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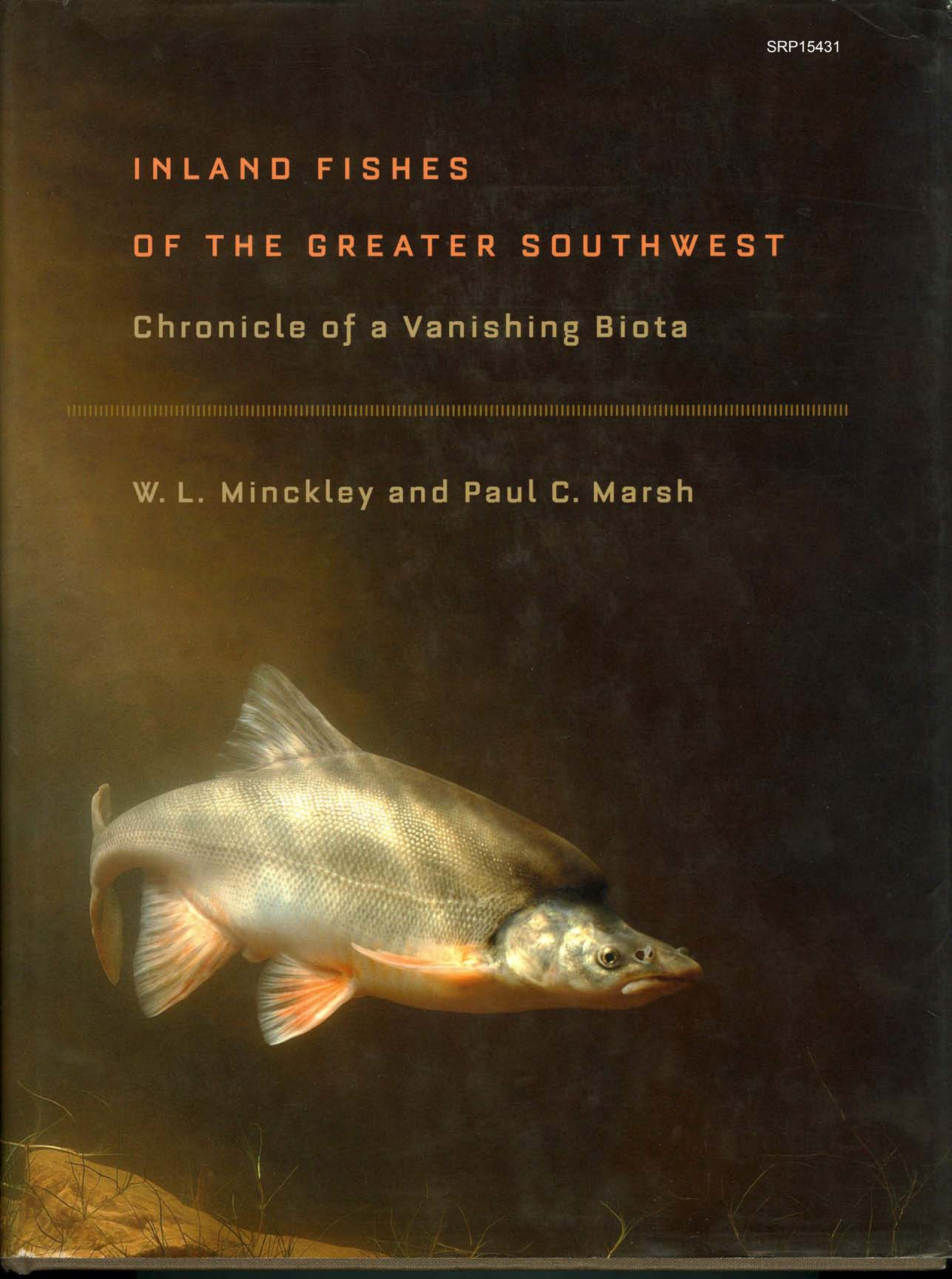
INLAND FISHES OF THE GREATER SOUTHWEST

Chronicle of a Vanishing Biota

W. L. Minckley and Paul C. Marsh



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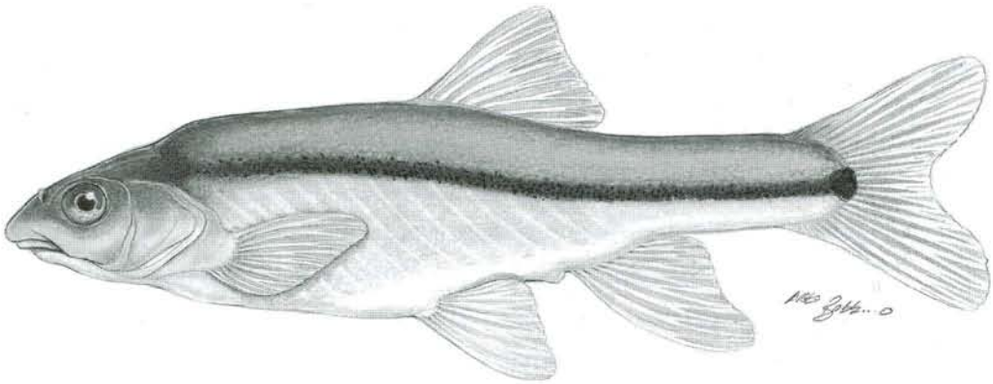

FIGURE 4.41. *Agosia chrysogaster* (Girard), longfin dace, charalito aleta larga (*pl. 5*).

Agosia chrysogaster (Girard), longfin dace, charalito aleta larga

Description Longfin dace (fig. 4.41; pl. 5) have fusiform, rounded bodies and thick, blunt heads. The mouth is terminal, with the upper jaw longer than the lower. A minute barbel is almost always present on each side of the upper jaw. The scales are small, usually 72–80 (av. ~75) in the lateral line. The pelvic fins are expanded in breeding males, presumably to assist in holding the female during spawning, and the anal fin is elongate in adult females, likely functioning in placement of eggs. There are 9 dorsal rays, 8 (7–9) rays in the anal fin, and 7–9 in the pelvic fins. The peritoneum is black, the intestine is long, and the pharyngeal teeth are in a single row, 0,4-4,0. SL seldom exceeds 82 mm.

The body color of both sexes is dark gray or black above and white below. Iridescent silver or gold flecks often appear on the upper sides. A dark lateral band is present, when intense diffusing onto the caudal fin. A basicaudal spot is more evident in juveniles, often obscured by the lateral band in dark-pigmented adults. Breeding males develop faint yellow pigmentation on the lower body and bases of paired fins, but not spectacularly so. The vertical and pectoral fins of breeding fish of both sexes may become dusky, especially distally. In breeding males and rarely in females, fine, sandpaper-like tubercles and larger, coarser tubercles are scattered over the upper parts of the head. Fine breeding tubercles also develop over the scales of the upper body, sides, and some fin rays in fish of both sexes.

The longfin dace is fairly uniform in morphology but is genetically diverse throughout its range (Hendrickson 1987; Tibbets 1993, 1998; Tibbets and Dowling 1996), a fact that remains unexplained. Levels of mitochondrial DNA (mtDNA) divergence between Verde River and other Gila River basin samples were much higher than expected, suggesting long-term isolation of geographic regions. However, the genetic similarity of populations exclusive of Verde River indicated high levels of gene flow for the species (Tibbets and Dowling 1996). There is evidence for some gradation of morphologic and genetic characters between this species and the southern *Agosia* sp. in Ríos Sonoyta and de la Concepción (see later).

Distribution and Status *Agosia chrysogaster* ranges naturally from the Bill Williams and Gila rivers south to the Río de la Concepción, most commonly in low-gradient reaches at lower elevations (map 4.10). It has been introduced into the Virgin River and the closed Hualapai Red (Dry) Lake basin in Arizona (Hendrickson 1987), and in the Zuñi and Mimbres rivers and Rio Grande in New Mexico (Sublette et al. 1990). Introduced populations have not spread extensively except in the Mimbres system, where a rise to numerically dominate the fish community may have contributed to the decline and extirpation, respectively, of the native Chihuahua chub

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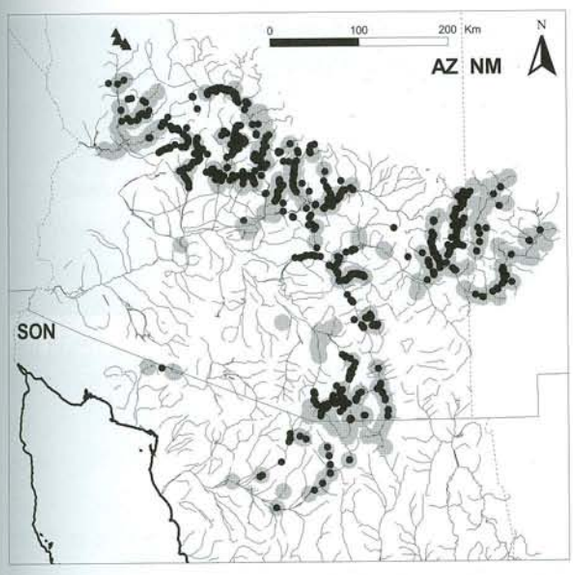

MAP 4.10. Distribution of *Agosia chrysogaster* (Girard), longfin dace, charalito aleta larga. Gray circles represent historical (pre-1980) collections; black circles are 1980 and later records.

and the beautiful shiner. The Zuñi River stock has apparently disappeared (Sublette et al. 1990). The status of the non-native stocks in the Rio Grande and Virgin River is unknown, but to our knowledge none has been reported recently from either system.

Although reduced in abundance and distribution, as with all western fishes, the longfin dace remains the most widespread and abundant of all native species in regional lowlands in the United States. Its remarkable capability for dispersal and resistance to environmental extremes allow persistence where other species, including many non-natives, are excluded. SEDESOL (1994) nonetheless included it as a threatened species in México, based primarily on *Agosia* sp.

Habitat and Biology This highly adaptable fish occupies diverse habitats from low-elevation sand-bottomed desert streams through intermediate elevations to clear, cool mountain creeks. It is rarely abundant in large streams or above ~1800 m above msl. Although most intimately associated with moderate, almost-laminar flow over smooth sand bottoms, it also occupies eddies below riffles and turbulent areas in upper parts of pools. The dace tends to remain near bottom, seeking cover when disturbed in deep places along shore or beneath overhanging vegetation. It succeeds in resisting drought crowded in intermittent pools, and individuals have been known to survive in moist depressions beneath wet debris or algal mats over at least a day, perhaps longer (Barber and Minckley 1971).

Spawning occurs in low-desert streams throughout most the year, although peak reproductive activity is in spring–late summer. At cooler, higher elevations, longfin dace spawn in late spring–midsummer. Males in reproductive condition are present throughout the year in Aravaipa Creek, Arizona (Kepner 1982); sex ratios did not differ from 1:1. Mature ovaries had at least three distinct classes of ova, and analyses of egg sizes indicated one or two cohorts progressively maturing from a general ovarian stockpile, characteristic of bi- or multimodal spawning periods or punctuated spawning over a long period of time. The last seems the case, a female producing only a few ripe ova at a time, spawning, then developing to spawn a few more.

Maturity indices (computed as ovary weight/total body weight, including ovaries) varied from a minimum of 0.2% to 23.1%, with maxima (av. >10%) in January–April, but upper limits at or >10% in 10 months of the year (Kepner 1982). A few mature females are thus available to spawn in essentially any month of the year. Numbers of mature and maturing ova varied from none in spent females to >650 in the largest, most gravid females (84 mm TL); the smallest mature female was ~42 mm TL. High variability in fecundity was attributed to asynchronous spawning among individuals, semiannual reproductive periodicity, and the protracted spawning season.

Some aspects of breeding behavior have been described by W. L. Minckley (1969a, 1973), Barber and Minckley (1971), and Lewis (1978) and have been studied extensively by S. Vives (pers. comm.). Males excavate saucer-shaped depressions 7.5–20 cm in diameter (av. 13.5 ± 2.6 [s.d.] cm) and 1.0–4.6 cm deep (2.3 ± 0.8 cm) in coarse sand bottoms by circular, swirling motion in water 2.9–17.9 cm (8.5 ± 4.0 cm) deep on the downstream ends of sandbars (Kepner 1982). Currents over nest areas were slow, averaging 7.0 ± 4.0 cm/

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sec, and there was evidence that nesting was concentrated in places where underflowing (hyporheic) water rose from the porous substrate. Groups of spawning depressions occurred at densities varying from 8 to 50/m^2 (av. 21.3 (11.9/m^2); no concentrations exceeding a total of 100 have been observed, but 25–30 depressions in a single small area is not unusual. W. L. Minckley (1973) provided the following account of breeding activity (paraphrased):

> Tuberculate males move randomly back and forth over the nest area, without obvious territoriality. Females enter the area singly. [An individual female] . . . is immediately flanked by 1–4 males and followed closely as she appears simply to wander through the area. One or rarely two males position themselves posterolaterally to the female. She then dips into a depression, closely followed by the male(s), and a flurry of sand obscures what must be the actual spawning act. The fish then lie quietly for a second, then move rapidly away, the males to resume patrolling and the female out of the area, usually into deeper waters.

