SYSTEMATICS AND VARIATION OF THE AZTEC SHINER, *NOTROPIS SALLEI,* A CYPRINID FISH FROM CENTRAL MEXICO

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Abstract.—*Notropis sallei* (Gunther) inhabits upper tributaries of the Río Balsas, Río Lerma, and Río Pánuco drainages, the Valley of Mexico, and the small endorheic basin of the Río Grande de Morelia. The Aztec shiner has had a confusing taxonomic history, having been placed in no fewer than eight genera and 16 nominal taxa. There is much variation within populations and overlap of ranges for most characters analyzed among disjunct populations, thus supporting our conclusion that recognition of only a single highly variable taxon, properly named *Notropis sallei,* is warranted. A redescription is presented and the generic assignment of the Aztec shiner is discussed.

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The Aztec shiner, *Notropis sallei* (Gunther), is one of the southernmost representatives of the American Cyprinidae. It is confined to the Río Lerma system, including its former Pleistocene connectives within the geological limits of the Mesa Central of Mexico (West, 1964:Fig. 8). The species inhabits upper tributaries of the Río Lerma, Río Balsas, and Río Pánuco drainages, the Valley of Mexico, and the small endorheic basin of the Río Grande de Morelia (Fig. 1). All of these are or have been tributary to the Pacific except the Rio Pánuco, which flows to the Gulf of Mexico. Headwater erosion by the Río Pánuco into the Mexican Plateau (Segerstrom, 1962) has transferred the Aztec shiner and other Lerma basin fishes to the Atlantic Slope (Hubbs and Turner, 1939; Barbour, 1973; Barbour and Miller, 1978).

The minnow populations here referred to *Notropis sallei* had a confusing taxonomic history over the last century, with assignment to no fewer than 8 genera, 7 species, and 16 nominal taxa (see below). Papers by Meek (1904), Regan (1906-08), de Buen (1940) and Alvarez (1970) failed to resolve the number of taxa represented by the Aztec shiner or to clarify their geographical distributions. This situation resulted from inadequate study material and from different concepts of what constitute recognizable species and genera. Not enough was known to permit proper evaluation of traits that were thought to distinguish the Aztec shiner generically from its northern relatives, especially within the species-rich genus *Notropis.* Although we still need more information for confident generic assignments of American min-
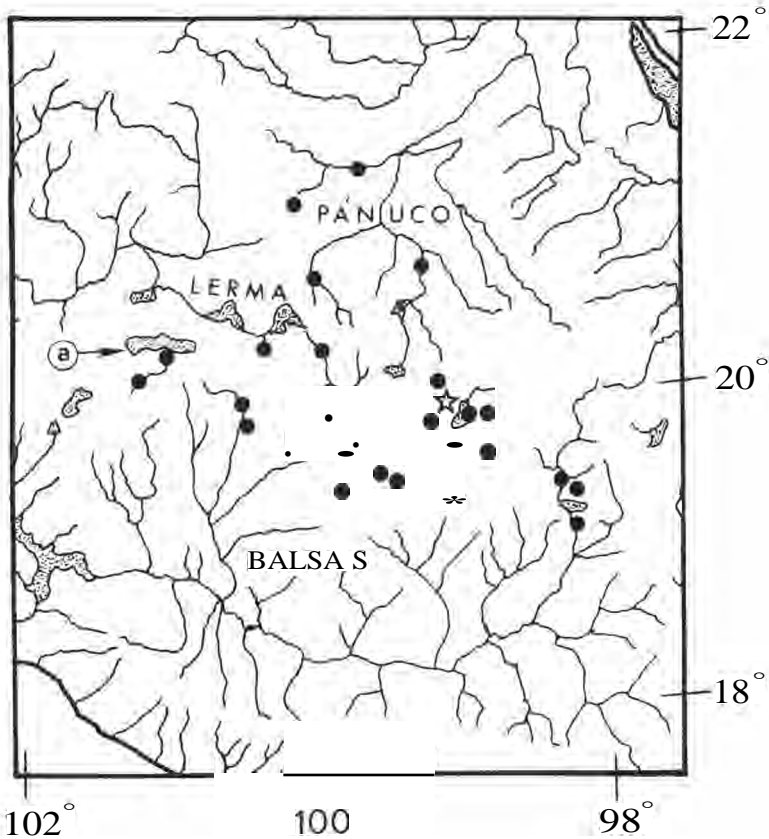
Fig. 1. Study locations (solid dots) of *Notropis sallei* from the Mesa Central of Mexico. The solid star indicates the type locality of *Ceratichthys sallaei:* the open star shows Mexico City in the Valley of Mexico; "a points to Lago de Cuitzeo and the Rio Grande de Morelia drainage; Balsas is the Rio Balsas drainage; Lerma is the Rio Lerma drainage; and Pánuco is the Rio Pánuco drainage.

nows, this study demonstrates for the first time that the Aztec shiner belongs to a single taxon—a conclusion tentatively reached by Miller (1976). Gilbert (1978) followed Miller (1976) but corrected the spelling from *N. sallaei* to *Notropis sallei,* because the species was named for Mr. A. Salle (Regan, 1906-08:vii).

The purpose of this paper is to determine the proper specific name for the Aztec shiner, analyze the geographic variation of its disjunct populations, and decide whether they represent more than one taxon. In addition, we comment on the generic placement of *N. sallei* and provide a redescription.

Methods and Materials

Most specimens were examined for 13 meristic and 15 morphometric variables, including those previously considered to be diagnostic among the nominal taxa. Counts and measurements are as per Hubbs and Lagler (1964). Vertebral counts include the Weberian complex as four and the urostylar vertebra as one. All measurements were made with dial calipers to the nearest 0.1 mm.

