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BAIT FISHES OF THE LOWER COLORADO RIVER FROM LAKE MEAD, NEVADA, TO YUMA, ARIZONA, WITH A KEY FOR THEIR IDENTIFICATION¹

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INTRODUCTION

Transformation of the unpredictable, silt-laden, lower Colorado River into the placid blue waters which now characterize its course for long stretches, has brought with it unforeseen problems in biological management. One of these problems concerns the bait needs of the thousands of fishermen who yearly seek the recreation afforded by the river and its artificial lakes. Such major introductions as the rainbow trout (*Salmo gairdneri*), channel catfish (*Ictalurus punctatus*),² largemouth black bass (*Micropterus salmoides*), and bluegill (*Lepomis macrochirus*), have created a fishing intensity which the lower Colorado River has never experienced heretofore. Few, if any, of the multitude of fishing enthusiasts who purchase bait fishes are aware of the possibility that the escape of some species could, with establishment in the river, do major damage to the fishery. Indeed, it is only the unusual individual who observes that bait dealers offer more than a single species for sale. Neither are most bait dealers cognizant of the fact that the introduction of exotic species into the Colorado might lead to the serious curtailment or elimination of their business through a decline in the fishery.

A major purpose of this article, therefore, is to distinguish between the species of bait fishes that are being (or have been) utilized along the river, from Lake Mead to Yuma, and to make it possible for bait dealers, interested fishermen, fishery biologists, and wardens to identify most of the species that are being sold. Nearly all of the species are illustrated by a line drawing and each is further identified by means of an artificial key, " which provides a rapid index to the distinctive characters of each kind. The known or probable origin of the species is given, along with a considered judgment as to whether its establishment in the river will cause damage to the fishery. The natural distribution and general habitat requirements of each bait fish are also presented, insofar as they are known. Some of the bait fishes listed below (such as the carp, mosquitofish, bluegill, and green sunfish) are already a part of the river fauna, but, with the possible exception of the Utah chub (*Gila atraria*) and the Bonneville mottled sculpin (*Cottus bairdi semiscaber*), none of the others has become established so far as known at present (May 1, 1951) .

¹ Submitted for publication May, 1951. The field work was financed through a research grant from the Horace H. Rackham School of Graduate Studies, University of Michigan. Common names employed herein are those officially adopted by the California Department of Fish and Game and are not necessarily the choice of the author.

² It has been found that *I. lacustris* is synonymous with *Lota lota*. See article by J. Murray Speirs in *Copeia* (in press).

ACKNOWLEDGMENTS

In the preparation of this article, I have been favored with splendid cooperation from many sources, and without this help the following presentation would have been inadequate. Members of the University of California at Los Angeles, the Scripps Institution of Oceanography (University of California) at La Jolla, and the California Department of Fish and Game actively participated in the field work in the spring of 1950. Intermittent sampling of bait tanks has been continued since then, chiefly by the California Department of Fish and Game, with the result that additional bait species have been discovered along with new data on sources of supply. Carl L. Hubbs has collaborated in identifying the bait fishes and has offered valuable advice during the preparation of the manuscript. I am grateful to William L. Brudon, staff artist of the Museum of Zoology, University of Michigan, who prepared the line drawings.

Bait collectors, especially Milt Holt, have supplied valuable information and bait distributors likewise have volunteered useful data. All of the following individuals have cooperated in various ways: Clarence G. Alexander, Al A. Allanson, Fred Baumiller, Richard D. Beland, Bob Bolam, Delbert Coombs, Philip A. Douglas, Willis A. Evans, Arthur Flechsig, Russell K. Grater, Luis Guzman, Mil Holt, Al Jonez, Tommy Kinder, Tim Murphy, Sidney Peritz, Leo Rossier, George Savard, Vic Spratt, Boyd W. Walker, Kirby H. Walker, O. L. Wallis, Bob Williams, Howard E. Winn, Donald E. Wohlshlag, and A. W. Yoder.

The "Colorado River Fishing-Hunting Atlas" contains an excellent set of maps that show some of the best hunting and fishing spots, roads and towns, places mentioned in this article, and other points of interest from Lake Mead to Yuma. This is a valuable guide for anyone interested in this section of the Colorado River, and may be purchased along the river or from C. E. Erickson and Associates, Berkeley 9, California, for 50 cents. An excellent source of information on bait fishes is the illustrated booklet entitled "Propagation of Minnows and other Bait Species," published in 1948 as Circular 12 of the United States Fish and Wildlife Service; it is available from the Superintendent of Documents, Washington 25, D. C., for 35 cents.

AN ILLUSTRATED KEY TO THE BAIT FISHES OF THE LOWER COLORADO RIVER

In the dichotomous key that follows, the reader has two alternatives (a and b) to choose at a time and, having made a choice, he then chooses again between two sets of opposed characters, and continues until the name of a species is reached. The contrasting characters for each pair are always indicated by the same number, for example 2a and 2b; please read both of the opposed characters before reaching a decision as to which one to follow. Technicalities have been purposefully reduced to a minimum in this simplified key, and it is hoped that most users of the key will be able to identify their specimens largely from the drawings.

It should be possible, with practice, to recognize most of the 32 species keyed out below. However, the identity of some of the species of suckers (particularly the mountain-suckers of the genus *Pantosteus*) is difficult

to determine even for the expert, and a workable key to such species is hardly practical. Thus certain portions of this key (particularly items 15a to 17b) are presented with the realization that they will not work for every specimen. The scale on each drawing represents one inch.

- 1a. A small, fleshy fin (the adipose fin) on the back just in front of the caudal (tail) fin.
Teeth in jaws large and sharp -----
----- Mexican banded tetra, *Astyanax fasciatus mexicanus*

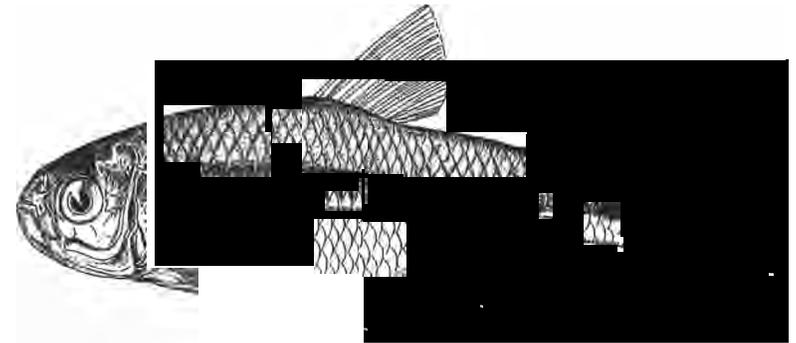


FIGURE 1. Mexican banded tetra

- 1b. No adipose fin. Teeth in jaws small or absent.
2a. Pelvic (belly) fins attached to abdomen below pectoral (breast) fins. Dorsal fin comprising two parts, a spinous and a soft portion, which are either united or separate. (The spinous part may be only feebly spine-like.)
3a. Body without scales but typically with a small patch of prickles on each side behind pectoral fins ---- Bonneville mottled sculpin, *Cottus bairdi semiscaber*

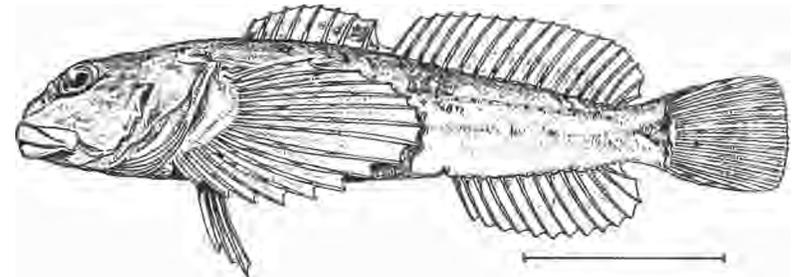


FIGURE 2. Bonneville mottled sculpin

- 3b. Body covered with scales (very small in the mudsuckers)
- 4a. Body long and slender, the tail rounded. Jaws extremely long, extending backward nearly to end of head (mudsuckers, genus *Gillichthys*).
- 5a. Pectoral fin rays (all rays counted) usually 19 to 21, infrequently 18 or 22 ---- Longjaw mudsucker, *Gillichthys mirabilis*
- 5b. Pectoral rays usually 22 to 23, sometimes 21 or 24 ----- Gulf mudsucker, *Gillichthys detrusus*

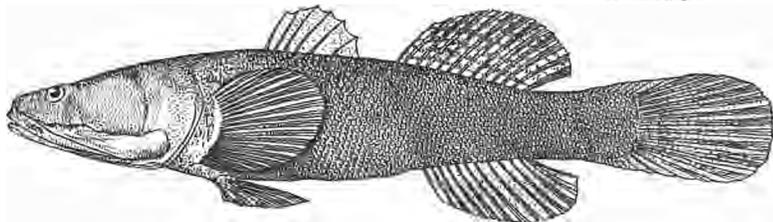


FIGURE 3. Gulf mudsucker (after Gilbert and Scofield)

- 41). Body moderately slender to deep, the tail forked. Jaws normal, not extending beyond eye.
- 6a. Dorsal fin made up of two separate parts. Body crossed by prominent, dark vertical bands. Two spines in anal fin ---- Yellow perch, *Perca flavescens*

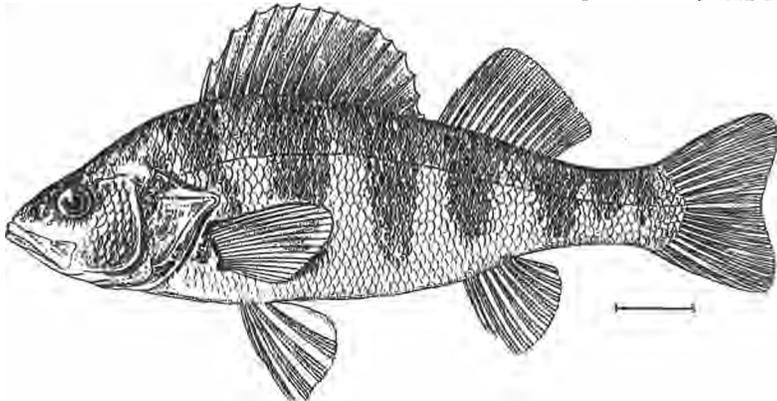


FIGURE 4. Yellow perch (after Forbes and Richardson)

* The key to the two species of *Gillichthys* is taken directly from a manuscript by Isaac Ginsburg, through his kind permission. See text for status of *G. detrusus* in California.