Eggs deposited in bottoms and walls of the depressions are buried by ongoing spawning activity. The eggs are not guarded. Kepner (1982) obtained 12 and 20 nonadhesive eggs 2.3 ± 0.2 mm in diameter from two nests sampled with fine-meshed netting. Young 6.4 ± 0.3 mm TL at hatching appear in <4 days at water temperatures >24°C, and larvae remain in the "nest" until yolk is depleted, then disperse to stream margins to feed and grow. Young hatched in late winter–early spring in warm, low-desert habitats are large enough (~40–45 mm SL) to spawn their first summer–early autumn of life (Kepner 1982) and probably do so. Few individuals live longer than three summers.

The species is a facultative omnivore, eating detritus as well as a wide variety of living plant and animal foods (Fisher et al. 1981; Grimm 1988). In Aravaipa Creek, Arizona, diatoms and unattached green algae, characteristic of stream margins and quiet areas where longfin dace graze, were a substantial proportion of the diet. Large quantities of baetid mayfly larvae also were consumed, apparently taken from the drift. Use as food of other taxa, including stonefly nymphs, caddisfly larvae, and immature dipterans, corresponded generally with their availability, while winged stages also were taken but were not a major dietary component.

Additional References (Synonyms: *Agosia chrysogater* [*sic*], *A. metallica*, *Hyborhynchus siderius*, *Zophendum siderium*, *Rhinichthys chrysogaster*; see W. L. Minckley 1973; Mayden et al. 1992.) Girard (1857, 1859a); Jordan (1885a, 1885b, 1891b, 1963); Jordan and Evermann (1896); Gilbert and Scofield (1898); Meek (1904); J. O. Snyder (1915); Jordan et al. (1930); R. R. Miller (1946d, 1952b, 1961b, 1964a); C. L. Hubbs and Miller (1948b); Evans and Douglas (1950); Winn and Miller (1954); Koster (1957); John (1964); R. R. Miller and Lowe (1964, 1967); W. L. Minckley (1965a, 1969a, 1971, 1972, 1980a, 1981); Barber and Minckley (1966); Lowe (1967); Lowe et al. (1967); W. L. Minckley and Deacon (1968); W. L. Minckley and Johnson (1968); Stout et al. (1970); C. Hubbs and Echelle (1972); LaBounty and Minckley (1972); Lewis (1978); Mpoame (1982); Mpoame and Rinne (1983); Propst et al. (1986, 1988); Zneimer (1986); Sublette et al. (1990); Deacon and Minckley (1991); Ward et al. (2003); Propst et al. (2008).

Agosia sp., Mexican longfin dace, charalito mexicana

Description This undescribed species (fig. 4.42) resembles *Agosia chrysogaster* but has greater predorsal and shorter postdorsal lengths, resulting in a more dorsally arched predorsal profile and more posterior positioning of the dorsal fin. There also is a lesser distance from snout to barbel; more lateral-line scales (av. 78, vs. 75 in *A. chrysogaster*); smaller adult size; less sexual dimorphism; and less extreme tuberculation in breeding males, with neither large, coarse tubercles on the head nor fine tubercles on the body scales as in *A. chrysogaster*. Further, this species is not known to create the distinctive spawning "nests" that characterize its congener. The maximum known SL is ~87 mm. Color patterns of *A.* sp. and *A. chrysogaster* are similar, relatively drab even when breeding, and with no distinctive yellow or red pigments.

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from Astin Spring to the border and intermittent (a single pool existed) in 1968. When the entire habitat, including Astin Spring, dried in summer 1969, all fishes were lost except for ~200 individuals each of *G. purpurea* and *Poeciliopsis sonoriensis*, transplanted into a flood tributary of Whitewater Draw (Río Yaqui basin) in the Swisshelm Mountains, Leslie Creek, Cochise County, Arizona. The stocking succeeded, and a chub population persists today, protected by an extension of the San Bernardino–Leslie Creek National Wildlife Refuge (SBNWR) (DeMarais and Minckley 1993; USFWS 1994a). A second, smaller population, estimated at 20 or fewer chubs (McNatt 1974), persisted until 1972 in marshes fed by an artesian well, then also disappeared (USFWS 1986b).

In 1979, The Nature Conservancy (TNC) purchased the historic San Bernardino Ranch, including most of the former range of *Gila purpurea* (and a number of other fishes) in the United States (Lanning 1981; DeMarais and Minckley 1993). Leslie Creek was acquired by TNC in 1988, and the two parcels were transferred to USFWS in 1982 and 1988, respectively, to establish SBNWR. Old ponds were renovated, new ponds built, and erosion control helped begin recharge of the water table, soon reestablishing surface flow in Black Draw.

As a result of these and other efforts, the present range of *Gila purpurea* is equal to or larger than the original (DeMarais and Minckley 1993). A large percentage of the existing fish may be traced to repatriations originating with the original translocation from Astin Spring to Leslie Creek. The chub responded positively to management, forming self-sustaining stocks in diverse habitats (Hendrickson and Brooks 1991; USFWS 1994a). Further, DeMarais and Minckley (1993) found no discernible morphologic or genetic evidence for detrimental effects of past or present habitat changes, population variations, or management manipulations.

Habitat and Biology This species lives in springs, spring-fed ditches, and creeks over substrates of silt, clay, mud, sand, gravel, and boulders. Water may be clear or muddy, vegetated by skunkgrass, watercress, cattail, pondweed, and willows. Depths of captu vary to >1.5 m; currents are none to moderate. Tran located stocks in Leslie and West Turkey creeks, Ar zona, are strongly associated with the deepest pool and cover in the form of overhanging riparian veg etation, boulders, or cutbanks. Young in creeks oc cupy near-shore zones and eddies near lower ends o riffles. The species proved highly adaptable to ponds where adults remain mostly in the shadows of marginal aquatic plants near deep water. Young (small) fish move in loosely aggregated schools in open water or along banks, feeding actively near the surface. Hendrickson et al. (1981) provided further observations on the behavior of *G. purpurea*.

Peak reproduction is in spring–early summer but has been recorded in all but midwinter months (late November–February). Reproductive potential is high, and large populations develop quickly from only a few adults (DeMarais and Minckley 1993). Maturation is rapid, commonly in the first summer of life. The species feeds mostly on algae, insects, and detritus (Galat and Gerhardt 1987). Major foods of 20 small adults examined by W. L. Minckley (1973) also were mostly algae, with fewer terrestrial insects and arachnids.

Additional References (Synonyms: *Leuciscus purpureus*, *Richardsonius purpureus*, *Squalius purpureus*, *Tigoma purpurea*; see W. L. Minckley 1973; DeMarais 1991.) R. R. Miller (1945b); Uyeno (1961); R. R. Miller and Lowe (1964, 1967); USBSFW (1966); J. N. Rinne and Minckley (1970); W. L. Minckley (1971, 1980c); W. L. Minckley and Brooks (1986).

Gila robusta Baird and Girard, roundtail chub, charalito, carpa cola redonda

Description This chub (fig. 4.56; pl. 16) has a moderately slim, streamlined body. The length of the caudal peduncle divided by its depth is >2.3, and the head length divided by the depth of the caudal peduncle is >3.25 (on a population basis). The fins are large in size, usually transparent, and their distal margins are typically square to convex; the dorsal fin may be weakly falcate in larger individuals. The scales are thin and narrowly overlapping, with basal radii absent to weak.

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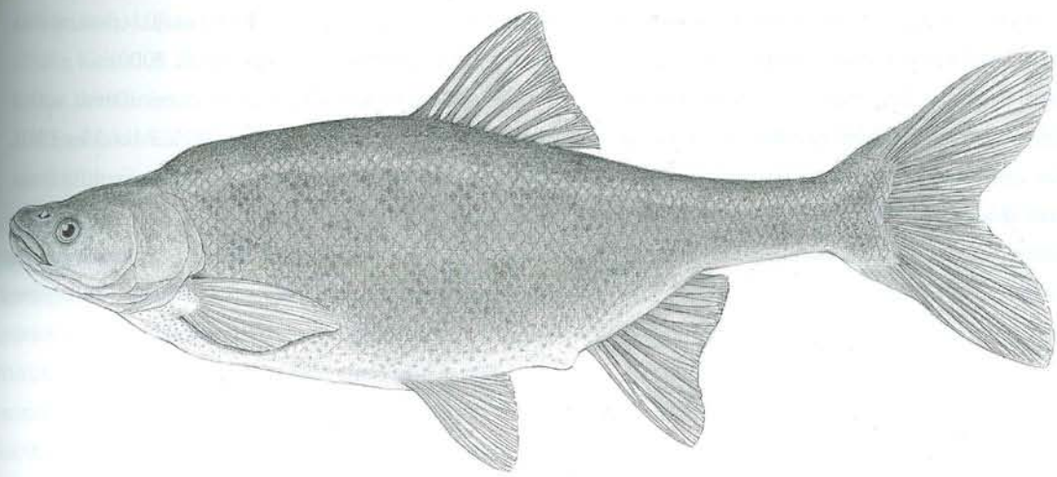
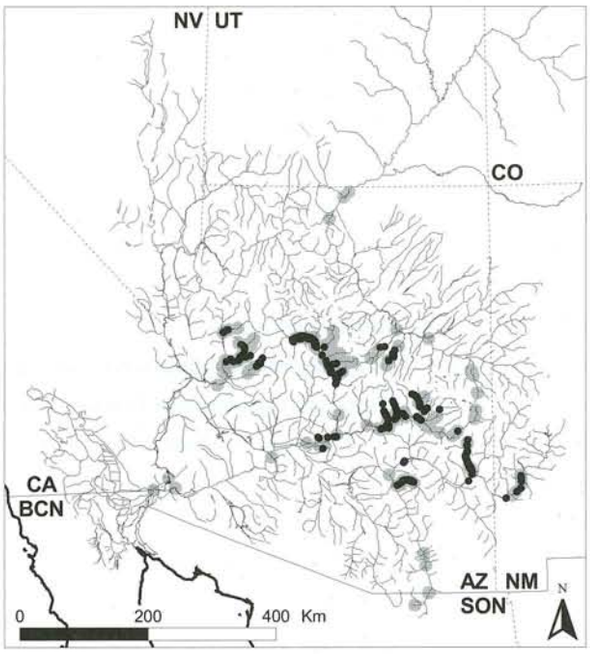


FIGURE 4.56. *Gila robusta* Baird and Girard, roundtail chub, charalito, carpa cola redonda (*pl. 16*).

The lateral line typically has >82 (76–99) scales. There are 9 (rarely 8) dorsal and anal rays, and usually 9 rays in each pelvic fin. The pharyngeal arch has an elongate lower ramus, approaching that of the Colorado squawfish (*Ptychocheilus lucius*) in shape, with teeth in two rows, 2,5-4,2. The maximum SL is 45 cm.

The body color is typically silvery, especially on the sides, or darker above and lighter below. Dark, diffuse lateral bands develop rarely, especially in clear water. Dark dorsal and lateral blotching (as in *Gila jordani* and less so in *G. nigra*) is rare, most commonly seen in specimens from the Bill Williams drainage, Arizona. Breeding males are red to orange red on the lower parts of the head and branchiostegals, the lower sides and belly, and the fin bases except the dorsal. They further develop small breeding tubercles over much of the body. Females may also become red or yellowish, less intensely so than males, and tubercles are usually restricted to their heads, opercles, and caudal peduncles.



MAP 4.25. Distribution of *Gila robusta* Baird and Girard, roundtail chub, charalito, carpa cola redonda. Gray circles represent historical (pre-1980) collections; black circles are 1980 and later records.

Distribution and Status *Gila robusta* is distributed throughout much of the Colorado River basin from Colorado and Wyoming southward throughout much of the Bill Williams and Gila drainages (map 4.25). On occasion it must have penetrated the Colorado River delta in northern Sonora and Baja California Norte. The species is declining rangewide (Bezzerides and Bestgen 2000; Voeltz 2002) and is under consideration for protection as endangered or threatened, with critical habitat in the lower Colorado River basin in the United States (USFWS 2005b). However, it appears that state-led conservation programs—for example, those by the Arizona Game and Fish Department (AZGFD 2006) and the Utah Department of

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Natural Resources (UTDNR 2006)—will serve in lieu of listing for this and several other needy species.