To correct for distributional properties of ratios, means and 95% confidence intervals were computed from the arcsine transformed morphometric ratios (Sokal and Rohlf, 1969). Accordingly, the upper and lower confidence limits are asymmetric about the mean. The variability of several characters was compared, independent of the mean, with the coefficient of variation (CV). Principal components analysis (see Sneath and Sokal, 1973) was used to assess concordant changes in morphometry; a priori groups are not formed with this method. Principal components were computed from the correlation matrix of standardized log-transformed morphometric variables (variables in Table 1 plus eye diameter and standard length). The Michigan Interactive Data Analysis System, developed by the Statistical Research Laboratory at The University of Michigan, was used to perform numerical and statistical analyses.

Specimens examined or recorded belong to the following institutions: British Museum of Natural History (BMNH); Field Museum of Natural History (FMNH); Texas Cooperative Wildlife Collection, Texas A&M University (TCWC); Tulane University (TU); University of Michigan Museum of Zoology (UMMZ); and United States National Museum of Natural History (USNM).

Types of the following taxa were examined (the name of the Mexican state follows each locality). *Ceratichthys sallaei:* Syntypes, BMNH 1868.3.3.1-3 (3 specimens), Río Balsas at Cuernavaca, Puebla. *Notropis aztecus:* Lectotype, USNM 45569 (1), Mexico City, Distrito Federal (DF); Paratypes, USNM 47505 (1), USNM 125172 (1), FMNH 6604 (5), Mexico City, DF. *Notropis lermae:* Holotype, USNM 50003 (1), Lake Lerma, México. *Aztecula mexicana:* Syntypes, FMNH 3606 (50), UMMZ 162462 (10), USNM 55764 (85), San Juan del Río, Querétaro.

Other material listed by drainages. Río BALSAS: FMNH 4557 (2), UMMZ 66263 (1), Puebla, Puebla; UMMZ 124457 (13), Manantial at Hacienda de Polaxtla, Puebla; UMMZ 172177 (115), Río Tuxpan at Tuxpan, Michoacán; UMMZ 173637 (3), E branch Río Cuitzamola, W Toluca, Michoacán; UMMZ 191695 (383), Río Atepitzingo, SE Totimehuacán, Puebla. Rio LERMA: UMMZ 97439 (150), Río Lerma near Lerma, Mexico; UMMZ 124430 (2), Almoloya del Río, Mexico; UMMZ 172173 (260), Laguna Agua Blanca, SW Toluca, Mexico; UMMZ 192374 (4), Río Lerma N Toluca, Mexico;

UMMZ 192378 (2), Rio Lerma N Toluca, Mexico; UMMZ 192382 (2), trib. Río Lerma S Maravatío, Michoacán; TU 31872 (28), Río Lerma W Atlacomulco, Mexico; UMMZ 193482 (3), Presa near Tabernillas, Mexico; UMMZ 193478 (50), trib. Río Lerma NW Toluca, Mexico; UMMZ 201548 (3), Río Lerma at Toluca, Mexico; UMMZ 201550 (22), trib. Río Lerma E Zitácuaro, Mexico. Rio PÁNUCO: UMMZ 193440 (8), Río San Lorenzo at Peña Blanca, Querétaro; TCWC 0035.1(41), 3.5 km S Huimilpan, Querétaro; UMMZ 192368 (57), UMMZ 124322 (10), Río Tula at Ixmiquilpan, Hidalgo. VALLEY OF MEXICO: FMNH 4528 (4), FMNH 4530 (5), UMMZ 108625 (192), Lago de Chalco, Mexico; UMMZ 97440 (23), Lago de Texcoco, DF; UMMZ 97441 (2), Xochimilco, DF; UMMZ 189622 (135), UMMZ 192373 (369), UMMZ 192555 (39), Presa de Guadalupe, Mexico. Río GRANDE DE MORELIA: UMMZ 172178 (2), Presa de Cointzio, Michoacán; UMMZ 182346 (23), Río de Morelia, Michoacán.

Osteological comparisons were made from the following cleared and stained (CS) and skeletal (S) UMMZ material: *Agosia chrysogaster* 162668-CS (4); *Algansea aphanea* 192196-CS (6); *A. barbata* 194166-CS (2); *A. tincella* 193665-CS (6); *Hybopsis storeriana* 150037-CS (4); *Notropis amnis* 157459-CS (11); *N. atherinoides* 147017-CS (16), 203986-S (19); *N. boucardi* 178579-CS (5); *N. calientis* 154338-CS (6); *N. cerasinus* 198728-S (2); *N. chihuahua* 161735-CS (10), 161750-CS (2); *N. chrysocephalus* 203935-S (4); *N. cornutus* 203936-S (10); *N. emiliae* 166119-CS (2); *N. formosus* 182402-CS *(5); N. galacturus* 198735-S (2); *N. hudsonius* 163857-CS (2), 203803-S (25); *N. imeldae* 188855-CS (2); *N. lutrensis* 113359-CS (6), 198730-S (2); *N. mekistocholas* 197680-CS (2); *N. nazas* 161725-CS (8); *N. ornatus* 196726-CS (4); *N. sallei* 172173-CS (12), 172177-CS (6), 182346-CS (6), 189622-S (1), 191695-CS (6), 192373-CS (6); *N.* sp. (Mexico) 172218-CS (4); *N. stramineus* 161911-CS (2), 203943-S (83); *N. tropicus* 192897-CS (6); *N. venustus* 166280-CS (8); *N. zonistius* 157882-CS (11); *Yuriria alta* 179703-CS ([1]).

