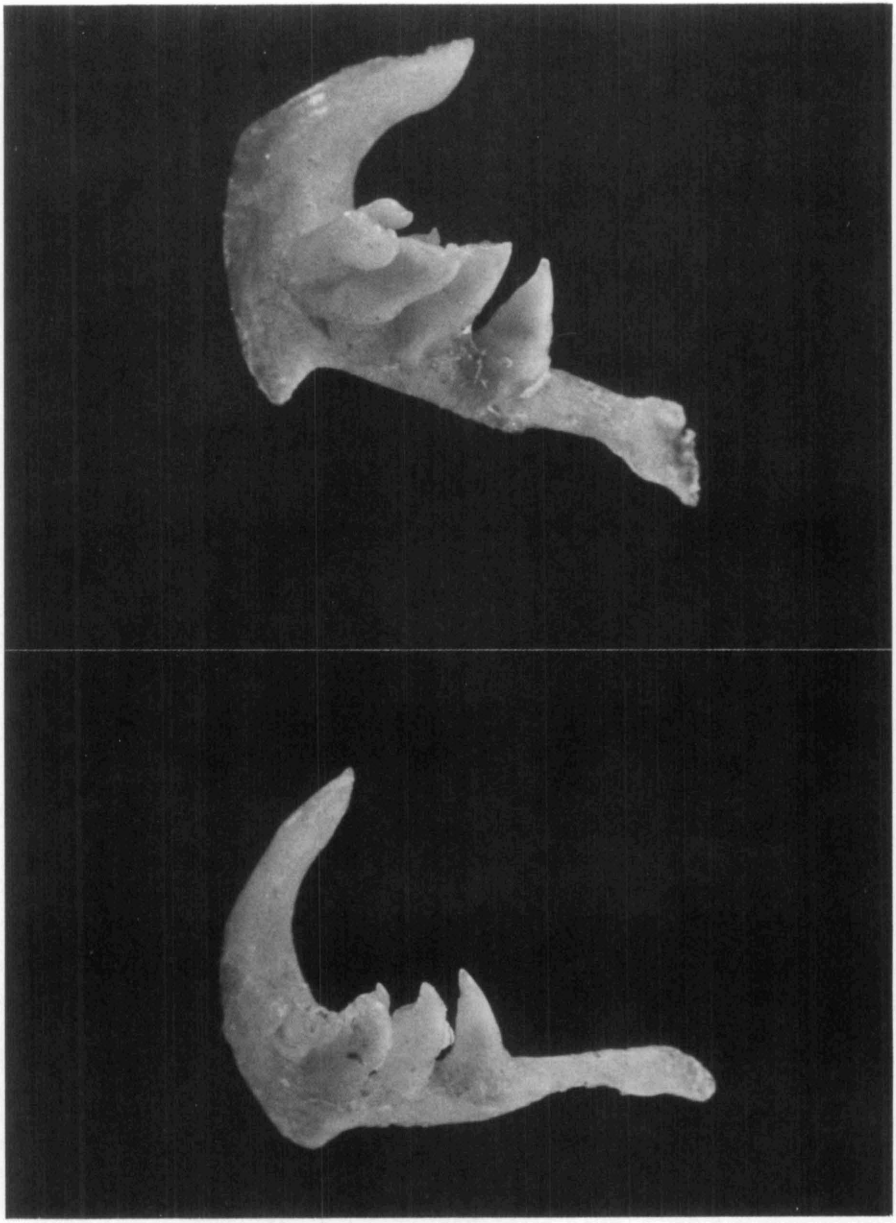

Figure 2. Mesial views of the right pharyngeal arches of *Notropis simus simus* (above) and *Notropis orca* (below).

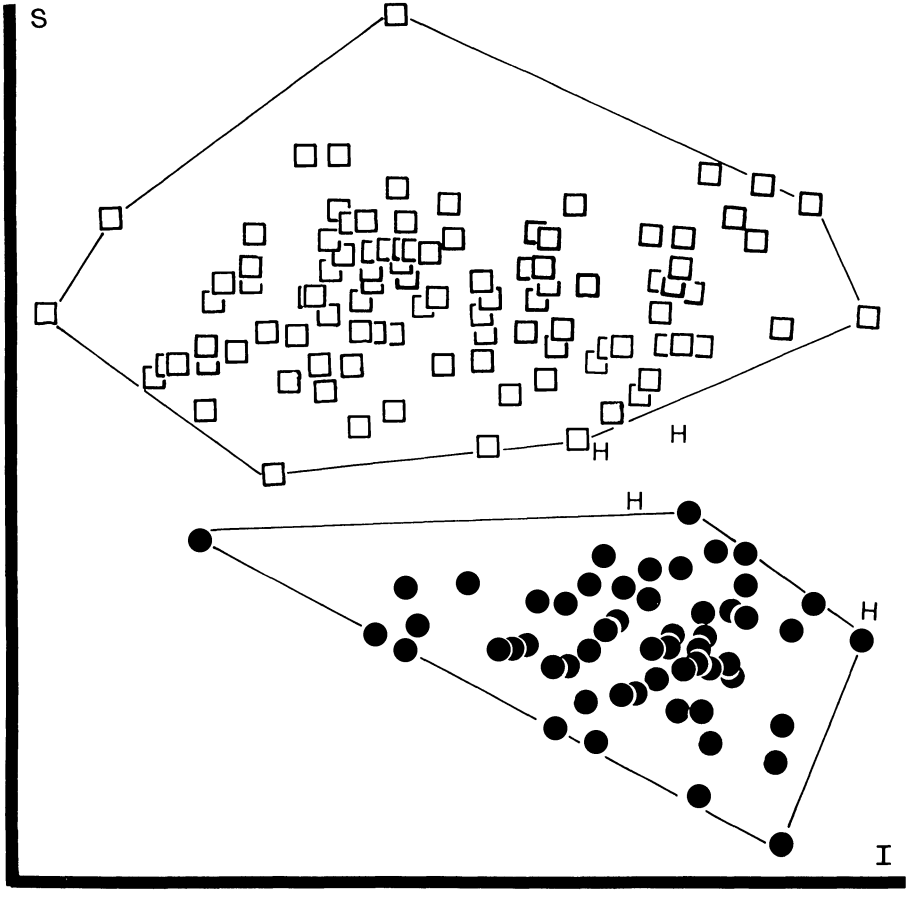

Figure 3. Plot of morphometric principal component scores for *Notropis orca* (circles), *Notropis simus simus* (squares) and their hybrids (H's). Abscissa: principal component I (I). Ordinate: sheared principal component II (S).

for *N. orca*). Jordan, Evermann and Clark, 1930:126 (*Orcella* raised to full genus).

Orcula orca, Jordan and Evermann, 1900:3140 (substitute name for *Orcella*, erroneously regarded as preoccupied).

Nototropis orca, Meek, 1904:64,69 (chars. in key; descr. from Jordan and Evermann).

Notropis simus (misidentifications). Hubbs, 1957a:6 (in part; listed), 1957b:93 (in part; distr.). Koster, 1957:52, 66-67 (in part; descr.;