- 6b. Dorsal fin single. Body with less marked bands, often indistinct or absent. Three spines in anal fin (sunfishes, genus *Lepomis*).
- 7a. Mouth larger, upper jaw extending to below middle of eye. Pectoral fins short and rounded, their length entering about 4 times in distance from tip of snout to base of tail fin ---- Green sunfish, *Lepomis cyanellus*

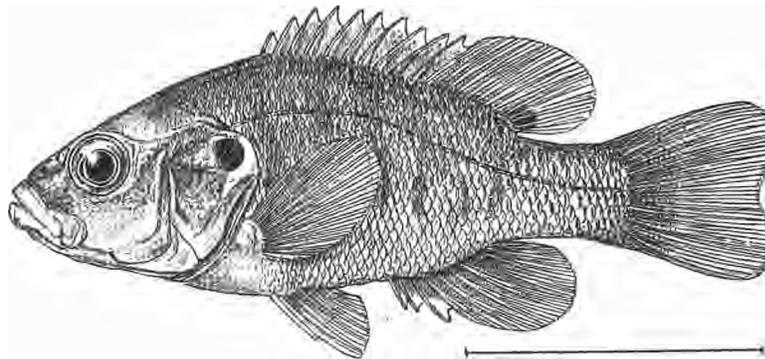


FIGURE 5. Green sunfish

- 7b. Mouth smaller, upper jaw not extending back as far as anterior margin of eye. Pectoral fins long and pointed, their length contained about 3 times in distance from tip of snout to base of tail fin ----- Bluegill, *Lepomis macrochirus*

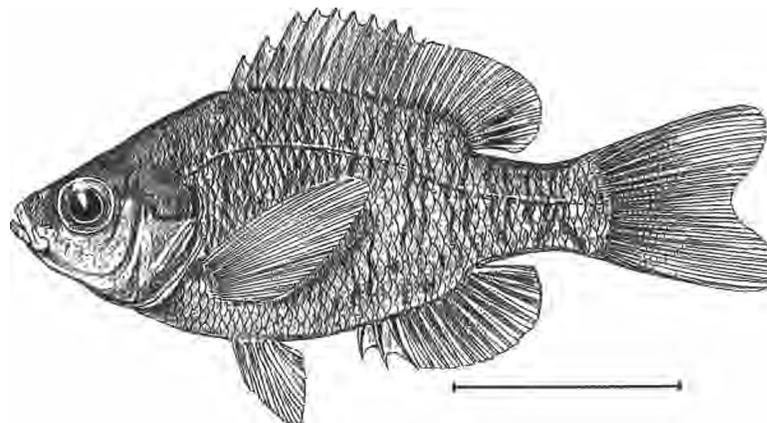


FIGURE 6. Bluegill

- 2h. Pelvic fins attached to abdomen well behind pectoral fins, usually nearly below origin of dorsal fin. A single, soft-rayed dorsal fin.
- 8a. Head covered with scales. Dorsal and anal fins about equal in size, the origin of the dorsal slightly before, to well behind, that of the anal. Small teeth in jaws.
- 9a. Dorsal fin small, typically with only 6 rays (including first small ray and last two counted as one), its origin well behind that of anal fin. Anal fin of mature male modified into a spike-like reproductive organ ----- Western mosquitofish, *Gambusia affinis affinis*

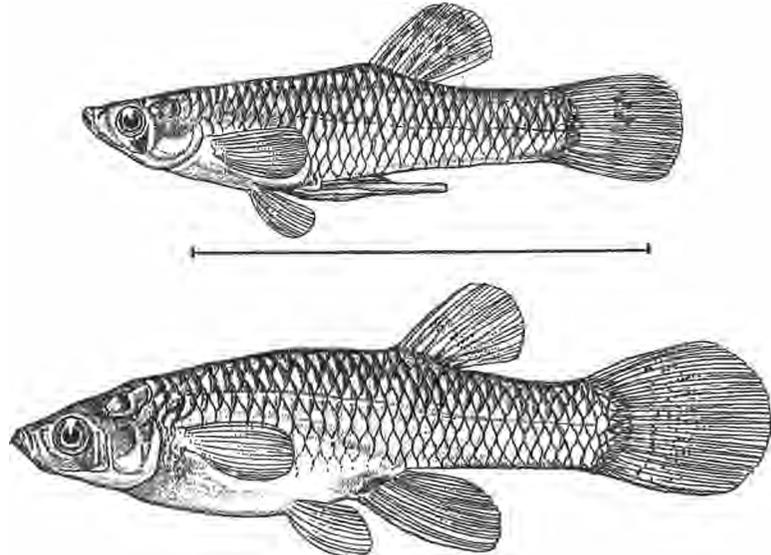


FIGURE 7. Western mosquitofish, male (above) and female

- 9b. Dorsal fin much larger, with 12 or more rays, its origin over or slightly in front of that of anal. Anal fin of male not modified into a spike-like organ.
- 10a. Sides of body with a weak lateral band that tends to form irregular spots and incomplete vertical bars posteriorly. Scales in lateral series (from end of head to base of tail) fewer than 40 ----- Southern California killifish, *Fundulus parvipinnis parvipinnis*

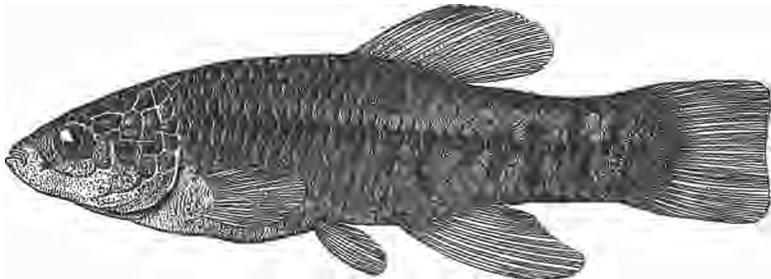


FIGURE 8. Southern California killifish (male)

With a serrated spine in the carp and goldfish, or 2 smooth spines in *Plagopterus* and *Leptomeda*. See items 19a and 19b.

- 10b. Sides of body crossed by numerous vertical bars, broader and more conspicuous in males than in females. Scales in lateral series more than 40 ----- Southwestern Plains killifish, *Fundulus zebivittatus*

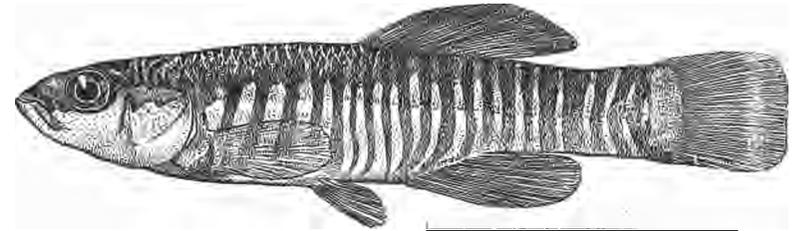


FIGURE 9. Southwestern Plains killifish (male)

- 8b. Head scaleless. Dorsal and anal fins typically unequal in size, the origin of the dorsal always well in advance of that of the anal. No teeth in jaws.
- 11a. Mouth on lower side of head, with thick fleshy lips. Caudal rays 18; 16 branched (suckers, family *Catostomidae*).
- 12a. No distinct notch (see Fig. 1411) at corner of mouth between upper and lower lips. Upper lip nearly flat, covered with small papillae. Lower lip with a deep, median notch (genus *Catostomus*).
- 13a. Dorsal and caudal fins very large, the dorsal with a sickle-shaped margin. Caudal peduncle (base of tail) pencil-shaped. Scales very small, 80 to 112 along lateral line ----- Plannelmouth sucker, *Catostomus latipinnis*

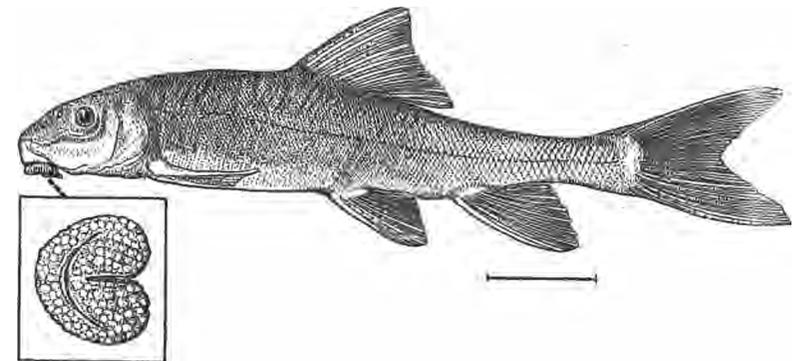


FIGURE 10. Plannelmouth sucker. Inset shows ventral view of mouth.

- 13b. Dorsal and caudal fins not notably enlarged, the dorsal not sickle-shaped. Caudal peduncle not pencil-shaped. Scales large, 55 to 70 along lateral line.
- 14a. Mandible (lower jaw) short, its length contained 3.5 or more times in the head length. Upper lip narrow -----
 ---- Western white sucker, *Catostomus commersoni suckleyi*

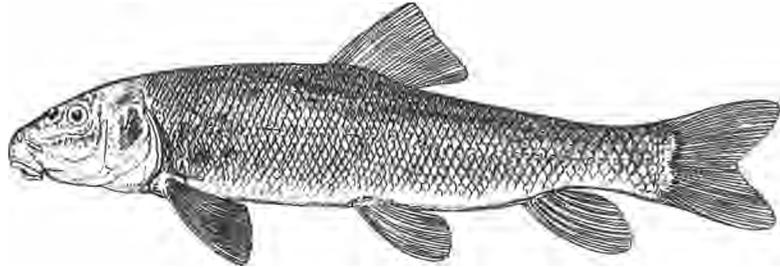


FIGURE 11. Western white sucker

- 14b. Mandible long, its length contained 3.3 or less times in the head length. Upper lip broad -----
 ----- Utah sucker, *Catostomus ardens*

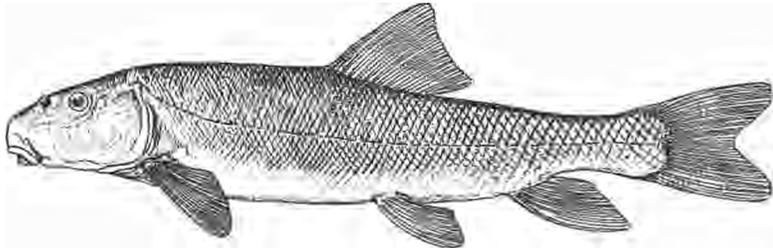


FIGURE 12. Utah sucker

- 12h. A distinct notch (Figure 14B) at corner of mouth between upper and lower lips. Upper lip recurved, smooth. Lower lip with a shallow, median notch (genus *Pantosteus*).
- 15h. Fontanelle on top of skull (Figure 14A, O) typically open (exposed by scraping away skin and membranous cover).
- 16h. Pigment on sides extending below base of pectoral fin and onto lower surface of head -----
 ----- Dusky mountain-sucker, *Pantosteus* species

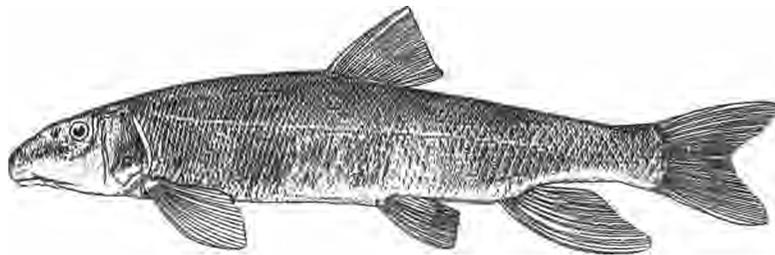


FIGURE 13. Dusky mountain-sucker

Except in *Pantosteus plebeus* in which it is deeper than usual for the genus.

- 16b. Pigment on sides not extending below a horizontal line well above pectoral base; none on lower surface of head -----
 ----- Bonneville mountain-sucker, *Pantosteus platyrhynchus*

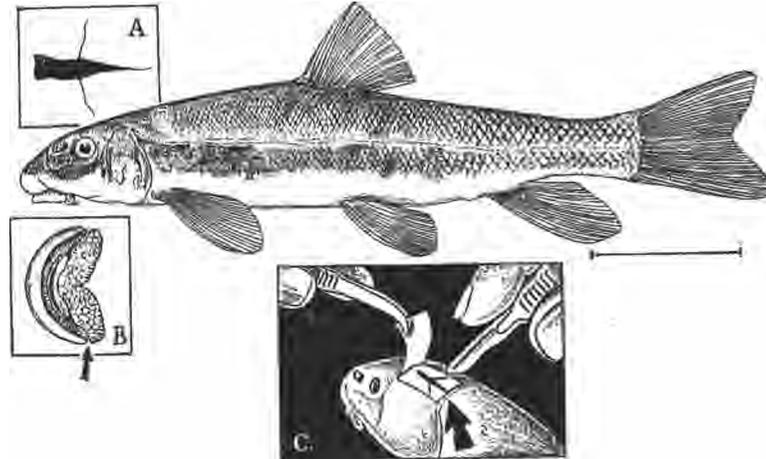


FIGURE 14. Bonneville mountain-sucker. Inset A shows open fontanelle; B, notch at lip corners; and C, method of exposing fontanelle.