Habitat and Biology The roundtail chub is typical of the largest, deepest pools of middle-sized (often large) streams and rivers. It is less strongly associated with cover than many *Gila*, commonly living in and near open eddies and in the deep, middle parts of pools. Kaeding et al (1990) found adults relatively mobile in the upper Colorado River; 15 radiotagged individuals moved a mean (± s.e.) of 27.4 ± 8.1 km (17.1 ± 5.1 mi) from the point of tagging (mean max. 33.9 ± 9.3 km [21.2 ± 5.8]) over a mean duration of 87.2 ± 7.2 days. It is notable that 88% of radiotracked humpback chubs were within Black Rocks Canyon, Colorado, while 78% of roundtail contacts were outside, demonstrating spatial segregation of the two species during their concurrent spawning seasons.

Despite their wide distribution and former abundance, little specific information exists for roundtail chubs. Muth et al. (1985) cultured them to study developmental stages. Adults were collected from the upper Yampa River, Colorado (Muth and Haynes 1984), spawned artificially, and their eggs transferred to the laboratory. Two females 44.4 and 45.5 cm TL yielded ~900 eggs/cm of body length. The eggs were 1.6–2.4 mm in diameter before fertilization and increased to 2.5–3.1 mm a few hours after fertilization. Hatching at 19°C began in 5.3 and ended in 6.5 days. Growth of young fed ad libitum through all larval stages was from ~7.5 mm to ~22 mm TL over 58 days at 19°C.

Roundtail chubs in the mainstream Colorado River, Colorado (Kaeding et al. 1990), had gonads >10% of total body weight from mid- to late June in females and >2% from May to early July in males. Ovary weights dropped to <5% and male testes to <1.0% at other times of year. Females were "ripe" (had expressible eggs) from mid-June to mid-July; males yielded milt for a bit longer over the same general period. Breeding judged by maximum gonad weights and ripeness was on and following peak spring discharge at water temperatures between 14°C and 24°C. Spawning in lower Colorado River streams was in February to June at temperatures near 18°C. Females from Verde River, Arizona, 27.0–42.7 cm TL contained an average of 13,948 ova (Brouder et al. 2000).

Spawning of roundtail chub is consistent with a generalized cyprinoid behavior (W. L. Minckley 1981), whereby groups of males aggregate in spawning areas, often over clean gravels in runs, riffles, and flowing pools with modest current, where they are joined by single females. The female and one (infrequently two) male align and simultaneously release their gametes; fertilized ova are adhesive and presumably settle into the substrate. After hatching, fish may disperse downstream—for example, roundtail chub made up 6.0%–13.1% of larval fishes captured in shoreline drift in the upper Colorado River (Carter et al. 1986).

Age and growth data are equivocal, but annual growth is highly variable. Growth was approximately 50 mm through age 4 for upper Gila River New Mexico (Propst 1999) and slowed thereafter. Brouder (2005) reported on a large sample of fish up to 42.7 cm TL and including individuals 1–7 years old from Verde River, Arizona. He determined based on comparison with known-age hatchery fish that otoliths (sagittae) provide a reliable method for ageing this species. The maximum size exceeds 50 cm, but longevity is unknown.

The species is an opportunistic omnivore, consuming a wide variety of terrestrial and aquatic invertebrates, plant material, fish and other small vertebrates if available, and detritus (Schreiber and Minckley 1981; Propst 1999). Diet varies with size, becoming more carnivorous in larger individuals, and seasonally in response to availability of different food resources.

Additional References (Synonyms: *Gila gracilis, G. nacrea, Ptychocheilus vorax*; see W. L. Minckley 1973; J. N. Rinne 1976.) S. F. Baird and Girard (1853a, 1853b); Girard (1857, 1859a, 1859b); Cope and Yarrow (1875); Jordan and Gilbert (1883); Cockerell (1908); R. R. Miller (1945b, 1946c, 1955, 1961b); Simon (1951); LaRivers (1952, 1962); LaRivers and Trelease (1952); Hemphill (1954); Koster (1957); R. R. Miller and Hubbs (1960); Uyeno (1961); Uyeno and Miller (1963, 1965); R. R. Miller and Lowe (1964, 1967); Barber and Minckley (1966); Cole (1968); Holden

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(1968); A. E. James (1968); W. L. Minckley and Alger (1968); Kobetich (1969); W. L. Minckley (1969a; J. N. Rinne (1969); Vanicek and Kramer (1969); Holden and Stalnaker (1970, 1975); J. N. Rinne and Minckley (1970); C. Hubbs and Echelle (1972); LaBounty and Minckley; (1972); R. R. Miller (1972b); Holden (1973); Cross (1978b); Hatch (1978, 1979); Schreiber (1978); G. R. Smith et al. (1979); Holden and Minckley (1980d); Cole (1981); Schreiber and Minckley (1981); W. H. Miller et al. (1982); Mpoame (1982); Mpoame and Rinne (1983); Schumann (1983); Bestgen (1985a, in part; 1985b); Bestgen et al. (1985, 1987); Propst et al. (1986, 1987); Bestgen and Propst (1989, in part); M. E. Douglas et al. (1989, 1998, 1999); Rosenfeld and Wilkinson (1989); Ziebell and Roy (1989); Carp and Tyus (1990a); Muth (1990); C. M. Williams (1991); Dowling and DeMarais (1993); McElroy and Douglas (1995); Bezzerides and Bestgen (2000); W. L. Minckley and DeMarais (2000); Brouder (2001); Voeltz (2002); Norris et al. (2003); Schwemm (2006); USFWS (2007); Propst et al. (2008).

Gila seminuda Cope, Virgin River chub

Description The body of this species (fig. 4.57; pl. 17) is attenuate, streamlined, and generally intermediate in shape between that of *Gila robusta* and *G. elegans*. The length of the head divided by the depth of the caudal peduncle is typically between 4.0 and 5.0 (very rarely exceeding 5.0, which characterizes *G. elegans*). The fins are large, expansive, and tend to be falcate in large individuals. The back, breast, and parts of the belly have small, deeply embedded scales that are sometimes almost absent. The scales are small, numbering >85 in the lateral line, and lack basal radii or, at most, have radii represented by faint lines. The maximum SL is ~41, but few exceed 31 cm.

The overall body color often appears almost translucent, overlain by a silvery sheen, but is sometimes darker, gray to olive gray above, grading to white below. Breeding males develop watery yellow to light yellow orange pigments on the lower parts of the head and in the axillary and inguinal areas, and some yellowing of other ventrolateral surfaces; extremely fine tubercles develop over much of the body. Females have no evident breeding colors and more limited tubercle development.

This is a species of hybrid origin (DeMarais et al. 1992; Dowling and DeMarais 1993).

Distribution and Status *Gila seminuda* lives only in the mainstem Virgin River from Pah Tempe (La Verkin) Spring, Utah, presumably downstream (originally) from its confluence with the Colorado River (now Lake Mead), Nevada, and in the lower Moapa River, Nevada (J. N. Cross 1978b; DeMarais et al. 1992) (map 4.26). It has not been caught in any numbers downstream of Mesquite, Nevada, since the late 1970s (USFWS 1995b). The fish is listed (as *G. robusta seminuda*) by USFWS (1989a) as endangered in the Virgin River, but the agency has failed as yet to accept genetic evidence (DeMarais et al. 1992; Dowling and DeMarais 1993) aligning the Moapa River population with *G. seminuda*, so it is neither listed nor considered in recovery plans (USFWS 1995b; but see USFWS 1996). Critical habitat for Virgin River chub was proposed (USFWS 1995c) and eventually designated (USFWS 2000b).

Conservation efforts for the Virgin River fish fauna, including this chub, are largely summarized in the woundfin species account. A 1988 attempt to eradicate non-native red shiner with rotenone was unsuccessful in removing the unwanted alien but severely depleted the numbers of chub in more than 80 km of stream. Prepoisoning samples indicated a single panmictic population of Virgin River chub, while samples from natural reproduction in poisoned reaches indicated a genetic bottleneck caused by severe reduction in number of spawning adults (DeMarais et al. 1993); the altered genetic pattern persisted at least 2.5 years postpoisoning. Prior to chemical treatment, about 1600 fish were transferred to an upstream pond, and 160 of these were transported to Dexter National Fish Hatchery and Technology Center (DNFH) and later propagated artificially and voluntarily. Progeny from both of the last two processes also underrepresented the original situation because of the small number of adults used. Mechanical control of red shiner also has

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eggs, larvae, and adults. Laboratory and in situ experiments by Blinn and Runck (1992) and Blinn et al. (1993) demonstrated high predation rates on spinedace by rainbow trout, even when natural cover and alternative prey were abundant. Spinedace showed little predator avoidance. Other markedly predatory fishes, brown trout and centrarchids, also co-occur, and must impact spinedace to a degree; crayfish, now abundant everywhere spinedace are found, also have negative impacts (J. N. White 1995; Fernandez and Rosen 1996; Bryan et al. 2002).

Additional References (Synonym: *Lepidomeda jarrovi*; see R. R. Miller and Hubbs 1960; W. L. Minckley 1973.) Cope (1874); Cope and Yarrow (1875); Jordan and Copeland (1876); Jordan and Gilbert (1883); Evermann and Rutter (1895); Jordan and Evermann (1896); H. W. Fowler (1925); Jordan et al. (1930); R. R. Miller and Hubbs (1960); R. R. Miller (1961b, 1963a, 1964a, 1972a); R. R. Miller and Lowe (1964, 1967); W. L. Minckley (1965a, 1970, 1971); Branson (1966); USBSFW (1966); W. L. Minckley and Carufel (1967); W. L. Minckley and Deacon (1968); Deacon (1969); Barber et al. (1970); Uyeno and Miller (1973); Blinn and Runck (1992); Runck and Blinn (1993); Blinn et al. (1994, 1998); Sweetser et al. (2002); Robinson et al. (2003).

Meda fulgida Girard, spikedace

Description Spikedace (fig. 4.62; pl. 22) have slim bodies, oval in cross-section anteriorly and becoming laterally compressed nearer the caudal peduncle. The mouth is subterminal, and the snout is pointed. Barbels are absent. The origin of the dorsal fin is well behind the insertion of the pelvic fin. Scales are essentially absent, represented as small, deeply embedded plates visible only after clearing and staining. The first, spinous, sharp-pointed dorsal ray is the strongest. There are 7 dorsal rays and 9 anal rays. The pharyngeal teeth are in two rows, 1,4-4,1. The maximum SL is ~76 mm.

The body color is light brown to olive gray above, with bright silvery sides and black specks and blotches on the back and upper sides (the latter vertically elongate) that coalesce into dark, irregular dorsal pigmentation and an ill-defined, ragged lateral band. Breeding males develop bright brassy yellow on the head and fin bases, a strong yellow to brassy suffusion over the back and sides, and yellow bellies and fins.

Based on both morphological and molecular characters, spikedace in the Verde River are distinctive (A. A. Anderson and Hendrickson 1994; Tibbets and Dowling 1996), likely at the species level, from those in the upper Gila River. Dowling, Tibbets, et al. (2002) estimated Pleistocene divergence times of the Verde and Gila rivers of 0.9–3.4 mya. Further, based on molecular analyses, the genus *Meda* diverged from other plagopterine genera early in geologic time, in the Early Miocene or before.

Distribution and Status *Meda fulgida* is restricted to the Gila River basin in Arizona, New Mexico, and (likely) Sonora (R. R. Miller and Winn 1951; R. R. Miller and Hubbs 1960) (map 4.33). It has suffered marked reductions in range and abundance over the past few decades and is listed as threatened (USFWS 1986c). Its decline has been attributed to habitat deterioration and loss and interactions with non-native species, principally red shiner (see review by Marsh 1991a and M. E. Douglas et al. 1994). Verde River populations are disappearing (J. N. Rinne et al. 1998) or perhaps gone, yet others, like that of Eagle Creek, Arizona (Marsh et al. 1991), appear, persist for a time, then disappear for years, only to reappear again. Some in the Gila River, New Mexico (Propst et al. 1986), and Aravaipa Creek, Arizona (Barber and Minckley 1966, 1983; Barber et al. 1970), however, have maintained themselves, despite dramatic year-to-year fluctuations.