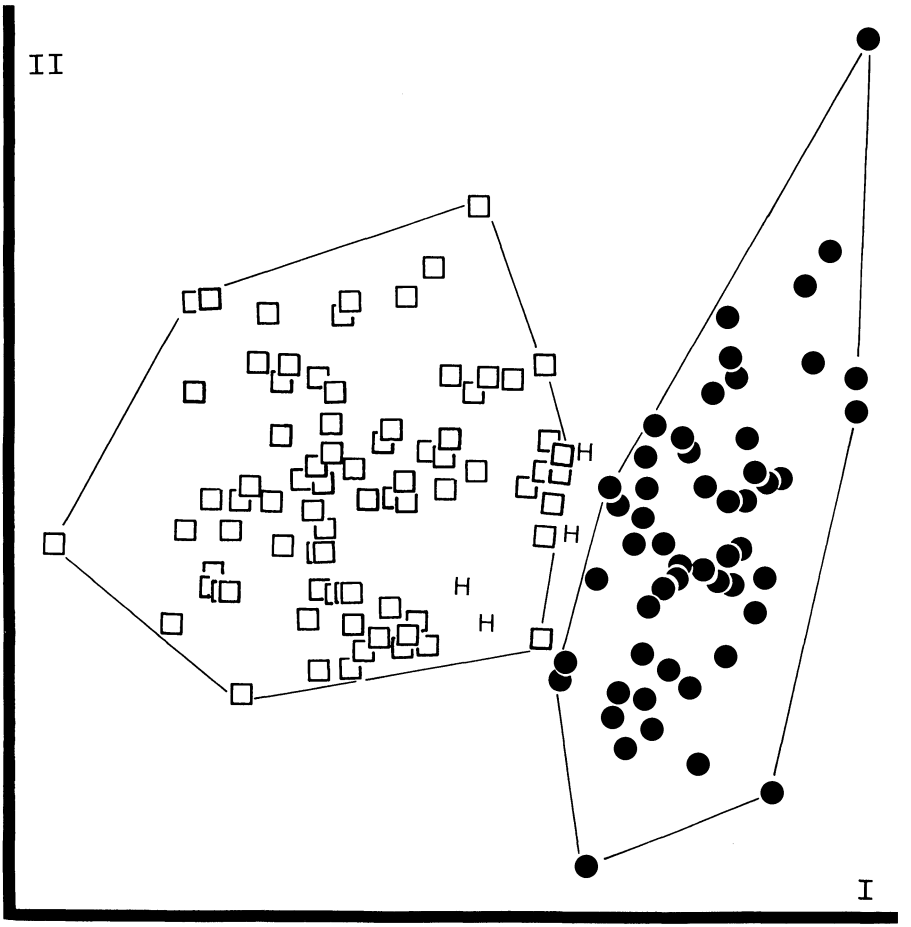

Figure 4. Plot of meristic principal component scores for *Notropis orca* (circles), *Notropis simus simus* (squares) and their hybrids (H's). Abscissa: principal component I (I). Ordinate: principal component II (II).

distinctive chars.; size; Rio Grande; use as bait). Moore, 1957:117, 127 (in part; key; chars; distr.). Hubbs, 1958:6 (in part; distr.), 1961:6 (in part; distr.). Moore, 1968:73,82 (in part; key; chars.; distr.). Eddy, 1969:130 (in part; chars. in key; range). Hubbs, 1972:3 (in part; distr.). Hubbs and Echelle, 1972:150-152, 162-163 (in part; listed from upper Rio Grande basin; "Texas-Mexico affinity"; potentially endangered; "morphologically distinct

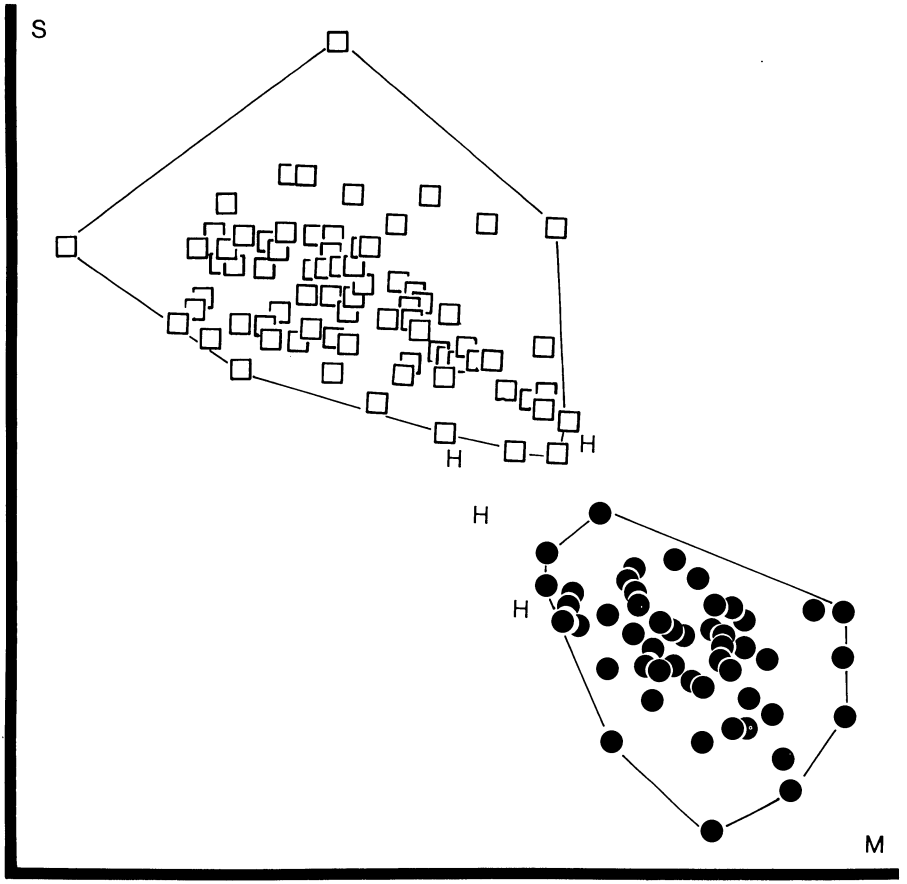

Figure 5. Plot of scores on meristic and morphometric discriminators for *Notropis orca* (circles), *Notropis simus simus* (squares) and their hybrids (H's). Abscissa: meristic principal component I (M). Ordinate: sheared principal component II (S).

races" in Rio Grande, Rio Conchos, Pecos R.; recorded from Rio Conchos without reference to voucher specimens). Hubbs, 1976:3 (in part; distr.; endangered). Miller, 1976:11 (in part; synonymy; comparison between types of *orca* and *simus*). Hubbs et al., 1977:91,96 (in part; possibly extinct in U.S. waters; comments on former occurrence). Gilbert, 1978:16,20,67,80 (in part; syntypes listed with SL, range and some counts; synonymy). Hatch,

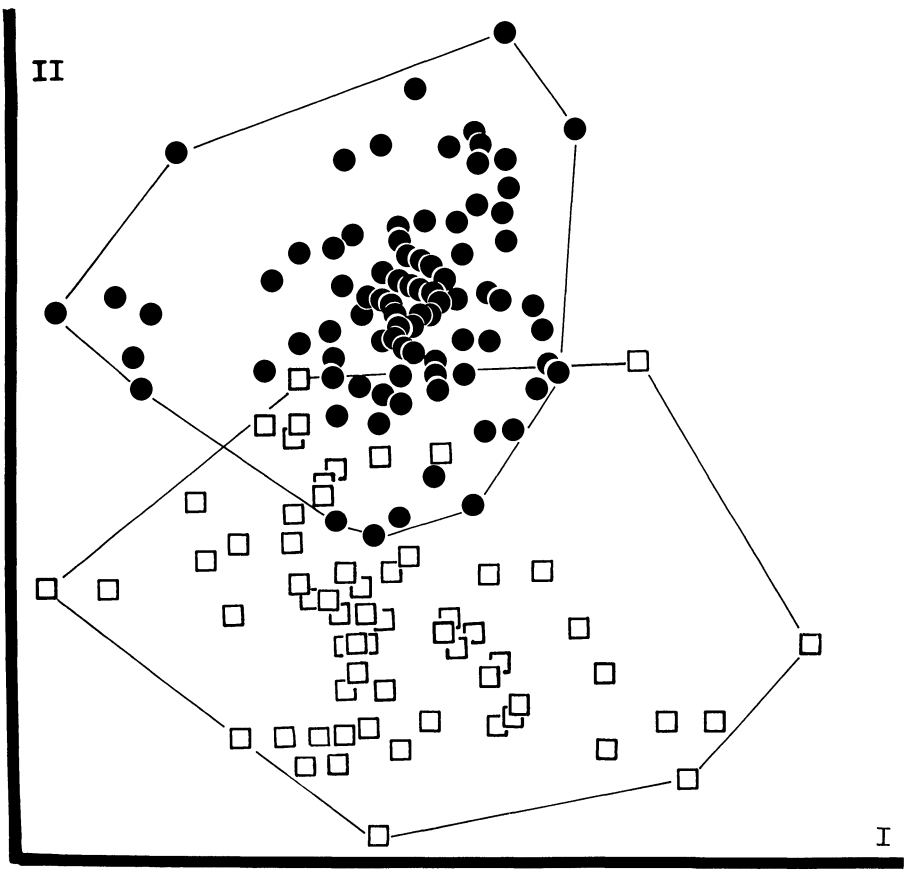

Figure 6. Plot of scores for *Notropis simus simus* (squares) and *Notropis simus pecosensis* (circles) on the first two morphometric principal components (I,II).

1978:E29-30 (in part; descr., from Koster, 1957; range; status in New Mexico; endangered species; proposals on conservation). Miller, 1978:370,376,378 (in part; listed; Rio Grande; assigned to Chihuahuan Fish Province; endangered species). Deacon et al., 1979:35 (in part; range; endangered species). Hatch, 1979:E27-28 (in part; descr.; range; endangered species; conservation). Miller, 1979:1 sheet (in part; endangered species; status; distr.; habitat; conserv.; refs.). Gilbert, 1980:310 (in part; distr. mapped; comments on syst.; habitat; factors of decline).