Results and Discussion

The number of lateral-line scales has long been used to distinguish nominal taxa here referred to *N. sallei* (Meek, 1904; Regan, 1906-08; Alvarez, 1970). Frequency distributions show that Río Balsas and Río Pánuco individuals usually have more than 50 scales, whereas specimens from the Valley of Mexico and Río Lerma have fewer than 50 (Fig. 2). However, 26% of the Valley of Mexico fish have more than 50 scales. Populations within and among drainages exhibit a large degree of phenotypic overlap; this character clearly is not indicative of separate taxa. Rather, these data either support the recognition of a single highly variable taxon (with a total range of 26 counts) or are not useful for discriminating formerly recognized taxa.
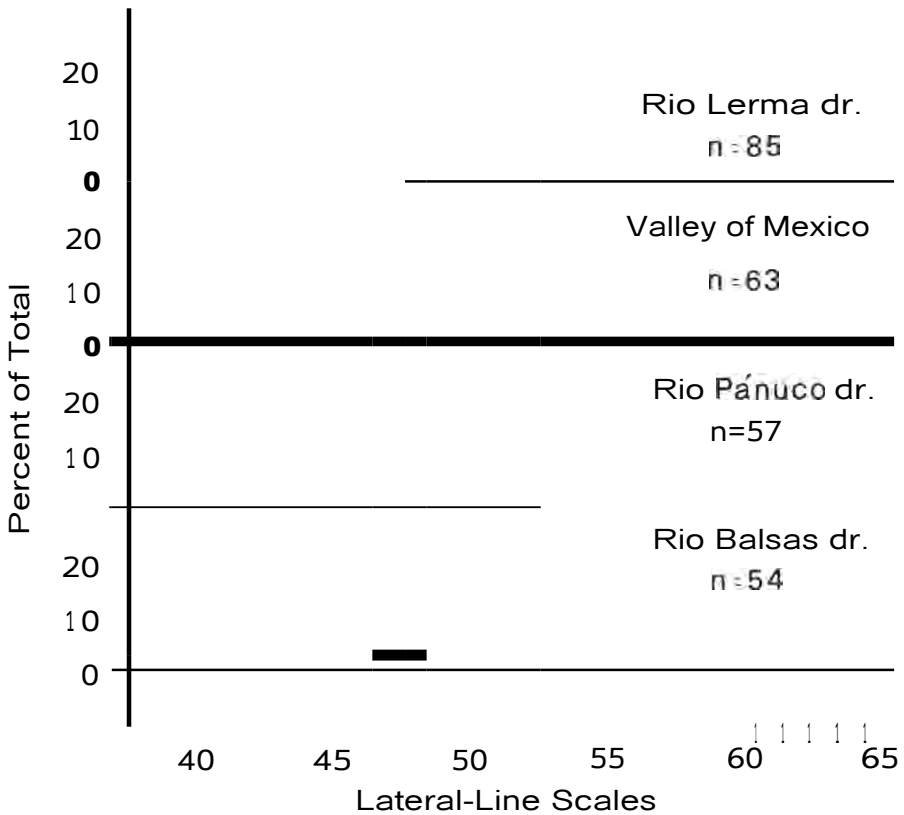
Fig. 2. Variation of lateral-line scales among N. *sallei* from four drainages.

Large populational variation (15-20 scales) and broad overlap of ranges are also manifest in the number of body-circumference scales within and among drainages (Fig. 3). On the average, Río Balsas and Río Pánuco fish have more circumferential scales than those in the Valley of Mexico and Río Lerma (means are 43.7 and 44.8 vs. 38.0 and 38.8, respectively). Separating this character into its components, i.e. scales above and below the lateral line (Table 1), reveals the same pattern. Similarly, the number of scales around the caudal peduncle (Table 1) exhibits the greatest degree of phenotypic overlap among the drainages for scale variables, and again indicates the presence of only one taxon.

Comparison of numbers of precaudal, caudal and total vertebrae reveals that ranges and means are not significantly different among populations ($P > .05$; Table 1). Vertebral numbers are considerably less variable than longitudinal or circumferential scale counts. For example, the range of CV's among drainages for several variables follows: total vertebrae 1.5-2.7; lat-
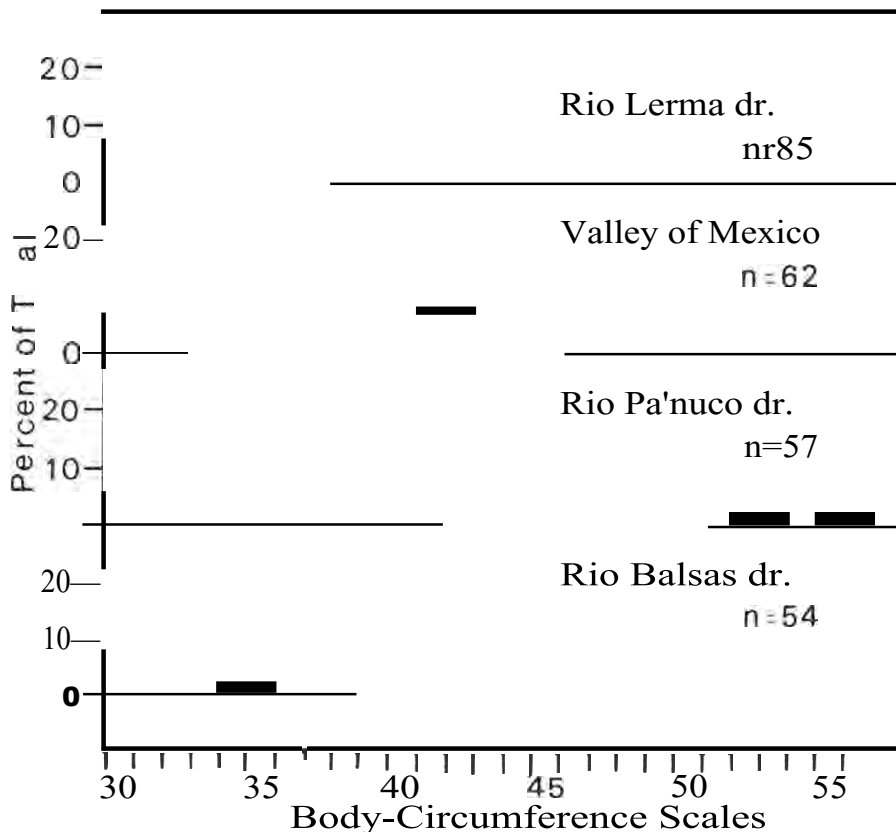
Fig. 3. Variation of body-circumference scales among N. *sallei* from four drainages.

eral-line scales 6.4-8.7; body-circumference scales 7.5-10.0; and scales ar'ound the caudal peduncle 7.1-10.5. Nonetheless, significant correlations between vertebral and scale variables exist. Total vertebrae and caudal ver-tebrae are correlated with lateral-line scales and body-circumference scales ($r > .185$, 114 df, $P < .05$), and caudal vertebrae are correlated with scales around the caudal peduncle ($r = .259$, 114 df, $P < .01$). Because precaudal vertebrae are not correlated with scale variables, the trend of total vertebrae reflects the variation of caudal vertebrae. This does not imply that precaudal vertebrae are less variable than caudal vertebrae; the range of CV's for each are 2.8-4.4 and 3.1-4.6, respectively. This similarity is difficult to interpret because it could also be due to problems in assigning the first caudal ver-tebra. Concordant variation of scales and vertebrae was also noted by Stew-art (1977) for Barbus radiatus.