Although much effort has been expended to attribute decline of spikedace to physical habitat changes associated or not with introduced species (J. N. Rinne and Kroeger 1988; J. N. Rinne 1991c), we are convinced that decline of spikedace, and most other southwestern fishes as well, results mostly from interactions with non-natives. Recent research has documented extensive larval predation by small-sized introduced minnows (Dunsmoor 1993; Ruppert et al. 1993), some, like fathead minnow, previously considered innocuous. Competitive interactions may also

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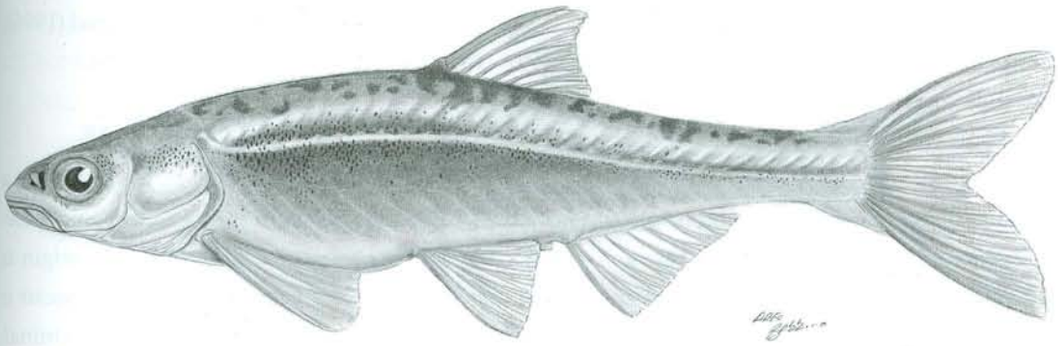
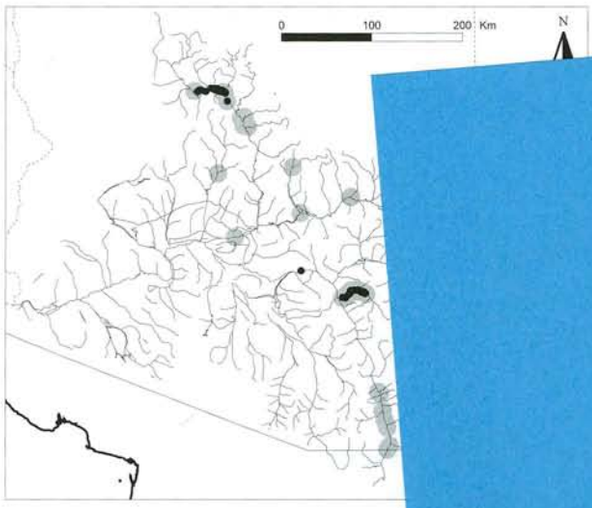


FIGURE 4.62. *Meda fulgida* Girard, spikedace (*pl. 22*).

be involved—for example, M. E. Douglas et al. (1994) demonstrated statistically that adult spikedace moved into swift, more energetically demanding habitats than "normal" when in contact with red shiners.

The process of affording critical habitat for this species and the loach minnow has been convoluted. In the United States, critical habitat for the two species was proposed (USFWS 1985e) and designated (USFWS 1994f), then revoked (USFWS 1998c), reproposed (USFWS 1999), and redesignated (USFWS 2000a), the last in response to legal action, and later vacated by court order (U.S. District Court New Mexico, No. CIV 02-0199 JB/LCS). In the midst of this contortion was a proposal to reclassify both species from threatened to endangered, which was determined warranted but precluded (USFWS 1994g). Critical habitat was proposed yet again (USFWS 2005c), but future designation is uncertain and must await additional legal, procedural, and administrative machinations. A recovery plan is available (USFWS 1991b).

Habitat and Biology Spikedace live in streams in water typically <1 m deep, and adults frequently aggregate in shear zones along gravel-and-sand bars, in broad shallow areas above such bars, and in eddies along the downstream margins of riffles (Propst and Bestgen 1986; J. N. Rinne and Kroeger 1988). Small young fish occupy quiet areas along pool edges over finer-grained bottoms. Specific habitat associations vary seasonally, among streams, and ontogenetically (R. M. Anderson 1978; J. N. Rinne 1985b; Propst et al. 1986; J. N. Rinne 1991d). Spikedace in larger rivers often were associated



MAP 4.33. Distribution of *Meda ful*
spikedace. Gray circles represent histo
collections; black circles are 1980 and

with tributary mouths, and in springtime fish occupied strongly flowing areas over sand-and-gravel substrates.

Native species that commonly use the same habitats as spikedace include loach minnow, speckled dace, and desert and Sonora suckers (Marsh 1991b). Longfin dace may be found with spikedace in areas of shallow, laminar flow, and larvae of all these, plus roundtail chub, may occur together along quiet stream margins. Non-native red shiner occupies and apparently displaces spikedace from its preferred habitats (M. E. Douglas et al. 1994) to the detriment of the native (Marsh 1991b).

Spikedace are opportunistic, drift-feeding carnivores that eat mostly entrained aquatic and terrestrial

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insects (R. M. Anderson 1978; Barber and Minckley 1983; Propst et al. 1986). Larval mayflies, hydropsychid caddisflies, and chironomid dipterans are most important, with kinds and quantities of these and other consumed foods varying with their availability. Pupae and adults of aquatic forms are important at times of emergence. Dietary diversity is greatest among smaller spikedace, whereas adults become more specialized on larger prey items.

Springtime increases in stream discharge and temperature initiate breeding in April–June, the exact timing depending on locale and climate. Male spikedace patrol in moderate current in shallow riffles, and although spaced evenly do not set up or defend territories. Females that move into the area attract one to six males, and typically two of these remain closely alongside as gametes are expressed into the water column or onto the substrate. Eggs are demersal and adhesive. Fecundity ranges from about 90 to 250 ova per female, which are ~1.5 mm diameter at spawning. Artificially produced fertilized ova were about 1.8 mm diameter, and at 19°C, yolked embryos hatched in 7 days at 4.5 mm SL (Parmenter and Platania 2004). Young in nature grow to 35–40 cm SL by November, after which winter growth is slow to nil, and fish attain 50–63 mm by the end of their second year. Life expectancy typically is 1–2, rarely 3 years.

Additional References Girard (1857, 1859a); Cope (1874); Cope and Yarrow (1875); Jordan (1886); Evermann and Rutter (1895); Jordan and Evermann (1896); Gilbert and Scofield (1898); Fowler (1925); D. S. Jordan et al. (1930); R. R. Miller and Winn (1951); Winn and Miller (1954); Koster (1957); R. R. Miller and Hubbs (1960); R. R. Miller (1961b, 1964a, 1969); R. R. Miller and Lowe (1964, 1967); Barber and Minckley (1966); W. L. Minckley and Deacon (1968); Barber et al. (1970); W. L. Minckley (1970, 1971, 1981); Uyeno and Miller (1973); Hatch (1978, 1979); Schreiber (1978); Schreiber and Minckley (1982); Barber and Minckley (1983); Bestgen (1985a, 1985b, both in part); Bestgen and Propst (1986); Propst et al. (1986, 1988); Marsh et al. (1991); J. N. Rinne (1992); M. E. Douglas et al. (1994); Marsh (1996); J. N. Rinne and Stefferud (1996); Ward and Hilwig (2004); Propst et al. (2008).

Moapa coriacea Hubbs, Moapa dace

Description Moapa dace (fig. 4.63; pl. 23) have a rounded body that becomes more slender and laterally compressed posteriorly. The dorsal fin origin is over or just behind the pelvic insertion. The snout is long but blunt, and the mouth is slightly subterminal. The lips are thickened, the upper expanded at its front into a fleshy shield shape. The premaxillary groove is continuous but shallow on its median line, as if a hidden frenum were present. The skin is leathery, with small, deeply embedded scales. Radii are on all fields of the scales, and the lateral line is complete or incomplete, with 69–79 scales. There are 7 or 8 anal rays. The pharyngeal teeth are in a single row, 0,5-4,0. The maximum SL is 76 mm.

The body is olivaceous above, with a broad, dusky middorsal stripe interrupted by a cream-colored spot at the origin of the dorsal fin. Greenish brown blotches are along the upper side. A turquoise stripe, most intense posteriorly, is also present above a dark golden brown stripe on the side, which ends in a discrete black spot that begins near the end of the hypural plate and extends onto the medial caudal rays. The belly is dusky to dirty cream in color. Breeding individuals have intensified dark pigmentation but apparently develop no other distinctive pigmentation. Small, blunt tubercles are on top of the head and less on the opercles and occur as smaller, pointed structures on the upper surface of the body and the sides of the caudal peduncle.

Distribution and Status The monotypic genus *Moapa* Hubbs is endemic to thermal, constant-temperature headwater springs of the Moapa (Muddy) River, Clark County, southeastern Nevada (map 4.34). The springs lie in an arc ~4.8 km long near the foot of stony terraces marking the former course of pluvial White River southward from Arrowhead Canyon (see Hubbs and Miller 1948a, pl. 3). The species now occupies about 9.5 km of habitat within five spring systems

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C. H. Gilbert [1893]) and also noted, based on local testimony, that water likely flowed down Vegas Wash to the Colorado River after heavy rains. He further recorded cottonwoods (*Populus* spp.) and willows (*Salix* spp.) along the banks, and that the valley below the springs had firm, fine soils, black and rich when watered, and large meadows. In 1903, the collective discharge of all springs was 9.75 m^3/min. The discharge of one spring in 1908 was ~0.71–0.83 m^3/min, and the combined flow of the other two was ~1.31 m^3/min in 1912. The fish was again noted in 1934, as a possible contaminant of a domestic water supply.

Remnants of the natural system remained in 1938, when the types of *Rhinichthys deaconi* were collected in a Las Vegas park. A cottonwood limb blown down by a windstorm almost disabled Frances Hubbs, Dr. Robert Miller's future wife (R. R. Miller et al. 1991). Local residents again reported that springs spreading over an area of 6.2 ha were the original and principal sources of Las Vegas Creek. In 1938, the system began in two springs, neither warm nor cold, and in several deep artesian wells ~2.7 km from the Las Vegas town center, and was used as a city and ranch water supply. There were other smaller inflows along the main channel. The creek was clear, 1–6 m wide, with a bottom of sand, gravel, and mud and no aquatic plants other than cattails. The current was moderate, varying from none to swift, and depths were ~15–46 cm. The only remnant of the system in 1983 was a deep pit with stagnant water at its bottom (R. R. Miller 1984).

Additional References (Synonyms: *Rhinichthys* sp., *R.* [*Apocope*] *nevadensis*, *R. osculus* [in part]; see C. H. Gilbert 1893; C. L. Hubbs and Miller 1948b; LaRivers 1962; Bradley and Deacon 1967.) G. R. Smith et al. (2002); G. R. Smith and Dowling (2008); Spencer et al. (2008).

Rhinichthys osculus (Girard), speckled dace

Description *Rhinichthys osculus* (fig. 4.67; pl. 27), as now recognized, is almost certainly the most variable fish in western North America (R. R. Miller and Miller 1948). Quantitative information for the complex as a whole includes moderately small scales, rarely <60 or >90 in the lateral line; 6–9 (usually 8) dorsal rays; and 7 (rarely 6) anal rays. The pharyngeal teeth are in two rows in various combinations of 1 or 2,4-4,1 or 2. SL seldom exceeds 88 mm.

The body color can vary as dramatically as other characters, from an olivaceous background through gray to light tan, always darker above and lighter below. Dark brown to black pigments are usually present, ranging from small, fine speckles to sizable blotches that may coalesce into a single or double lateral band. A few populations (or individuals within a population) are almost unicolored, while others have profuse speckles over essentially all body surfaces. Males of all forms have intensified dark pigments when breeding and develop brilliant red or orange red on the bases of the paired fins and nearby body surfaces; on and near the anal fin base; and on the lower caudal peduncle, the lower lobe of the caudal fin, and the mouth, cheeks, and upper opercles.

This remarkable complex of fishes is often referred to the subgenus *Apocope* Cope, distinguished mostly by nuptial tuberculation from *Rhinichthys* of northern and eastern North America. Tubercles are absent from the leading (unbranched) pectoral ray and the head, body, and other fins. They only occur, one per segment and usually uniserially, on the first several branched rays (at least rays 2–4 or 5) of the pectorals. Another character for *Apocope* is the absence or weak development of a frenum (C. L. Hubbs et al. 1974; R. R. Miller 1984), a character not always holding true in swift-water forms in the Colorado basin, where a frenum is perhaps secondarily derived.

