FISHES OF THE RÍO YAQUI BASIN, MÉXICO AND UNITED STATES[1]

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INTRODUCTION. — The Río Yaqui drainage basin of northwestern México comprises about 73,000 km² of the most inaccessible and rugged terrain in western North America (Blásquez 1959). An average annual discharge of almost 2,800 ha³ makes the Río Yaqui one of the major watersheds of that region (Tamayo and West 1964). The small percentage of this system that lies within southwestern United States contributes a substantial proportion of the native ichthyofauna of that area — 6 to 8 species of fishes were originally present, of which 5 did not occur elsewhere in the United States. Changes in land and water uses have largely destroyed these native animals in the United States (McNatt 1974), so the presently reported survey was planned and executed in spring and summer 1978 to determine population status and geographic distributions of those and other fish species in the Mexican portion of the drainage. A review of literature and of specimens in museums completed data upon which this report is based.

DESCRIPTION OF THE AREA. The Río Yaqui begins as the Río Papigochic system of western Chihuahua, enters eastern Sonora (as the ríos Aros-Sirupa) to receive the Río de Bavispe (into which the United States' portion of the system flows), then trends southward after collecting the ríos Moctezuma-Nacozari system to enter the Sea of Cortez near Ciudad Obregón, Sonora (Fig. 1). The drainage is limited generally by parallels 27° and 32° N and meridians 107° and 110° 40' W. Much of the delta of the Río Yaqui now is modified for irrigated agriculture, especially near Ciudad Obregón, but a substantial part of the uplands of the basin remains relatively undisturbed.

Access to the Río Yaqui basin generally parallels the high, rugged Sierra Madre Occidental. Paved highways follow structural valleys in lowlands of the west, and the high plateau of the Mesa del Norte to the east (West 1964a). Mountains are crossed by following river valleys, or more often over high, precipitous passes. Larger cities form a boundary for the basin (Fig. 2), and many smaller towns remain in a frontier condition, especially on the Chihuahua side. These villages act as supply bases for mining, lumbering, and cattle industries of the interior.

Topography and Geology. — As is typical in areas of complex relief, the Río Yaqui basin has stimulated more than one scheme of landform description. Angular peaks alternating with flattened erosional surfaces on horizontal beds of lava flows create some of the most spectacular mountain scenery in North America (Hovey 1905, 1907). King (1939) and Imlay (1939) provided geomorphic and geologic information, which, when combined with Brand's (1937) description of northwestern Chihuahua, adequately depict the area. West (1964a) gave a general treatment in his coverage of landforms of Middle America.

Highest elevations in the drainage are in the Sierra Madre Occidental Province, separated by King (1939) into a Barranca Section and an eastern Plateau Section. The first takes its name from deep, narrow gorges — *barrancas* — incised by headward erosion into the western rim of the Plateau by Pacific drainages. This youthful terrain is remarkably irregular in relief. More than 1,800 m

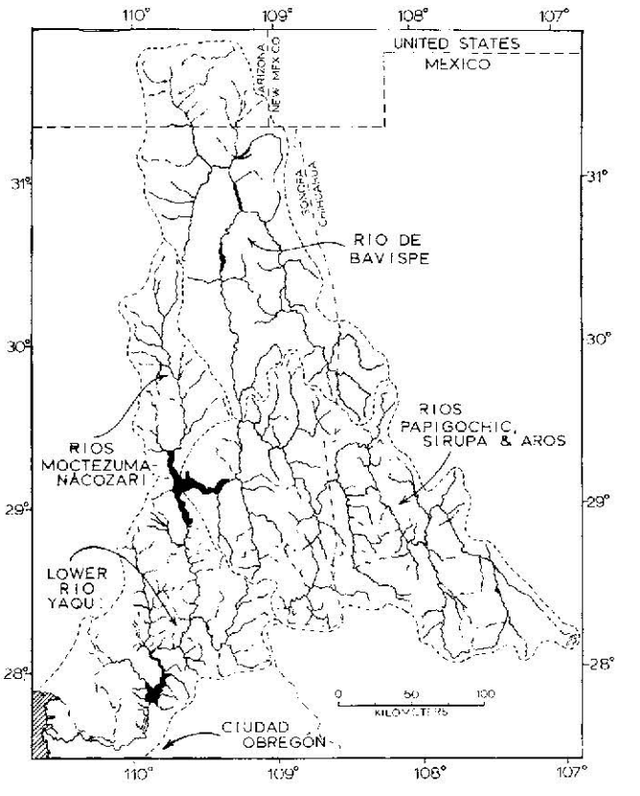

Figure 1. Major sub-basins of the Río Yaqui basin.

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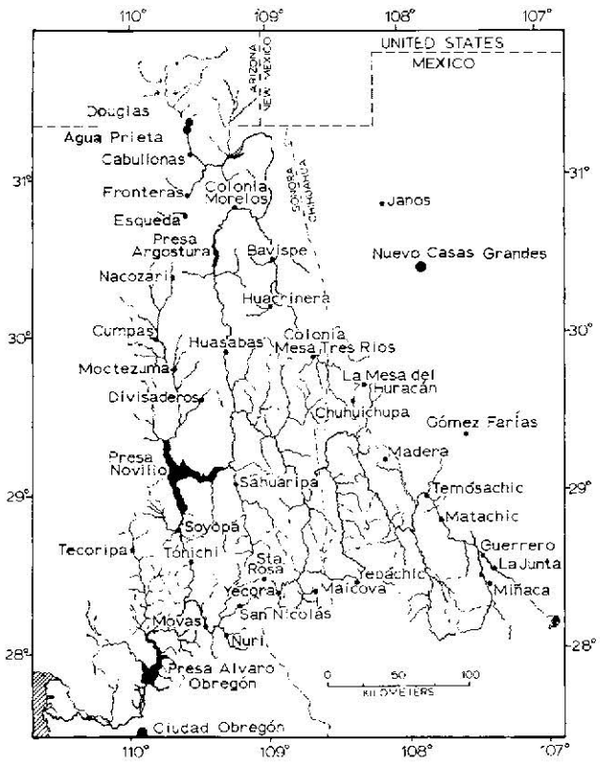

Figure 2. Río Yaqui basin place names used in text.

of Tertiary volcanic strata are exposed in steep canyon walls (Albritton 1958), and Mesozoic and older strata are exhumed in some places (Hovey 1907; Imlay 1939; King 1939). When viewed from the west, peaks hewn from the Plateau stand as a massive, bold escarpment, rising to their maximum elevations above deeply incised canyonlands.

From its ragged western edge the Plateau Section slopes gently east as part of the Mesa del Norte (West 1964a). This surface consists of a base of horizontally uplifted lavas marked with scattered, folded and faulted, partially-buried mountains. Peaks rise to 700 m above deep intermontane basin fills, the surfaces of which lie at elevations of 1,500 to 2,000 m (Hovey 1907; West 1964a). Much of this section has been or is endorheic, with streams ending in expansive, shallow, closed basins or *bolsones*. Some of these basins have been captured and drained by through-flowing rivers that pass to the Río Bravo del Norte (Río Grande), to the Pacific Ocean, or to both. Rivers in this section typically meander across broad valleys bordered by forested uplands, and drainage divides may be surprisingly low.

West of the 109th meridian, the Sierra Madre Occidental gives way to King's (1939) Province of Parallel Ranges and Valleys, an area considered by Sauer (1930) as a southern extension of the Basin and Range of southeastern Arizona. It is complex in structure, but basically consists of two longitudinal troughs bounded by mountains that are structural blocks. Upfaulting of these blocks was such that west-facing escarpments were produced and eastern slopes dip gently into surrounding terrain. The ranges and basins are almost parallel, and trend on the average north (10° W) (King 1939, Imlay 1939). Streams are not so deeply entrenched in their canyons as in the Barranca Section, often cutting through conglomerates and having occasional, narrow, alluvial terraces.

The northern, wedge-like prominence of the Sierra Madre Occidental Province was considered by King (1939) to end at a point 16 km south of the 31st parallel, just east of the Río de Bavispe Valley. This leaves the province of Parallel Ranges and Valleys to border on the east with the Mexican Basin and Range Province as it passes north to the United States and Mexican Boundary. West (1964a) extended the Sierra Madre Occidental to the Boundary. On the south, rugged barranca topography and parallel Plateau Section surfaces of the Sierra extend to the Río Mezquital of southern Durango (Garfías and Chapín 1949), or perhaps farther (West 1964a), to pass into structural complexes of the Mesa Central of México.

Also drained by the Río Yaqui *via* Arroyo Tecoripa is a small area of arid Sonoran Desert Province lying west of the Parallel Ranges and Valleys. This is a zone of north-south-oriented, low mountains, of old crystalline rock, widely separated by alluvial plains. Ranges rise abruptly from desert and lie parallel near the Sierra Madre Occidental. They then decrease in height toward the west and become less regular in position as a result of interment by fluviatile sediments. Low hills of granitic stone extend into the sea, where some form natural harbors in the Sea of Cortez (Thompson *et al.* 1979). Terrain, described in detail by Dumble (1900), is similar in aspect to deserts of southwestern Arizona.