Meek (1904:60) indicated that Aztecula lermae (Evermann and Golds-

Table 1.-Comparison of ranges and means of meristic and mensural variables (in % SL) among populations of *Notropis sallei* from the four drainages; sample sizes given parenthetically.

Characters	Río Balsas Range	(N)		Rio Pánuco Range	(N)		Valley of Mexico Range	(N)		Rio Lerma Range	(N)	
Scales above lateral line	15-23	(54)	19.4	16-28	(32)	20.8	14-21	(61)	17.4	15-20	(85)	17.3
Scales below lateral line	17-27	(54)	22.4	17-39	(32)	23.2	13-24	(61)	18.7	13-25	(84)	19.5
Scales around peduncle	17-28	(54)	23.1	18-25	(55)	22.4	17-23	(61)	19.8	17-24	(85)	20.1
Dorsal rays	7-8	(44)	8.0	7-8	(40)	8.0	7-9	(48)	8.1	7-8	(65)	8.0
Anal rays	6-8	(44)	7.1	6-7	(40)	7.0	6-8	(48)	7.2	6-7	(65)	7.0
Total vertebrae	34-37	(39)	36.1	35-38	(15)	36.8	36-37	(25)	36.4	34-38	(20)	35.9
Precaudal vertebrae	18-20	(39)	19.3	19-20	(15)	19.7	19-21	(25)	20.0	18-21	(20)	19.4
Caudal vertebrae	16-19	(40)	16.9	16-18	(15)	17.1	16-17	(25)	16.4	15-18	(20)	16.5
Predorsal length	36.8-61.1	(44)	57.6	54.6-74.2	(40)	57.2	52.8-63.5	(48)	58.0	53.2-59.8	(63)	56.6
Preanal length	67.0-76.7	(44)	72.9	67.8-75.0	(40)	71.5	67.3-77.7	(48)	72.6	66.9-75.7	(63)	71.7
Prepelvic length	38.4-56.5	(44)	53.9	49.5-54.8	(40)	52.5	49.0-58.9	(48)	53.7	35.2-57.4	(63)	52.3
Postdorsal length	31.6-38.6	(44)	34.4	32.8-38.7	(40)	35.7	29.7-38.5	(48)	35.0	31.7-40.2	(63)	35.9
Length caudal peduncle	15.5-25.0	(44)	19.8	18.2-24.9	(40)	20.8	16.3-24.5	(48)	20.5	16.8-24.9	(63)	20.6
Head length	24.6-29.4	(44)	26.8	24.8-28.9	(40)	26.8	24.6-31.8	(48)	27.1	24.5-29.9	(63)	27.1
Postorbital head length	12.4-14.9	(44)	13.6	12.1-14.6	(40)	13.3	12.3-15.4	(48)	13.8	11.7-15.5	(63)	13.5
Snout length	5.8-8.4	(44)	7.0	5.3-7.1	(40)	6.2	5.1-7.2	(48)	5.9	4.9-7.8	(63)	6.4
Upper jaw length	6.2-8.7	(44)	7.1	6.2-7.6	(40)	6.9	5.6-7.6	(48)	6.8	5.3-8.9	(63)	7.1
Body depth	21.2-31.7	(44)	27.8	23.9-30.9	(40)	27.2	21.0-31.6	(48)	26.5	23.4-34.0	(63)	26.5
Body width	10.6-20.9	(44)	16.9	10.3-20.2	(40)	14.1	9.2-18.3	(48)	12.3	10.1-19.0	(63)	14.4
Least depth caudal peduncle	11.1-15.3	(44)	13.5	11.0-14.5	(40)	12.8	9.4-13.8	(48)	12.1	9.8-14.8	(63)	12.7
Caudal peduncle width	3.7-7.4	(44)	5.3	3.1-6.1	(40)	4.5	2.5-7.3	(48)	4.0	2.9-7.3	(63)	4.8

borough) has nine dorsal rays; the other taxa he recognized have eight. This was probably a misprint. We examined the types as well as other material from the Río Lerma system, and found no specimens with nine dorsal rays (Table 1). Nine rays occurred, infrequently, only in Valley of Mexico populations, and their mean was within the 95% confidence limits of the other drainages.

Eye diameter and least depth of caudal peduncle were used by Meek (1904) to distinguish between *Aztecula vittata (=Notropis aztecus;* see Miller, 1976) and *A. lermae.* Río Balsas *N. sallei* have smaller eye diameters; the mean and 95% confidence limits do not overlap those from other drainages (Fig. 4). However, the range of Río Balsas populations is almost totally contained within the ranges of Valley of Mexico and Rio Lerma *N. sallei.* We consider the variability of this character to be extreme, especially for the Valley of Mexico populations. These data show that eye diameters of fish within and among drainages can vary by as much as 4% of the standard length of the fish. In contrast, Río Balsas populations tend to have the largest average snout lengths (Table 1). The combination of small eye diameters and larger snout lengths for Río Balsas populations, and the converse for the other drainages, coupled with similar postorbital lengths, has resulted in rather uniform head lengths among the Aztec shiners from the different drainage basins (Table 1). The data for eye diameter, snout length, and least depth of caudal peduncle (Table 1) support recognition of only one taxon; however, these data do indicate that, on the average, Río Balsas populations are somewhat modified from those of other drainages.