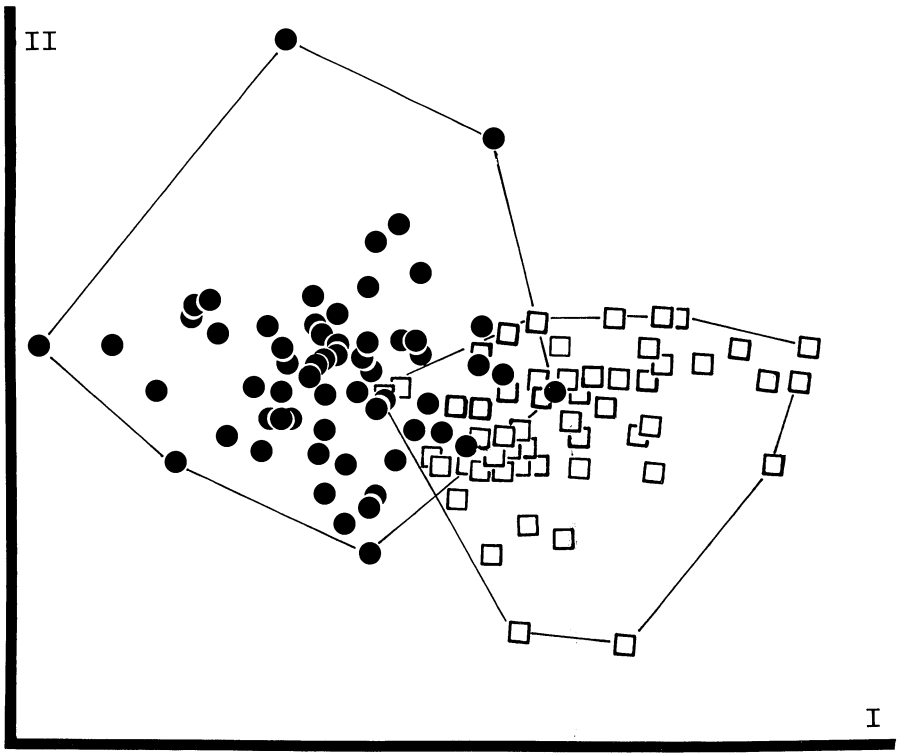

Figure 7. Plot of scores for *Notropis simus simus* (squares) and *Notropis simus pecosensis* (circles) on the first two meristic principal components (I,II).

Notropis simus orca (misidentification). Alvarez, 1970:60,62 (Mexican form; chars. in key).

MATERIAL.—The lectotype, UMMZ 207680 (formerly IU 4856), is an adult female 56.2 mm SL, collected in Rio Grande at El Paso, El Paso Co., Texas, in 1891, by A. J. Woolman. Paralectotypes are as follows: CAS-SU 2278 (4), 51.7-64.9 mm, UMMZ 207681 (formerly IU 4856), (5),48.0-58.1 mm, USNM 212260 (2), 58.1-64.8 mm, same data as lectotype; UMMZ 207682 (formerly IU 4843), (2), 44.3-47.1 mm, Rio Grande at Juárez, Chihuahua, Mexico, 1891, Woolman.

Other material is as follows:

New Mexico.—UNM 4140 (20), 50.1-74.4 mm. Rio Grande, just N Valencia Co. line, Bernalillo Co., 9 June 1939. UMMZ 207688 (5),

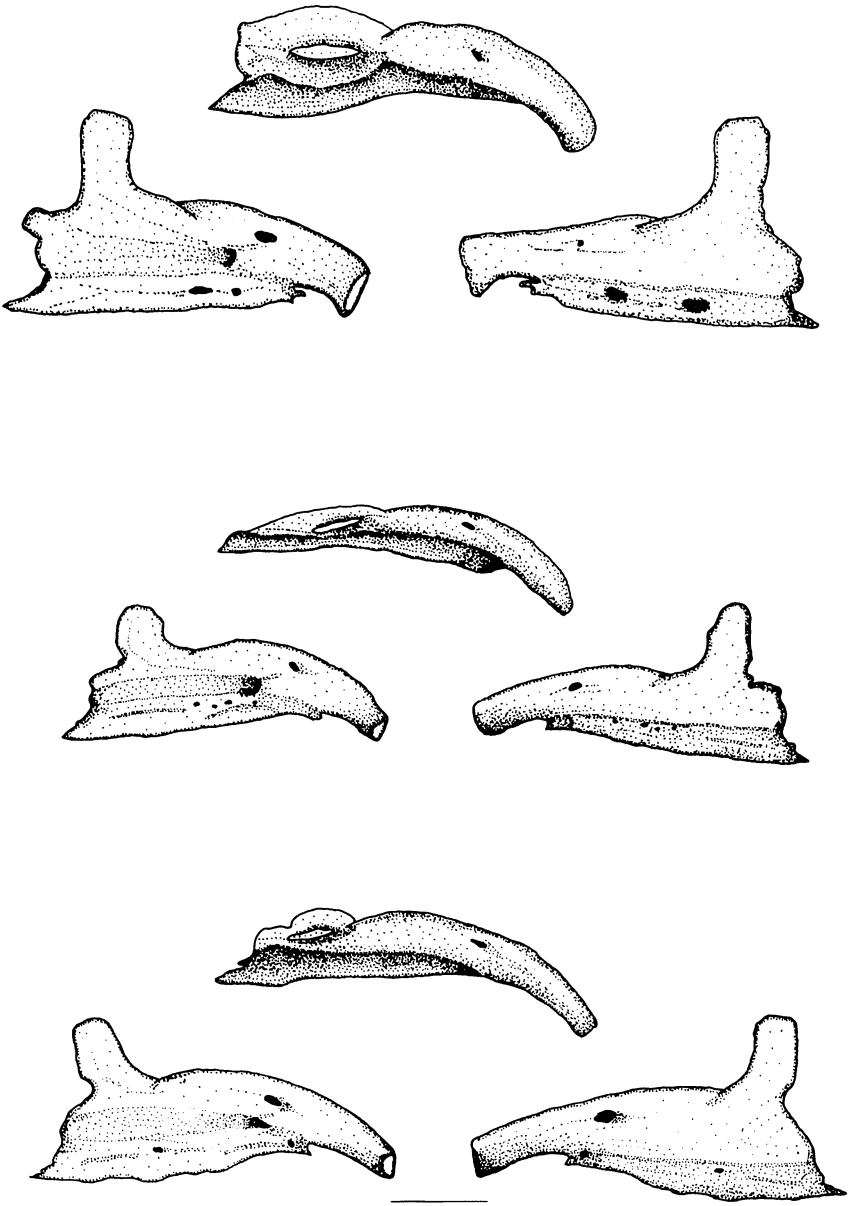

Figure 8. Mesial, dorsal and lateral views (left to right) of left dentaries of *Notropis orca* (top), *Notropis simus simus* (middle) and *Notropis simus pecosensis* (bottom). A mm scale bar is shown at bottom.