Excepting stony outliers, deltaic plains of the ríos Sonora, Matape, Yaqui, Mayo, and Fuerte have largely coalesced to form a narrow coastal plain between inland provinces and the sea.

Geologic history of this vast area is complicated and difficult to condense. Most studies have been of a reconnaissance nature, but have included valuable expeditions on horseback into interior parts of the drainage basin that yet remain inaccessible. Older reports are remarkably detailed and authoritative. Widespread Paleozoic deposition, mostly of limestone, was followed in Mesozoic by laying down of the thick Barranca Clastics in what is now northeastern Sonora and western Chihuahua (Maldonado-Koerdell 1964). Close of the Cretaceous saw the region an active participant in the Laramide Orogeny that so radically altered the face of much of western North America, and the basic shape of northwestern México was created.

Following Post-Cretaceous adjustments, land surfaces were highly eroded, in places into rugged relief, before being blanketed in Early Tertiary by outpourings of lava. Thickest in the Plateau Section (Imlay 1939), these extrusives thinned to the west across the Province of Parallel Ranges and Valleys. Mid-Tertiary times saw extensive deformation of these strata in the latter region, but faulting and uplift occurred with a minimum of folding or tilting on the Plateau, where many beds remain relatively undissected and almost level (King 1939; West 1964a). At about the same time the present faulted systems of Parallel Ranges and Valleys began to form, and those structures, in movements probably related to the Cascadian Orogeny to the north (Imlay 1939), began to assume their present form. By Late Tertiary the Báucarit Formation (Dumble 1900; King 1939) was being deposited in intermontane valleys of the area. This thick conglomerate was derived from adjacent, high mountains, forming as coalesced alluvial fans (fanglomerates) interbedded with finer fluvial and occasionally lacustrine sediments. Formation of these extensive beds was similar to, and likely contemporaneous with, a complex widely known as the Gila Conglomerate of southeastern Arizona and southwestern New Mexico (Gilbert 1875; Heindl 1952, 1962). The Gila Conglomerate consists of materials from more than a single cycle of deposition in a number of distinct basins, and use of a single name to describe so complex a situation has been seriously questioned (Heindl 1962). Yet the presence of structural and depositional materials of similar geologic age in tectonically-related basins adds a cohesive flavor to a region that is otherwise remarkably heterogenous. Scarce fossils from the Gila Conglomerate and associated deposits are Pliocene to Early Pleisotocene in age (Taylor 1967); no datable fossils are known from the Báucarit Formation (King 1939).

Post-Báucarit times saw renewed orogenic activity along pre-existing lines of folding and faulting in northwestern México. Overthrusting to the west occurred north of the 28th Parallel, which includes most of the Río Yaqui drainage (Fig. 1), while normal faulting prevailed south of that line (King 1939). At that time, or a bit later, the then-mature erosional surface of the present Plateau Section was uplifted. This provided well-watered uplands from which streams flowed to entrench and excavate the western margin of the plateau, creating the complicated Barranca Section that persists today.

Development and Integration of the Basin. – The present Río Yaqui drainage system is a complex of sub-basins. Channels reflect structural control in their longest reaches, flowing a few degrees west of a northerly direction, and along mountain blocks. Shorter reaches breach mountain trend-lines from northeast to southwest, either through antecedent channels or as a result of stream piracy. Even in areas of thick Tertiary lavas, notably in most of the Barranca Section, southeast-to-northwest structure is indicated by the surficial drainage patterns. Dendritic patterns are present only on alluvial surfaces of the Plateau Section in headwaters of the Río Papigochic, in the San Bernardino and Douglas valleys of southeastern Arizona, and in broader basins of the Parallel Ranges and Valleys and Sonoran Desert provinces (Río Moctezuma and Arroyo Tecoripa, respectively).

Melton (1960) believed that several northeast-southwest-trending rivers existed in southeastern Arizona and adjacent México prior to Basin and Range orogenic activities of Miocene times. These rivers in part maintained their through-cutting capabilities as the event progressed, carving existing northeast-southwest-trending gorges. Formation of major structural axes along fault blocks, produced by west-southwest – east-northeast-directed expansion (Rehrig and Heidrick 1976), plus local vulcanism, must have diverted rivers northwestward or southeastward with formation of perpendicular structure in the region in Late Miocene or Early Pliocene times. Troughs of substantial continuity can be traced from southeastern Arizona throughout the Río Yaqui basin and into at least the Río Mayo drainage, especially west of the Sierra. King (1939) pointed out that the Eastern Longitudinal Valley of his Province of Parallel Ranges and Valleys (now occupied by the south-flowing, lower Río de Bavispe and the north-flowing Río Sahuaripa) arches southward east of Yécora and out of the basin. So does his Central Valley, which passes south through Movas and Río Cedros, and contains on the north the ríos Moctezuma-Nacozari system. The San Simon Trough, a northward extension of the Río de Bavispe-San Bernardino depression (Sauer 1930), was discussed by Blásquez (1959) as a probable connection between southern Arizona and the Río Yaqui basin. Melton (1960) proposed that the upper Gila River followed the San Simon Trough southeast, received the Río de Bavispe or its precursor, then passed westward to connect with the Santa Cruz Trough of southern Arizona, through which it descended to the Phoenix basin. Continuing uplift in Middle Pliocene severed the connection between the Gila and Santa Cruz rivers. The upper Gila River then flowed south into México (Kottlowski *et al.* 1965), or was ponded in the vicinity of Safford, Arizona (Melton 1960), or upstream near the Arizona - New Mexico border (Cooley 1968). It eventually flowed northwest through the Safford Valley to possibly enter the Salt River northwest of Globe (Melton 1960) and again join the Phoenix basin. The Mexican headwaters continued to flow northward into the San Simon Trough or Sulphur Springs Valley, accounting perhaps for some of the vast deposition of the latter (more than 1,500 m; Meinzer and Kelton 1913). By Early Pleistocene the Gila River had succeeded in cutting to the southwest, reoccupying the gorge through the Mescal Mountains and establishing connection to the Sea of Cortez, either directly or through the lower Colorado River. Melton (1960) proposed that drainages of northern México turned southward near this time to occupy the lower Río de Bavispe. This may have resulted from general upwarping to the north, which caused massive stripping of alluvium from former basin fills (Simon 1964; Cooley 1968). Antecedent channels north of Tertiary lavas of the Sierra Madre Occidental also were available to facilitate this transfer. Lava flows in the vicinity of the San Bernardino Ranch, Cochise County, Arizona, considered by Sauer (1930) as "...recent, almost current," plus uplift of the Chiricahua Mountain mass, also must have assisted in southerly diversion of those systems.

Integration of the Río Papigochic basin into the present Río Yaqui system most likely was a process of massive headward erosion by streams fed by abundant precipitation in the highlands themselves. Zones of weakness produced by forces that shaped adjacent provinces must, however, be reflected in the pattern of erosion, because, as noted before, major reaches of channels trend parallel. Streams following trendlines of the Plateau Section, flowing northward among faulted and horizontally-uplifted ranges, incised *in situ* with onset of Pliocene uplift. Lateral stream captures by west-flowing tributaries began to occur when, as a result of greater rainfall in uplifting highlands, headward erosion of the Plateau margin was accelerated. As drainage basins enlarged, more rapid downcutting speeded removal of lavas, and a trellis-like drainage pattern emerged.

Many exchanges of small watersheds have been possible among the ríos Papigochic, Casas Grandes, Santa María, and Conchos, over low drainage divides of the relatively undissected Plateau Section. Meek (1903: 775), commenting on the occurrence of numerous Río Grande fishes in the Río Yaqui basin, stated that the headwaters of the Río Papigochic formerly drained through Laguna Bustillos (his Lago de Castrillos) into the Río Conchos. Miller (1959) suggested a minor stream capture about 45 km due south of Miñaca, Chihuahua, by the Río Papigochic from the Río Conchos. He also noted that the former river could easily become (or could have been) a headwater of the Río Casas Grandes did it not abruptly turn westward northwest of Miñaca to begin its passage through the high Sierra. The presence of *bolsones* further complicates interpretation of drainage relations. Any recent topographic map will reveal the obvious capture of Laguna de los Mexicanos by headwaters of the Río Papigochic, pirating it from earlier probable connections to the ríos Conchos or Santa María. Fossiliferous beds in the vicinity of Yepómera provide additional testimony to incision and capture of such lacustrine habitats in the distant past (Tom Van Devender, personal communication).