Alvarez (1970) distinguished *N. sallei* from *N. lermae* and *N. aztecus* by the position achieved in projecting the postdorsal length anteriorly from the origin of the dorsal fin. For example, if this projected length reaches as far as, or anterior to, the nares, then *N. sallei* is indicated. This character is really a complex variable dependent upon postdorsal length, eye diameter, snout length, and postorbital head length. That is, the same result could be achieved by changes in either the head components or the postdorsal length. This complex, as well as other concurrent variations in morphology, is more appropriately assessed by multivariate ordination procedures (e.g. principal components analysis).

Principal components analysis identifies suites of characters that contribute to morphological variation. The character complexes indicated below are those upon which former taxa have been based. The first principal component explains 88.4% of the variance (eigenvalue = 13.3) and is related to size; all variables are highly correlated with this axis ($.79 < r < .99$, $P < .01$). Axes II and III are interesting because they elucidate trends in character variation independent of size. Axis II explains 3.4% of the variation (eigenvalue = .51), is positively correlated with eye diameter ($r = .54$, $P < .05$), and negatively correlated with maximum body width ($r = -.26$,
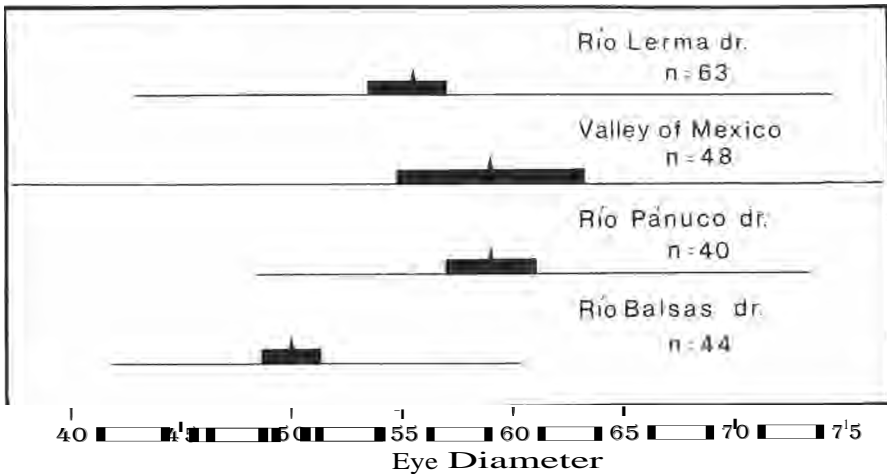
Fig. 4. Comparison of eye diameter (thousandths of SL) among **N.** *sallei* from four drainages. Horizontal line indicates range; shaded portion is the mean ± upper and lower 95% confidence limits; and vertical point indicates the mean.

$P < .05$) and caudal peduncle width ($r = —.33$, $P < .05$). When projection scores for individuals are plotted on the first two principal component axes and clusters for populations within drainages outlined, a morphocline results, with fish having smaller eye diameters and wider bodies on the left, and laterally compressed morphs with larger eyes on the right (Fig. 5; fish from Río Pánuco and Río Grande de Morelia drainages overlapped broadly with clusters shown and were deleted from the figure for clarity of presentation). These axes fail to segregate any population or those from a drainage into a discrete cluster, thereby confirming the broad range of phenotypic variability within and among populations, especially for Río Lerma individuals. The third principal component explains 2.7% of the variance (eigenvalue $= .41$) and is positively correlated with snout length ($r = .20$, $P < .05$) and negatively correlated with caudal peduncle length ($r = — .46$, $P < .05$) and postdorsal length ($r = — .27$, $P < .05$). When projection scores for this axis are plotted against scores for the first two axes, discrete clusters do not occur, and results similar to those in Fig. 5 are obtained.

These comparisons lead us to accept only one taxon, *Notropis sallei.* Presumably diagnostic characters have been shown to be highly variable among populations and do not delimit the former taxa. It is, therefore, understandable why previous researchers having far less material for study assigned several names to these minnows. Furthermore, we now resolve the epithet to be *sallei* because one of us (RRM) examined the syntypes of *Ceratichthys sallaei* and determined that this species is not a synonym of
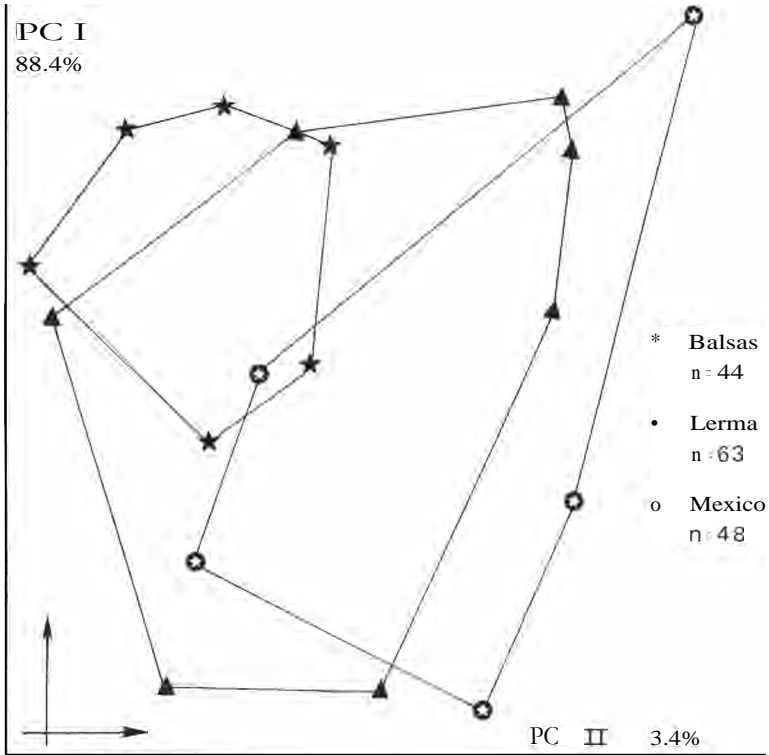
Fig. 5. Outlines of population clusters for *N. sallei* on the first two principal component axes (I, II). The variance explained by each component is indicated.