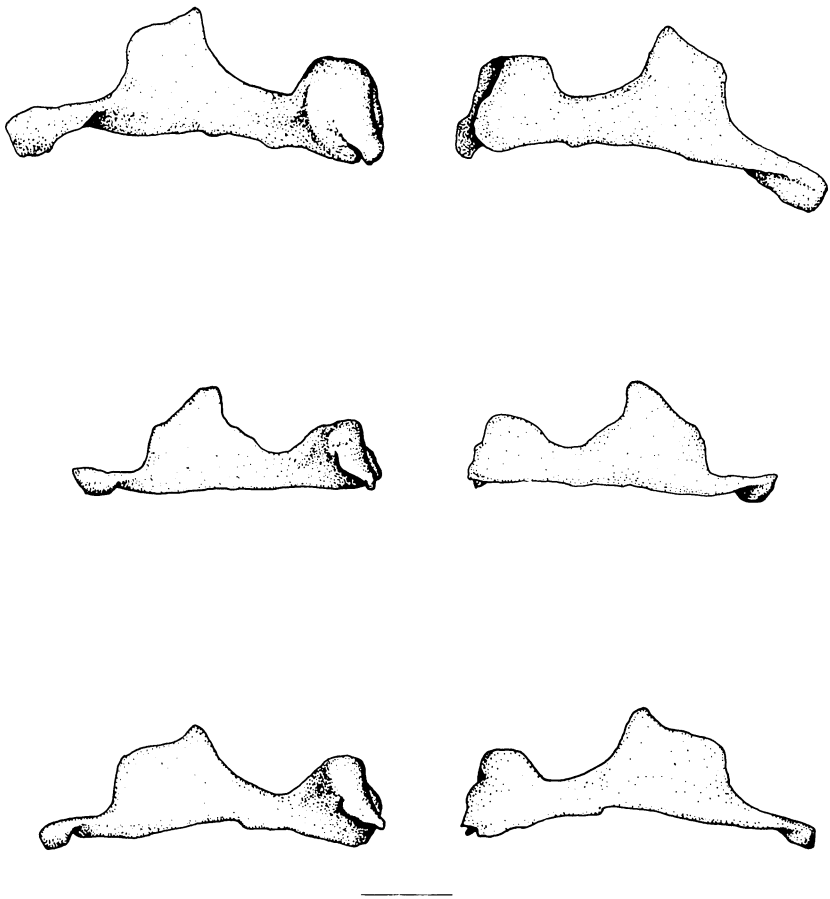

Figure 9. Mesial (left) and lateral (right) views of left maxillae of *Notropis orca* (top), *Notropis simus simus* (middle) and *Notropis simus pecosensis* (bottom). A mm scale bar is shown at bottom.

48.8-64.9 mm, Rio Grande at Los Lunas, Valencia Co., 20 Sept. 1926. UNM 4139 (19), 41.0-70.3 mm, Rio Grande at Bernardo, Socorro Co., 19 June 1939.

Texas.—UMMZ 170112 (1), 40.0 mm, Pecos R. at US 90, 9 km SSE Shumla, Val Verde Co., 25 Aug. 1940. UMMZ 170126 (1), 38.8 mm, Rio Grande at Eagle Pass, Maverick Co., 26 Aug. 1940. UMMZ 97395 (20), 16-26 mm, Arroyo Chacon, 2 km E Laredo, Webb Co., 13

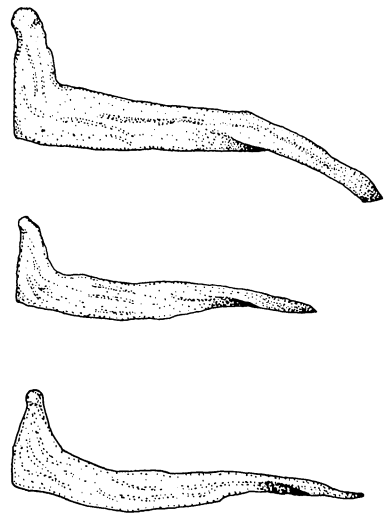

Figure 10. Lateral views of left premaxillae of *Notropis orca* (top), *Notropis simus simus* (middle) and *Notropis simus pecosensis* (bottom). A mm scale bar is shown at bottom.

April 1930. UMMZ 170188 (1), 21 mm, Rio Grande at Zapata, Zapata Co., 27 Aug. 1940. UMMZ 162249 (1), 30 mm, Rio Grande, 11 km SE McAllen, Hidalgo Co., 23 March 1951. UMMZ 138370 (2), 39-40 mm, Boca Chica Beach, Cameron Co., 19 March 1932.

Mexico.—UANL 2094 (1), 57.4 mm, Rio Grande, 4 km below Cd. Díaz Ordaz (ca. 30 km by air NW Reynosa), Tamaulipas, 28 Aug. 1975.

DIAGNOSIS.—A species of *Notropis* distinguished from *N. simus* and other congeners by the following combination of traits: pharyngeal dentition 2,4-4,2, rarely lacking teeth in minor row; anal-fin rays (7)8-9, modally 8; total vertebrae 37-39, modally 38; gill rakers 8-14 (usually 9 or 10) on first arch, 13-17 (usually 14-16) on second arch, and 10-12 (usually 10 or 11) on last half arch, sum of three arches

(32)33-38(39); body not tapering markedly posterior to anal fin; caudal peduncle relatively deep, 94-119 per mille SL; dorsal-fin origin just posterior to pelvic-fin insertion, and generally midway between snout tip and caudal-fin base; snout blunt, rounded and often overhanging upper lip; mouth terminal to subterminal, not sharply inclined; posterior edge of maxilla straight or slightly decurved, not extending under pupil; eye relatively small, 43-75 per mille SL; breast fully scaled; lateral-line scales 34-39; caudal fin longer than head; breeding tubercles small, profuse and irregularly distributed over head, and well developed on upper surface of first nine pectoral-fin rays of breeding males; fins generally immaculate, lacking chromatic breeding colors; body with silvery lateral stripe, its greatest width greater than orbit diameter; pigment absent from mandibular symphysis; posterior margins of dorsal and anal fins slightly falcate to straight; postero-ventral surface of urohyal bifurcate; posteriorly directed uncinate processes present on first four epibranchials; fifth cartilaginous epibranchial present.

DESCRIPTION.—Variational data on body proportions, anal-fin rays, gill rakers and vertebrae appear in Tables 2-4,6; values of lectotype indicated with asterisks, number of counts given parenthetically. Body rather deep and robust, tapering slightly to relatively deep caudal peduncle. Body wide and moderately to slightly compressed. Dorsal-fin origin above or just behind pelvic-fin insertion, and varying from between caudal base and snout tip to sightly closer to caudal base; postdorsal distance projected anteriorly from dorsal-fin origin reaching from anterior margin of nares to beyond. Snout blunt and rounded, often projecting beyond upper lip, which includes lower lip; head deep and wide. Mouth varying from terminal to subterminal and not sharply inclined from horizontal; maxilla may reach to edge of orbit but usually falls short of pupil, its edge straight or slightly decurved. Anterior lobe of dorsal fin longest, its posterior margin slightly falcate or straight. Anterior rays of anal fin usually subequal to posterior rays in depressed fin. Gut simple with two flexures, type 1 of Kafuku (1958); peritoneum silvery.

Dorsal-fin rays 8*(60), 9(2). Pectoral-fin rays: left side 14(13), 15*(34), 16(13), 17(3); right side 13(2), 14(11), 15*(35), 16(12), 17(2). Pelvic-fin rays: left side 7(3), 8*(56), 9(4); right side 7(2), 8*(56), 9(4). Lateral line, complete and slightly decurved anteriorly, scales 34(2),

TABLE 6

MEASUREMENTS OF *NOTROPIS ORCA*, EXPRESSED IN THOUSANDTHS OF SL.

Measurement	♀ Lectotype	Males (N=18) Range	Males (N=18) $\bar{X}$	Females (N=29) Range	Females (N=29) $\bar{X}$	Total (N=63) Range	Total (N=63) $\bar{X}$
Standard length, mm	56.2	48.8–71.8	61.0	38.8–74.4	55.7	29.0–74.4	55.3
Predorsal length	511	492–533	514	497–545	519	492–548	518
Postdorsal length	519	502–543	523	498–537	515	494–543	518
Preanal length	678	651–687	667	652–695	679	651–695	675
Prepelvic length	489	453–491	476	459–507	487	453–521	482
Postpelvic length	523	502–560	541	508–695	534	490–695	535
Head length	251	246–283	261	242–281	263	242–292	263
Postorbital head length	128	115–144	131	122–143	131	111–149	130
Head depth							
at eye	128	122–139	130	114–139	129	114–139	130
at occiput	162	153–180	170	153–185	172	153–185	171
Head width	126	122–144	135	115–160	135	110–160	134
Eye diameter	57	47–66	54	43–68	56	43–76	56
Snout length	64	62–82	72	63–78	71	62–82	71
Upper jaw length	77	70–88	81	74–90	81	70–93	81
Gape width	61	51–72	61	51–72	61	37–72	60
Body depth	215	203–255	232	193–284	238	181–284	233
Dorsal origin-anal origin	258	254–283	270	257–294	272	241–294	271
Body width	116	91–139	122	103–208	135	91–208	128
Caudal penduncle							
least depth	105	96–113	104	94–119	105	94–119	105
length	228	207–256	231	201–240	224	201–256	226
width	46	23–61	45	29–57	46	23–61	45
Dorsal fin base	117	112–127	118	102–125	113	102–131	115
Anal fin base	110	94–122	109	93–117	104	92–123	106
Dorsal fin length	228	214–238	225	204–249	227	204–259	229
Anal fin length	181	175–204	189	161–194	181	161–204	185
Pectoral fin length	196	162–239	215	148–223	200	148–239	206
Pelvic fin length	157	144–221	159	140–204	159	140–221	160