Streams west of the Sierra Madre Occidental represent the old lower Río Yaqui system. Distributaries on the delta are intimately related to those of smaller systems up and down the coast, and transfers of minor watersheds must have frequently occurred. Upstream, in the headwaters of Arroyo Tecoripa and Río Moctezuma, the system is reasonably well isolated by mountain ranges paralleling watercourses. In the Sonoran Desert Province, however, potentials for interconnection over low relief to the adjacent ríos Matape and Sonora are negated mostly by the arid climate.

Highlands separating headwaters of the Río Yaqui and the ríos Mayo and Fuerte are deeply dissected by *barranca* topography, which obscures any evidence of major basin transfers among those systems. However, King's (1939) Eastern Longitudinal Valley, discussed before with reference to the Río de Bavispe Gila River connection, does link at least the ríos Yaqui and Mayo, and interbasin transfers through such structural troughs have a high probability. Since the Sierra Madre Occidental is higher to the south in Chihuahua and Durango than in the Río Yaqui basin (West 1964a), headwater cutting by well-watered tributaries may well have pirated some of the Río Yaqui drainage basin.

Climate and Vegetation. – Major factors which control regional climates, latitudinal position, physical size of the area, surface configuration (especially altitudinal variation), and distance from the sea, all have profound influences on climate in the Río Yaqui basin. The mean annual air temperature along the coast and well inland through the Province of Parallel Ranges and Valleys is greater than 25°C, whereas in the Plateau section, average temperature is less than 15°C (Vivó 1964). Maximum summer temperatures exceed 40°C in lowlands, and often are higher than 30°C in montane areas. Frost is rare in deserts and along the coast, but freezing temperatures and substantial precipitation in the form of snow is common above 1,500 m elevation. Precipitation in the region varies 20 to 40% year to year (Wallen 1956), rarely exceeding 50 mm/year in lowlands, and exceeding 200 mm only in the extreme southern part of the basin (Shreve 1944; Vivó 1964).

West (1964b) included most of the Río Yaqui basin in "extratropical drylands," with a band of "extratropical highlands" following the Sierra Madre Occidental northward through the region and into the United States. His first subdivision was defined as being "characterized by definite winter and summer temperature seasons, by xerophytic plant assemblages of North American affinity, and by predominance of arid-type landforms." The cool, extratropical highlands are a zone of transition from oak-conifer forests of North American affinity to those of central and southern México where plant assemblages of South American origins begin to prevail.

Wagner (1964) included about the western third of the Río Yaqui basin in a "seasonal formation series" of vegetation, citing extensive studies by Shreve (1934, 1951) in his descriptions of vegetation on coastal areas and in the lower elevation parts of the Barranca Section of the Sierra Madre Occidental. The area between 27° and 28° latitude is a zone of rapid transition from thorny woodlands with trees to 10 m high and a canopy at 7 to 8 m (Sinaloan Deciduous Forest of Brown and Lowe 1980), to a vegetation of low, widely-spaced, xeromorphic shrubs (Sinaloan Thornscrub). At about 750 m, Madrean Evergreen Woodlands become evident in foothills of the Sierra, increasing with elevation to the east until Petran Montane Conifer Forests prevail (Shreve 1934, 1940; Gentry 1942; Brown and Lowe 1980). Small tracts of Chihuahuan and Sonoran Desertscrub vegetation are present in the Río de Bavispe and ríos Moctezuma-Nacozari systems near the United States boundary, and Semidesert Grasslands are present on rolling topography between 1,240 and 1,700 m in the northern third of the basin (White 1948). Riparian communities of these areas were described by Wagner (1964); most have been radically modified by man, especially where floodplains were amenable to agricultural development, so that only vestiges of many associations remain.

Streams and other Aquatic Habitats. – Morphology and general aspect of streams of the Río Yaqui basin have been generally described in preceding sections. Diversity is high, especially in upland habitats. Photographs of selected reaches of upland and lowland rivers, creeks, and brooks are provided as Plates I through VIII. Plates IX and X are of artificial habitats. Further descriptive information on specific localities is given in Appendix A in the itineraries of various collecting expeditions.

METHODS AND MATERIALS. – Collections of fishes were made with the following equipment, used alone or in combination: 1) backpack electrofishing gear, 150 volts, AC or DC, with pick up of stunned fishes through use of 3-mm mesh, nylon scape nets; 2) 4.6-m nylon seines, with 6.4-mm mesh (bar measure); 3) 1.2-m nylon seines, with 3.2-mm mesh; 4) variable mesh, nylon, lightweight gill nets; and 5) a 91-m trammel net, with 38-mm mesh in the inner wall.

Specimens were immediately preserved in 10% formalin. Larger fishes were preserved in stronger solutions and often injected to assure

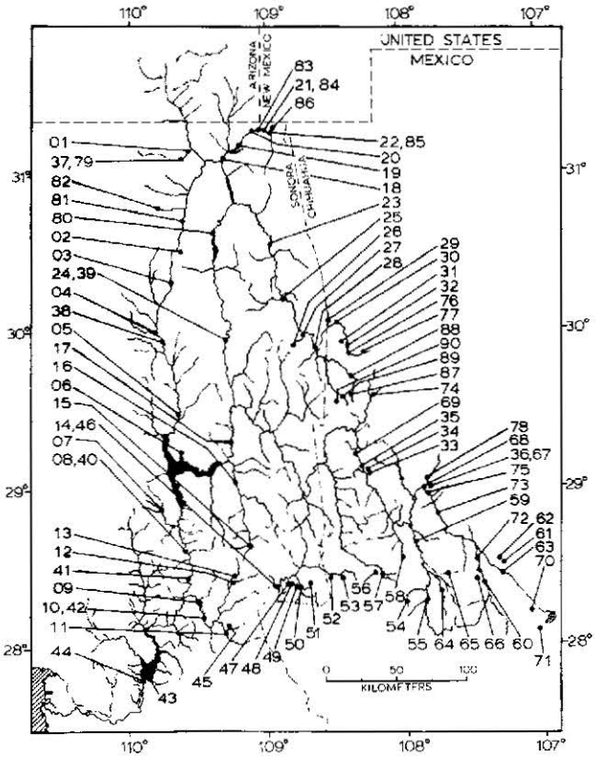

Figure 3. Authors' collection localities in the Río Yaqui basin. See Appendix B for descriptions and coordinates.

fixing, especially in warmer weather. After preservation, specimens were washed in multiple rinses of water and placed in 70% ethanol for permanent storage at Arizona State University and University of Michigan Museum of Zoology.

All of our locality descriptions and coordinates (termed localities in text, and numbered 1-90; Fig. 3) are based upon Series 1501, Edition 1, Joint Operation Graphic (Ground), 1:250,000 scale maps, published by the Aeronautical Chart and Information Center, U.S. Air Force, St. Louis, Missouri, which were made available through the U.S. Fish and Wildlife Service. Since data for most of these maps were compiled in 1969, subsequent road building in some areas and occasionally apparent errors in mapping made precise location of some localities impossible. In these few instances, names given by local residents were applied, as well as road distances from major population centers. Coordinates of such localities are obviously approximate, but should fall within a 10 km radius of the collecting locality; they are marked with an asterisk (*) in Appendix B.

Specimens in the following museums were checked for identification only if questionable. Some series identified only to genus in catalogs were not further examined, and were identified on geographic grounds if obvious, or are included as cataloged for sake of completeness: Arizona State University, Collection of Fishes (ASU); Universidad Autónoma de Nuevo León (UANL); California Academy of Sciences (CAS); Field Museum of Natural History (FMNH); Leland Stanford University (SU) (specimens now at CAS or UMMZ); University of Kansas, Museum of Natural History (KU); University of Arizona (UA); and University of Michigan Museum of Zoology (UMMZ). Locality data (termed sites in text, and numbered 101-173; Fig. 4) and lists of species are in Appendix B, as are species lists for major literature citations.

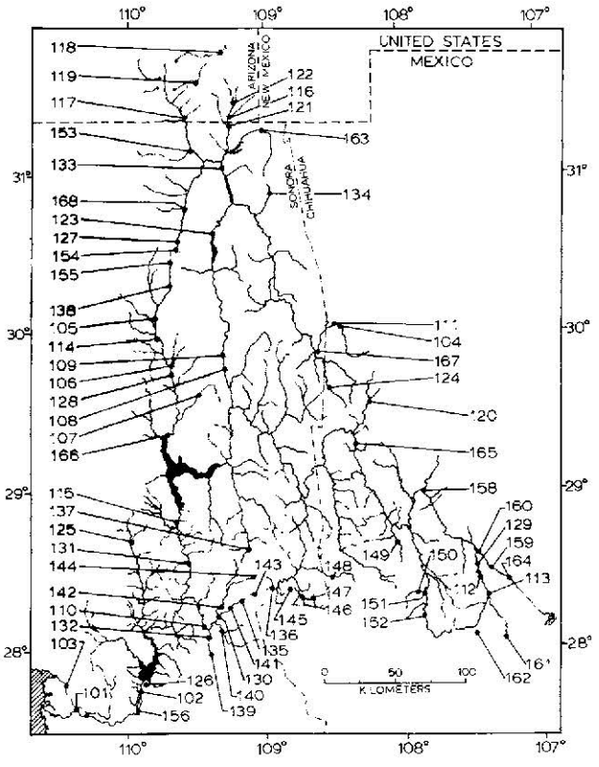

Figure 4. Literature and museum collection sites in the Río Yaqui basin. See Appendix B for descriptions and other data.