- 15b. Fontanelle typically closed (Figure 15).
- 17a. Dorsal rays usually 10 (rarely 9, occasionally 11; count includes only principal rays). Snout more bulbous, conspicuously overhanging the mouth. Cartilaginous sheaths on jaws well developed; median incision of lower lip shallow.
- 18a. Scales larger, about 75 to 95 in lateral line. Caudal peduncle deeper, its least depth about 2.7 to 3.1 times in head length -----
 ----- Utah bluehead mountain-sucker, *Pantosteus declivatus utahensis*

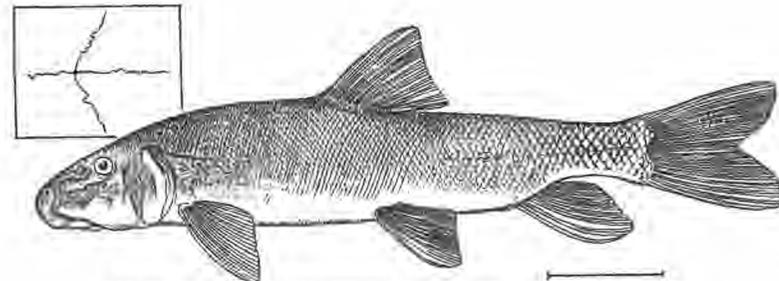


FIGURE 15. Utah bluehead mountain-sucker. Inset shows closed fontanelle.

18b. Scales smaller, about 96 to 118 in lateral line. Caudal peduncle slenderer, its least depth about 3.0 to 3.5 times in head length Northern bluehead mountain-sucker, *Pantosteus delphinus delphinus*

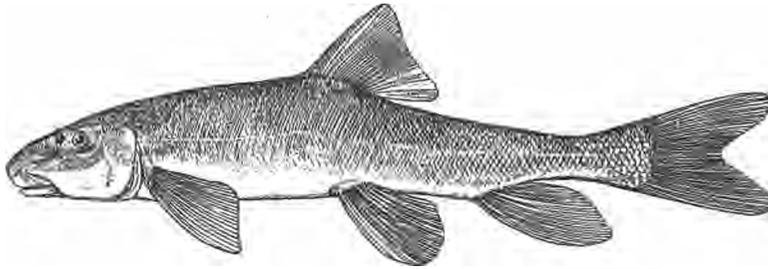


FIGURE 16. Northern bluehead mountain-sucker

17b. Dorsal rays usually 9 (occasionally 10). Snout slightly bulbous, hardly overhanging the mouth. Cartilaginous sheaths on jaws weak; median incision of lower lip rather deep Rio Grande mountain-sucker, *Pantosteus plebeius*

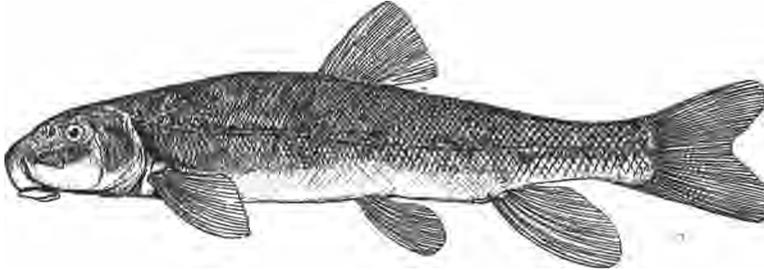


FIGURE 17. Rio Grande mountain-sucker

11b. Mouth terminal or subterminal, not on lower side of head, lips not thick and fleshy. Caudal rays 19, 17 branched (minnows, family Cyprinidae).

19a. Dorsal and anal fins each with a saw-edged, hard spine (rather inconspicuous in the young). Dorsal fin long, with more than 15 soft rays (branched rays plus one, the last two counted as one ray).

20a. Upper jaw with 2 fleshy barbels ("whiskers") on each side. Scales in lateral line 35 to 38, sometimes scaleless ("ladder" carp) or partially scaled ("mirror" carp). (Total gill rakers on first arch 21 to 27; pharyngeal teeth in 3 rows on each arch.)
----- Carp, *Cyprinus carpio*

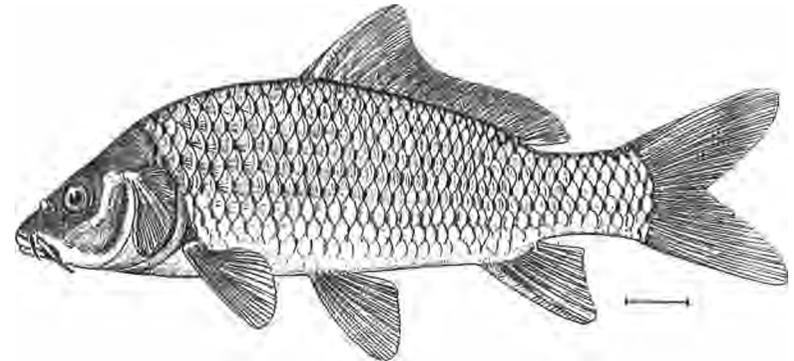


FIGURE 18. Carp (after Forbes and Richardson)

20b. Upper jaw without barbels. Scales in lateral line 26 to 29. (Total gill rakers 37 to 43; pharyngeal teeth in a single row.) -----
Carassius auratus

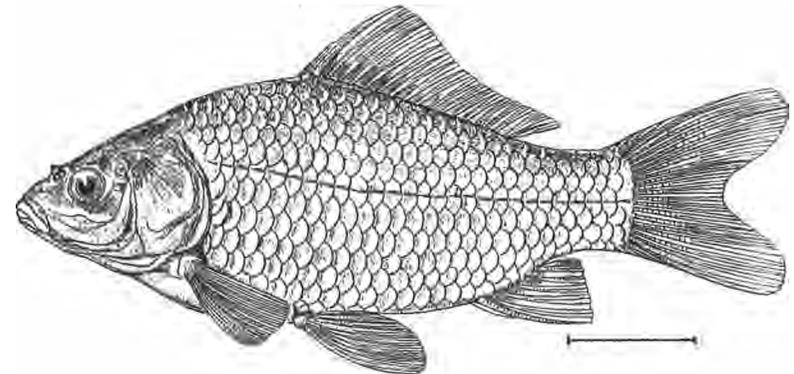


FIGURE 19. Goldfish

- 19b. Dorsal and anal fins without heavy, toothed spines, the dorsal fin with 2 smooth spines or none at all. Dorsal short, with 13 or fewer rays.
- 21a. First two dorsal rays modified as smooth spines, the anterior one with a groove on its posterior side into which the second fits. Inner border of pelvic fins attached to body by membrane, the pelvic rays spine-like (at least in part).
- 22a. First dorsal spine long and sharp. Body slender, elongate, its color like burnished silver. No scales. Eye small

----- Woundfin, *Plagopterus argenteus*

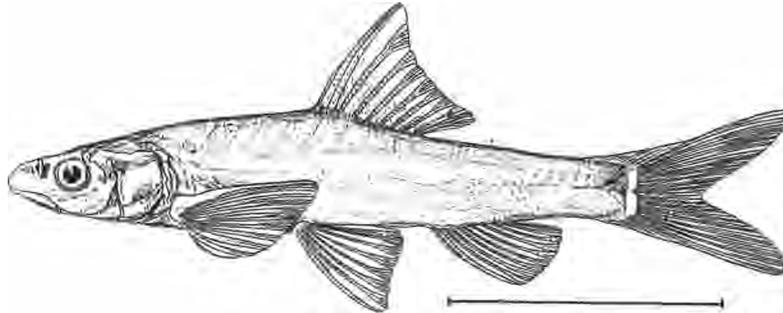


FIGURE 20. Woundfin

- 22b. First dorsal spine short, not sharp at tip. Body heavier and not bright silvery all over. Scales present except just behind pectoral fins. Eye large.
- 23a. Length of mandible (lower jaw) enters distance between origin of dorsal fin and tip of snout 4.6 to 4.9 times. Sides of body mostly silvery, somewhat mottled, with only scattered pigment below level of lateral line

----- Virgin River spine-dace, *Lepidomeda* species

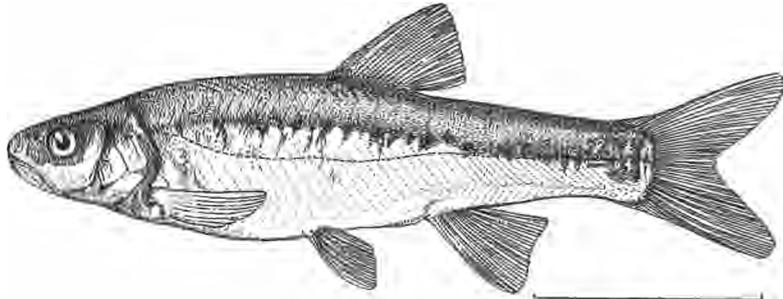


FIGURE 21. Virgin River spine-dace

- 23b. Length of mandible 4.1 to 4.6 times in distance from dorsal origin to tip of snout. Sides of body darker, with a strong tendency to form a dark lateral band, the pigment extending well below level of lateral line

----- White River spine-dace, *Lepidomeda* species

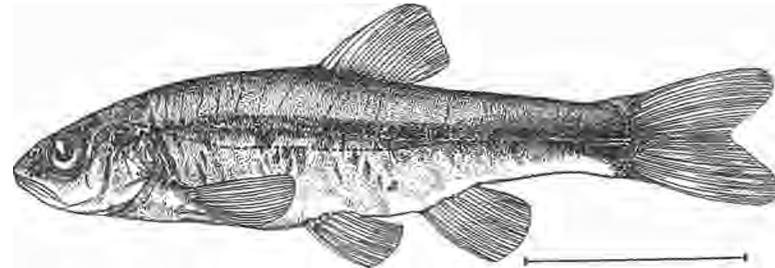


FIGURE 22. White River spine-dace

- 21b. Dorsal fin without spine-like rays. Inner border of pelvic fins not attached to body, the pelvic rays nowhere spine-like.
- 24a. Anal fin large, usually with 10 to 15 rays, the fin margin sickle-shaped. Origin of dorsal fin well behind that of pelvics. Lateral line notably decurved, running much nearer ventral profile than back.
- 25a. A fleshy keel on abdomen between pelvic and anal fins, over which the scales do not pass. Dorsal rays 8

----- Golden shiner, *Notemigonus crysoleucas*

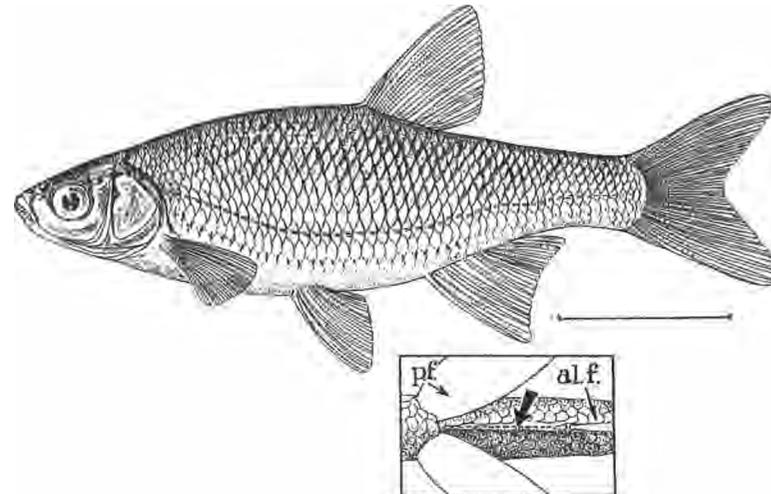


FIGURE 23. Western golden shiner. Inset shows keel

- 25b. No fleshy keel on abdomen. Dorsal rays 9 to 12.
 26a. Mouth short, not extending backwards much beyond nostrils. No pink or red band in life. (Dorsal 10 to 12, teeth 5-5, gill rakers 17 to 26.) ----- Sacramento hitch, *Lavinia exilicauda exilicauda*