35*(1), 36(13), 37(26), 38(13), 39(1). Body circumferential scales: total 25(1), 26*(3), 27(3), 28(10), 29(14), 30(21), 31(2), 32(3), 33(1); above lateral line 13*(9), 14(16), 15(30), 16(1), 17(1); below lateral line 11*(8), 12(10), 13(30), 14(9), 15(2). Caudal-peduncle circumferential scales: total 14*(4), 15(20), 16(26), 17(6), 18(2); above lateral line 6(1), 7*(49), 8(7), 9(1); below lateral line 5*(3), 6(21), 7(34), 8(1). Anterior dorsolateral scales 14(12), 15*(22), 16(12), 17(7), 18(1), 19(1). Scale rows

from dorsal-fin origin to lateral line 6*(17), 7(38), 8(4). Scale rows from anal-fin origin to lateral line 3*(1), 4(29), 5(26), 6(4). Preoperculo-mandibular pores: left side 10*(13), 11(8), 12(3); right side 10*(17), 11(5). Infraorbital pores: left side 12(1), 13(11), 14*(10), 15(1); right side 12(3), 13*(13), 14(4), 15(2), 16(1). Supraorbital pores: left side 7(1), 8*(11), 9(10); right side 8(13), 9*(8), 10(1). Pharyngeal-arch dentition 2,4-4,2*(19), 1,4-4,2 (1).

Scales thin and moderately imbricated, of normal shape (wider than high), and with well developed radii in posterior field. Breast fully scaled; scales not becoming obsolete or embedded.

Breeding adults with profuse, irregularly arranged tubercles over head, snout, lips, gular and branchiostegal regions, and breast. In breeding males pectoral fin with well developed tubercles over outer nine fin rays. Tubercles best developed on rays two to seven, with four to nine tubercles per segment. Outer pectoral ray with randomly scattered tubercles. Tubercles on rays two to nine arranged uniserially proximally, biserially mesially, and uni- or biserially along each branch. Interradial membrane thickened between outer nine rays, and may bear tubercles after outermost ray. Some individuals have small tubercles on anterior edge of dorsal and pelvic fins. Some breeding females with well developed but irregularly placed tubercles on upper surface of pectoral fin.

Most specimens are pallid, with little pigmentation. The following description is taken from the more highly pigmented individuals. Superficial pigmentation over heart-shaped brain pigment indistinct to absent. Small melanophores becoming distinct between nares and anteriorly onto snout, although pigment absent on front of snout just above lips. Flecks of pigment present under rostral flap of skin. Diffuse melanophores scattered between anterior rim of orbit and lateral edge of jaws. Dense concentration of small melanophores suborbitally between infraorbital canal and fleshy rim of orbit, restricted to lower half of eye. Slightly larger melanophores present on upper third of opercle and supratemporal region. Lips, mandibular symphysis, gular and branchiostegal regions immaculate. Opercle may appear silvery.

Dusky lateral stripe, intersecting lateral line anteriorly; flecks of pigment extending onto lateral line as far back as pelvic-fin insertion. Dusky stripe two to four scale rows above lateral line at mid-body, and intersecting lateral line at caudal base. Lower margin of dusky

lateral stripe, from pelvic insertion to caudal base, forming pigment streak. Random peppering of pigment flecks above dusky lateral stripe; scale margins not outlined. Small melanophores more densely concentrated in pre- and postdorsal stripes; melanophores slightly larger around base of dorsal fin. Body with silvery lateral band in some preserved specimens; greatest width of band >1.3x orbit diameter.

Pectoral fin with small pigment flecks along outer ray or immaculate. Dorsal and caudal fins with melanophores scattered along margins of rays; other interradial membranes generally lacking pigment. Some individuals with a small, irregular spot of pigment in crotch of superficial caudal musculature. Pelvic and anal fins immaculate.

RANGE AND STATUS.—*Notropis orca* formerly ranged from the upper Rio Grande of New Mexico, near Isleta, to the mouth of the river at Boca Chica Beach, Texas. A single individual of this species which was collected in 1975 from the lower Rio Grande, at Ciudad Díaz Ordaz (NW of Reynosa), Tamaulipas, Mexico, represents the only record of *N. orca* during the past 30 years. The taxonomic history of *N. orca* has precluded it from consideration for endangered species status, an action that should be undertaken as soon as possible. Monitoring of the river in the region of last capture was undertaken during the summer of 1981 by Salvador Contreras-Balderas and Robert J. Edwards.

ETYMOLOGY.—We suggest the common name "phantom shiner" for *Notropis orca* because of its morphological similarities with *N. simus* and its generally pallid appearance.

HYBRIDIZATION.-Four hybrids between *Notropis orca* and *N. simus* have been identified on the basis of pharyngeal-arch morphology and their mosaic external phenotypes. Two of the hybrids were found in the type series of *N. orca* from Juárez, Mexico, collected in 1891 (ex IU 4843, now UMMZ 207684; 52.8, 56.0 mm SL); a third was identified from a large collection taken in the Rio Grande just north of the Valencia County line, Bernalillo Co., New Mexico, in 1939 (ex UNM 1387b, now UNM 4141; 59.5 mm SL; herein referred to as "Valencia"); and a fourth was discovered in a nearby collection from an irrigation

ditch, near Isleta, Bernalillo Co., New Mexico, in 1940 (ex UMMZ 131134, now UMMZ 207689; 77.1 mm SL; Pl. 6). Although mosaic, the presumed hybrids are not necessarily intermediate and may resemble the parent species either meristically or morphometrically, but not both (Figs. 3-5).

The problem of recognizing hybrids, without experimentation, is complicated by the fact that hybrids need not be intermediate, as clearly demonstrated by Neff and Smith (1979). We acknowledge that we may have assigned to a species specimens that are in fact hybrids which simply resemble parental types. The problem can be further compounded by introgression. Circumstantial evidence leads us to infer that some individuals of *N. simus* from the Valencia collection may show introgressive hybridization. These specimens have the morphometric phenotype and the pharyngeal-arch morphology of *N. simus*, but are skewed towards *N. orca* in their meristic phenotype. For example, they comprise half of the specimens of *N. simus* with eight anal fin rays (Table 2). Thus, the Valencia bluntnose shiners predictably extend the *N. simus* cluster towards the *N. orca* cluster on the meristic PCA (Fig. 5).

The precise cause of hybridization between *N. orca* and *N. simus* is not known, but a few inferences can be made. Hubbs (1955) suggested that the probability of hybridization would increase if: a) spawning sites are limited and breeding individuals are forced into close proximity; b) composite populations contain largely unbalanced numbers of each species; and c) habitats are altered by man or nature. These situations pertain directly to the Rio Grande, especially in its upper course where *N. orca* and *N. simus* once lived sympatrically.

Although the Rio Grande is one of the longest rivers in the United States, much of its 2877-km course is through arid regions and it receives few tributaries, especially south of northern New Mexico. The upper Rio Grande is a storm-water stream, subject to large, sudden floods and droughts, and has had a long history of fluctuating flow (Horgan, 1954). The Pecos River and, especially the Rio Conchos, renew the Rio Grande where it is reduced to a minor creek in the driest part of the Chihuahuan Desert.

Lee (1907) studied the hydrology of the Rio Grande above El Paso for the nine-year period (1897-1905) and noted that diminished but permanent flows occurred in the upper portions near Santa Fe,

and that the river bed near El Paso was often dry and could remain so for up to six months. This was long before the construction of major dams or major irrigation diversions. Thus, natural intermittency in the upper river could explain why *N. orca* and *N. simus* were hybridizing at Juárez/El Paso in 1891. After 1942, increasing amounts of silt and soil were being washed into the river and salinity levels (greatly increased by excessive ground-water pumping) rose such that by 1956, wells in Hudspeth County, Texas, "averaged more than 5.5 tons of salt per acre-foot" (Hay, 1963:494-497). Such environmental perturbances (largely man-induced) affected the aquatic biota and may have played an important role in the decline and disappearance of *N. simus* and *N. orca* in the upper part of the Rio Grande. Habitat deterioration and the decrease in abundance of these species could have led to hybridization and possible introgression in subsequent years; not knowing the precise ecological niche of each species restricts us to speculation.

COMPARISON OF *NOTROPIS ORCA, N. S. SIMUS* AND *N. S. PECOSENSIS*

As noted in Figure 1, both *N. orca* and *N. s. simus* occurred sympatrically in the Rio Grande between El Paso/Juárez and Los Lunas, New Mexico. Because of prior confusion regarding these species, a detailed comparison is presented below.