Many taxa of stream-inhabiting fishes in the region share a combination of morphological features quite distinct from those isolated in desert springs (C. L. Hubbs 1941a, 1941b). This pattern exists within the *R. osculus* complex as well (R. R. Miller 1984). Forms that occupy flowing water share

elongate, slender bodies; large, falcate dorsal and anal fins; the frenum often or usually well developed; the barbel invariably present; generally small, closely

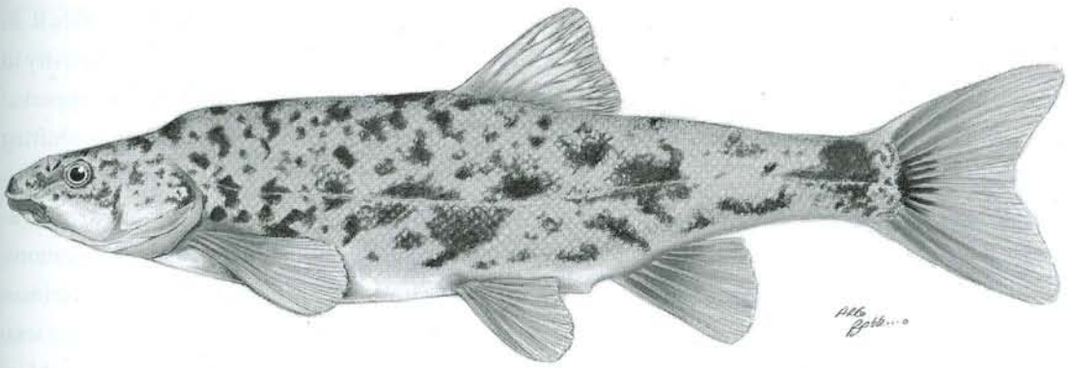

FIGURE 4.67. *Rhinichthys osculus* (Girard), speckled dace (*pl. 27*).

imbricated scales; a more anteriorly placed dorsal fin; and a large, deeply forked caudal fin. (R. R. Miller 1984, 15)

In contrast, populations in desert springs and marshes tend to have

a rather chubby body, small rounded fins and reduced ray counts, weak or no barbels . . . , no frenum or at most a weak one . . . , a posteriorly placed dorsal fin, a moderately large and often oblique mouth, an obsolescent lateral line . . . , and relatively large and comparatively loosely imbricated scales. (R. R. Miller 1984, 15)

The large number of different names applied to *R. osculus* in the Southwest alone reflects not only the vagaries of taxonomy but also confusion on the part of early and later workers confronted with the remarkable variation in morphology and pigmentation. A number of distinctive named taxa exist, and additional unnamed forms have been identified.

Two forms widespread in the lower Colorado basin are, first, a large, more banded to unicolored, streamlined kind referable to *Rhinichthys osculus yarrowi* (Jordan and Evermann) in streams draining from the southern and western margins of the Colorado Plateau (Mogollon Rim). The form ranges through the Little Colorado and San Juan drainages, the mainstem Colorado and Virgin rivers, and northward. Second is *R. o. osculus* (Girard), a small, chubby-bodied, highly speckled or blotched form occupying southern parts of the Gila River system. It is now reduced to four known remnants, one each in the San Simon and Santa Cruz basins and two in the Río San Pedro, all in Arizona. It is tempting to attribute the morphology of this southern form to spring adaptations arising in isolated, closed systems in the old regional basin and range (Nations et al. 1982), retained by fish living in *ciénegas* and other lower-gradient habitats of the now-integrated system.

Rhinichthys o. yarrowi and *R. o. osculus* seem to intergrade chaotically, in pigmentation at least, in a broad zone from the northwestern corner to the south-central border of Arizona on either side of a line generally marked by the Mogollon Rim. This intergradation was thought by W. L. Minckley (1973) to result from repeated transfer of the two by headwater stream captures over a long period of time, but such a pattern is not substantiated by recent genetic information (D. Oakey, pers. comm.).

A number of other distinctive local forms also exist, some clearly representing swift-water morphs and others of the spring-inhabiting body form. *Rhinichthys osculus moapae* Williams (J. E. Williams 1978) is known only in the Moapa River, in southern Nevada. It is large in size with a slender, torpedo-shaped body; a long head and snout; and large, falcate dorsal and anal fins. The caudal fin also is expanded and deeply forked. A well-developed premaxillary frenum and barbels are present. The body is silver blue dorsally and silvery below, a lateral band is present in life, and dark speckles are absent on most. As clarified by R. R. Miller (1984),

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R. o. velifer (Gilbert) is another swift-water morph in the Pahranagat Valley, Nevada. It is slender and terete with large, falcate dorsal and anal fins (the dorsal fin also is anterior in position), 8 dorsal and pelvic rays, and a well-developed frenum; barbels are almost invariably present. The pluvial White River and Pahranagat Valley also support one or more unnamed, chubby-bodied, small-finned dace with rounded dorsal and anal fins, a posteriorly placed dorsal fin, and 7 dorsal and pelvic rays; it typically lacks both a frenum and barbels. J. E. Williams (1978) and C. D. Williams and J. E. Williams (1982), perhaps misled by LaRivers (1962), erred in referring this(ese) form(s) to *R. o. velifer* (R. R. Miller 1984).

Other, unnamed morphs exist—for example, swift-water types in Grand-Marble and Salt River canyons and some lesser watercourses, and chubby, blunt-nosed, dark-colored stocks in springs along the Virgin River, some tributary to Grand-Marble Canyon, and elsewhere. Included in this array is the extinct *Rhinichthys deaconi* (R. R. Miller 1984). Another novel form in the Colorado basin is *R. o. thermalis* (C. L. Hubbs and Kuhne 1937), known only from a Wyoming warm spring (Kaya et al. 1992; Gryska and Hubert 1997).

Interrelationships of this diverse assemblage are anything but simple and are not yet understood, even with the application of molecular techniques. Similar forms may be independent derivations from quite different ancestors. Alternatively, divergent morphs may have arisen from similar progenitors, and hybridization may also be a factor. Additionally, the natural extinction of isolates with unique features of their evolutionary past lost forever is undoubtedly extensive. Finally, with continued human exploitation of surface water, so many more populations of this and other complexes are being eliminated that unraveling their relationships may never be possible, illustrating further the human tendency to allow the unexplored to vanish.

Distribution and Status The speckled dace is the only native fish species represented in all seven major drainages of the western United States (map 4.38), occurring as well in essentially all internal basins known to support fishes (C. L. Hubbs and Miller 1948b; R. R. Miller 1959a; C. L. Hubbs et al. 1974). Its proclivity to invade tiny headwater streams enhances the opportunities for migration between watersheds with shifting drainage divides, and an apparent capability to disperse through low-desert rivers has resulted in occupation of springs or streams at almost all elevations, even in the Death Valley system (Soltz and Naiman 1978). In the Southwest, the speckled dace is (or was) in all Colorado basin drainages in Arizona, New Mexico, and Nevada (W. L. Minckley 1973; Deacon and Williams 1984; Sublette et al. 1990), and also in the Los Angeles basin in California (Cornelius 1969; Swift et al. 1993). It originated in the last through drainage transfer related to the Pliocene integration of the lower Colorado River basin. Although not represented by specimens known to us, the speckled dace must also have occurred in the Gila River system (Colorado River basin) in México, in the San Pedro or Santa Cruz River or both. It is introduced and established in the Mimbres River, New Mexico (Sublette et al. 1990).

Speckled dace lived in historic times in larger streams as low as ~330 m (Salt River, Arizona) and in the mainstem Colorado, but it now is rare below ~1000 m, or higher in some areas (LaBounty and Minckley 1972). It ranges in the north to maxima of 1800+ m; in southern parts of the region, it remains locally common in small- to moderate-sized pool-and-riffle creeks between 1200 and 2200 m. As with many small-stream fishes, the lower Colorado River must have been inhospitable for permanent occupation, in part because of high water temperatures in summer, but also perhaps because of the prevalence of soft, shifting sand bottoms, which this species may avoid. The only record below Grand-Marble Canyon is for a larva taken over a razorback sucker breeding area in Lake Mohave (P. A. Douglas 1952; reidentified by Winn and Miller 1954).

As pointed out by Minckley (1991b), the ubiquity of speckled dace may spell danger, especially if it represents a complex of species (as many suspect) rather than a single, variable, widespread taxon. Commonness breeds complacency, and many studies targeting endangered or threatened species ignore other faunal

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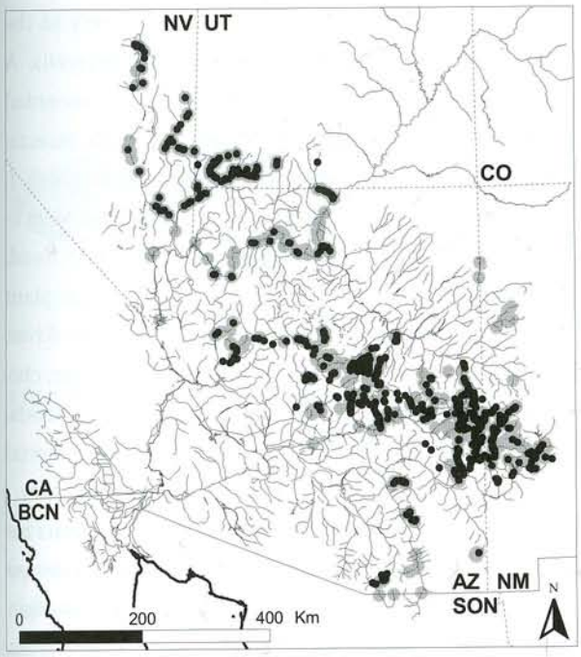

MAP 4.38. Distribution of *Rhinichthys osculus* (Girard), speckled dace. Gray circles represent historical (pre-1980) collections; black circles are 1980 and later records.

elements. For example, significant numbers of streams are poisoned to allow recovery of endemic trouts, which are restocked after renovation, but non-target species are not repatriated. Native minnows and suckers suffer as a result (J. N. Rinne and Turner 1991), and because of its widespread nature, the speckled dace is bearing the brunt of this practice.

Habitat and Biology Speckled dace usually occupy waters <0.5 meter deep, often congregating in pools below riffles and eddies. Breeding adults, particularly males, prefer swifter water, and both sexes are sometimes numerous in late winter and early spring in swirling turbulence behind stones or other obstructions in fast riffles. They occur along the channel in large rivers, usually adjacent to strongly flowing reaches and alongside torrential rapids. Large numbers may be seined on sand-and-gravel bars of the Colorado River in Grand-Marble Canyon and upstream in the Green and Colorado rivers and their larger tributaries.

According to Deacon et al. (1987), speckled dace from the Virgin River in Arizona, Nevada, and Utah prefer cool temperatures of 9.5°C–16°C but can resist temperatures exceeding 36°C if appropriately acclimated. The last notwithstanding, Lowe et al. (1967) found the species had relatively low tolerance for elevated temperature and reduced oxygen, attributing the elevational range in Arizona to those limitations.

Reproductive behavior in the wild has scarcely been detailed (see, however, Kaya 1991). Sublette et al. (1990, 181–82) noted that male *Rhinichthys osculus* "build . . . nests by cleaning gravel clear of aufwuchs [encrusting organics] and debris. When a female enters the cleared area, a cluster of males immediately surrounds her. As the female thrusts the posterior part of the body into the gravel bed and oviposits, the attendant males release sperm into the gravel." They cited no source for these observations. In other species of *Rhinichthys* in the eastern United States (Breder and Rosen 1966), males construct nests both by fanning gravel bottoms with the fins and body and "rooting" with the snout. Other species also are markedly territorial, defending a nest site and spawning with numerous females over a period of days. The spacing of males on riffles implies that this behavior may occur in speckled dace, but active defense of single sites has not been observed. Spawning by most species involves a single pair, with a male pressing his head and anterior body against the female, placing his caudal peduncle over her body, and performing rapid vibrations. The last behavior continues a few seconds, presumably coincident with release of gametes, and then the pair lies quietly for a moment before separating. After hatching in ~6 days at 18°C–19°C, larvae remain in interstices of gravel for 7–8 days (John 1963), then, in the Colorado mainstem at least (Carter et al. 1986), drift downstream in large numbers to enter backwater habitats to feed and grow.

John (1963) studied the reproduction of *Rhinichthys osculus* in intermittent streams of the Chiricahua Mountains, Arizona, documenting a breeding period in early spring and another in late summer. The first was coincident with rising water temperature, day length, and snowmelt runoff. The second was thought a response to summer rains, if at an appropriate time. Spawning did not occur without rain or if precipitation was in early summer but was common after late-summer flooding. Although late-summer repro-

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duction is not rare, in speckled dace or other native fishes, spawning was rarely detected as a highly correlated, direct response to summer floods in perennial Aravaipa Creek (e.g., Barber and Minckley 1971). It is likely that some factor related to flooding, such as mixing and cleaning of the gravel substrate by increased flow, is more important as a cue than changes in water volume. Mueller (1984) described spawning by several hundred specked dace in the San Francisco River (Gila River basin), New Mexico, over substrates disturbed by heavy equipment in the stream channel, which he interpreted as a surrogate of the natural conditions of scour, turbidity, and discharge fluctuation that initiate breeding elsewhere. Rapid apparent response to high runoff is, however, evident in recruitment in some southwestern stream fishes. Populations essentially disappearing over a number of low-discharge years almost invariably enjoy high recruitment success and quickly increase in numbers when conditions improve, but rapid surges in abundance do not necessarily result from two separate spawning periods.