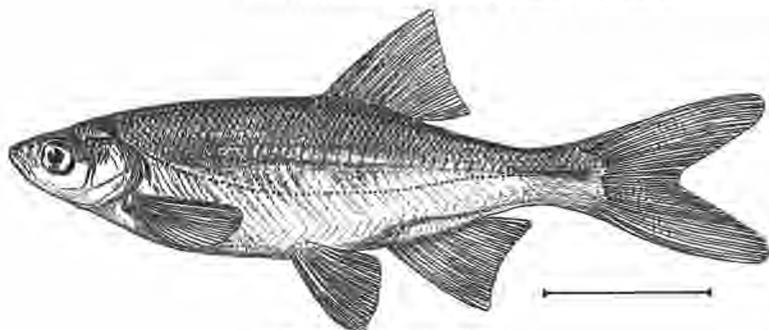


FIGURE 24. Sacramento hitch

- 26b. Mouth long, extending backward to or beyond anterior margin of eye. A pink or red band on side in both sexes, especially prominent on males in breeding season. (Dorsal 9 to 11, teeth 2, 5-4, 2, gill rakers 6 to 9.) ----- Bonneville redband shiner, *Richardsonius balteatus hydrophloa*

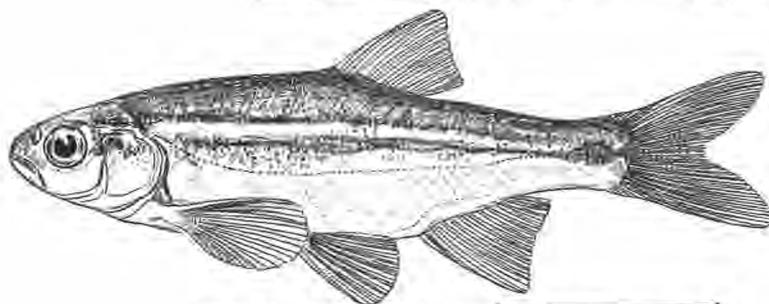


FIGURE 25. Bonneville redband shiner (nuptial male)

- 24b. Anal fin small, typically with 7 to 9 rays (occasionally 10 in *Notropis lutrensis*), the fin margin nearly straight or rounded. Origin of dorsal fin over or behind that of pelvics. Lateral line not notably decurved.
 27a. Scales very large, fewer than 40 along lateral line ----- Plains red shiner, *Notropis lutrensis lutrensis*

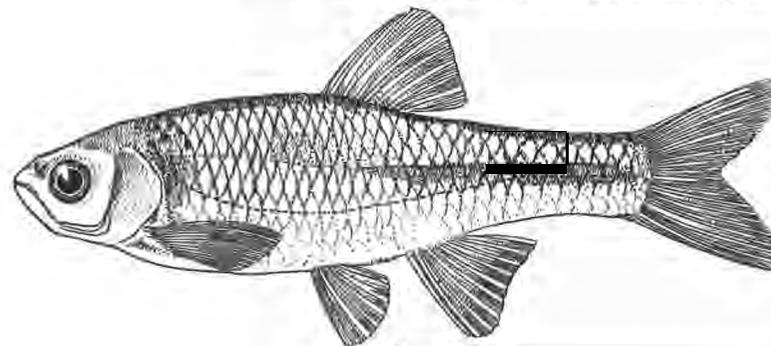


FIGURE 26. Plains red shiner

- 27b. Scales moderate to very small, about 45 to 90 along lateral line.
 28a. Anal fin with 7 rays only (very rarely 8 in *Rhinichthys*). Size small.
 29a. Origin of dorsal fin directly over that of pelvics. Scale radii on apical and lateral fields only. Head short, rounded, blunt ----- Southwestern fathead minnow, *Pimephales promelas confertus*

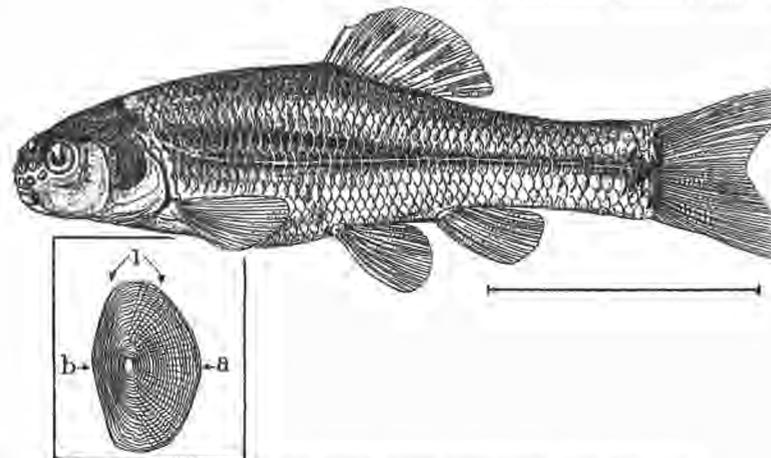


FIGURE 27. Southwestern fathead minnow (nuptial male). Inset shows scale.

- 29b. Dorsal fin located well behind pelvics. Scale radii on all fields, like the spokes of a wheel (Figure 29). Head not notably short, rounded and blunt.
- 30a. Sides of body silvery. Scales very small, usually 75 to 90 in lateral line. Anal fin of adult elongate, particularly in the breeding male. (Teeth 4-4, a small barbel invariably present.) -----
----- Longfin dace, *Agosia chrysogaster*

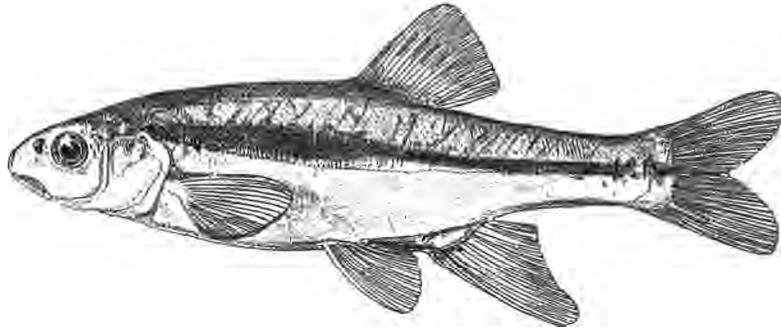


FIGURE 28. Longfin dace (male).

- 30b. Sides of body speckled ("salt and pepper" effect) or with a longitudinal band (or bands). Scales not so small, about 55 to 70 in lateral line. Anal fin not notably elongate. (Teeth 1, 4-4, 1, or 2, 4-4, 2, barbel present or absent.) -----
----- Speckled dace, *Rhinichthys rubellus*

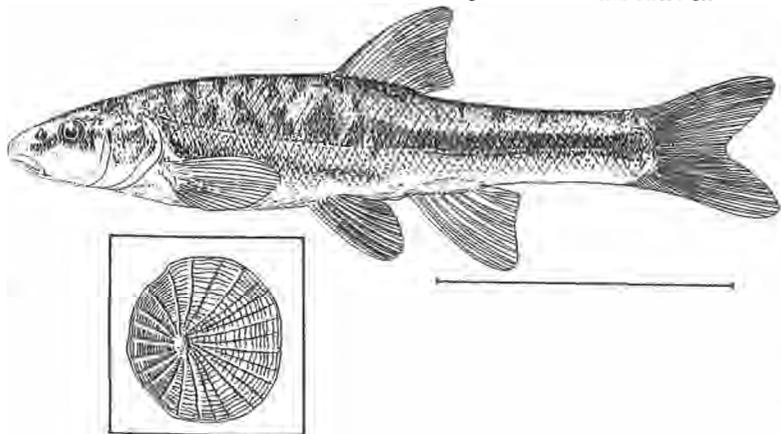


FIGURE 29 Speckled dace. Inset shows scale.

- 28b. Anal fin larger, typically with 8 rays. Size larger.
- 31a. Origin of dorsal fin over that of pelvics. Dorsal rays usually nine (occasionally eight). Radii on apical field of scale only. Body plain dark brownish or black, with yellowish cast. (Teeth 2, 5-4, 2, gill rakers 10 to 15, lateral-line scales 51 to 83.) -- Utah chub, *Gila utaria*

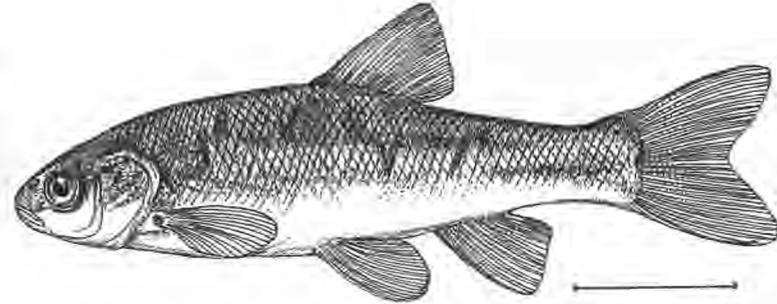


FIGURE 30. Utah chub

- 31b. Origin of dorsal fin behind that of pelvics. Dorsal rays typically eight. Scales with radii on apical and lateral fields. Coloration not uniform. (Teeth 2, 5-4, 2 in *G. nigrescens*, 2, 4-4, 2 in *Snyderichthys*, gill rakers 7 to 9, lateral-line scales 55 to 80.)
- 32a. Scales in lateral line fewer than 70. Sides of body often marked by two horizontal dark bands -----
----- Rio Grande chub, *Gila nigrescens*

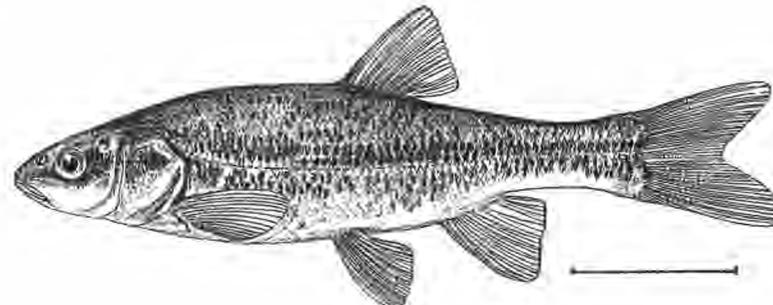


FIGURE 31. Rio Grande chub

- 32b. Scales in lateral line 70 to 80. Body bluish above, silvery below, with a dusky lateral shade and a leathery texture to the skin ----
 ----- Leatherside chub, *Snyderichthys alioiae*

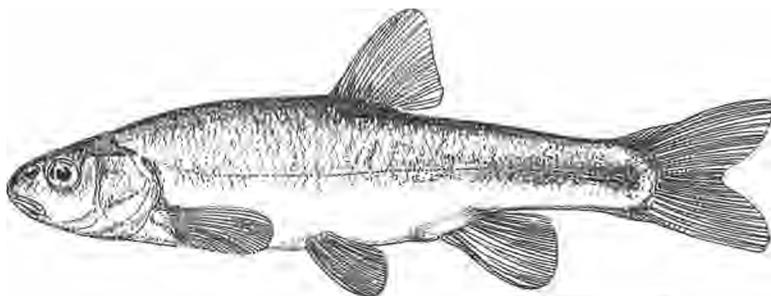


FIGURE 32. Leatherside chub

CHARACIN FAMILY (CHARACIDAE)

The American characins are almost wholly confined to South and Middle America. A single species reaches the United States in western Texas and New Mexico.

Mexican Banded Tetra, *Astyanax fasciatus mexicanus* (Filipp), Figure 1.

This characin was first recorded as a bait fish along the Colorado River by Evans and Douglas (1950) on the basis of specimens offered for sale at Bob Williams' Bait Shop in Yuma, Arizona. These individuals were examined by C. L. Hubbs and the writer on March 23, 1950.

The Mexican banded tetra evidently was accidentally included in a shipment (or shipments) consisting mostly of fathead minnows, *Pimephales promelas*, that came from Truth or Consequences (formerly Hot Springs) on the Rio Grande, New Mexico. These fish were being sold at Fisher's Landing, Laguna Dam, about 14 miles above Yuma, and in the Yuma area—only on the Arizona side of the Colorado River.

The aggressive and frequently vicious nature of this sharp-toothed characin is known to those who have had first-hand experience with it (Breder, 1943). The voracious nature of this species was conclusively proven to me from observations I made on a closely related subspecies in the lowlands of Guatemala in 1946 and 1947.

Under no circumstances should this potentially dangerous carnivore be used for bait, for its establishment in the Colorado River might well have a disastrous effect on the fishery.

SUCKER FAMILY (CATOSTOMIDAE)

This common group of fishes is largely restricted to North America. Two species live in eastern Asia and one penetrates southward to Guatemala.