ACCOUNTS OF SPECIES. – Accounts which follow are preceded by a list of earlier literature records for a species from the Río Yaqui system, if such exist. Statements of abundance typically deal with relative numbers of the animal within its habitat(s) or geographic range. Thus a "rare" species with respect to other fishes may have a gradation in abundance at the intraspecific level within various habitats. Unless otherwise noted, open circles on maps are for specimens reported in literature or housed in museums and solid dots are for localities where we caught the species concerned (Appendix B). "Localities" and "sites" (authors' and museum or literature records, respectively) as given in text are numbered and plotted on Figures 3 and 4.

CLUPEIDAE

Lile stolifera (Jordan and Gilbert)

Lile stolifera – Miller 1959.

This marine species penetrates the lower Río Yaqui for at least 100 stream-km to near where the river passes from low montane to coastal plain habitat (site 102b). The fish enters fresh waters of Middle America from Baja California to Perú (Miller 1966).

Dorosoma smithi Hubbs and Miller

Pacific shad (Fig. 5)

Dorosoma smithi – Hubbs and Miller 1941b; De Buen 1947; Miller 1959, 1960a; Alvarez 1970; Minckley *et al.* 1980.

Pacific shad had previously been recorded from the Río Yaqui only from delta habitats in the vicinity of Ciudad Obregón and downstream. Our specimens from Presa Novillo therefore represent an approximate 200 km extension of known range, northward and into the interior (Minckley *et al.* 1980). The species was abundant, as judged by the presence of flocks of piscivorous birds, observations of large schools of shad at and near the surface, and catches in gill nets. Most specimens decomposed overnight in hot surface waters, but examination of those which were preserved confirmed the proposal by Hubbs and Miller (1941b) that shad from the Río Yaqui differ in some respects from those of more southern rivers of the west coast of México (Minckley *et al.* 1980).

Populations of this species have undoubtedly been enhanced by construction of impoundments on rivers of western México. Introduced centrarchids in Presa Alvaro Obregón fed heavily on Pacific shad, and it is likely an important forage species.

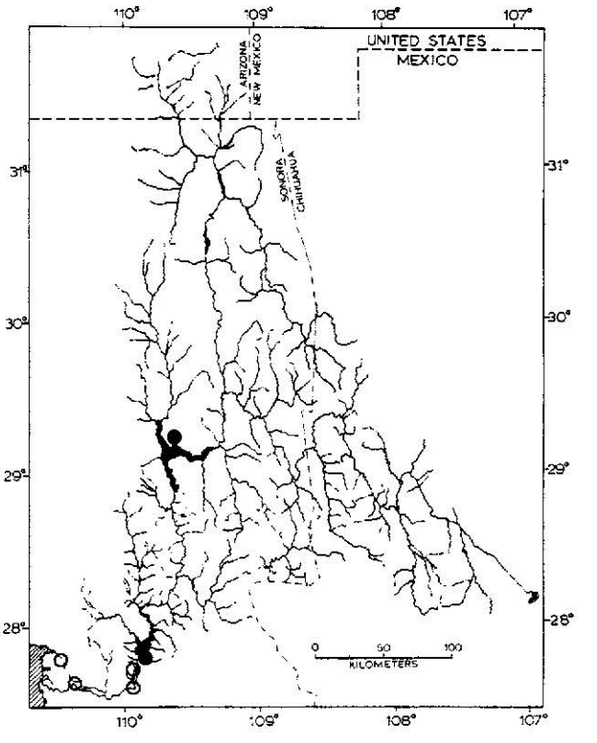

Figure 5. Distribution of Pacific shad *(Dorosoma smithi)* in the Río Yaqui basin.

ELOPIDAE

Elops affinis Regan

Machete (Pacific tenpounder)

Elops – Miller 1959.

Elops affinis – Branson *et al.* 1960.

Machete have been recorded from a distributary of the Río Yaqui near its mouth, presumably within the zone of tidal influence, and again from ditches on the delta (sites 101d and 103). The species often moves into estuaries and lower parts of rivers, and occurs in the Colorado River upstream to Imperial Dam, Arizona – California (Glidden 1941; Minckley 1973). It ranges widely on the Pacific Seaboard, from the Salton Sea, California, to Perú (Miller 1966).

SALMONIDAE

Salmo gairdneri Richardson

Rainbow trout

Rainbow trout have for years been stocked in Rucker Canyon Lake, a small impoundment in the Chiricahua Mountains, Arizona, to provide a local sport fishery. They also are in the stream below the lake, as a result of direct introduction or through unlikely escape, where they interact with the remnant population of native fishes (McNatt 1974). This situation was recently recognized, and a management plan for native species on Forest Service lands of southeastern Arizona has appeared (Rickel 1979). The Chiricahua Mountains stand as a sky island surrounded by desert and grassland, so that trouts introduced there are isolated by thermal barriers and ephemeral watercourses downslope. Rainbow trout introduced in Cajón Bonito, Sonora, in July 1953 had disappeared by October of that year (Frank B. Cross, personal communication). We collected an adult female rainbow trout from Presa de Moctezuma (locality 77).

Salmo sp.

Yaqui trout (Fig. 6)

Native trouts of the genus *Salmo* have long been known from the Río Yaqui basin (Meek 1904; De Buen 1940, 1947; Miller 1950, 1972a; Needham and Gard 1964; and others), but series adequate for definition of their taxonomic status have not been available. Potential introductions of non-native trout species also have plagued interpretation of the status of native populations. Most records for the system have been referred to nominal forms now in synonymy with *S. gairdneri*.

Field and preliminary laboratory impressions indicate that two kinds of *Salmo* may be native to the Río Yaqui basin. One is northern in distribution, in the Río Gavilán and its tributaries, and likely represented by populations in the adjacent Río Casas Grandes (Miller 1959). The other is in headwaters of more southern parts of the system and evidently is intimately related to native stocks of the Río Mayo. Data on the trouts are being accumulated by Miller, and will be presented elsewhere.

Yaqui trout are widespread and locally abundant in high-elevation tributaries. Residents informed us of many additional localities, especially more remote ones, that could not be visited because of constraints of time and access. Most populations were in erosive, high gradient creeks, where pools alternated with runs and riffles. The fish were characteristically secretive, associated with cover and with dense riparian vegetation (when present). Largest individuals were in the deepest pools, near boulders, undercut banks, overhanging cliffs, or fallen trees. Yaqui trout frequently were in shallow, warm, sun-exposed creeks at relatively low elevations (less than 2,000 m; Plate VII). Habitats were similar in these respects to those of *S. apache* Miller and *S. gilae* Miller in high-elevation brooks of New Mexico and Arizona (Harper 1978; Rinne 1978), although both those fishes and *S. chrysogaster* Needham and Gard of the Río Fuerte basin, México, are at present at higher elevation (above 2,200 m).

Since potential introductions have created problems in the past, we document here the transfer of trout from the Río de Bavispe basin to the southern headwaters near Madera (locality 33; Robert Stonoff, Phoenix, Arizona, personal communication). The stocked population seemed well established at the time of our sampling.

Salvelinus fontinalis (Mitchill)

Brook trout

Brook trout are infrequently stocked along with rainbow trout in Rucker Canyon Lake, Chiricahua Mountains, Arizona (site 118k), from which they appear to run upstream. Comments for *Salmo gairdneri* apply as well for this introduced species.

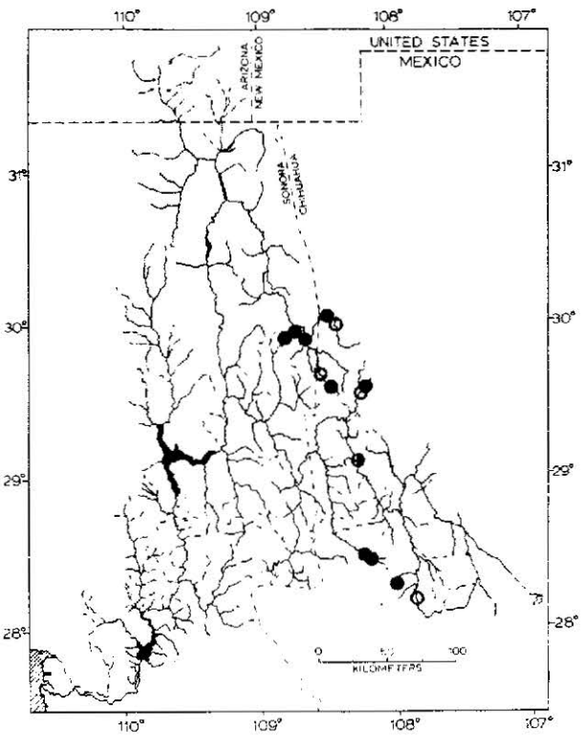

Figure 6. Distribution of Yaqui trout (*Salmo* sp.) in the Río Yaqui basin. The half-darkened circle is for a population known to be introduced from the Río de Bavispe system (see text).