In Grand-Marble Canyon (S. J. Carothers and Minckley 1981), speckled dace enter creeks that flow into the perennially cold Colorado River below Lake Powell in March to reproduce in April and May at water temperatures of 17°C–23°C. Young dace were common by late May and June; young and adults tended to remain through summer and autumn; then both disappeared into the mainstream in winter. C. O. Minckley (1978) attributed the exodus to interference by spawning, non-native trouts, but it also is possible that winter river temperature (then equally as warm as tributaries) made the channel more acceptable at that time of year (Suttkus and Clemmer 1979).

Adult speckled dace maintain position in streams during flash floods (Minckley and Meffe 1987), but young may be carried to their death in downstream pools that later desiccate (John 1964). The species also persists, however, even when crowded, diseased, and apparently starving, in intermittent pools for an amazingly long time during drought.

This fish often forages on or near the bottom, sometimes rising to midwater or more rarely to the surface to inspect and devour floating materials. A variety of studies in various habitats have recorded omnivory, with food items including aquatic insects, algae, detritus, and a few terrestrial invertebrates (S. J. Carothers and Minckley 1981; Schreiber and Minckley 1982; Angradi et al. 1991). On the other hand, Greger and Deacon (1988) reported virtually no plant material in diets of speckled dace in the Virgin River, with dipteran larvae (simuliids in February–June; chironomids in September–December) as major foods. Van Eimeren (1988) also found little plant material and mostly simuliids and chironomid larvae as prey.

Additional References (Synonyms: *Argyreus osculus, A. notabilis*; *Ceratichthys ventricosus*; *Apocope oscula, A. couesii, A. ventricosa, A. vulnerata*; *Agosia osculus, A. couesii*; *Rhinichthys nubilus*; see W. L. Minckley 1973; C. L. Hubbs et al. 1974.) Girard (1857, 1859a); Cope (1874); Cope and Yarrow (1875); Jordan and Gilbert (1883); Jordan (1886); Evermann and Kendall (1894); Evermann and Rutter (1895); Jordan and Evermann (1896); Gilbert and Scofield (1898); Meek (1904); D. S. Jordan et al. (1930); Tanner (1932, 1936); R. R. Miller and R. G. Miller (1948); LaRivers (1952); LaRivers and Trelease (1952); R. R. Miller (1952b, 1961b, 1963a, 1964a); Winn and Miller (1954); Koster (1957); R. R. Miller and Hubbs (1960); LaRivers (1962); Sigler and Miller (1963); R. R. Miller and Lowe (1964, 1967); W. L. Minckley (1965a, 1969a, 1971, 1981, 1987); Barber and Minckley (1966); Bradley and Deacon (1967); Lowe (1967); W. L. Minckley and Deacon (1968); Cornelius (1969); Stout et al. (1970); C. Hubbs and Echelle (1972); Schreiber (1978); Wallace (1980b); D. E. Snyder (1981); Baltz et al. (1982); Mpoame (1982); Mpoame and Rinne (1983); Carter et al. (1986); Propst et al. (1986, 1988); Deacon et al. (1987); Robinson et al. (1998); G. R. Smith et al. (2002); Oakey et al. (2004); Propst and Gido (2004); Propst et al. (2008); G. R. Smith and Dowling (2008); Spencer et al. (2008).

Tiaroga cobitis Girard, loach minnow

Description *Tiaroga cobitis* (fig. 4.68; pl. 28) is elongate, subfusiform, little compressed from side to

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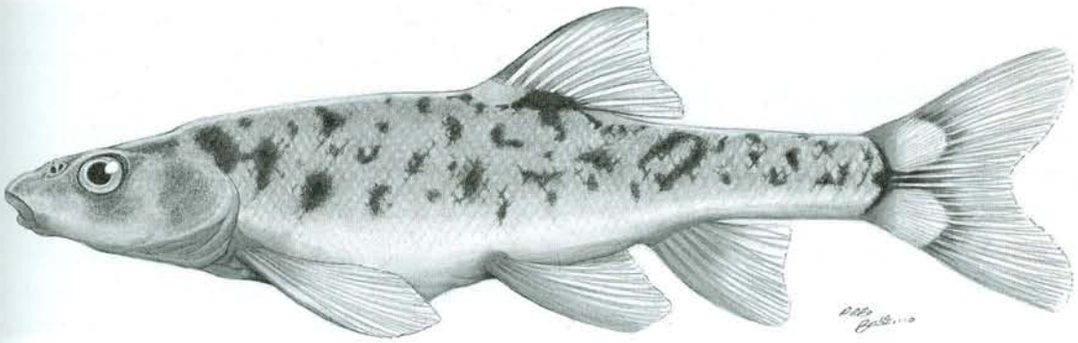
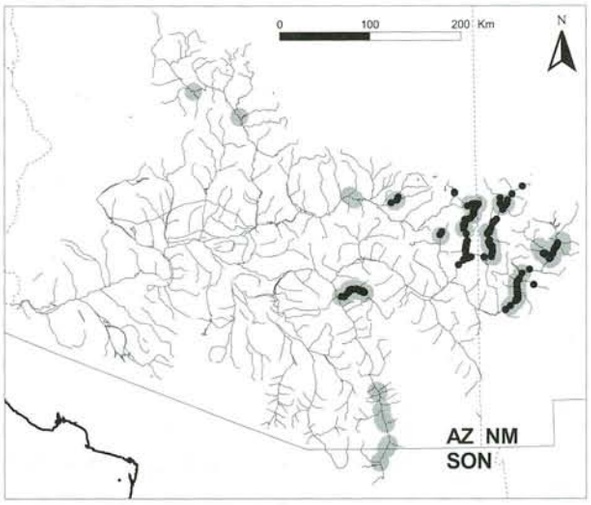


FIGURE 4.68. *Tiaroga cobitis* Girard, loach minnow (*pl. 28*).

side, sometimes humped behind the nape, and flattened ventrally. The mouth is small, terminal, and oblique and lacks barbels. The upper lip and snout are connected by a broad frenum, the gill openings are restricted, and the air bladder is reduced. There are 8 dorsal rays, 7 anal rays, and 65–70 lateral-line scales. Scales are absent or deeply embedded on the breast, belly, and the anterior and midline of the back. The pharyngeal teeth are in two rows, 1,4-4,1. This is a small species, rarely >70 mm SL.

The ground color is olivaceous, highly blotched and speckled with dark brown or black; the belly is immaculate, cream colored to white. Dirty white to cream-colored blotches are present before and behind the dorsal base and on the upper and lower edges of the caudal peduncle, the latter extending onto the proximal caudal fin, with a black basicaudal spot separating the upper and lower lightened areas. Breeding males develop vivid red to red orange on the fin bases and adjacent body surfaces; on the mouth and lower head, including the branchiostegal rays; often over the abdomen; and on the ventral caudal peduncle. Tuberculation is restricted mostly to males on the distal two-thirds of the second to fourth (rarely fifth) pectoral rays. Reproductive females have yellow to pale orange pigments on their lower body and fins and sometimes a few diminutive tubercles on the pectoral rays.

Distribution and Status The loach minnow is endemic to the Gila River basin in Arizona, New Mexico, and Sonora (map 4.39). It occurs between ~330 m and below ~2200 m elevation, almost exclusively in streams with clean, loose, gravel bottoms. It is increasingly rare, in part because of deterioration of its special habitat but also likely because of competitive and predative interactions with non-native fishes. R. R. Miller and Winn (1951) recorded it from headwaters of the Río San Pedro in Sonora, but it has not since been taken from upper parts of that basin in either Arizona or Sonora. It is listed as threatened by USFWS (1985h, 1986d) and as endangered in México (SEDESOL 1994). Critical habitat designation for this species has followed a path nearly identical to that for spikedace



MAP 4.39. Distribution of *Tiaroga cobitis* Girard, loach minnow. Gray circles represent historical (pre-1980) collections; black circles are 1980 and later records.

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(USFWS 1994h) and remains unresolved. A recovery plan is available (USFWS 1991d).

Habitat and Biology *Tiaroga cobitis* is a specialized little fish characterizing gravelly riffles. Adults are often associated with beds of coarse filamentous algae (*Cladophora*, *Pitophora*) either in shallow, swift, and turbulent reaches or along margins of torrential rapids and riffles (Barber and Minckley 1966; J. N. Rinne 1989; Propst and Bestgen 1991), although sluggish silty streams also are occupied (Marsh, Bagley, et al. 2003). Selection of various physical habitat parameters varies geographically, ontogenetically, and seasonally (Propst et al. 1988). In many respects, loach minnow behavior resembles that of darters (Percidae) of the eastern United States, particularly riffle-dwelling species of *Etheostoma*. As with many darters, loach minnows support themselves on the bottom with their pectoral fins, lifting the head to inspect floating debris or swimming from place to place in short bursts with exaggerated lateral body movements.

In most streams, the loach minnow's closest associates are speckled dace and juvenile desert suckers. The loach minnow and the sucker remain on the bottom at all times; both tend to be heavier than water and sink quickly unless swimming vigorously. The sucker feeds almost exclusively on diatomaceous films, other algae, and aufwuchs (encrusting organics) scraped from rocks, so any competitive interaction should be mostly for space. The loach minnow and the dace both eat aquatic insects, the former exclusively and the latter tending toward omnivory. Speckled dace can and do move readily in midwater, where they inspect and eat drifting materials. Sometimes, association of the two minnows seems almost mutually exclusive, with loach minnow on riffles and speckled dace in pools, especially under conditions of low flows, implying some kind of competition.

Loach minnow feed on riffle-inhabiting aquatic insects captured directly from the bottom, particularly simuliid and chironomid dipterans and mayfly larvae (Britt 1982; Propst et al. 1988; Abarca 1989; Propst and Bestgen 1991). Their feeding habits seem correlated with food availability, with rapid shifts from one major group to another closely following insect emergences, floods, or other factors that alter the invertebrate fauna (Schreiber and Minckley 1982).

Most spawning is in late winter–spring (February–May; W. L. Minckley 1973; Britt 1982; Propst et al. 1988), but it also occurs, occasionally at least, in late summer (Vives and Minckley 1991). Spawning is in the same riffles adults occupy in nonreproduction periods. Adhesive eggs are deposited on the undersides of flat rocks with cavities opening on the downstream side and the upstream side embedded in the substrate. It is not known if males excavate these "nests" or discover and use (perhaps clearing and enlarging) natural cavities; the latter seems most likely. Fecundity of individual females varies positively with size from 150 to 250 mature ova. Numbers of ova per "nest" are relatively few, 5 to ~250; means among populations vary from 52 to 63. Mature ova tend to be greater in diameter in females >60 mm TL (1.5–1.7 vs. 1.4–1.6 mm in smaller fish) (Britt 1982). Hatching occurs in 5–6 days at 18°C–20°C; larvae are ~5.0 mm TL at hatching. Growth proceeds throughout the year, faster in summer and slower in winter, so juveniles attain a maximum of ~60 mm TL in their first year. The first spawn occurs in the second summer of life, although some large individuals could (and may) spawn in their first autumn; few (if any) live to spawn a third summer.

Additional References (Synonyms: *Cliola cobitis*, *Rhinichthys cobitis*; see W. L. Minckley 1973, in part.) Girard (1857, 1859b); Jordan (1885a, 1885b, 1963); Evermann and Rutter (1895); Jordan and Evermann (1896); Gilbert and Scofield (1898); Jordan et al. (1930); R. R. Miller (1946c, 1961b, 1964b, 1969, 1972a); Winn and Miller (1954); Koster (1957); R. R. Miller and Lowe (1964, 1967); W. L. Minckley (1965b, 1971, 1980d, 1981, 1987); Barber and Minckley (1966); Branson (1966); W. L. Minckley and Carufel (1967); Cole (1968); Kobetich (1969); C. Hubbs and Echelle (1972); LaBounty and Minckley (1972); Hatch (1978, 1979); Schreiber (1978); Schreiber and Minckley (1982); J. E. Williams et al. (1985); Bestgen and Propst (1986); Propst et al. (1986, 1988, 2008); Vives and Minckley (1991); J. N. Rinne (1992); Knowles et al. (1995).

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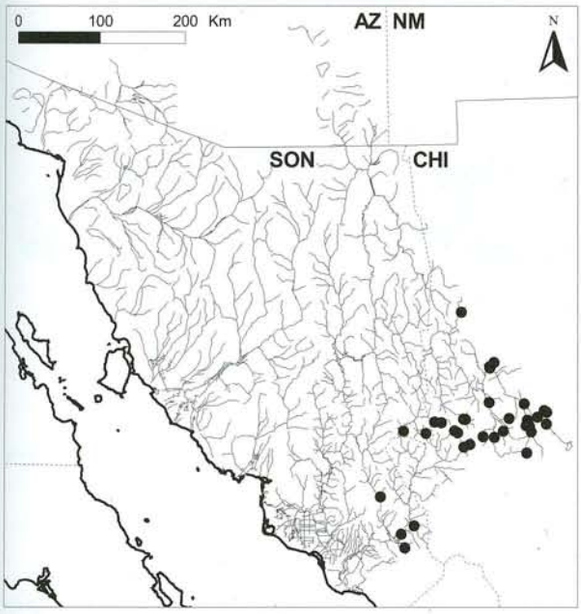

MAP 4.41. Distribution of *Catostomus cahita* Siebert and Minckley, Cahita sucker, matalote cahita. Black circles are all known records.

with Yaqui suckers. Most were in slight to moderate current over sand, gravel, rock, or boulder substrates, seeming to avoid strong currents. Associated aquatic vegetation consisted of green algae and sparse *Potamogeton*.