Western White Sucker, *Catostomus commersoni suckleyi* Girard, Figure 11.

This sucker, which is native to the streams of the eastern slope of the Rocky Mountains, was probably introduced as bait into the upper Colorado River near Hot Sulphur Springs, Grand County, Colorado, about 1938 (Hubbs, Hubbs, and Johnson, 1943, p. 12-13 and 39-40). It was first collected in the Colorado system on April 21, 1941, when John T. Greenbank took an adult in Dry Creek, three miles west of Olathe, Montrose County, Colorado. Since then it has rapidly increased (Hubbs and Hubbs, 1947, p. 153-154).

A single yearling sucker, which probably is this species, was brought in by Philip Douglas from Kinder's Camp, California, where it was collected on June 21, 1950. There is the slight possibility that it may be an aberrant specimen of the Utah sucker, *Catostomus ardens* Jordan and Gilbert.

- This species may have come from Green River, Utah, a locality frequently mentioned to me by bait distributors as one from which bait collectors have secured their specimens. If so, the western white sucker is spreading down the Colorado system.

Catostomus commersoni inhabits both streams and lakes and is one of the species preferred for propagation as a bait fish in the Great Lakes region. However, its use for this purpose along the lower Colorado River is not recommended at this time for the reason that other species of suckers which are native to these waters may well prove to be as suitable or even more so.

Utah Sucker, *Catostomus ardens* Jordan and Gilbert, Figure 12.

- This sucker is native to the basin of ancient Lake Bonneville, which covered most of Utah and adjacent parts of Idaho, Wyoming and Nevada, and to the upper Snake River (above Shoshone Falls), in Idaho and Wyoming. It is an adaptable species, living in lakes, rivers or creeks in warm to very cold temperatures, in slow to rapid current, in silty to clear water where the bottom varies from soft mud to clay, gravel and stones, and where there is usually some algae or submerged plants or both. In Bear Lake, it lives in water at least as deep as 76 to 80 feet (data through courtesy of Dr. R. M. Bailey).

This species has been taken twice from bait tanks along the lower Colorado River. Al Jonez, of the Nevada Fish and Game Commission, obtained one yearling from a bait box on Lake Mead in February, 1951, and Richard D. Beland, of the California Department of Fish and Game, picked up a yearling from the Havasu Springs Resort, Arizona, on April 10, 1951. The bait at the latter locality was reported by George Savard to have come from A. G. Sessions at Marysvale, Utah. This is on the Sevier River, a stream in which the Utah sucker is common.

- In Wyoming, the Utah sucker attains a length of 25½ inches and weight of more than 12 pounds and is known to eat trout eggs when available. (Simon, 1946, p. 56-57; species recorded as *C. fecundus*). This species is highly adaptable and has occurred in Utah Lake, Utah, in excessive numbers (Jordan, 1891, p. 31). Its establishment in the Colorado River, however, would probably prove to be harmless to the fishery.

The nomenclature throughout this paper is brought into line with the recent revisions in the International Rules of Zoological Nomenclature (Bulletin of Zoological Nomenclature, 1950).

Flannelmouth Sucker, *Calostomus latipinnis* Baird and Girard. Figure 10.

The flannelmouth sucker, so named because of the long, fleshy lobes of the lower lips in large adults, is one of the few species of native fishes found throughout the Colorado River system. The streamlined body admirably adapts this fish to a swift-water habitat, to which adults are confined. To my knowledge, however, this species has never been collected from the Colorado River below the Virgin River, the mouth of which is now flooded by Lake Mead. It is known from the Gila River drainage of southern Arizona, where, however, it is very rare.

Two subspecies have been recognized (as by Hubbs, Hubbs, and Johnson, 1943, p. 60), but the basis for this separation is so insecure that it seems unwise, for the present, to continue the use of trinomials.

This species was first noted as a bait fish by C. L. Hubbs on August 31, 1938, at Alexander's Bait Shop, Las Vegas; Mr. Alexander's source was the Virgin River west of Bunkerville, Nevada. On December 31, 1948, O. L. Wallis obtained a specimen (reportedly from Santa Clara River, Rah) at the Lake Mead Boat Dock. The flannelmouth sucker was secured by our party at the Lake Mead Boat Dock and from two bait dealers at Pittman, Nevada on June 16, 1950. It was also collected by Richard D. Beland in December, 1950, from Shorty's Bait Shop at Topock, and on June 21, 1950, two flannelmouth suckers were brought in by Philip Douglas from Kinder's Camp.

Most of the flannelmouth suckers that I have examined evidently came from the upper Colorado River, perhaps from the Green River basin or from the vicinity of Grand Junction, Colorado (the occurrence of this species and the western white sucker in the same bait tank suggests this latter source). However, the specimens from Las Vegas and Lake Mead came from the Virgin River and probably the Santa Clara River, respectively. Milt Holt, bait collector at Gunlock, Utah, has written (letters of March 18 and April 10, 1951) that he collects most of his fishes from Santa Clara River and Beaver Dam Wash, southwestern Utah, and that he has delivered bait to eight retailers in the Lake Mead area (including the two at Pittman). We collected flannelmouth suckers from Santa Clara River, 2½ miles below Gunlock on June 17, 1950.

This species typically has 12 or 13 (10 to 14) dorsal rays in the upper Colorado River (above Lees Ferry), 13 or 14 (12 to 15) in the Virgin River basin, and 13 to 15 (only 17 specimens counted) in the Gila River basin. Counts of nine specimens from the Pittman dealers gave a range of 10 to 13 (usually 12) dorsal rays which indicates, substantiating the testimony of the dealers, that these suckers came from the upper Colorado. The two Lake Mead specimens each had 13 dorsal rays. The two specimens from Kinder's Camp (counted by C. L. Hubbs) had 11 and 12 rays and each of the two from Shorty's Bait Shop (also counted by Hubbs) had 10 dorsal rays—clearly indicating importation from some point above Grand Canyon.

It is questionable if the flannelmouth sucker will become established in the lower river or its reservoirs as the habitat is unsuitable in the reservoirs and competition with trout would probably exclude the species in the swift, cold waters below the dams. The apparent absence of this species in the original river also argues against its possible establishment there now. This species is therefore regarded as a harmless bait fish.

Bluehead Mountain-Sucker, *Pantosteus delphinus* (Cope). Figures 15 and 16.

This sucker is not quite so widespread in the Colorado River as the flannelmouth, for it is unknown from the Gila River basin. It is common in the streams of the Virgin River drainage, where the adults seek the swift waters of riffles or the pool heads where the current is turbulent; the young may occur in quieter water. Like other mountain-suckers, this fish is a bottom feeder, eating much algae which it scrapes from rocks with the chisel-like ridge inside each lip. Because of their rapid- to very swift-water habitat, it was a surprise to find them surviving so well in bait tanks.

Two subspecies may be recognized (see Figures 15 and 16): a very fine-scaled form with a conspicuously slender caudal peduncle, called *Pantosteus delphinus delphinus* (Cope), and a coarser-scaled form with a deeper caudal peduncle, called *Pantosteus delphinus utahensis* (Tanner).

This species has been detected in bait dealers' boxes as follows: Alexander's Bait Shop, Las Vegas, August 31, 1938, C. L. Hubbs (*P. d. utahensis*, Virgin River); Lake Mead Boat Dock, December 31, 1948, O. L. Wallis (*P. d. utahensis*, Santa Clara River); Pittman, Nevada (two dealers), June 16, 1950, R. R. Miller and H. E. Winn (*P. d. delphinus*); Shorty's Bait Shop, December, 1950, R. D. Beland (two identified by C. L. Hubbs as *P. d. delphinus* and two others as *P. d. utahensis*); Murphy's Windmill Camp, February 3, 1951, R. D. Beland (6 *P. d. utahensis* and one not certain as to subspecies); bait box on Lake Mead, February, 1951, Al Jonez (two small adults, *P. d. utahensis*).

The streamlined subspecies (*delphinus*) very probably came from Green River, a known bait source for fishes handled by the dealers at Pittman. The chubbier form (*utahensis*) undoubtedly (except for the one sample known to have come from Virgin River) came from Santa Clara River near Gunlock, Utah, a stream in which it abounds and from which bait samples are taken.

Neither of these native subspecies is likely to become established in the lower river or its reservoirs; even if they should adapt themselves successfully, it is not expected that they would do so in numbers great enough to affect the fishery adversely. The local subspecies, *P. d. utahensis*, is regarded by Milt Holt as his best bait. Whether this fish can be propagated is not known, but some species of *Pantosteus* may live two or more years in dirt tanks (personal observation).

Bonneville Mountain-Sucker, *Pantosteus platyrhynchus* (Cope). Figure 14.

This species is native to the Bonneville basin, Utah, and the Snake River above Shoshone Falls. It inhabits cool, moderately slow to very swift waters, living in pools, on riffles and in rapids. It is one of the common fishes of the Bonneville basin.

The first specimen of the Bonneville mountain-sucker from the Colorado River to come to my attention is a small adult deposited in the Lake Mead Recreational Area Museum and bearing the following data: "Lake Mead, September 8, 1938, collected by Johnny Westen." This record received advance notice by Wallis (1951, p. 89). The data are meager but it seems evident that this specimen represents a bait introduction, possibly from the Sevier River, Utah. That bait fishes were being handled as early as 1938 is evident from the testimony of Milt Holt and also from

the field records of C. L. Hubbs. On July 3, 1938, he interviewed Clarence Alexander of Las Vegas, who was supplying live bait for the fishing at Lake Mead. This species was not, however, one of those noted in Mr. Alexander's tanks, for he reported that his fishes were seined in the Virgin River west of Bunkerville, Nevada, and thus not within the natural range of this sucker.

On February 3, 1951, R. D. Beland obtained a small specimen of this species from Murphy's Windmill Camp, California, and on April 10, 1951, he picked up three specimens at Havasu Springs Resort, Arizona. The latter were reported by George Savard to have come from A. G. Sessions at Marysvale, Utah, on the Sevier River.

It is not expected that this species will become established in the Colorado River and hence its use as bait seems harmless. It is possible that this sucker might be more suitable for propagation than the bluehead mountain-sucker. A. G. Sessions of Marysvale, Utah, reports that he is attempting to propagate this fish. Simon (1946, p. 60) wrote that, where plentiful, this species is an important forage and bait fish in Wyoming.

Rio Grande Mountain-Sucker, *Pantosteus plebeius* (Baird and Girard)? Figure 17.

The precise range of this species is imperfectly known but it is generally attributed to the Rio Grande, in Colorado and New Mexico, and to streams of northern Mexico. Its preferred habitat is similar to that of other mountain-suckers—rather shallow, swift, cool water.

The only record of this species as a bait fish along the Colorado River is of a single yearling identified by Hubbs and secured by Willis A. Evans on July 5, 1950, from the Intake Store, California.

This specimen evidently came from the basin of the Rio Grande, probably in New Mexico (as the genus is not known to occur naturally in Texas). A logical source is Truth or Consequences (formerly Hot Springs), where bait is propagated (see account of fathead minnow).

The Rio Grande mountain-sucker is no more likely to become established in the Colorado than the previous species of *Pantosteus*, and it is therefore judged to be harmless.

Dusky Mountain-Sucker, *Pantosteus* species. Figure 13.

This species is only known from the northern part of Spring Valley, an interior basin lying to the east and northeast of Ely, Nevada. It was first collected there by Hubbs and Miller in 1938, at which time it was so rare that only three specimens were secured.

On June 16, 1950, Miller and Winn obtained two half-grown specimens from the Shell Oil Station at Pittman, Nevada, and Richard Beland obtained a small adult from Murphy's Windmill Camp on February 3, 1951. The latter evidently was supplied by the Pittman dealer where we saw numbers of live individuals of this species. The Pittman dealer told me that this sucker came from near Caliente, Nevada (in the drainage of Meadow Valley Wash), but careful comparison with specimens of the *Pantosteus* inhabiting that region fails to confirm this testimony. Spring Valley is about 100 miles north of Caliente, and evidently was the real source.