CYPRINIDAE

Cyprinus carpio Linnaeus

Carp

Cyprinus carpio — Branson *et al.* 1960.

Carp were surprisingly rare in the Río Yaqui system. The species was first caught in the upper drainage in the United States in 1939 and 1943 (sites 117a-b, respectively), from just south of the border in 1944 (site 121f), and from near the mouth of the Río Yaqui in 1940 (site 101a). The fish was first introduced into Arizona in the 1880s (Taggart 1885). Adequate time has obviously elapsed for its spread into suitable parts of the river system. However, they were rare in streams and usually occurred as single adults. Mainstream reservoirs were densely populated, as was one relatively large irrigation pond. Perhaps swift, uncontrolled, canyon-bound rivers resist invasions by carp and only after adequate lentic waters are created by impoundment can the animal spread to occupy such highly erosive drainage networks. Much of the Río Yaqui basin in the Mesa del Norte of Chihuahua, however, seems to be more than suitable for carp. Large pools of the Río Papigochic, for example, have dense beds of macrophytes over soft bottoms. According to local residents, the fish is abundant in a small reservoir near Madera, so its spread into upper parts of the system may be anticipated.

Carassius auratus Linnaeus
Goldfish

Goldfish were caught in the Río Yaqui basin in 1939 and again in 1943 from Whitewater Creek, Arizona (sites 117 a-b). This species rarely establishes viable populations in the American Southwest, except occasionally in reservoirs; most individuals appear to result from direct release of bait or aquarium fish (Minckley 1973).

Campostoma ornatum Girard
Mexican stoneroller (Fig. 7)

Campostoma ornatum — Rutter 1896; Evermann and Goldsborough 1902[a]; De Buen 1940, 1947; Eddy 1957, 1969; Moore 1957, 1968; Miller 1959, 1972b; Branson *et al.* 1960; John 1964; Miller and Lowe 1964, 1967; Anonymous 1966, 1968, 1973; Alvarez 1970; Minckley 1971, 1973; Burr 1976; Buth and Burr 1978; Deacon *et al.* 1979.

Campostoma pricei — Jordan and Thoburn, in Jordan and Evermann 1896 (original description, Rucker Canyon, Arizona); Jordan *et al.* 1930; Schrenkeisen 1938; Hubbs 1940; Böhlke 1953; Moore 1957, 1968.

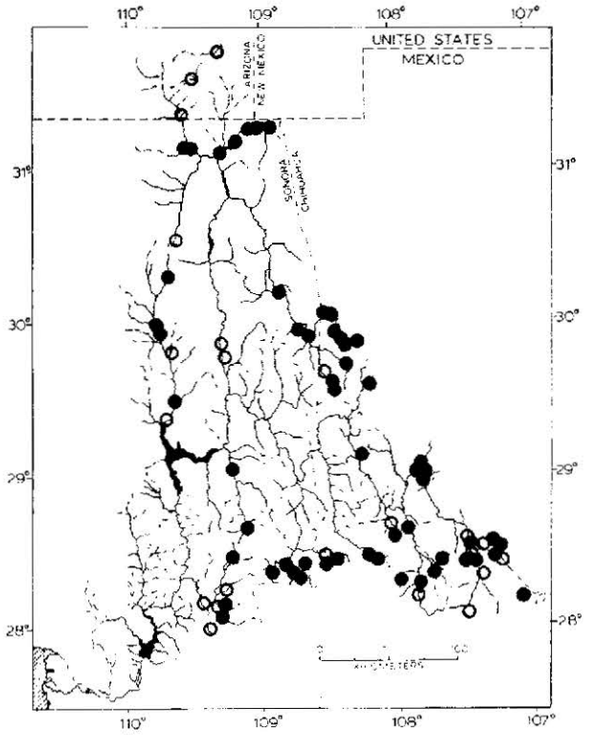

Figure 7. Distribution of Mexican stoneroller (*Campostoma ornatum*) in the Río Yaqui basin.

Campostoma ornatum is widespread in mountainous portions of the Río Yaqui basin. The species prefers shallow riffles and runs over gravel/cobble substrate. Large adults, however, are often in flowing segments of pools or along undercut banks or other cover. A prolonged reproductive season is present since specimens in breeding condition and tiny young were taken throughout the study period.

[a]C. H. T. Townsend and C. M. Barber collected fishes "near the summit of the Sierra Madre, Chihuahua" in what must have been the Río Yaqui system since longfin dace also were taken (Evermann and Goldsborough 1902).

Burr (1976) discussed morphological differentiation of *C. ornatum* through its range and noted a higher degree of similarity between populations of the Río Yaqui and Río Casas Grandes, Chihuahua, than was indicated among stocks from other river systems. He concluded that variation within the species was too great to warrant recognition of subspecies at the present state of knowledge, and recommended relegation of the nominal *C. pricei* to synonymy, an action equitable with current taxonomic practice.

Mexican stoneroller seems to occupy essentially all of its known range in México at population levels resembling those recorded in the past. In Arizona it fluctuates radically in abundance in Rucker Canyon (Minckley 1973; McNatt 1974), where it is under pressures of variation in habitat availability due to alternating flood and drought. That population also is influenced by periodic introductions of salmonids for a local fishery. In many years of sampling only two specimens of *C. ornatum* (ASU) were taken from Leslie Creek, Arizona, where the population is scarcely if at all viable. The channels of Whitewater and San Bernardino creeks, formerly or at least potentially occupied by the species in the United States, now are ephemeral and deeply incised, and no longer suitable.

Populations of Mexican stoneroller also are variable in size and occurrence in Texas (Hubbs and Wauer 1973), where they live mostly in mouths of creeks tributary to the Río Grande (Hubbs *et al.* 1977). They are therefore subject to rapid destruction if those fragile habitats are altered.

Gila purpurea (Girard)
Yaqui chub (Fig. 8)

Tigoma purpurea — Girard 1857 (original description, Río San Bernardino, Sonora), 1859; Jordan *et al.* 1930.

Squalius purpureus — Jordan and Gilbert 1883.

Leuciscus purpureus — Jordan and Evermann 1896; Rutter 1896.

Leuciscus nigrescens — Meek 1904.

Richardsonius purpureus — Snyder 1915.

Gila purpurea — Miller and Simon 1943; Miller 1945, 1959, 1972b; Eddy 1957, 1969; Moore 1957, 1968; Branson *et al.* 1960; Miller and Lowe 1964, 1967; Anonymous 1966, 1968, 1973; Rinne and Minckley 1970; Minckley 1971, 1973; McNatt 1974; Rinne 1976; Barbour and Miller 1978; Deacon *et al.* 1979.

The Yaqui chub is a small, secretive species that exhibits highly localized distribution. Even in long reaches of permanent water the fish will occur in a single pool or single segment, and be absent from another, apparently suitable area. Places of occupation are typically the most permanent habitat, usually a deep, undercut zone adjacent to (and formed through influence of) a fixed object such as a cliff face, large boulder, or roots of a mature riparian tree. It was intimately associated with springs and artesian wells in Arizona, and persists there only as a single introduced population in Leslie Creek (Minckley 1973), and in an artesian bore and associated pool on the San Bernardino Ranch near Douglas (McNatt 1974).

The species also is scarce in the Río Yaqui basin in México. A single individual was collected during our survey, in the Río Moctezuma at Cumpas in May (Plate III). We returned to that locality in June, but captured no additional specimens. R. G. Miller and assistant collected nine specimens of *G. purpurea* at that locality in 1941, and J. T. Greenbank and party took one there in 1951. The only other record from the Río Yaqui system is from Cabullonas, a short distance south of Agua Prieta (site 153; Branson *et al.* 1960). We sampled that area intensively on three separate dates in 1978, but caught no Yaqui chubs. Extensive questioning of local residents indicated that no aquatic habitats other than those surveyed were present in the vicinity.