Algansea tincella, as stated by Meek (1904:45), nor does it belong in the genus *Algansea,* as placed by Jordan and Evermann (1896:212); see below.

The variation of *N. sallei* is comparable to, if not greater than, other highly variable minnows, e.g. *N. atherinoides* (Bailey and Allum, 1962; Resh et al., 1976), *N. cornutus* (Gilbert, 1964), *Pimephales promelas* (Vandermeer, 1966), *Campostoma ornatum* (Bun, 1976), and *Barbus radiatus* (Stewart, 1977). However, each of these cyprinids occupies a much greater geographic range than does *N. sallei.* The overall morphological plasticity of the Aztec shiner may be a function of adaptations and responses to the diverse and often isolated environments in which they occur (lakes, pools, high- and low-gradient streams). For example, *N. sallei* from lakes, e.g. Presa de Guadalupe in the Valley of Mexico, tends to have larger eyes and is more laterally compressed (occupying the right hand side of Fig. 5), whereas those from high-gradient streams of the Río Balsas, Río Lerma and

Fig. 6. *Notropis sallei*. A. ♂ UMMZ 191695, 56.3 mm SL, Mexico, State of Puebla, Río Balsas drainage, Río Atepitzingo SE Totimehuacán. B. ♀ UMMZ 124322, 62.6 mm SL, Mexico, State of Hidalgo, Rio Pánuco drainage, Río Tula at Ixmiquilpan.

Río Pánuco drainages are more terete, with smaller eyes (occupying the left portion of Fig. 5).

  Hubbs (1941) and Smith (1966) have noted that populations from fast water were more attenuate than their quiet-water conspecifics. Similarly, the third principal component axis is related to elongation of the caudal peduncle (see above), and *N. sallei* from high-gradient streams has the lowest scores on this axis (the characters are negatively correlated). Stewart (1977) speculated that body attenuation could be associated with an increase in vertebrae due to the influence of such factors as temperature. Scale and vertebral variables were tested for correlation with the 2nd and 3rd principal components to evaluate relationships among meristics and morphological variation in the lateral and longitudinal planes, respectively. The second axis is negatively correlated with body-circumference scales and scales around the caudal peduncle ($r < -.26$, $P < .01$) and positively correlated with precaudal vertebrae ($r = .38$, $P < .01$); the third axis was not correlated ($P > .05$) with meristics. As the body (thorax and caudal peduncle)

A

Fig. *7. Notropis sallei.* A. *d* UMMZ 193478, 63.9 mm SL, Mexico, State of Mexico, Río Lerma drainage, Río Lerma NW Toluca. B. *d* UMMZ 192555, 52.1 mm SL, Mexico, State of Mexico, Valley of Mexico drainage, Presa de Guadalupe.

increases in width, the number of circumferential scales increases, while precaudal vertebrae decrease in number. The physical relationship between circumferential scales and body width is clear; however, we cannot explain the decrease in precaudal vertebrae. Elongation of the caudal region does not seem to be associated with changes in longitudinal meristic elements (i.e. scales or vertebrae).

Because we synonymize formerly recognized taxa with *N. sallei,* and our data base significantly expands published ranges for various characters, a redescription of the Aztec shiner follows.

<div align="center">

Notropis sallei
Aztec Shiner
Figs. 6, *7*

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Codoma vittata (non Leuciscus vittatus DeKay) Girard, 1856:195 (original description; type locality: Valley of Mexico; unavailable due to secondary homonymy created when Gunther (1868:207) united *Codoma* with *Leuciscus);* 1859:53 (redescription).—Gilbert, 1978:87 (synonymy).

Ceratichthys sallaei Gunther, 1868:484 (original description; type locality: Cuernavaca, Puebla).—Gilbert, 1978:77 (synonymy).

Hudsonius sallaei: Jordan, 1879:226 (synonymy, description).

Zophendum australe Jordan, 1880:300 (misidentification, =*Algansea tincella,* based on our re-examination of types: USNM 23130 (3), USNM 23131 (1)). Jordan, 1890:288 (synonym of *Algansea tincella).*

Cliola sallaei: Jordan and Gilbert, 1883:164 (synonymy, description).

Cliola vittata: Jordan and Gilbert, 1883:172 (synonymy, description).

Notropis aztecus Woolman, 1894:63 (original description; type locality: canals around Mexico City).—Jordan and Evermann, 1896:258 (description).—Regan, 1906-08:160 (synonymy, description).—Alvarez and Navarro, 1957:23 (synonymy, description).—Alvarez, 1970:61 (keys).—Miller, 1978:369 (may equal *Ceratichthys sallaei).*—Gilbert, 1978:28 (synonymy).

Algansea sallaei: Jordan and Evermann, 1896:212 (description).—de Buen, 1940:14 (synonymy).

Aztecula mexicana Meek, 1902:81 (original description; type locality: San Juan del Río, Querétaro).—Meek, 1904:61 (description).—de Buen, 1940:21 (synonymy).—Alvarez, 1950:53 (keys).—Gilbert, 1978:61 (synonymy).

Aztecula azteca: Meek, 1902:82 (listed, distribution).

Notropis lermae Evermann and Goldsborough, 1902:147 (original description; type locality: Lago de Lerma, México).—Alvarez, 1970:61 (keys).—Gilbert, 1978:54 (synonymy).

Algansea tincella: in part: Meek, 1904:45 (included *Ceratichthys sallaei* and *Algansea sallaei* as synonyms).

Aztecula vittata: Meek, 1904:59 (synonymy, description).—de Buen, 1940:20-21 (synonymy).—Alvarez, 1950:53 (keys).

Aztecula lermae: Meek, 1904:60 (synonymy, description).—de Buen, 1940:21 (synonymy).—Alvarez, 1950:53 (keys).

Notropis sallaei: Regan, 1906-08:157 (synonymy, description).—Alvarez, 1970:61 (keys).—Miller, 1976:10 (synonymy).