Osteological examinations show that *N. orca* differs trenchantly from *N. simus* in the morphology of the pharyngeal arch, dentary, maxilla and premaxilla. The structure of these features clearly indicates that the new form (*pecosensis*) is allied with *N. simus* rather than with *N. orca*, a conclusion that is somewhat less obvious when considered solely on the basis of external morphological characteristics.

The pharyngeal arch (= fifth ceratobranchial) morphology and dentition are definitive aids for the identification of these species (Fig. 2). *N. simus* has a robust arch, with the anteriormost tooth (conical in shape) the strongest in the series, and nearly equaled in size and strength by the second tooth. The ala is broadly expanded posteriorly and reaches extreme development in *N. s. pecosensis*. The dorsal and

anterior limbs are short and stout. In comparison, the pharyngeal arch of *N. orca* is slender: the teeth are thinner and the anteriormost tooth is not necessarily the strongest, the ala is narrower, and the dorsal and anterior limbs are longer and more slender. The dorsal limb is more broadly curved in *N. orca* than in *N. simus*. *N. orca* almost consistently has a 2,4-4,2 dentition, whereas *N. simus* tends to lose one tooth (but rarely both) in the minor row.

The dentary of *Notropis orca* is robust; the anterior limb is deep and strong, does not taper appreciably and is curved mesially but not deflected ventrally (Fig. 8). The symphyseal region is expanded and forms a knob ventrally. The gnathic ramus is strong and wide, the gnathic edge flares distinctly antero-laterally. In contrast, the dentary of *N. simus* is more gracile; the anterior limb is narrower and attenuate, curved mesially and deflected ventrally. The symphyseal region is not expanded and lacks a knob. The gnathic ramus is narrower and is only slightly flared laterally; the gnathic edge appears almost completely vertical from dorsal view. *N. s. pecosensis* differs slightly from *N. s. simus* by having a somewhat longer and more slender anterior limb.

The maxilla of *N. orca* is more massive than that of *N. simus*. *N. orca* has a very strong and large premaxillary process of the maxilla, which curves antero-ventrally and decreases only slightly in circumference towards its tip (Fig. 9). The lateral face of the rostral process of the maxilla is deep and broad; the palatine process is large and lacks a notch on its posterior mesial surface. The posterior (dentary) process is long and flares broadly from a stout pedicel. *Notropis simus* has a slender premaxillary process that tapers almost to a point distally, the palatine process is not very enlarged and bears a notch on its posterior mesial surface, and the posterior process is long and may flare moderately from a gracile pedicel.

The premaxilla of *N. orca* is more robust (Fig. 10); the ascending process, in particular, is long, and the postero-ventral process is not greatly constricted, being almost the width of the ascending process. *N. simus* has a short triangulate ascending process, and the postero-ventral limb is extremely slender.

The branchial apparatus of *N. simus* and that of *N. orca* are generally of similar shape. The hypobranchials are small and reduced, and the second pharyngobranchial is enlarged, overlaps the first, and is connected to the third and fourth epibranchials via

cartilages. Both species have all four epibranchials with posteriorly directed uncinate processes. They also have a fifth cartilaginous epibranchial, which provides additional attachment for the muscle bundle separated from the main body of the levator posterior (=cucullaris profundus of Harrington, 1955; see Winterbottom, 1974), and which in turn inserts on the pharyngeal bone (= fifth ceratobranchial). (Note that not all species of *Notropis* have uncinate processes on all four epibranchials or possess a cartilaginous fifth epibranchial, e.g., *N. bifrenatus*, see Harrington, 1955.) The fourth epibranchial of *N. simus* is noticeably different from that of *N. orca*; the uncinate process arises at ca. 1/3 and 2/3 the height of the fourth epibranchial (measured from the ceratobranchial articulation) in *N. simus* and *N. orca*, respectively. Furthermore, *N. orca* has stouter hypo-, cerato- and epihyals, and cerato- and epibranchials than *N. simus*.

Because the morphologies of the pharyngeal arch and jaws have not been previously studied, recognition of *N. orca* as distinct from *N. simus* has been obscured by overlapping ranges of external characteristics. Several characteristics that distinguish these taxa merit discussion.

The number of anal-fin rays (Table 2) helps to distinguish *N. orca* from *N. s. simus*, the former usually having eight and the latter nine or 10. *N. s. pecosensis* is more varible than the nominal subspecies and 31% of the Pecos form have eight or fewer anal rays.

The number of total vertebrae varies continuously among *N. orca*, *N. s. simus* and *N. s. pecosensis* (Table 4), which primarily reflects differences in the number of precaudal and caudal vertebrae. *N. orca* differs from both subspecies of *N. simus* by having more precaudal vertebrae, usually 15 or more vs. usually 14 or fewer (Table 4); whereas *N. s. pecosensis* has modally fewer caudal vertebrae than *N. s. simus* (Table 4).

Morphological differentiation related to trophic structures is also found in the number of gill rakers. *N. orca* consistently has more gill rakers, on the average, on each of three arches examined than does *N. simus* (Table 3). The more numerous gill rakers possessed by *N. orca*, especially on the anterior side of the first arch, result from development of more gill rakers on the upper limb (epibranchial). Individuals of *N. simus* commonly lack gill rakers on the first epibranchial.

The gill rakers on the anterior two arches, in both species, are generally short and nubby, usually not extending to the base of an adjacent gill raker when depressed; however, the reduction in size and pointedness (e.g., in comparison to *N. jemezanus*) of each raker is more extreme in *N. simus*.

The number of anterior dorso-lateral scales is moderately useful for recognizing these taxa. *N. s. simus* usually has 15-20 scales in this series, *N. s. pecosensis* usually has 15-17 scales, and *N. orca* usually has 14-17. The utility of this character is limited by the broad ranges exhibited by each of these taxa.

Body shape and proportions are clearly divergent among these taxa (Pls. 1-5). The most noticeable difference between *N. orca* and *N. s. simus* is the posterior taper of the body and depth of the caudal peduncle. *N. orca* is more even in dorsal contour, lacks a distinct rise between the occiput and the dorsal fin, and tapers little postdorsally. *N. s. simus*, on the other hand, appears to be more gibbous predorsally, and tapers greatly postdorsally. The postdorsal body shape is reflected in the caudal-peduncle least depth (Tables 1,5,6), which is diagnostic for these taxa. *N. s. pecosensis* differs from the nominal subspecies by having a more robust caudal peduncle, similar in proportion to *N. orca*. Unlike *N. orca*, *N. s. pecosensis* is more gibbous in predorsal outline. Additionally, *N. orca* has, on the average, the longest caudal peduncle, *N. s. simus* the shortest and *N. s. pecosensis* is intermediate (Tables 1,5,6).

The overall head physiognomy serves to distinguish *Notropis simus* from *N. orca*. With the exception of a few specimens, the posterior edge of the jaw reaches under the pupil in *N. simus*; whereas, in most individuals of *N. orca* the posterior extension of the jaw falls short of the pupil. There is a greater tendency in *N. orca* to have the jaw inclined somewhat more sharply than in *N. simus*. The postorbital head length averages slightly longer and eye diameter slightly shorter in *N. orca* than *N. simus* (Tables 1,5,6).

Other important average differences among these taxa are: the position of the dorsal fin (pre- and postdorsal lengths); preanal length; and depressed length of the anal fin (Tables 1,5,6). It is noteworthy that for these and some other characters *N. s. simus* and *N. orca* (from the Rio Grande proper) are the most divergent and *N. s. pecosensis* is intermediate between them. This, coupled with the

observation that *N. s. pecosensis* is more variable than *N. orca* or *N. s. simus*, would seem to imply the operation of character displacement. However, we agree with Dunham et al. (1979) that explanations involving character displacement must be proven rather than invoked, and we cannot support or refute any hypothesis at present.

Differences in body shape are better examined from a multivariate perspective. PCA performed on *N. orca*, *N. s. simus* and four suspected hybrids, *N. orca* x *N. simus*, utilized 21 distance measures (Table 7). The variable loadings on PCI, all positive and not isomorphic, indicate that size and shape are inherent in this component. Scores for individuals plotted on the first two principal components confirm that PCII is confounded with size as evidenced by the oblique orientation of the clusters. After partialling size out of PCII, the clusters reside horizontally on the plot of sheared-PCII vs. PCI (Fig. 3). The *N. orca* cluster is clearly distinct from the *N. s. simus* cluster and reflects the shape differences between these species. The discrimination contained in the sheared-PCII is a function of the deeper and longer caudal peduncle, longer postorbital head length and shorter anal-fin base in *N. orca* relative to *N. s. simus*.