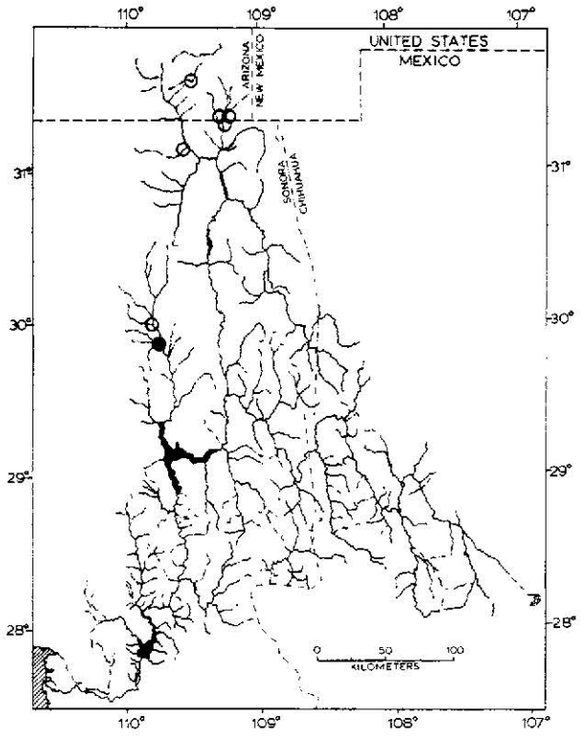

Figure 8. Distribution of Yaqui chub *(Gila purpurea)* in the Río Yaqui basin; the most northern locality for this species is an introduced population (Minckley 1973).

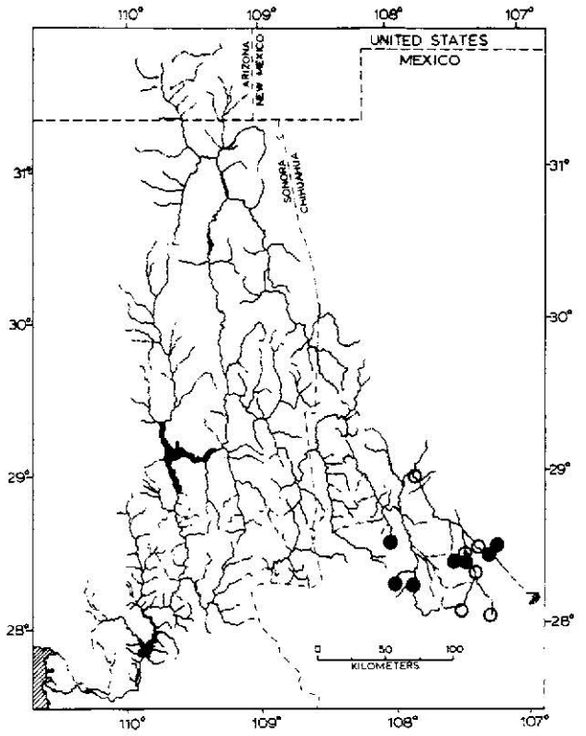

Figure 9. Distribution of Mesa del Norte chub *(Gila pulchra)* in the Río Yaqui basin.

Gila purpurea is widespread and locally abundant in the small Río Matape system of Sonora, and locally present in the Río Sonora basin (Barbour and Miller 1978). Specimens from those watersheds, especially the former, appear differentiated from Río Yaqui fish, but no data have been compiled to test this impression. Specimens recorded by Rutter (1896) from Morse Canyon, Arizona, in the Pluvial Lake Cochise basin, were presumably lost in the San Francisco earthquake of 1904.

Gila pulchra (Girard)
Mesa del Norte chub (Fig. 9)

Lenciscus (sic.) nigrescens - Meek 1902.
Leuciscus nigrescens – Meek 1904; De Buen 1940, 1947; Alvarez 1970.
Gila "nigrescens" – Miller 1959.
Gila pulchra – Miller 1976a; Barbour and Miller 1978.

Gila pulchra is restricted to the southeastern corner of the Río Yaqui system, where it occurs in headwater and moderate-sized streams in association with a large number of other species. It also is found in upper parts of the adjacent Río Mayo system, and Río Fuerte, and far more abundantly in the upper Río Conchos watershed of Chihuahua (Miller 1976a, 1978).

Largest populations of *G. pulchra* were in small streams with substantial pool development, clear and permanent water, and cover such as undercut banks or overhanging roots of trees. *Gila robusta* Baird and Girard replaces *G. pulchra* at downstream localities, but they were taken together in the Río Tomochic and were recorded syntopically at Miñaca in the Río Papigochic by Meek (1902, 1904; as *G. minacae* and *G. nigrescens*, respectively), and more recently in that area by Miller (site 113) and presumably by Contreras (site 112d; specimens not checked). *Gila robusta* and the similarly thick-bodied *G. intermedia* (Girard) have the same mutually exclusive distributions in the Gila River basin of Arizona (Minckley 1973; Rinne 1976).

Gila robusta Baird and Girard
Roundtail Chub (Fig. 10)

Ptychocheilus lucius – Bean 1898 (= *G. robusta, fide* Miller 1976a).
Gila minacae Meek 1902 (original description, Río Papigochic at Miñaca, Chihuahua). 1904; De Buen 1940, 1947.
Gila robusta – Miller 1959, 1976a (*G. minacae* synonymized); Smith *et al.* 1979.
Gila r. robusta – Miller 1976a.

Roundtail chubs range widely in the Río Yaqui system, but are most abundant in rivers, or in smaller streams that have well-developed and permanent pools. The species was taken in 1950 on the Río Yaqui Delta (site 102a), and still persists in the mainstream below Novillo and La Angostura reservoirs. In the Río Sirupa near Madera (Plate VI), where the fish was abundant, individuals occupied open pools and rapids alike, with many being taken from eddies behind boulders adjacent to currents that exceeded a meter per second. As with other species of *Gila*, most individuals in smaller streams tended

to be in the most permanent habitat available. Roundtail chubs are top carnivores in medium-sized streams in Arizona, where they feed on a wide variety of foods that includes small fishes, and other, relatively large, aquatic and terrestrial animals (Schreiber 1978). At times they also feed heavily on algae to the exclusion of other items. The versatility of this species includes the potential for large size (greater than 50 cm) and presumed long life, coupled with a capability to reproduce at small sizes (less than 10 cm) in the second or third summer of life (Minckley, original data).

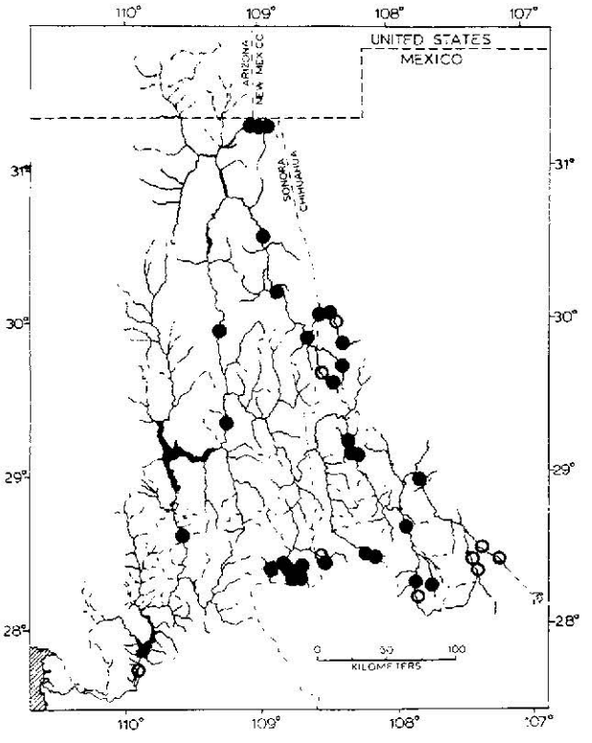

Figure 10. Distribution of roundtail chub *(Gila robusta)* in the Río Yaqui basin.

The abundance of roundtail chub in Cajón Bonito, near the United States and Mexican boundary (Fig. 10), and their resemblance to specimens from the Gila River basin of Arizona, indicate that Minckley (1973) may have erred in considering specimens in the University of Arizona collection from "San Bernardino Creek, Arizona," a result of mislabeling. Those specimens have not again been found, but almost certainly represented records of *G. robusta* from the United States' portion of the Río Yaqui drainage. Rapid movements of relatively long distances are known to be accomplished by roundtail chub in Aravaipa Creek, Arizona (Siebert 1980), and migration from México is not at all unreasonable in period of flood. The specimens may also have represented a remnant of a formerly-viable population in pools of San Bernardino Creek, or in associated habitats such as artesian-fed ponds in that area.

Agosia chrysogaster Girard
Longfin dace (Fig. 11)

Agosia chrysogaster — Rutter 1896; Evermann and Goldsborough 1902; Meek 1904; Schrenkeisen 1938; De Buen 1940, 1947; Miller and Simon 1943; Branson *et al.* 1960; John 1964; Miller and Lowe 1964, 1967; Alvarez 1970; Minckley and Barber 1971; Minckley 1973; McNatt 1974.

Agosia (near *chrysogaster*) — Miller 1959.

In the northern portion of the Río Yaqui drainage longfin dace was most abundant in streams flowing through desert and semi-desert areas, while to the south it occurred in broad, eroding streams of subtropical areas in Sinaloan Thornscrub. Essentially all occurrences of the species in the Río Yaqui basin are below 1,500 m elevation. Longfin dace were often taken in intermittent pools, and regularly with topminnows *(Poeciliopsis* spp.). *Agosia chrysogaster* in the Río Yaqui is ecologically similar to the typical form of the Gila River basin, notes on which have been provided by Minckley and Barber (1971). It is an adaptable, opportunistic species, feeding on a wide array of plant and animal foods (Schreiber 1978; Fisher *et al.* 1981), but rarely becoming common in association with more than one or two other fish species.