Aztecula sallaei: Alvarez, 1950:52 (keys).

Notropis sallei: Gilbert, 1978:20 (synonymy, corrected spelling of epithet).

Diagnosis.—*Distinguishable* among all congeners by some combination of: small scales, 39-64 in lateral line, with apical radii only; reduced pharyngeal dentition, 0,4-4,0; short head with blunt snout; small fins; simple intestine with 1 loop; head and body of breeding males with profuse small tubercles that are larger on pectoral rays 2-8 (9) and weak on 1 and 9 or 10-14; maxilla without barbels; ventral surface of urohyal ovoid, without lateral projections joining ventral midline to form V-shaped notch; ascending process of angular not extending above ⅓ height of coronoid process of

dentary; interneural elements extending posteriorly from Weberian apparatus for only 2-4 vertebrae; juveniles and smaller adults with concentration of melanophores on dorsal and ventral sides of caudal peduncle near base of procurrent caudal rays. *Notropis sallei* differs from *Algansea, Gila crassicauda* and *Temeculina* (subgenus of *Gila),* in having a tubular dermosphenotic (platelike in others, except *A. aphanea;* see Barbour and Miller, 1978).

Description.-Measurements expressed in thousandths of SL, n = 212 except where indicated; means given in parentheses. Standard length to 80 mm; predorsal length 368-742 (573), dorsal fin originating over or anterior to insertion of pelvic fins; preanal length 669-777 (723); posterior edge of dorsal and anal fins straight; dorsal fin when depressed extends posteriorly from vertical at ⅓ anal base to beyond anal base; prepelvic length 252-589 (531); postdorsal length 297-401 (353); caudal peduncle length 155-273 (204); head length 245-317 (270); postorbital head length 117-155 (135); eye diameter 37-77 (56); snout length 49-84 (64); upper jaw length 53-87 (70); mouth often oblique and terminal, corner just reaches anterior margin of orbit; maximum body depth 210-340 (269); body laterally compressed to moderately terete, maximum width 92-209 (145); caudal peduncle least depth 155-273 (204); caudal peduncle width 25-74 (47).

Dorsal rays 7 (5 counts), 8 (205), 9 (4); anal rays 6 (5), 7 (195), 8 (14); lateral-line scales 39 (1), 40 (1), 41 *(5),* 42 (9), 43 (14), 44 (15), 45 (17), 46 (19), 47 (29), 48 (23), 49(20), 50 (18), 51(12), 52 (19), 53 (13), 54 (9), 55 (18), 56 (16), 57 (7), 58 (2), 59 (3), 60 (3), 61(1), 62 (1), 63 (0), 64 (1); lateral line incomplete to complete; body-circumference scales 30 (1), 31(1), 32 (0), 33 (4), 34 (9), 35 (17), 36 (18), 37 (15), 38 (25), 39 (25), 40 (22), 41(24), 42 (24), 43 (17), 44 (14), 45 (12), 46 (14), 47 (8), 48 (9), 49 (5), 50 (6), 51(0), 52 (2), 53 (1), 54 (0), 55 (1), 56 (1); scales above lateral line 14 (2), 15 (7), 16 (32), 17 (63), 18 (51), 19(40), 20(19), 21(13), 22 (15), 23 (4), 24 (2), 25 (0), 26(0), 27 (0), 28 (1); scales below lateral line 13 (2), 14 (0), 15 (0), 16 (15), 17 (24), 18 (23), 19 (37), 20 (30), 21(30), 22 (27), 23 (23), 24 (16), 25 (10), 26 (7), 27 (2), 28 (0), 29 (2); scales around caudal peduncle 17 (6), 18 (14), 19 (44), 20 (57), 21(42), 22 (39), 23 (26), 24 (24), 25 (11), 26 (5), 27 (3), 28 (1); total vertebrae 34 (2), 35 (15), 36 (60), 37 (37), 38 (2); precaudal vertebrae 18 (7), 19 (52), 20 (54), 21(3); caudal vertebrae 15 (2), 16 (40), 17 (62), 18 (12), 19 (1).

Color in preservation variable, from pallid to dark (Figs. 6, 7); melanophores always small, present on dorsal half of body, becoming concentrated towards dorsum, not generally present below lateral line; scattered melanophores on lips, becoming concentrated on snout, head, and circumorbital regions; upper ⅔ of opercle and ⅓ of preopercle with melanophores; pigment lacking on intermandibular, gular and branchiostegal regions; predorsal stripe diffuse to distinct, expanded and intensified near dorsal-fin origin

(often obscured in melanistic specimens); postdorsal stripe less well defined than predorsal, expanded and intensified where it approaches anteriormost base of procurrent caudal rays (a similar, but usually weaker, concentration of melanophores lies directly opposite on ventral surface of peduncle, but is frequently lacking; see Fig. 7); lateral stripe often diffuse anteriorly and uniform or darker behind, extending posteriorly from opercle to end of caudal peduncle; melanophores often form blotch at base of caudal rays, sometimes extending onto caudal rays; a herringbone pattern of thin lines of pigment extending dorsally from lateral stripe and terminating on caudal peduncle (obscured in darkest individuals); melanophores scattered on dorsal, caudal and along outermost rays of pectoral fins in non-breeding individuals; breeding fish additionally with milky substance on anal fin (similar to *Cyprinella)* and blotches of pigment along anal rays; breeding males with pigment on distal portions of pelvic fins.

Breeding males, in life, with pinkish red on mandibles and throat; males with small profuse tubercles over head and body; pectoral fins large and rounded in males, short and pointed in females; head and snout rounded and blunter in males than females.

Generic Status

Our placement of *sallei* in *Notropis* is provisional. The problem was succinctly stated by Hubbs and Miller (1974:3), who noted: ". . . the present chaotic state of generic evaluations among American cyprinids . . . ."