¹ Researches to date on the genus *Pantosteus* strongly suggest that *P. plebeius* is confined to tributaries of Lake Guzman in southern New Mexico and northern Chihuahua, Mexico. If so, the Rio Grande species should have a different name, but what name is not yet clear.

The further use of this species for bait is to be discouraged because of its restricted range and the desirability of conserving an interesting species for posterity.

MINNOW FAMILY (CYPRINIDAE)

The members of this diverse group of fishes, commonly called chubs, shiners, dace, etc., are usually small. Like the suckers, they have no jaw teeth but do have pharyngeal teeth, deep in the throat. One of the largest minnows in the world, the so-called "Colorado salmon" (*Ptychocheilus luctius*), is still rarely taken in the lower Colorado; in former years when it was abundant, it is said to have reached a length of six feet and a weight of 100 pounds.

Minnows are of considerable economic importance, for their wide distribution and abundance make them important in the food cycles of all predacious fishes. Their value for bait is well proven.

More than 200 species of minnows are recognized in the United States and since many are very similar in appearance their identification is often difficult, even for the specialist. Fifteen species have thus far (May 1, 1951) appeared in the bait tanks and boxes along the lower Colorado River.

Carp, *Cyprinus carpio* Linnaeus. Figure 18.

This well-known species, originally from Asia, has been established in the river for more than 60 years (Gilbert and Scofield, 1898, p. 487). Its preferred habitat is warm rivers and lakes. Although the early introduction of carp into the United States was hailed, this fish has repeatedly been condemned by biologists and most laymen. Since it is an extremely hardy and prolific fish, attempts to rid our waters of it have generally proved to be fruitless.

Young carp appear sporadically in bait tanks along the river and have been used either as live bait or cut bait for some time (Dill, 1944, p. 153). The two varieties—mirror (with a few enlarged scales) and leather (largely scaleless)—are not infrequently seen. Carp were being sold for \$1.25 per dozen at Shorty's Bait Shop, on April 7, 1950, and this species was the chief bait handled. Bob Bolam, operator of the Needles Boat Landing, told me on June 15, 1950, that he sells young carp for bait and that they come from Pahranaagat Lakes, Lincoln County, Nevada. We identified a few specimens in his bait tank. Small carp were also being sold by the two dealers at Pittman, on June 16, 1950; these were reported to have been brought in by youngsters from Nevada, perhaps from the same Pahranaagat Lakes which are readily accessible and are known to contain carp. The species (leather variety) was also noted by Philip Douglas (identified by C. L. Hubbs) at Kinder's Camp on June 21, 1950, and by R. D. Beland at Havasu Springs Resort on April 10, 1951.

Since the carp is already excessively abundant in sections of the river its continued introduction will probably not affect the fishery.

Goldfish, *Carassius auratus* (Linnaeus). Figure 19.

This familiar aquarium and pond fish has been widely transplanted from its original home in eastern Asia. Warm lakes and quiet streams, with abundant vegetation, are its preferred habitats.

The only published record of the use here of this species for bait, of which I am aware, is that by Dill (1944, p. 177), who said that goldfish were kept for bait in live-boxes at Lake Havasu. None was seen along the river or in it during our short survey, but O. L. Wallis wrote (April 16, 1951) that this species was being used for bait at Temple Bar Wash, Arizona, in March, 1949. Mr. Wallis was told that fishermen from King-
 ■ an were bringing in the goldfish.

It is doubtful if this species will become adapted to the Colorado River, although it might gain a foothold in the warmer parts of the reservoirs. Its use as a bait fish is not recommended.

Speckled Dace, *Rhinichthys nubilus* (Girard), Figure 29.

This exceedingly variable species is widely distributed over the western United States. Within the limits of its range, it has evolved into a confusing array of local kinds, the status of which is imperfectly known. Hence, for the purposes of this paper, no subspecific designations will be used, although it has often been possible to recognize the general or even precise source of the several kinds that have appeared in bait tanks.

The conditions to which the speckled dace is adapted vary from swift, cold riffles of mountain streams and the strong current of lower, warmer rivers, to less rapid waters and to the quiet conditions of isolated warm springs and their outflow ditches.

This species has been taken from bait tanks at the following places: Alexander's Bait Shop, Las Vegas, C. L. Hubbs, August 31, 1938 (from Virgin River west of Bunkerville, Nevada); Lake Mead Boat Dock, O. L. Wallis, December 31, 1948 (two types, source uncertain, one probably Santa Clara River); Pittman (two dealers), Miller and Winn, June 16, 1950, two distinct stocks, one from "Green River" and the other from Meadow Valley Wash, evidently in the vicinity of Caliente, Nevada; Kinder's Camp, P. A. Douglas, June 21, 1950, seven adults, probably from the Virgin River system; Shorty's Bait Shop, R. D. Beland, December, 1950, two stocks (as identified by C. L. Hubbs), one from the Bonneville basin (evidently Sevier River, Utah) and the other from the Virgin River system; Murphy's Windmill Camp, Richard Beland, February 3, 1951, two stocks—one from Meadow Valley Wash in southeastern Nevada, and the other from the Virgin River system (probably from Santa Clara River); bait box on Lake Mead, Al Jonez, February, 1951, said to be from the "St. George, Utah, area" (probably from Santa Clara River).

The kind attributed to Green River (handled by the Pittman dealers) is known to occur in San Rafael and Fremont rivers, tributaries to the Colorado River below its junction with the Green River. Specimens are in the University of Michigan collections from near Emery and near Huntington, Emery County, Utah. It is significant that these localities are on the shortest route from Green River to Lake Mead and the lower Colorado and I conclude that during their drive from Green River, the bait collector (or collectors) evidently stopped to pick up these dace en route.

Since this species was unknown in the original lower Colorado River, evidently because it is not fitted to live in such an environment, and since the new river and its reservoirs are probably an even poorer habitat for

R. nubilus has line priority over *R. oregonus*, the name usually applied to this species, and is now to be used according to the revised International Rules of Zoological Nomenclature (Bulletin of Zoological Nomenclature, 1950, p. 328).

it, I do not believe that any possible harm can come to the fishery from the use of the speckled dace for bait. Its suitability for bait may be questioned since it seldom attains a large enough size. However, the species is an important bait fish in certain parts of Wyoming (Simon, 1946, p. 75-76, 78).

.....**Illie Redside Shiner, *Richardsonius balteatus hydrophlox* (Cope), Figure 25.**

This brightly colored fish is a characteristic inhabitant of the creeks and rivers of the Bonneville basin, the upper Snake River (above the falls), and certain upper tributaries of the Columbia River and lower Snake River. It also has been taken in lakes as in Utah Lake, Utah, Bear Lake, Idaho and Utah, Two Ocean Lake, Wyoming, and in Lake Malheur, Oregon.

The Bonneville redbside shiner has been sampled from bait tanks along the river as follows: Shorty's Bait Shop, Miller and party, April 7, 1950; Pittman (dealer in Shell Oil Station), Miller and Winn, June 16, 1950; Kinder's Camp, P. A. Douglas, June 21, 1950 (identified by Hubbs); and Shorty's Bait Shop, R. D. Beland, December, 1950. This shiner has 9 to 13, typically 10 to 12, anal rays, which readily distinguishes it from the Columbia redbside shiner, *Richardsonius balteatus balteatus* (Richardson), which has 13 to 22, usually 14 to 18, anal rays (Miller and Miller, 1948, p. 183).

This species is usually abundant in its natural range and has already become established in the Colorado River system in Wyoming, through introduction as a bait fish (Simon, 1946, p. 81). Its spread in the Green River drainage is indicated by the capture of a specimen by W. F. Sigler and party from Sheep Creek, Daggett County, Utah, on August 6, 1950. It is carnivorous and has been observed to prey upon newly released grayling fry, but most of its food consists of small aquatic insect larvae and crustaceans (Simon, 1946, p. 82). It attains a length of 51 inches in Wyoming and is used as a bait fish there. Since its establishment in the lower Colorado might be detrimental, I recommend that this species not be used for bait.

Utah Chub, *Gila atraria* (Girard), Figure 30.

This fish is widely distributed in springs, streams and lakes of the Bonneville system and the upper Snake River in Utah, Idaho, Wyoming and extreme eastern Nevada. It is a prolific and hardy minnow, abounding in most of the waters where it occurs and often crowding out its fish associates.

Utah chubs have been noted in bait tanks at the following places: Kinder's Camp and Shorty's Bait Shop, Miller and party, April 7, 1950; at both the dealers in Pittman, Nevada, Miller and Winn, June 16, 1950; Kinder's Camp, P. A. Douglas, June 21, 1950 (identified by Hubbs); Shorty's Bait Shop, R. D. Beland, December, 1950 (determined by Hubbs); Murphy's Windmill Camp, R. D. Beland, February 3, 1951.

When introduced into other waters, particularly lakes or reservoirs, this species may multiply quickly so as overpopulate such waters. For example, in Strawberry Reservoir east of Provo, Utah, the Utah chub became so abundant that a special trash fishery was set up to handle the menace (see The Progressive Fish-Culturist, Vol. 11, No. 1, 1949, p. 85-86). In Fish Lake, Utah, the introduction of this species for bait led

to a marked decrease in the important trout fishery (Hazzard, 1936, p. 127-128; Davis, 1940, p. 6). The species reaches a length of 16 inches and a weight of more than two pounds (Simon, 1946, p. 78) and can prey on the young of game fishes. For these reasons, the use of the Utah chub for bait should be strictly prohibited. Unfortunately, this undesirable fish may already have gained a foothold in the river. Mr. Richard D. Beland, in a letter to the author (April 29, 1951), wrote that Bob Bolam (Needles Boat Landing) reported that in early April, 1951, he observed an angler catch a nine-inch "Utah minnow" near his pier.

Rio Grande Chub, *Gila nigrescens* (Girard), Figure 31.

The distribution of this chub is generally attributed to include the Rio Grande drainage in Colorado, New Mexico and Texas, from which it ranges southward an unknown distance into Mexico. This species typically lives in small, cool streams, with moderate to swift current, and is a midwater swimmer, frequenting the pools.

There is only one record of this species from bait tanks along the Colorado River. It was taken by Willis Evans on July 5, 1950, from the Intake Store (identification by C. L. Hubbs).

Little is known about this chub and, for that reason, it would probably be wise to discourage its use for bait until more information on its life history is available.

Leatherside Chub, *Snyderichthys alicia* (Jouy). Figure 32.

This species, known for many years as *Gila copei* (Jordan and Gilbert),¹⁰ is another inhabitant of the Bonneville basin and the upper Snake River. Its distribution has been discussed by Hubbs and Miller (1948, p. 31, 77). This minnow typically inhabits small, clear streams, where the adults live either in pools or on swift riffles.

The leatherside chub has been taken as follows: Kinder's Camp and Shorty's Bait Shop, Miller and party, April 7, 1950; Pittman (Shell Oil Station), Miller and Winn, June 16, 1950; the Lake Mead Boat Dock, R. K. Grater, about August 1, 1950; Shorty's Bait Shop, R. D. Beland, December, 1950; and Havasu Springs Resort, R. D. Beland, April 10, 1951. Most of these specimens probably came from Marysvale, Utah.

This is one of the three species of minnows which, through introduction as bait, has become established in Strawberry Reservoir, Utah. However, its effect upon the lower Colorado River fishery would probably not be harmful.

Golden Shiner, *Notemigonus crysoleucas* (Mitchill). Figure 23.

The golden shiner is an inhabitant of weedy lakes and the quieter sections of rivers where it is commonly found amongst dense vegetation. The species is one of those preferred for propagation as a bait or forage fish in the east, and ranges widely over eastern North America from southeastern Canada southwestward as far as the mouth of the Rio Grande (one record in 1878). Two subspecies have been identified among

As with the Rio Grande mountain-sucker, this species may be confined to the basin of Lake Guzman.