The presumed hybrids were identified prior to PCA on the basis of pharyngeal-arch morphology and their mosaic external phenotypes. Three of the hybrids (two from El Paso and one from the Valencia collection) lie between the parent species in body shape, although two are more closely associated with the *N. simus* cluster and one with the *N. orca* cluster (Fig. 3). The fourth hybrid, from an irrigation ditch near Isleta, is clearly aligned with the *N. orca* cluster (Fig. 3), reflecting its deep body and long caudal peduncle. However, this specimen has the head morphology of *N. s. simus* as well as the posterior body taper (Pl. 6).

The results of PCA on *N. orca* and N. s. simus using 12 meristic variables are shown in Table 8, and the PCA-scores are plotted on PCII vs. PCI (Fig. 4). All of the useful discrimination is contained in PCI, which accounts for 30% of the variance, and again completely separates each of the species. The postion of *N. orca* is a function of having fewer anal-fin rays and anterior dorso-lateral scales, and more numerous total vertebrae and gill rakers on the second arch. Two of the presumed hybrids lie between the parental species; however, the hybrids from Juárez are contained within the *N. simus* cluster.

A useful summary of information is contained in Figure 5, where the scores of individuals are plotted on the best meristic and morphometric discriminators (after Humphries et al., 1981). This plot puts all specimens in perspective to assess carefully the large degree of meristic and morphometric divergence of *N. orca* and *N. s. simus*; the presumed hybrids are positioned outside the parental clusters. It is not problematic that the presumed hybrids are positioned close to or fall within the parental clusters because Neff and Smith (1979) demonstrated that some experimentally created hybrids, *N. spilopterus* x *N. whipplei*, fell within each of the parental clusters.

PCA was performed on mensural variables to compare the external morphologies of *N. s. simus* and *N. s. pecosensis* (Table 7). The plot of scores on the first two principal component axes (Fig. 6) reveals that, unlike the comparison of *N. orca* and *N. s. simus*, the clusters for each taxon are not entirely distinct. Rather, the phenotype of each subspecies grades into the other. The position of *N. s. pecosensis* on PCII reflects its shorter dorsal- and anal-fin bases and deeper caudal peduncles than *N. s. simus* (Table 7). Because the clusters appear almost horizontal in the plane of these axes (Fig. 6), the shear technique is not used.

When meristic variables were included in the PCA on the two subspecies, similar results were obtained (Fig. 7); i.e., *N. s. pecosensis* melds into the meristic phenotype of *N. s. simus*. The relative position of the nominal subspecies on PCI reveals its tendency to have higher counts for most meristic variables than the Pecos River form (Table 8).

The two subspecies of *N. simus* can be distinguished by other traits. *N. s. pecosensis*, in general, is more heavily pigmented than *N. s. simus* and differs primarily in the more distinct, broader dusky lateral stripe, which contains a definite streak of pigment laterally (Koster, 1957). This lateral stripe is composed of larger melanophores, sometimes ending in a small caudal spot in *N. s. pecosensis*. In addition, the scales between the lateral stripe and mid-dorsal scales are often outlined in the Pecos subspecies and not in the Rio Grande form. *N. s. simus* usually has the breast appearing naked or partially scaled because its breast scales have a tendency to become heavily embedded or obsolete; the breast of *N. s. pecosensis* appears totally scaled superficially.

TABLE 7

PRINCIPAL COMPONENTS ANALYSES OF MORPHOMETRIC VARIABLES FOR A) *NOTROPIS ORCA* (N=55), *NOTROPIS S. SIMUS* (N=102) AND THEIR HYBRIDS (N=4); B) *NOTROPIS S. SIMUS* (N=63) AND *NOTROPIS S. PECOSENSIS (N*=88)

	A			B	
	PC I	PC II	Sheared PC II	PC I	PC II
% variance	94.5	2.0	—	91.3	2.4
Predorsal length	.20	.11	.09	.21	-.09
Preanal length	.22	-.03	-.04	.22	-.02
Prepelvic length	.20	.04	.03	.21	-.08
Head length	.21	-.10	-.11	.21	-.01
Postorbital head length	.24	-.26	-.28	.22	.02
Eye diameter	.13	.14	.13	.16	.19
Snout length	.23	.04	.02	.22	-.11
Upper jaw length	.19	.05	.04	.20	.09
Gape width	.24	.27	.25	.26	.06
Head depth					
at eye	.21	-.03	-.04	.22	.03
at occiput	.21	-.05	-.06	.21	.09
Head width	.24	.12	.11	.24	.05
Body depth	.23	.00	-.02	.23	.20
Body width	.28	.17	.15	.27	.14
Caudal peduncle					
length	.23	-.35	-.37	.20	.16
least depth	.23	-.42	-.44	.19	.42
Dorsal origin-anal origin	.24	-.13	-.15	.23	.08
Postdorsal length	.23	-.16	-.17	.21	-.02
Postpelvic length	.22	-.06	-.08	.21	-.07
Dorsal fin base	.20	.24	.23	.22	-.43
Anal fin base	.18	.60	.59	.22	-.67

COMPARISONS OF *NOTROPIS ORCA* AND *N. SIMUS* WITH OTHER SPECIES, AND SUBGENERIC PLACEMENT

Although *Notropis orca* and *N. simus* can be readily distinguished from other congeners in the American Southwest, several comparisons are nevertheless in order. *N. orca* and *N. simus* have their dorsal fins originating in a position intermediate to that seen in *N. shumardi* (in which the dorsal origin is above the pelvic insertion)

TABLE 8

PRINCIPAL COMPONENTS ANALYSES OF MERISTIC VARIABLES FOR A) *NOTROPIS ORCA* (*N*=53), *N. S. SIMUS* (N=78) AND THEIR HYBRIDS (N=4); B) *N. S. SIMUS* (N=53) AND *N. S. PECOSENSIS* (N=60)

	A		B	
	PC I	PC II	PC I	PC II
% variance	31.5	17.8	27.8	11.7
Anal fin rays	-.39	.06	.29	-.18
Pectoral fin rays	.04	.11	.14	-.24
Lateral line scales	.26	.10	-.01	.01
Predorsal circumference scales				
above lateral line	-.21	.42	.40	.22
below lateral line	-.12	.47	.38	.20
Circumpeduncular scales				
above lateral line	.15	.31	.01	.55
below lateral line	.23	.24	.28	.12
Scale rows				
dorsal origin to lat. line	.20	.44	.36	.33
anal origin to lat. line	.22	.43	.34	.01
anterior dorso-lateral	-.38	.15	.38	-.10
Gill rakers, arch 2	.41	-.09	-.16	.44
Total vertebrae	.36	-.10	.29	-.36

and in *N. jemezanus* and *N. oxyrhynchus* (in which the dorsal origin is noticeably more posterior). However, *N. simus* is more similar to the latter two species and *N. orca* is more like *N. shumardi* in this regard. *N. jemezanus* also has the anal fin positioned more posteriorly on the body (669-740 per mille of SL, $\bar{x}$ = 703, n=42) in comparison to *N. orca* and *N. simus* (Tables 1,5,6).

One of the most obvious differences is the shape of the head. *N. simus* and *N. orca* have fleshy, blunt and rounded snouts, which often overhang marginally oblique, subterminal, sometimes decurved mouths. *N. jemezanus, N. oxyrhynchus* and *N. shumardi* have oblique terminal mouths; *N. jemezanus* and *N. shumardi* have somewhat parabolic shaped muzzles whereas *N. oxyrhynchus* has a distinct, sharply pointed snout. *N. oxyrhynchus* can further be distinuished from these four taxa because its caudal fin is subequal to its head length; *N. orca, N. simus, N. jemezanus* and *N. shumardi* have caudal fins that are longer than their heads.

Each of these species possesses a silvery lateral stripe that varies

in width among them. *Notropis orca* and *N. simus* have a wide lateral stripe that is greater (at least 1.3x) than the width of the orbit; the silvery stripe is roughly equal to the orbit diameter of *N. jemezanus* and *N. oxyrhynchus*; and *N. shumardi* has an orbit diameter greater than the width of the lateral stripe (Gilbert and Bailey, 1962).

The number of gill rakers on the outer side of the first arch forms a morphocline among these species. The usual numbers are as follows: *N. simus*, 6-8; *N. shumardi*, 7-9; *N. orca*, 9-10; *N. jemezanus*, 10-11; and *N. oxyrhynchus*, 11-13.