Additional References (Synonyms: *Pantosteus plebeius* [misidentification], *Catostomus* sp.; see Siebert and Minckley 1986.) Meek (1902, 1904); R. R. Miller (1959a); Hendrickson et al (1981).

Catostomus insignis Girard, Sonora sucker, matalote sonoriense

Description The Sonora sucker (fig. 4.85; pl. 30) has a thick, fusiform body, including a robust, stubby caudal peduncle. The head and snout are large, rounded dorsally, and flattened below. Moderately expanded fleshy lobes form the lower lip (except in rare individuals; see below), which is only ~3 times as wide as the upper lip. The dorsal fin is square distally and usually has 11 rays (rarely 12). The scales are relatively large, typically <60 (54–67) in the lateral line, crowded anteriorly but not markedly so. The maximum SL is ~61 cm, but few exceed ~50 cm. The head and body are sharply bicolored, brownish dorsally and yellow beneath. The dorsolateral scales are sharply outlined by melanophores, each with a discrete broadening into variably distinct spots arranged to form punctate lines on the upper sides (especially in dark individuals). The interradials of the dorsal, caudal, and pectoral fins are variously darkened, but the anal and pelvic fins are usually yellow or yellow white, similar to the coloring of adjacent body surfaces.

Some exceptionally large individuals otherwise identifiable as *C. insignis* develop massive, soft, and fleshy lobes of the lower lip, far more than is typical even for *C. latipinnis*. Such individuals are rare, and we have not seen one for more than a decade; the significance of this condition is unknown.

Distribution and Status *Catostomus insignis* is endemic to the upper Gila and Bill Williams rivers in Arizona, New Mexico, and Sonora (map 4.42). Interestingly, it was never reported in the Gila system downstream from what is now the Phoenix metropolitan area, Arizona, perhaps avoiding the soft, shifting sand bottoms characterizing the lower mainstem. The Sonora sucker remains common in better-watered northern, western, and central parts of its range but is increasingly rare and localized or extirpated in drier landscapes in the south. It is listed as endangered by SEDESOL (1994).

Habitat and Biology Adults seek deep water and shade in pools along cliff faces, in log piles, or in other kinds of cover in daytime. Remarkable numbers sometimes are hiding in such places, in small, almost-intermittent streams during summer drought. When concentrated, they are highly vulnerable to biologists with electrofishing equipment or seines, and presumably were so in the past to Native Americans, who used the species extensively as food. Their remains are often the most common of all fish bones in archaeological sites in central and southern Arizona (W. L. Minckley and Alger 1968; W. L. Minckley 1975, 1976; S. R. James 1993, 1994).

Large individuals move onto riffles and along margins of pools to feed at night, mostly on aquatic inver-

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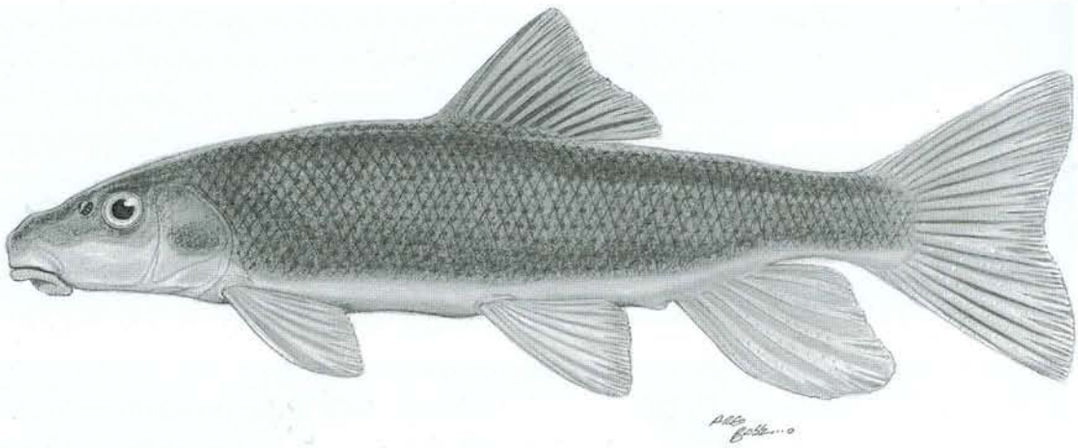
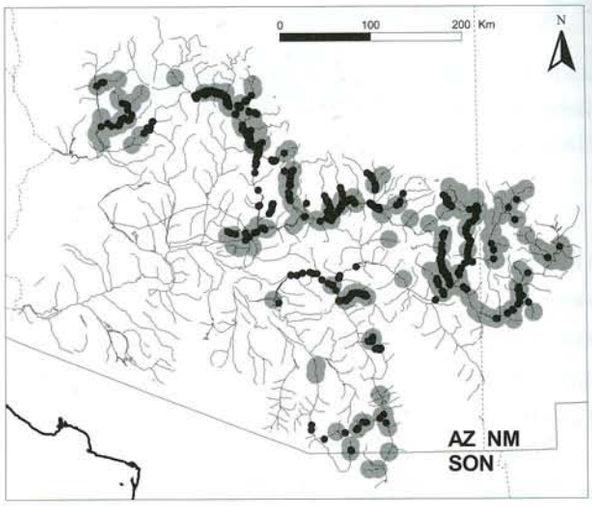


FIGURE 4.85. *Catostomus insignis* Girard, Sonora sucker, matalote sonoriense (*pl. 30*).

tebrates (Schreiber and Minckley 1982; R. W. Clarkson and Minckley 1988). They stir the bottom when feeding, dislodging materials that drift downstream to attract other, more midwater species, mostly small minnows. When Sonora suckers are concentrated in pools, the guts of adults may be filled with plant debris, mud, and/or algae. Airborne cottonwood seeds floating on the water surface also are taken. Large fish lift their heads upward and sideways clear of the water to "suck" clumsily with their ventral mouths at seed rafts accumulated behind obstructions, and their digestive tracts are packed with these seeds. Younger, smaller suckers occupy shallower water, aggregating in large, loose schools in runs or slow riffles to feed on insect larvae and debris.

Reproduction is in late winter, spring, and early summer, from January (more usually February–March) through early July, and occasionally during and following late summer rains. Some populations appear not to recruit for a number of years, then produce strong year-classes for two or more years in a row. Little apparent correspondence has been detected, other than with water temperatures (warm winters often result in earlier spawning), of reproductive seasonality or of either positive or negative recruitment success and broader patterns of stream flow or climatic conditions.

Areas where Sonora suckers and other catostomids spawn on shallow riffles can be identified as elongate clean patches where algae- or debris-coated gravel bottoms are stirred and disturbed. Eggs and larvae are buried in the gravel, from which they are readily obtained by stirring the bottom into a fine screen held downflow. After hatching and exiting the bottom, larvae usually drift downstream for a distance before stopping alongshore and in backwaters to feed and grow (Propst et al. 1987). Sonora suckers hybridize in nature with razorback and desert suckers (C. L. Hubbs et al. 1943; R. W. Clarkson and Minckley 1988), perhaps in part because of their prolonged, often coincident breeding seasons.



MAP 4.42. Distribution of *Catostomus insignis* Girard, Sonora sucker, matalote sonoriense. Gray circles represent historical (pre-1980) collections; black circles are 1980 and later records.

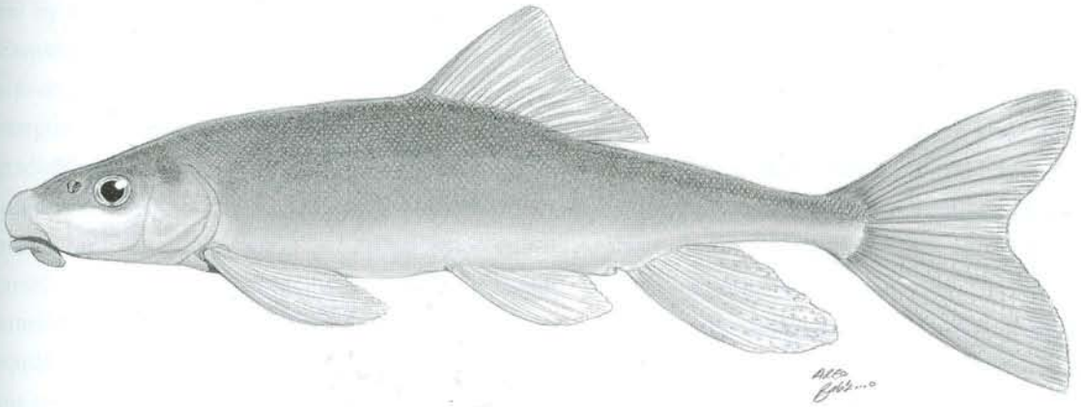


FIGURE 4.86. *Catostomus latipinnis* Baird and Girard, flannelmouth sucker (*pl. 31*).

As with most southwestern fishes, Sonora suckers seem intolerant of reservoir conditions. Only a few were captured in six years of test netting in Roosevelt Lake, Arizona (J. E. Johnson et al. 1970; Bersell 1973; J. N. Rinne 1973, 1975b). They must enter from inflowing streams; even greater efforts in reservoirs with no natural inflows produced no captures.

Additional References (Synonyms: *Minomus insignis, Catostomus insigne, C. gila*; see W. L. Minckley 1973.) S. F. Baird and Girard (1854); Girard (1857, 1859b); Cope and Yarrow (1875); Jordan (1885a, 1885b, 1963); H. W. Fowler (1913); Koster (1957); Barber and Minckley (1966); Amin (1968, 1969b); A. E. James (1968); Kobetich (1969); G. R. Smith and Koehn (1971); C. Hubbs and Echelle (1972); LaBounty and Minckley (1972); W. L. Minckley (1973, 1980g); Schreiber (1978); Clarkson (1982); Mpoame (1982); Mpoame and Rinne (1983); Propst et al. (1986, 1988); Bestgen et al. (1987); C. M. Williams (1991); Propst et al. (2008).

Catostomus latipinnis Baird and Girard, flannelmouth sucker

Description *Catostomus latipinnis* (fig. 4.86; pl. 31) is elongate, fusiform, thickened anteriorly, and thin posteriorly. The caudal peduncle varies from relatively thick to thin and pencil-like, the latter sometimes so extreme that F. W. Chamberlain (see W. L. Minckley 1999b, 211) called individuals from Salt River, Arizona, "bonytail" suckers. The head is relatively long but thick, rounded above and flat below; the enlarged lower lip has large, fleshy lobes that become more expansive in old (large) adults. The lower lip also is deeply incised, with no papillae (or rarely 1 row) crossing the narrow midline. There are 5–6 papillae crossing the midline of the upper lip. All the fins are large, thickened anteriorly, and leathery, the dorsal fin typically falcate with 10–14 (usually >12) rays. The scales are relatively small, with 90–116 in the lateral line, and are often deeply embedded on the anterior body surfaces. The maximum SL may be >56 cm.

The body color is usually light gray, tan, or greenish brown dorsally and lighter below. The dorsolateral scales are sometimes outlined by melanophores or marked by scattered dark blotches on the upper sides, coalescing middorsally into a uniformly darkened dorsal surface. The vertical fin interradials are often transparent, sometimes dusky, and rarely dark brown; the paired fins may be either white or essentially transparent. With the exception of a general darkening of the body, no breeding colors have been noted in Arizona populations. Some develop yellow or orange on the fins and rarely a faint, brownish, or russet-colored lateral band (W. L. Minckley 1991b). A yellowish, red, or red brown lateral band often appears in breeding individuals from the upper Colorado basin (McAda 1977; McAda and Wydoski 1985).

Natural hybridization between flannelmouth and razorback suckers has long been known (C. L. Hubbs and Miller 1953; Buth et al. 1987; W. L. Minckley, Marsh, et al. 1991), but occurrences are few (see also

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Distribution and Status The Little Colorado sucker is restricted to the upper Little Colorado River basin in Arizona (map 4.46). W. L. Minckley (1973, 159) reported an apparent introduction into the Salt River, Arizona, where it co-occurred with Sonora and flannelmouth suckers but apparently never established. A conservation plan for the Little Colorado sucker and several other species has been developed (AZGFD 2006).