¹⁰ The specific trivial name *copei* cannot be used because at one time *Gila copei* and *Leuciscus copei* (a *Notropis*) were both placed in *Leuciscus*, thereby creating a secondary homonym. This fact was recognized by Gilbert and Evermann (1894, p. 195) who used the combination *Leuciscus alicia*. Miller (1946, p. 28) proposed the generic name *Snyderichthys*.

the bait samples secured along the Colorado River: *N. c. seco* (Girard), the Southwestern golden shiner, and *N. c. auratus* (Rafinesque), the Western golden shiner. These subspecies are very similar and their distinctive characters have not been fully worked out. They are usually distinguished on the basis of the number of anal rays: 10 to 14, usually 11 to 13, in *auratus*, and 11 to 16, usually 12 to 14, in *seco*.

This minnow was obtained by Willis Evans from the Intake Store, on July 5, 1950, along with four other species of fishes that occur in the southwest. This stock probably came from the vicinity of Lake Buchanan, a reservoir on the Colorado River in Llano and Burnett counties Texas, and hence is referred to *N. c. seco*. Kirby H. Walker learned that bait minnows from this source were supplied to the Arizona Fish Farms, Inc., which operates opposite Blythe in Arizona.

Although the golden shiner was established in certain lakes of the Coconino National Forest, Arizona, by or before 1934 (Madsen, 1935, p. 9), and had subsequently contributed to the deterioration of the trout fishery resource in that region, it is not likely to become established in the Colorado River or its reservoirs because of the absence of large weed beds. The golden shiner is well adapted to pond culture, attains its good size (up to 10 inches) and grows rapidly. It is an important bass forage fish in the midwest. This species is believed to be well suited as a bait fish along the lower Colorado River as long as the present sparseness of submerged aquatic vegetation persists. Should this over-all situation change, and extensive weed beds become common, this species might contribute to a reduction of the fishery as it did in Upper Lake Mary, Arizona (see footnote 11). At the present time attempts are being made by the California Department of Fish and Game to propagate Western golden shiners in an isolated pond near Blythe. It is also being raised in a 10-acre pond (along with *Notropis lutrensis*) by the Arizona Fish Farms, Inc., who have recently obtained stocks of *N. c. auratus* from San Dieguito Reservoir near San Diego (letter of August 15, 1951, from W. A. Evans to W. A. Dill).

Sacramento Hitch, *Lavinia exilicauda exilicauda* Baird and Girard. Figure 24.

This exclusively Californian fish inhabits the Sacramento-San Joaquin drainage system, including streams tributary to San Francisco Bay. A closely related subspecies lives in the Pajaro and Salinas Rivers and their tributaries in west-central California. The hitch prefers the lower, sandy to muddy, slow-moving stretches of rivers or the quiet pools of creeks, generally in fairly warm water. According to Murphy (1948, p. 101) it appears to require gravel-bottomed streams for successful spawning. It feeds, in large part at least, on fine microscopic organisms (plankton), as shown by the rather numerous gill rakers, the long intestine and the grinding type of pharyngeal teeth. The hitch closely approaches the golden shiner in general appearance but lacks the distinctive fleshy keel on the abdomen which distinguishes the golden shiner.

The hitch has appeared in bait tanks as follows: Site Six, Lake Havasu, P. A. Douglas, March 2, 1950; Kinder's Camp, Miller and party, April 7, 1950; and at the same place, P. A. Douglas, June 21, 1950.

¹¹ Unpublished report, 1949, by H. Milton Borges, in the files of the Arizona Game and Fish Commission; sent to me through the courtesy of A. W. Yoder.

This minnow unquestionably was imported from the Central Valley of California. Milt Holt wrote me (March 18, 1951) that he collected bait "north of Modesto" late in 1949 and early in 1950. Vic Spratt, operator of the Site Six camp, told P. A. Douglas that his hitch were being trucked and flown to Site Six from Fresno by C. L. Ballard, Jr., and Mr. Kinkillea. In order to limit the species of bait fishes, and because the biological effect of this species is problematical, its further use for bait is not recommended.

Plains Red Shiner, *Notropis lutrensis lutrensis* (Baird and Girard). Figure 26.

This fish ranges widely over the central United States, from Illinois and South Dakota southward and westward to the basin of the Rio Grande in Texas and New Mexico; its distribution in northern Mexico is imperfectly known. It is an inhabitant of both creeks and rivers, tolerating the muddy waters of the Great Plains.

This shiner has been taken only at the Intake Store north of Blythe. Five specimens were obtained there by Willis Evans on July 5, 1950, and three more were secured on September 6, 1950, by Donald E. Wohlschlag. The stock came from the vicinity of Lake Buchanan, Texas, according to information kindly obtained by Kirby H. Walker. The shiners were transported to the Arizona Fish Farms, Inc.

It is doubtful if this species will become established in the Colorado River as the present habitat there seems wholly unsuited to it. The use of this shiner for bait is therefore not considered to be harmful; however, its suitability as a bait fish may be questioned since it is regarded to be too small for a desirable bass bait. Kirby H. Walker informs me (letter of April 27, 1951) that the Arizona Fish Farms, Inc., has a 10-acre pond devoted to the propagation of this species (as well as golden shiners).

Southwestern Fathead Minnow, *Pimephales promelas confertus* (Girard). Figure 27.

The species *Pimephales promelas* ranges widely over eastern North America, from southern Canada and New York westward and southward between the Appalachians and the Rockies to northern Mexico. The southwestern type is a typical inhabitant of silty lakes and streams.

The only record at hand of this fish from bait tanks is of specimens offered for sale at Williams' Bait Shop (Evans and Douglas, 1950, p. 435). These fish were imported from Truth or Consequences (Hot Springs), New Mexico, where they are being reared in bait tanks adjacent to the Rio Grande below Elephant Butte Dam.

The fathead minnow eats chiefly microscopic plant foods but will also take insects and smaller animal life. It is a prolific and hardy fish and is ideal for propagation in ponds. In the midwest it is a popular bait for panfish and its use as a bait fish on the Colorado River is to be encouraged.

Longfin Dace, *Agosia chrysogaster* Girard. Figure 28.

This little silvery minnow is the commonest native fish in the Gila River drainage of southern Arizona and southwestern New Mexico, at low to medium elevations (generally below 4,500 feet). It persists in desiccating streams to the last water hole and is usually abundant wherever found. To the north of the Gila drainage it occurs only in the Bill Williams River of western Arizona (Miller, 1946, p. 206).

The longfin dace was first observed along the Colorado River on April 2, 1948, when Leo Rossier obtained specimens from Shorty's Bait Shop

(Evans and Douglas, 1950, p. 435). On June 13, 1949, April 7, 1950, and December, 1950, this fish was again noted at the same place.

Reports indicate that this species is being brought in from the Bill Williams River drainage and from Hassayampa River, just below Wickenburg, Arizona. It is abundant in both areas. The report of this fish from a tributary of Virgin River (Evans and Douglas, 1950, p. 435) probably stems from the fact that distributors receive some of their bait from that drainage and are not able to distinguish between the different kinds of fishes brought to them.

The longfin dace is primarily herbivorous in its feeding habits and is a small-creek fish. Since it has never become established in the Colorado River there is no reason to believe that occasional individuals escaping from fishermen's hooks will build up a population in the river. Consequently it is regarded as a harmless bait fish. It might prove to be an adaptable species for propagation in shallow runways with a coarse sand bottom and slight current. It is known to spawn on such a bottom (personal observations).

Virgin River Spine-dace, *Lepidomeda* species. Figure 21.

This species lives in the Virgin River and its tributaries in Nevada, Arizona and Utah. It is an inhabitant of the rather swift portions of pools, in rapidly flowing creeks.

The Virgin River spine-dace was noted as a bait fish by Carl L. Hubbs when he interviewed Clarence Alexander, bait dealer in Las Vegas, on August 31, 1938. Two specimens were secured by O. L. Wallis from the Lake Mead Boat Dock on December 31, 1948, and three more were picked up from a bait box on Lake Mead by Al Jonez, of the Nevada Fish and Game Commission, in February, 1951.

The specimens for sale by Mr. Alexander, for use on Lake Mead, were seined by him in the Virgin River west of Bunkerville, Nevada. Those picked up by Mr. Jonez were reported to have come from the St. George, Utah, area, likely from Santa Clara River where this species abounds and from which Milt Holt seines his bait and delivers it to the Lake Mead area.

Little information is available on the biology of this fish, but since it is unknown from the main Colorado it is not likely to become established in the present river or its lakes. Consequently its use as a bait fish is probably harmless.

White River Spine-dace, *Lepidomeda* species. Figure 22.

This minnow inhabits the upper White River in White Pine and Nye counties, Nevada, where it lives chiefly in cool springs and their outflows.

On February 3, 1951, Richard Beland obtained four adults from Murphy's Windmill Camp, California. This constitutes the only record to date (May, 1951) of the use of this species as a bait fish along the Colorado River. The specimens must have come from the upper White River.

There is little likelihood that the White River spine-dace will become established in the Colorado River. However, because of its very restricted range, and hence its interest to science, the use of this species for bait should be discouraged.

Woodfin, *Plagopterus argenteus* Cope. Figure 20.

This streamlined minnow, which shines like burnished silver when first taken from the water, is now known to inhabit only the Virgin River and its tributaries in Arizona, Nevada, and Utah. It formerly was found in the Gila River basin, from which it has been recorded only three times, the last in 1894.

On June 16, 1950, Miller and Winn obtained one specimen from the boat dock on Lake Mead. Otherwise it has not turned up in the bait tanks along the river.

This is an interesting and gradually vanishing species which should be protected from further reduction.

KILLIFISH FAMILY (CYPRINODONTIDAE)

This is a large family of small fishes that are widely distributed in fresh, brackish, mineralized and salt waters of the New World.

Southwestern Plains Killifish, *Fundulus zebrinus* Jordan and Gilbert. Figure 9.

This killifish inhabits the Rio Grande (including the Pecos River), in New Mexico and Texas, and probably other rivers in Texas and northern Mexico. It is a fish of rather small, shallow, open streams.

This species was first observed for use as bait on March 23, 1950, at Williams' Bait Shop in Yuma (Evans and Douglas, 1950, p. 435). On July 5, 1950, W. A. Evans secured a specimen (identified by Hubbs) at the Intake Store.

It is doubtful if the Southwestern Plains killifish will establish itself in the lower Colorado River or its reservoirs. Consequently, the use of this species for bait is probably harmless.

Southern California Killifish, *Fundulus parvipinnis parvipinnis* Girard. Figure 8.

This killifish inhabits salt, brackish and fresh waters from Morro Bay, California, to northwestern Baja California. It is commonly found over the mud bottoms of estuaries but also ascends the clear, sandy stretches of streams in the southern part of its range.

The only information that I have concerning the possible use of this fish for bait is contained in a letter, dated April 29, 1951, from Richard D. Beland. On February 14, 1951, he found that Bob Williams (Williams' Bait Shop, Yuma) was holding a number of these fish in his tanks on an experimental basis to determine if they could be handled and used for bait. One specimen was preserved to check the identification and proved to be this fish. Subsequently Beland was informed that attempts to utilize this species for bait had been abandoned.

Mr. Williams reported that his specimens were caught in traps and shipped in from San Diego Bay, California.

The Southern California killifish is not likely to become established in the river, but further attempts to use it as a bait fish are not encouraged because there are other, more suitable species available.

TOPMINNOW FAMILY (POECILIIDAE)

The members of this exclusively American family are all small fishes, largely tropical in distribution, and notable because they bring forth their young alive.

Western Mosquitofish, *Gambusia affinis affinis* (Baird and Girard). Figure 7.

This fish, called mosquitofish because of its fame as a destroyer of mosquito larvae, is native to the central United States from southern Illinois to Alabama and the mouth of the Rio Grande. It is an inhabitant of quiet, shallow waters where it feeds at or near the surface. It has been widely introduced throughout the world for malaria control.

The inclusion of this fish in the list rests upon the statement by Dill (1944, p. 163) that it has been used as live bait. I did not observe any being so utilized on our recent survey and the species has not been reported from bait tanks in recent months.

The western mosquitofish was planted in California in 1922 (Dill, 1944, p. 162) and eventually reached the Colorado River through its spread for mosquito control.

Since the species is well established in the river, is a good forage fish, and seems to be having no deleterious effect upon the fishery, its use as bait is harmless.