Notropis shumardi can be further distinguished from *N. orca* and *N. simus* by the width of the intermandibular (gular) region. *N. orca* and *N. simus* have widely separated mandibles such that the distance between them at their posterior margin is roughly equal to the diameter of the pupil. In contrast, the left and right mandibles of *N. shumardi* are very close together, almost touching, and the intermandibular width is narrower than the pupil. *N. jemezanus* and *N. oxyrhynchus* appear to be variable in this regard.

Understanding the phylogenetic relationships of *N. orca* and *N. simus* is not possible at this time because we believe that relationships among/between taxa should be based upon shared derived characters. Under a phylogenetic framework, substructure within the genus *Notropis* could be recognized as subgenera, each representing a monophyletic group. The presently recognized subgenera of *Notropis* are based upon overall similarity and in some cases represent well marked, possibly monophyletic assemblages (e.g., *Cyprinella*, not including *N. ornatus*, see Gibbs, 1957, and Chernoff and Miller, 1981). We will evaluate the subgeneric placement of *N. orca* and *N. simus* with available criteria so that future studies will not exclude these shiners from consideration.

Snelson (1968) noted that the subgenus *Notropis* as a whole could be loosely defined. Within *Notropis* (s.s.) he recognized two species groups based on pectoral-fin tuberculation and the presence or absence of breeding colors. *N. orca* and *N. simus* would, therefore, appear to belong within *Notropis* (s.s.) and assignable to the *atherinoides* series. As far as known, *N. orca* and *N. simus* lack breeding colors, have small profuse tubercles over the head, tubercles on the leading pectoral ray and on pectoral rays two to eight, the tubercles being biserially arranged in the mesial portion of the ray in breeding males.

Like *N. shumardi* (see Gilbert and Bailey, 1962), *N. orca* and *N.*

simus could be considered divergent members of the *atherinoides* species group because of the reduction in number of anal-fin rays (i.e. below 9-11 rays) and the more anterior position of the dorsal fin. Snelson (1968) noted that *N. ariommus, N. amabilis* and *N. telescopus* are similarly divergent for these characteristics. These "divergent" species cast doubt on the utility of anal-fin rays and dorsal-fin position to define *Notropis* (s.s.) because six out of 15 species (=40%) in *Notropis* (s.s.) are divergent.

Although Suttkus (1980) criticized Snelson (1968) for comparing *N. shumardi* with *N. blennius,* the morphologies of *N. orca* and *N. simus* do necessitate comparison to *N. blennius* and several other species seemingly placed in the subgenus *Alburnops.* That is, a continuum of morphological variation exists between *Notropis* (s.s.) and *Alburnops* with respect to position of the dorsal fin, number of anal-fin rays, and snout morphology.

Notropis simus and especially *N. orca* compare favorably with *N. blennius, N. potteri* and *N. edwardraneyi.* These latter three species are robust, deep bodied, have deep caudal peduncles and do not, to any appreciable degree, taper posteriorly. Like *N. simus* and *N. orca* they have heads that are deep and wide; however, the eye in *N. blennius* and *N. edwardraneyi* is larger than that in *N. simus* and *N. orca* (see Suttkus and Clemmer, 1968). *N. blennius* and *N. potteri* have blunt snouts and terminal mouths but *N. edwardraneyi, N. orca* and *N. simus* have blunt snouts that slightly overhang a more or less subterminal mouth. *N. blennius, N. potteri* and *N. edwardraneyi* fall at the end of the morphological continuum having their dorsal fins placed over or anterior to the pelvic-fin insertion, and having eight or less anal-fin rays. These species have immaculate fins and lack chromatic breeding colors; *N. edwardraneyi* and *N. potteri* have pigment patterns similar to *N. orca, N. simus* and other *Notropis* (s.s.) although *N. blennius* tends to be a more highly pigmented species. These three members of *Alburnops* also have similarly shaped fins, small profuse tubercles over the heads of breeding males and *Notropis* (s.s.)-like tubercles on the upper surface of the pectoral fin (see Suttkus and Clemmer, 1968; and Snelson, 1968).

The similarities of these species of *Alburnops* to *N. orca, N. simus* and, perhaps, other species of *Notropis* (s.s.) may well be due to morphological convergence and therefore obscure true phylogenetic relationships. The convergence might involve the morphological consequences of living in big rivers. However, the continuum in

morphological variation between *Notropis* (s.s.) and *Alburnops* may also be indicative of a monophyletic lineage; the sister-group relationships between pairs of taxa and groups of taxa cannot be inferred at this time. Nonetheless, future phylogenetic considerations of *N. orca* and *N. simus* cannot exclude *Notropis* (s.s.) or *Alburnops*.

SUMMARY

The taxonomy of the fishes referred to *Notropis simus* (Cope) and the undescribed Pecos shiner of Koster (1957) is reevaluated. From a comprehensive analysis of morphometric, meristic, pigmentary and osteological characteristics, we conclude that *N. orca* Woolman is not a synonym of *N. simus*, and that the Pecos shiner represents a new subspecies of *N. simus*; diagnoses and descriptions are provided. The subgeneric placement of *N. orca* and *N. simus* is discussed, and they are compared with other taxa.

Notropis s. simus is known to have inhabited the Rio Grande above El Paso/Juárez. *N. orca* ranged from the vicinity of Isleta, New Mexico, to the mouth of the Rio Grande, and *N. s. pecosensis* is restricted to the Pecos River system of New Mexico. *N. orca* was collected with *N. s. simus* at four localities, and four presumed hybrids have been identified. The species were apparently hybridizing as long ago as 1891; the possibility of introgressive hybridization and its possible causes are discussed. Both species are regarded as endangered; *N. orca* was last collected in the Rio Grande in 1975; and *N. simus* may now survive only in the Pecos River, where its populations have shown marked decline and are dependent upon large volumes of water flow (Hatch, 1979).

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Plate 1. Lectotype of *Notropis simus*, USNM 16982, 62.8 mm SL, from New Mexico, Santa Fe Co., Rio Grande at San Ildefonso.

Plate 2. Sexual dimorphism of *Notropis simus simus*, UF 25141, from New Mexico, Sandoval Co., Rio Grande above Angostura dam; male (above) 61.1 mm SL, female (below) 67.4 mm SL.

Plate 3. *Notropis simus simus*, TU 35683, male 65.2 mm SL, from New Mexico, Sandoval Co., Rio Grande N of Peña Blanca; last known collected specimen, 1964.

Plate 4. Holotype of *Notropis simus pecosensis*, UMMZ 207686, female 48.8 mm SL, from New Mexico, Chaves Co., Pecos R. NE Roswell.

Plate 5. Lectotype of *Notropis orca*, UMMZ 207680, female 56.2 mm SL, from Texas, El Paso Co., Rio Grande at El Paso.

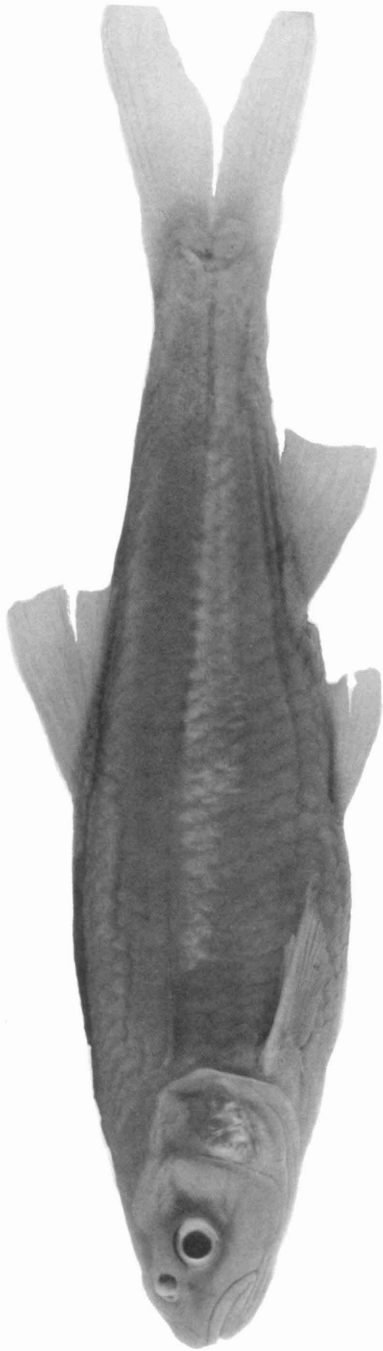

Plate 6. Hybrid of *Notropis orca* x *Notropis simus*, UMMZ 207689, 77.1 mm SL, from New Mexico, Bernalillo Co., irrigation ditch near Isleta.