Habitat and Biology This sucker occupies pools in the daytime, as is typical of many large species of *Catostomus*, most commonly in deep water in canyon-bound reaches, along canyon walls and near boulders or other larger obstructions. Adults disturb large areas of gravel and sand when foraging on riffles and runs in late evening, at night, and in the early morning. Foods consist of aquatic invertebrates along with detritus, algae, and some higher plants. Young tend to occupy slow-moving riffles and runs along with subadult bluehead suckers and adult speckled dace (in part, W. L. Minckley 1973).

Additional References Jordan and Gilbert (1883); Evermann and Rutter (1895); Jordan and Evermann (1896); Jordan et al. (1930); Rostlund (1952); Eddy (1957); and R. R. Miller and Lowe (1964, 1967) as *Catostomus latipinnis*. R. R. Miller and Hubbs (1960); R. R. Miller (1963a); Koehn (1966); G. R. Smith (1966); W. L. Minckley (1971, 1980j); Dobberfuhl (1995).

Pantosteus clarki (Baird and Girard), desert sucker, matalote del desierto

Description Morphological variation in populations now assigned to *Pantosteus clarki* (fig. 4.90; pl. 33), as noted by W. L. Minckley (1973, 166–169) more than 30 years ago, remains difficult to interpret. G. R. Smith's (1966) diagnosis, which he considered then and still considers now to include a complex of more than one species, is below (brackets are ours):

lips large with small papillae evenly dispersed over lower lip and oral face of upper lip, but absent from anterior face of upper lip; lateral notches at juncture of lower and upper lip well developed; median notch in lower lip shallow, separated from upper by 4–7 rows of papillae; ridge of lower jaw truncate, 4.1 to 8.7, usually 5 to 8 percent of standard length; width of isthmus 6.9 to 11.0, usually 8 to 11 percent of standard length; gill rakers 28–43 (usually 30–40) in external row and 38–59 in internal row of first arch in specimens over 70 mm in standard length; . . . frontoparietal fontanelle usually closed in adults, reduced in young specimens; peritoneum usually black, occasionally dusky; intestine long, up to 8.8 times standard length with 6 to 16 coils anterior to liver, usually 10 or more coils in specimens over 70 mm in standard length; swimbladder reduced or not, length 15 to 30 per cent of standard length; scales in the lateral line 61 to 104, usually 65 to 80 in the Gila drainage, 70 to 80 in the White River drainage [Nevada] [considered here as *Pantosteus intermedius*]; 75 to 90 in Meadow Valley Wash [Nevada] and Beaver Dam Wash [Nevada and Arizona]; and 80 to 100 in the Virgin River [Nevada, Arizona, and Utah] and Bill Williams River [Arizona] drainages; predorsal scales 13 to 52, usually 15 to 30 in the Gila River drainage, 25 to 35 in the White [= *P. intermedius*] and Bill Williams drainages, 30 to 45 in most of the remainder of the Virgin River drainage [except 42–52 in Birch Creek, Utah]; post-Weberian vertebrae 41 to 47, usually 43 to 46 in the Gila drainage and 42 to 45 elsewhere; dorsal rays 8 to 12 , usually 10 or 11; pelvic rays 8 to 12, usually 9 or 10; pelvic axillary [inguinal process] reduced to a simple fold or absent; caudal peduncle 6.9 to 11.2, usually 8.5 to 10 percent of standard length.

Adult sizes vary from 100 to 325 mm SL in various populations, with smaller individuals occurring in smaller habitats (G. R. Smith 1981).

Body coloration varies from silvery tan to dark greenish or greenish brown above and silvery below. All but the pelvic and anal fins, which tend toward the same color as the adjacent body surfaces, have pigments dispersed over both the rays and the interradial membranes. Breeding colors include darkening of all body pigmentation, development of reddish brown to red orange lateral bands in males of some populations, and yellowing of the lower head, lips, and belly in fish from the Gila River drainage.

Distribution and Status *Pantosteus clarki* is found in lower Colorado River tributaries downstream

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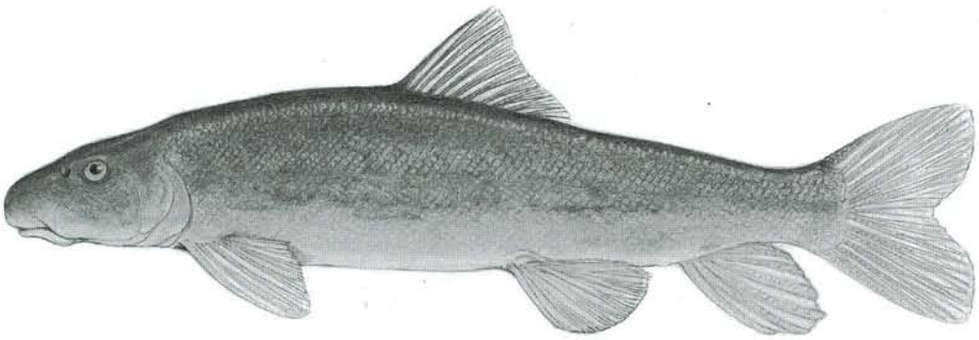
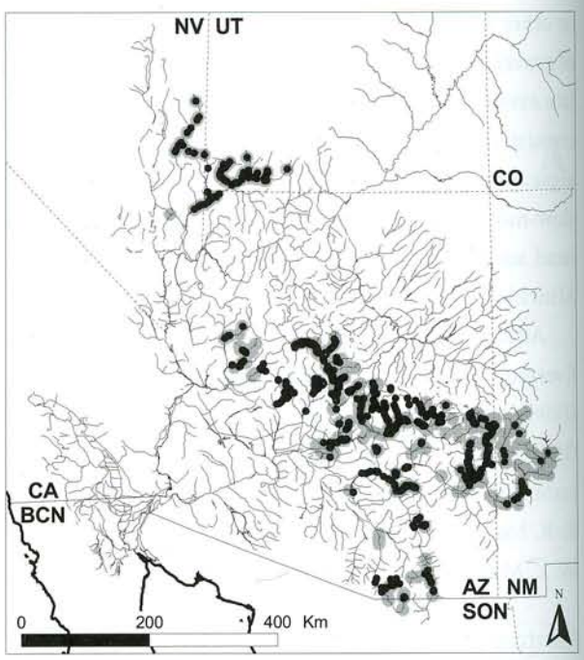


FIGURE 4.90. *Pantosteus clarki* (Baird and Girard), desert sucker, matalote del desierto (*pl. 33*).

from the Grand Canyon, including the Virgin River in Arizona, Nevada, and Utah; the pluvial White River and Meadow Valley Wash in Nevada; and the Bill Williams River basin in Arizona (map 4.47). It is also found upstream of the Phoenix metropolitan area in small to intermediate-sized mountain streams and creeks throughout the Gila River basin in Arizona, New Mexico, and Sonora. The desert sucker persists in much of its historical habitat but has disappeared from some portions of its former range and declined in others (Desert Fishes Team 2004); it is not yet afforded legal protection as an imperiled species.

Habitat and Biology During the night, desert suckers frequent rapids, riffles, eddies, and flowing pools of creeks and rivers. In the daytime, adults seek shady areas near cliff faces, boulders, or large woody debris, remaining relatively sedentary on the bottom in large pools. They avoid or are unable to persist in reservoirs and lakes. Spawning is on gravel-and-cobble bottoms of riffles and rapids, usually in early spring and sometimes into early summer, infrequently in late summer after scouring floods from summer rains. Young drift to settle downstream in inlets and along stream margins, often associated with marginal beds of aquatic plants or algae, where they grow to later move into ever-swifter areas as juveniles, then as adults into eddies and pools. Young grow quickly to mature in their second or third summer of life.

At night, juveniles and adults alike move to shallow, hard-bottomed areas to feed (Bestgen et al. 1987). Chironomid dipteran larvae are the principal foods of young. The food habits of adults are similar in New Mexico, Arizona, and Utah (Kobetich 1969; R. W. Clarkson and Minckley 1988; Greger and Deacon 1988). Fish of all sizes are mostly herbivores, scraping encrusting organics (aufwuchs) from surfaces of gravel and boulders on riffles, and also ingesting detritus, sand, and silt from interstices. Fine, diatom-rich material is most often present in the foreguts of young and adults, along with substantial volumes of green algae and lesser numbers of animals characteristic of riffles (chironomids, simuliids, mayflies, etc.).



MAP 4.47. Distribution of *Pantosteus clarki* (Baird and Girard), desert sucker, matalote del desierto. Gray circles represent historical (pre-1980) collections; black circles are 1980 and later records.

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Additional References (Synonyms: *Minomus clarki*; *Notolepidomyzon arizonae*, *N. clarki*, *N. utahensis*; *Pantosteus arizonae*, *P. delphinus utahensis*, *P. platyrhynchus* [in part], *P. delphinus* [in part]; see W. L. Minckley 1973.) S. F. Baird and Girard (1854); Girard (1857, 1859b); Jordan (1885a, 1885b, 1963); C. H. Gilbert, in Jordan and Evermann (1896, 1898a, 1898b, 1900); Jordan and Evermann (1902); H. W. Fowler (1913); C. L. Hubbs et al. (1943); G. R. Smith (1966); Amin (1968, 1969b); A. E. James (1968); Koehn (1969a, 1969b); G. R. Smith and Koehn (1971); C. Hubbs and Echelle (1972); LaBounty and Minckley (1972); W. L. Minckley (1973, 1980f); Schreiber (1978); Brienholt and Heckman (1980); R. W. Clarkson (1982); Mpoame (1982); Schreiber and Minckley (1982); Mpoame and Rinne (1983); Propst et al. (1986, 1988); Bestgen et al. (1987); Crabtree and Buth (1987); Deacon et al. (1987); R. W. Clarkson and Minckley (1988); Greger and Deacon (1988); Ivanyi (1989); Sublette et al. (1990); C. M. Williams (1991); Ivanyi et al. (1995); Ward et al. (2003); Scoppettone et al. (2004b); Propst et al. (2008).

Pantosteus discobolus (Cope), bluehead sucker

Description Bluehead suckers (fig. 4.91; pl. 34) appear in many body shapes, from streamlined, fusiform, and dorsoventrally flattened in some mainstem Colorado River populations to short, thick, and round in tributaries. Their caudal peduncles are remarkably variable, from pencil-thin and elongate to short and thick, often in specimens from the same collection site. Fish from tributaries more often have short, thick peduncles that are far more uniform among individuals. All have broad, papillose lips, with the upper and lower lips separated by deep, lateral indentations. The anterior face of the upper lip is smooth or slightly papillose. The median notch of the lower lip is shallow, with 3–4 rows of papillae crossing its midline. The apex of the lower jaw is rounded or truncate. There are 78–122 lateral-line scales, usually 50 or more crowded and often deeply embedded scales before the dorsal fin, and 28–32 pharyngeal teeth. The maximum SL is ~60 cm.

The body color in live, large-river specimens is typically olivaceous or dark brown above, including diffuse blotches or faint, dark stripes on the sides; the belly is usually white but in tributary fish can be mottled or suffused with dusky pigments. The caudal membranes are dusky, and other fins are clear to dusky. The top of the head in adults from large streams has at least a distinctively blue cast that becomes an intense sky blue when in breeding condition; there may be a faint, reddish lateral stripe. Tributary populations, some of which may well represent separate species (especially that in the Little Colorado River) are darkly blotched on the dorsum and lighter below, with males developing a red lateral band when breeding. The blue pigment on the head is scarcely developed or absent in tributary populations.

The diverse populations referred to as bluehead sucker are in need of revision; more than one species is almost certainly present. Especially distinctive is the small, chubby-bodied form of the Little Colorado River and its tributaries that drain the White Mountains and the north-sloping rim of the Colorado Plateau.

Distribution and Status This species was long known as *Pantosteus delphinus* (Cope). It has a complex synonymy (G. R. Smith 1966), in large part because a diversity in body shapes led to confusion by early workers. As now defined, bluehead suckers range throughout much of the Colorado River mainstream and its larger tributaries upstream of Lake Mead, Arizona, to its headwaters in Colorado, Wyoming, and Utah (map 4.48). It further occupies parts of the Bonneville and upper Snake River drainages (Columbia River system) in Idaho, Wyoming, and Utah (G. R. Smith 1966). A conservation plan for bluehead sucker and two other Colorado River species has been adopted by all of the basin states except California (UTDNR 2006; see also AZGFD 2006).

A distinctive subspecies, the Zuñi sucker, *P. d. jarrowi* Cope, is isolated and rare in the upper Zuñi River system in New Mexico. It has received substantial conservation effort (see Carman 2004). Many other populations of bluehead suckers remain relatively secure, although generally unstudied. Sublette et al. (1990) provided morphological features distinguishing the Zuñi sucker from other bluehead populations in New Mexico, some of which are (*P. d. jarrowi*, followed by *P. discobolus* subspp.) as follows: the apex of the lower jaw