SUNFISH FAMILY (CENTRARCHIDAE)

The sunfishes, which include the familiar largemouth black bass and smallmouth black bass, are a truly North American group. All but one species, the Sacramento perch (*Archoplites interruptus*) of California, are native only to the region east of the Rocky Mountains; but many have become widely established in the West through introduction.

Bluegill, *Lepomis macrochirus* Rafinesque. Figure 6.

This well-known fish has been established in the Colorado River for many years (at least since 1938) and is a favorite of the warm-water angler. Three subspecies of bluegill have been recognized in eastern United States; the predominant one in the Colorado River is the northern form, *L. m. macrochirus* Rafinesque. The southwestern bluegill, *Lepomis macrochirus speciosus* (Baird and Girard), collected in Arizona in 1943 (Salt River at Tempe; specimens at University of Michigan), is also now evidently established in the Colorado River through introduction and hence available for bait (fide C. L. Hubbs in letter of May 10, 1951, to R. I. Beland, and letter from Beland of August 23, 1951, to W. A. Dill). This subspecies has been distinguished from the northern form by the fewer anal soft rays, 9 to 11 (usually 10) in *speciosus* rather than 10 to 12 (usually 11) in *macrochirus*.

Moffett (1943, p. 185) noted that the bluegill was being used for bait on Lake Mead about 1941, and Dill (1944 p. 171) remarked that this sunfish has value as a bait species and that it is sometimes caught for use as such by bass fishermen. In March, 1949, O. L. Wallis noted that bluegills were being used for bait by bass fishermen at Temple Bar Wash, Lake Mead. It is well established that young bluegills are an excellent forage fish for bass.

Since the bluegill is already a part of the fauna, its continued use as bait cannot be regarded as harmful provided that supplies are not obtained by wholesale seining practices.

Green Sunfish, *Lepomis cyanellus* Rafinesque. Figure 5.

This species is less familiar to fishermen as its introduction in the West has not met with the success accorded the bluegill. It has probably been

established in the river as long as, or perhaps longer than, the bluegill. Dill (1944, p. 172) roughly estimated that this species was outnumbered by the bluegill about 10 to 1.

On June 15, 1950, I identified a few individuals of the green sunfish in Bob Bolam's bait tank at Needles Boat Landing. Dill (1944, p. 173) wrote that the species has value as a bait fish. Its use as such seems to be very limited, however.

Since green sunfish are now a part of the river fauna and since they do not appear to be of major importance in the fishery, their use as bait is not regarded as detrimental.

PERCH FAMILY (PERCIDAE)

This group of fishes includes the perches, pike-perches, and darters which, in North America, are native only to the waters east of the Continental Divide.

Yellow Perch, *Perca flavescens* (Mitchill), Figure 4.

This familiar fish is distributed from west-central and eastern Canada south to Nebraska and the northern parts of the central states, and along the Atlantic seaboard from New Brunswick to South Carolina. It has been established elsewhere by introduction, but attempts to acclimate it south of its range have been largely unsuccessful.

This species lives under varied conditions, but usually in lakes, ponds, and quiet parts of streams, preferring cool to cold waters.

The only record known to me of its occurrence in bait tanks is of a single yearling picked up by R. D. Beland, on March 31, 1951, at Shorty's Bait Shop. According to testimony obtained by Mr. Beland (letter to author April 12, 1951), this specimen came from the holding ponds of A. G. Sessions at Marysville, Utah.

The use of this species for bait is not recommended because yellow perch could become established in the river and experience elsewhere suggests that an overpopulation of stunted fish might result. If this were to happen the trout fishery in particular would suffer. Not only would the young compete with the young of other, more desirable species, but the adults, which eat fish, would compete with other adult fish and would prey on their young (Curtis, 1949, p. 269).

SCULPIN FAMILY (COTTIDAE)

The sculpins are fresh-water representatives of a predominantly marine family and are widespread in the northern hemisphere. They have broad, flattened heads and large pectoral fins and either lack scales or have few to many prickles, usually only behind the bases of the pectoral fins. They are bottom dwellers and eat algae, aquatic insects, fish eggs and fishes.

Bonneville Mottled Sculpin, *Cottus bairdi semiscaber* (Cope), Figure 2.

This species is distributed throughout the Bonneville basin and the upper Snake River. It is typically found in clear, cool, rapid streams over a bottom that varies from mud to loose rocks; it may also occur around lake margins.

On April 6, 1949, O. L. Wallis obtained one adult of this sculpin from the bait tank at Las Vegas Wash; it was also observed at the same time at the Lake Mead Boat Dock. Mr. Wallis was informed that the live bait with which this fish was associated came from Santa Clara River near St. George, Utah. No native sculpin has been reported, however, from farther down the Colorado River system than the headwaters of Fremont River, in south-central Utah. The most plausible source for this specimen is the Sevier River, where the Bonneville mottled sculpin is common and where bait fishes are known to be obtained.

Philip A. Douglas wrote (April 28, 1951) that on March 17, 1950, he saw what he is certain was a sculpin in Lake Havasu. The individual, appearing to be about six inches long, was lying on the rubble bottom in 18 inches of water approximately six feet off the first point south of the Needles Boat Landing. In its appearance and movements it closely resembled *Cottus bairdi*. No other such reports have come to my attention.

Sculpins are sometimes used as bait by anglers in various parts of the United States. Their use for this purpose along the Colorado River may be questioned because of the accusations that sculpins are predatory on trout eggs and young. However, a recent study (Zarbock, 1951) indicates little or no predation by this sculpin on trout eggs in the Logan River, Utah.

GOBY FAMILY (GOBIIDAE)

This is another group of typically marine species of small size that is almost worldwide in distribution. A few gobies occur in fresh water in the United States.

Longjaw Mudsucker, *Gillichthys mirabilis* Cooper, See Figure 3.

This species, which is the chief bait used by both salt-water and fresh-water fishermen in Southern California, attains a length of at least eight inches and is common in the bays and estuaries of Southern California and northwestern Baja California (Weisel, 1947, p. 77). It occurs northward in California to Mendocino County (Puget Sound records thus far checked by Isaac Ginsburg are not this species) and is represented at the head of the Gulf of California by *G. detrasus*, a very closely related species.

Mudsuckers were seen by our party at various places along the river in 1950, but few samples were preserved. Those observed at Kinder's Camp on April 7, 1950, were reported to come from Seal Beach, California, well within the range of this species. Bob Bolam (Needles Boat Landing) told me on June 15, 1950, that he used mudsuckers for bait up until three months prior to our visit. These came from San Diego and San Quintin, Baja California. On June 16, 1950, mudsuckers were sampled from the Lake Mead Boat Dock and were reported to have been "flown in from Mexico" (possibly from San Quintin, northwestern Baja California). These proved to be *G. mirabilis*. Mudsuckers were also seen at the Shell Oil Station in Pittman, Nevada, on June 16, 1950, but were not sampled. The dealer told me that these came from Long Beach; if so, they were this species. The Pittman dealer was then selling 100 per week to Bud Sunderland, a dealer just below Davis Dam.

Mr. Sidney Peritz of San Diego, who traps *Gillichthys* for the live-bait industry, told Carl L. Hubbs on May 31, 1950, that he had about 30

Mexicans trapping mudsuckers in San Quintin Bay, northwestern Baja California, and that the fish are flown to Del Mar, California. They are kept in large wire containers in the slough near the Del Mar airport, from which orders are flown out to the Colorado River and elsewhere. Mr. Peritz reported that the dealers gradually diminish the salt content of the water in which the mudsuckers are kept until it is entirely fresh, in which medium *Gillichthys* will live for several weeks.

Gillichthys detrusus Gilbert and Scofield, described from near the mouth of the Colorado River, has been reported (Evans and Douglas, 1950) as a bait fish along the Colorado River and from Salton Sea, California. However, Dr. Carl L. Hubbs, who identified these samples, wrote to W. A. Evans (August 8, 1951) that he has reidentified most of the specimens as *G. mirabilis* (using the key character worked out by Isaac Ginsburg; see p. 10). The specimens picked up at the pelican rookery in Salton Sea are *G. detrusus*, but it has been concluded that the pelicans fed at the head of the Gulf of California or in the tidal part of the Colorado River and thus flew in the dead specimens reported by Evans and Douglas (1951, p. 436). Consequently there is no basis at this time for the inclusion of *detrusus* in the Californian fauna. Figure 3 was drawn when the records of the Gulf mudsucker were unquestioned, but it will serve equally well as an illustration of the longjaw mudsucker.

Attempts to propagate this fish for bait are being made and should be thoroughly explored and encouraged. If a successful method can be devised, the mudsucker may become one of the most valuable bait fishes along the Colorado River and elsewhere. Without propagation, the drain on the natural populations of this fish will presumably lead to a take insufficient for commercial operations and hence result in the abandonment of the industry as a major undertaking. This species is now established in Salton Sea (letter of C. L. Hubbs to W. A. Evans, June 21, 1951) and may multiply sufficiently there to serve as an important source for replenishing bait stocks.

Since this species is able to live for some time in fresh water but cannot propagate there, it is particularly well suited for use as bait.

RECOMMENDATIONS

During the past 15 years, 31 species of fishes are known to have been utilized for bait along the Colorado River, from the vicinity of Lake Mead to Yuma. More than half of these are minnows and suckers which constitute the most popular group of fishes for bait. Only four of the 31 are recommended without reservation as desirable bait fishes under the present environmental conditions of this section of the river. These are: the Utah mountain-sucker, the golden shiner, the fathead minnow, and the longjaw mudsucker. Most of the remainder are regarded as having a neutral effect on the fishery or are believed to be potentially undesirable. However, there are three species, the Mexican banded tetra, Utah chub, and yellow perch, which should be strictly prohibited because their establishment in the drainage would be likely to cause irreparable harm to the fishery.

The introduction of species from foreign waters presents the possible establishment of parasites and diseases that could be harmful to the native or acclimated fishes. Viewed in this light, any introduction is potentially harmful. The variety of habitats along the lower Colorado River, such as

the reservoirs, the cold-water tail races below dams, the oxbow lakes and the irrigation canals, makes it possible for some species to become locally established without affecting the fishery as a whole. Thus it is not easy to predict whether a given kind will or will not become acclimated to some part of the drainage system.

It is not in their own interest for bait dealers to carry on or encourage practices that may lead to the introduction of deleterious species or which will deplete sources of supply beyond the recovery point. The fishery that is now established and steadily increasing along the river - must be subjected to sound, long-time management practices if a major economic asset is not to vanish as rapidly as it arose. The interested states should agree on a selected number of species which appear to be wholly safe for use as bait fishes, and then encourage the propagation and distribution of these kinds. The local rearing of a few bait fishes should supply the needs of anglers and would then make it unprofitable to ship in mixed fish, some of potential harm.

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MECHANICAL AIDS FOR BIRD BANDING¹

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Many thousands of birds, especially waterfowl and pen-reared game birds, are banded each year with conventional aluminum bands. These bands, individually numbered, come from the factory threaded on string or wire. This type band must first be opened enough to slip over the tarsus of the bird, then closed again. The task of keeping the bands in order as they are used is not a small one where large numbers of birds are banded. Uniform spreading of bands is usually accomplished only with difficulty. A few devices for keeping the bands in order have been described in banding manuals ("Manual for Bird Banders" by Frederick C. Lincoln and S. Prentiss Baldwin, U. S. Dept. Agriculture, Misc. Pub. No. 58, Nov., 1929, and subsequent issues), but little has been published on how to spread bands conveniently and uniformly. The usual method has been to open the bands with long-nosed pliers as they are taken from the string. Anyone who has used this procedure, especially on thousands of the larger-sized bands, has probably realized the need for a more efficient method. The devices described in this paper were developed to meet this need, and also with the idea of incorporating a band expander on the band holder or on the banding pliers.

To spread the bands easily required pliers with a reversed pivot action or some device which would convert the closing action of conventional pliers into a spreading action that would open the bands. Utica "horse-shoe" lock-ring pliers No. 534 had the reversed action and were relatively easy to adapt. However, they were rather large for small-sized bands, necessitating the construction of smaller pliers by hand. The expander effect was also obtained by modifying two different types of banding pliers.

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