Taxonomic status of the Río Yaqui form, often alluded to as differentiated from the typical population of the Gila River system (Miller 1959; McNatt 1974), has yet to be worked out.

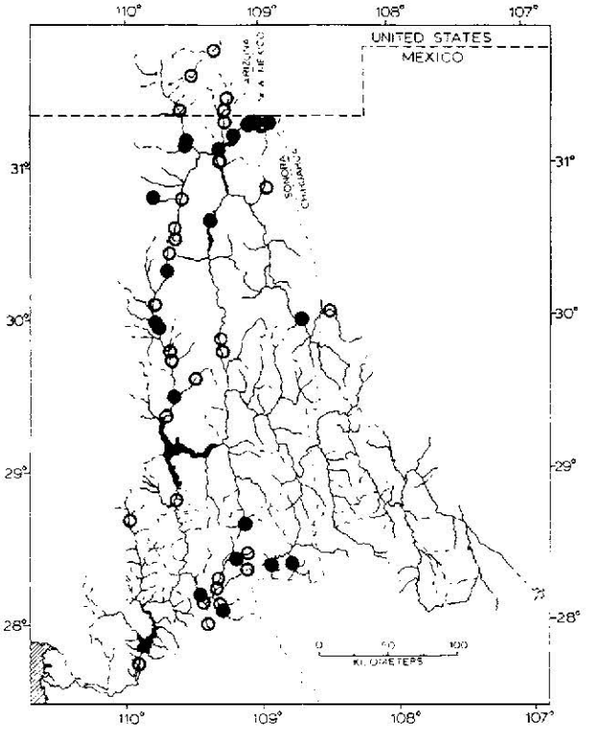

Figure 11. Distribution of longfin dace *(Agosia chrysogaster)* in the Río Yaqui basin.

Codoma ornata Girard
Ornate minnow (Fig. 12)

Notropis ornatus – Meek 1902, 1904; Alvarez 1970; Miller 1959.

Codoma ornata – Jordan *et al.* 1930; De Buen 1940, 1947; Miller 1976a, 1978; Contreras 1978.

This novel species is widely distributed in northwestern México in the Río Conchos basin of the Atlantic slope, the endorheic ríos Nazas-Aguanaval system, and Pacific drainages of the ríos Yaqui, Mezquital, and Fuerte (Contreras 1978). In the Río Yaqui system, large populations were present only above 1,500 m elevation in the southeastern part, mostly in the Río Papigochic drainage. This distribution may be temperature related, with the few individuals from lower elevation being taken in large rivers that are cooler in summer because of greater discharge.

Breeding individuals were collected at numerous sites, with highly-tuberculate and brightly-colored males in especially high density on riffles over boulder/bedrock bottoms. In Arroyo Ahumado (locality 54; Plate VII), ova were present on the undersides of rocks in such a riffle, and males were actively defending crevices and loose rocks on the bottom. Minckley (in Miller 1976a) observed identical breeding activity and egg placement in the Río de Parral, Chihuahua, in 1971.

Codoma ornata is remarkably similar to the fathead minnow, *Pimephales promelas* Rafinsque, in external morphology. Miller (1976a) proposed that *C. ornata* may lie near the basal stock of North American cyprinid fishes from which the tribe Pimephalini was derived.

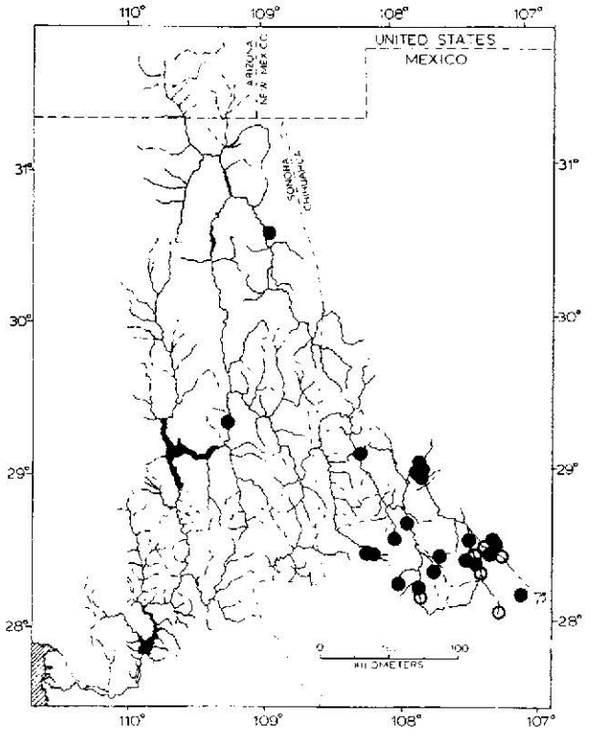

Figure 12. Distribution of ornate minnow *(Codoma ornata)* in the Río Yaqui basin.

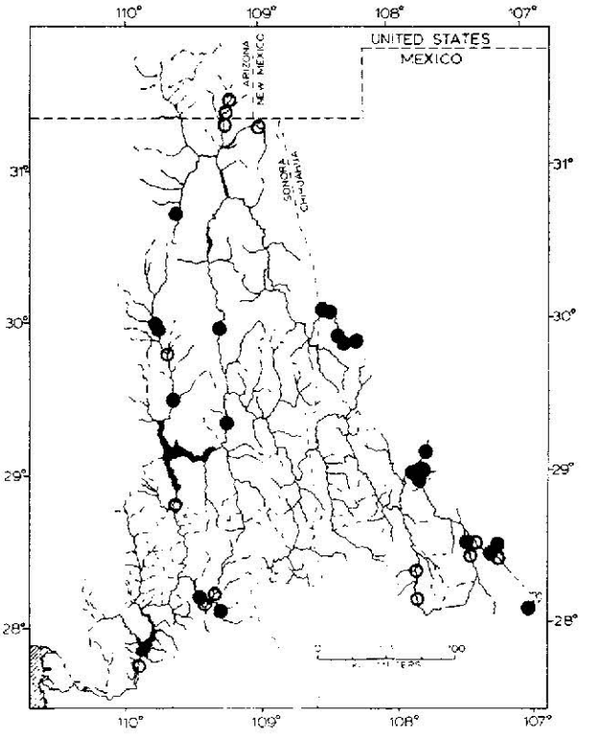

Figure 13. Distribution of beautiful shiner *(Notropis formosus)* in the Río Yaqui basin.

Notropis formosus (Girard)
Beautiful shiner (Fig. 13)

Notropis lutrensis – Meek 1902; Contreras 1978.

Nototropis lutrensis - Meek 1904.

Notropis mearnsi – Snyder 1915 (original description, San Bernardino Creek, Sonora); Miller and Simon 1943; De Buen 1947; Hubbs 1954; Eddy 1957, 1969; Moore 1957, 1968; Miller 1959; Miller and Lowe 1964, 1967; Alvarez 1970; Hubbs and Miller 1978.

Hesperoleucus mearnsi – Jordan *et al.* 1930; De Buen 1940.

Moniana lutrensis – De Buen 1940.

Notropis lutrensis lutrensis – De Buen 1947.

Notropis formosus mearnsi – Hubbs 1954; Minckley 1971, 1973; Deacon *et al.* 1979.

Contreras (1978) considered nominal forms of the genus *Notropis* in northwestern México (*N. mearnsi* Snyder, *Moniana formosa* Girard, and *N. santamariae* Evermann and Goldsborough), plus some undescribed forms, as subspecies of the widespread *N. lutrensis* (Baird and Girard). Until we can evaluate the published basis for his action we retain *N. formosus* as a separate species (see also Miller 1976a, 1978). At least two distinct subspecies of *N. formosus* are present in the Río Yaqui watershed. *Notropis f. mearnsi* Snyder occurs in the north, on the Pacific side of the Sierra Madre Occidental. The other is a yet-to-be-described form in the Río Papigochic subbasin, east of the Sierra (Contreras 1978).

We found the beautiful shiner relatively scarce throughout its wide range in the Río Yaqui area. Largest populations were on riffles of smaller streams, or in intermittent pools of creeks that have a high percentage of riffle habitat in wetter periods. The species was uncommon in rivers when present, but was collected from rapids often in current exceeding a meter per second, over rocky substrate. In contrast, it was relatively abundant in a large earthen tank at the extreme head of Arroyo Moctezuma, Chihuahua (2,130 m; locality 81), and present in another tank in desert – semidesert habitat at Hacienda Cuchuta (1,160 m; locality 77, Plate X). Prior to extirpation of the species from the United States it lived in small tanks and in the artesian-fed ditches that supplied them with water (McNatt 1974). The species has been recorded in the aquarium industry and as a few introduced individuals from canals in central Arizona (Minckley 1973).