Jordan and Evermann (1898:2799) placed *Notropis aztecus* in their subgenus *Aztecula,* a replacement for *Azteca* Jordan and Evermann (1896:258) which was preoccupied in entomology. Meek (1904) elevated *Aztecula* to generic level and referred four taxa to it (see above). Is *sallei* best referable to *Notropis, Aztecula,* or perhaps to some other genus (e.g. *Algansea)?* A similar problem was faced by Hubbs and Miller (1977) with respect to the generic status of *Dionda.*

Studies by Cortés (1968), Snelson (1971), and Gilbert and Bailey (1972) have eliminated characters previously considered to be diagnostic of *Notropis* (e.g. absence of maxillary barbels, more than four pharyngeal teeth in the major row, a single-looped intestine, etc.). Gilbert (1978) concluded that of six diagnostic characters, two remained: scales never numbering more than 55 and usually fewer than 40, and standard length less than 100 mm. The inclusion of *sallei* in *Notropis,* thus, eliminates another characteristic—low scale numbers. Furthermore, *Notropis nazas* Meek, with 44-57 lateral-line scales (original counts of paratypes, FMNH 33572), also proves to be an exception to the upper limit of 55 scales. Moreover, the numerous scales of *N. sallei* and *N. nazas* tend to form a morphocline within *Notropis,* rather than an hiatus. We conclude that the number of
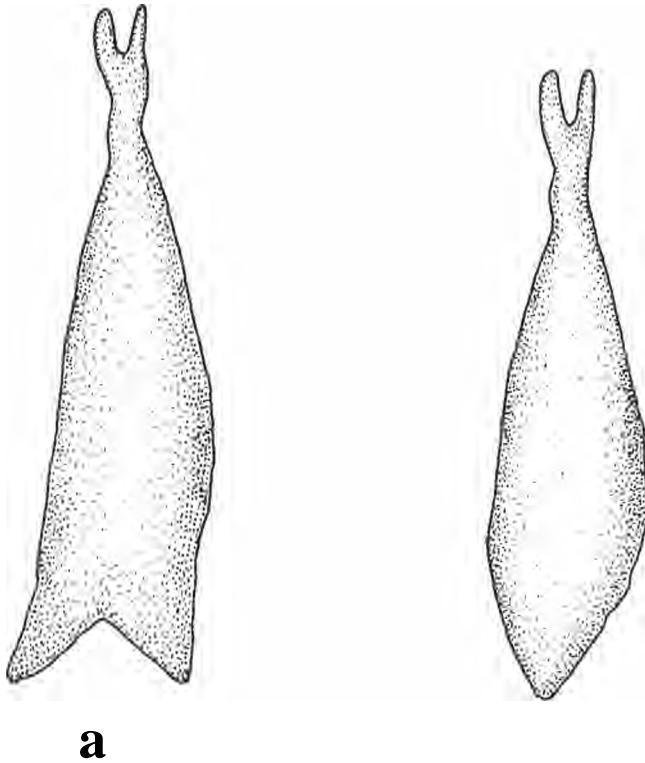
a

Fig. 8. Ventral view of the urohyal bone of *(a) N. lutrensis* and (b) *N. sallei.*

scales (as stated above) is not diagnostic for *Notropis,* and that seemingly only body size remains.

Comparison of the urohyal among selected American cyprinids yields some interesting results. With the exception of *N. amnis, N. boucardi, N. imeldae, N. ornatus,* and *N. sallei,* the urohyals of all *Notropis* examined (see methods and materials) have the ventral surface with lateral projections that extend up to or beyond the posterior margin of the dorsal aspect of the bone, joining the ventral midline to form a V-shaped notch (Fig. 8). *Notropis sallei, N. amnis* and *N. ornatus* have urohyals with an ovoid ventral surface (Fig. 8); this surface is reduced laterally and less than ovoid in *N. boucardi* and *N. imeldae.* The urohyals of these five species are phenetically similar to *non-Notropis* examined *(Hybopsis storeriana, Agosia chrysogaster, Yuriria alta, Algansea aphanea, A. barbata* and *A. tincella;* also see Barbour

and Miller, 1978). We cannot determine, at this time, which of the states is primitive or derived. However, it is clear that the five putative species of *Notropis* cannot share the derived state with the other species of *Notropis* examined. Furthermore, we decline to infer relationships of these five species with other cyprinid genera because of the possibility that ovoid or subovoid urohyals are primitive, and relationships based upon symplesiomorphy should be avoided (Hennig, 1966). It is of further interest that *N. amnis, N. boucardi, N. imeldae,* and *N. ornatus* are also debatably referred to *Notropis* (see Clemmer, 1970; Miller, 1976, 1978; and Gilbert, 1978).

Although *sallei* is distinguished from many *Notropis* (including the type species, *N. atherinoides* Rafinesque) by the shape of the urohyal, the small scales, and its "chub-like" rather than "shiner-like" appearance, we do not propose that *sallei* be reassigned to *Aztecula.* Rather, we provisionally refer *sallei* to *Notropis* because generic changes should not be made until relationships among diagnosable genera have been determined (clearly beyond the scope of this paper); therefore, we maintain nomenclatural stability and follow recent authors who have placed *sallei* in *Notropis* (e.g. Alvarez, 1970; Miller, 1976; and Gilbert, 1978).

Resumen

Notropis sallei (Gunther) habita los ríos del este de la Mesa Central incluyendo las cabeceras de las systemas siguientes: Rio Balsas, Río Lerma, Rio Pánuco, y las cuencas cerradas del Valle de Mexico, y el Río Grande de Morelia. *N. sallei* ha tenido una historia taxonómica confusa y ha sido incluido en no menos de ocho géneros y diéciseis especies. Los carácteres morphológicos varian mucho dentro de las diferentes poblaciones y se superponen mucho entre poblaciones alopátricas. La variabilidad de las carácteres diagnósticos de las especies identificadas con anterioridad también se superponen. Este estudio muestra por la primera vez que estas poblaciones comprenden una sola especie. Gilbert (1978) corregió el deletreo de *N. sallaei* a *N. sallei* porque la especie era en honor del Sr. A. Salle. La posición genérica de la especie es discutida y al mismo tiempo una redescripción es dada.

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