Pimephales promelas Rafinesque
Fathead minnow

Pimephales confertus Meek 1902; De Buen 1940.
Pimelocephales confertus – Meek 1904.
Pimephales promelas confertus – De Buen 1947; Alvarez 1970.
Pimephales promelas – Miller 1959.

Meek's (1902, 1904) record of fathead minnow, based upon a single specimen (FMNH 3570, examined by Miller), formed the basis for all subsequent citations for that species in the Río Yaqui basin. We regard this record as an error, probably as a result of sorting in the laboratory. No fathead minnows were caught in a number of collections in the upper Río Papigochic basin between 1902 and 1970. Three of four collections of the species in the 1970s were in the vicinity of Miñaca (sites 112d, 129a, and 159b), and the fourth site (site 118j) was in Rucker Canyon, Arizona. We again collected *P. promelas* near Miñaca during the present survey, and at four other localities in the northern part of the basin, which were on or near a route from Arizona to Presa La Angostura, where releases of bait fishes would be expected.

Fathead minnows were common only in one small, possibly ephemeral, stream where they comprised the entire fauna. It occurs similarly in other parts of the American Southwest, where it occupies peripheral habitats in small numbers, and becomes abundant only when other fishes are rare or absent (Minckley 1973).

CATOSTOMIDAE

Carpiodes carpio (Rafinesque)
River carpsucker (Fig. 14)

Origin of river carpsucker in the Río Yaqui system is unknown. They were likely transferred to the area with sport fishes, stocked in one or more mainstream reservoirs, and then spread to most large streams lower than 1,400 m elevation. Many carpsuckers caught in pools of smaller streams were mature and obviously spawning or preparing to do so. Young were abundant along banks of Río de Bavispe at La Playa, just upstream from Presa La Angostura, in July. In Presa Novillo (Plate IX) the species was exceedingly common in shallow areas (flooded cornfields) over mud bottoms, where they essentially clogged a gill net (along with carp) that was set overnight. The species has been present since the early 1970s at least (site 140a), long enough to become well known and sought after as food by residents. They are known as *"Conchudo"* or *"Bocachiquito,"* and seasonal spawning migrations of considerable distance from reservoirs is indicated by local testimony and some of our more remote, upstream records (*e.g.* Cajón Bonito, locality 23; see Fig. 14).

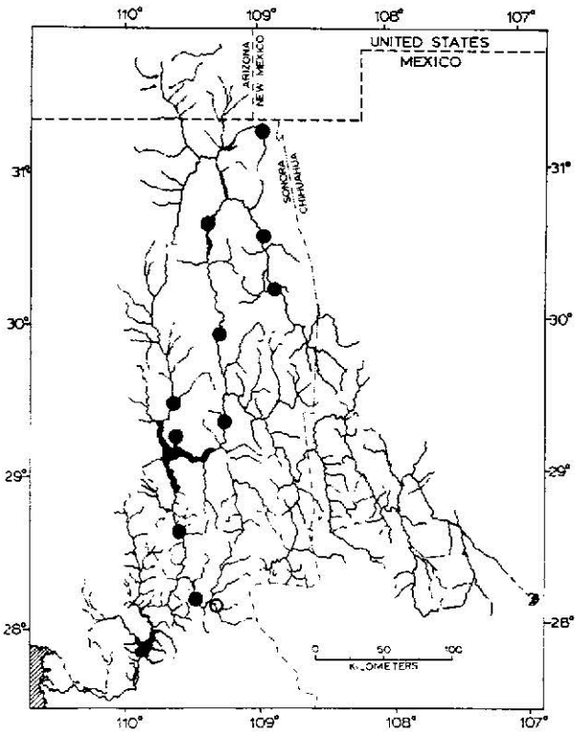

Figure 14. Distribution of river carpsucker *(Carpoides carpio)* in the Río Yaqui basin.

Comparisons in Table 1 indicate the Río Yaqui specimens are most similar to fish from the Río Grande basin. Correspondence in head length (shorter in Río Yaqui and Río Grande material), size of the eye (smaller), body depth (less), ratio of orbit/snout (smaller), postdorsal length in standard length (longer), dorsal fin-base in standard length (shorter), and on the average fewer dorsal fin-rays and more lateral line scales, all align the Río Yaqui material with *C. c. elongatus* Meek of the Río Grande system and coastal streams of the western Golfo de México. In addition, the symphyseal process at the tip of the lower jaw, characteristic of *C. c. carpio*, is variably developed, ranging from moderately produced to obsolescent, the scale pockets are conspicuously cross-hatched with melanophores, and the anterior part of the back is highly arched, all of which are characteristic of *C. c. elongatus* (Hubbs and Black 1940).

Catostomus bernardini Girard
Yaqui sucker (Fig. 15)

Catostomus bernardini – Girard 1857 (original description, Río San Bernardino, Sonora), 1859; Jordan and Gilbert 1883; Jordan 1886; Jordan and Evermann 1896; Rutter 1896; Bean 1898; Meek 1902, 1904; Jordon *et al.* 1930; Schrenkeisen 1938; Miller and Simon 1943; De Buen 1940, 1947; Eddy 1957, 1969; Moore 1957, 1968; Miller 1959, 1972b, 1976a; Miller and Lowe 1964, 1967; Alvarez 1970; Minckley 1971, 1973; McNatt 1974; Deacon *et al.* 1979.
Catostomus sonoriensis – Meek 1902 (original description, Miñaca, Chihuahua; synonymized with *C. bernardini* by Miller 1976a),

Table 1. Morphologic and meristic characters of river carpsucker *(Carpiodes carpio)* from Río Yaqui basin, México, compared with those of specimens from Río Grande and Mississippi River basins; means are followed by ± one standard error of the mean.

Characters	Río Yaqui	Río Grande[1]	Mississippi R. basin[2]
Standard Length (SL), in mm	247.6 ± 59.9	143.5 ± 109.2	72.2 ± 62.8
No. specimens	40	28[3]	16[4]
Head length, per mille SL	244.4 ± 15.1	250.6 ± 7.7	288.6 ± 3.2
Orbit length, per mille SL	51.4 ± 6.1	51.3 ± 5.7	77.6 ± 8.7
Snout length, per mille SL	75.6 ± 5.9	77.1 ± 3.7	77.9 ± 7.8
Body depth, per mille SL	281.3 ± 20.3	300.0 ± 21.2	340.7 ± 22.5
Origin dorsal fin-origin anal fin/SL	178.8 ± 10.0	181.3 ± 9.8	217.6 ± 15.3
Orbit/snout length	680.8 ± 66.0	661.9 ± 70.3	1008.8 ± 81.8
Dorsal fin-base/SL	2.91 ± 0.09	2.87 ± 0.15	2.48 ± 0.08
Caudal penducle L/ dorsal fin-base	1.53 ± 0.14	1.50 ± 0.11	2.28 ± 0.21
Dorsal fin-rays	23.46 ± 0.94	23.28 ± 1.05	24.00 ± 0.91
Lateral line scales	36.04 ± 0.68	35.81 ± 0.40	34.38 ± 0.50

[1]ASU 688, Río Grande, New Mexico; ASU 886, Río Conchos, Chihuahua.
[2]ASU 149, Red River, Oklahoma; ASU 442, Red River, Texas; ASU 1910, Little Blue River, Nebraska; ASU 2126, Kansas River, Kansas; ASU 3480, Nemaha River, Nebraska; ASU 3541, Deep Creek, Kansas.
[3]Only specimens longer than 140 mm used for measurements (16 fish).
[4]Only specimens longer than 90 mm used for measurements (8 fish).

1904; Synder 1915; Jordan *et al.* 1930; De Buen 1940, 1947; Alvarez 1970.

Catostomus (Catostomus) bernardini — Koehn and Rasmussen 1967.

The Yaqui sucker enjoys one of the widest geographic and ecologic distributions of any fish species in the river basin. Specimens were taken from small creeks of mountain and desert alike, in deep pools and runs of the mainstream Río Yaqui below major reservoirs, and in pools and rapids of other large rivers such as the Río Sirupa. Habits of this species closely resemble those of *C. insignis* Baird and Girard of the Gila River basin, Arizona (see Minckley 1973 and Schreiber 1978). Explosives are used in larger streams to obtain *C. bernardini* and other species for food (Lumholtz 1902 and original data).

Yaqui sucker formerly occupied San Bernardino Creek in the United States, and a remnant population persisted in the headwaters of that stream, Astin Spring, until about 1968 (McNatt 1974). The population was apparently dwarfed, and breeding males had markedly expanded fins (see photograph in Minckley 1973). Most specimens from the Río Yaqui are far less distinctive, and Miller and Lowe (1967) noted that two specimens collected by J. R. Simon in 1943, and a series taken by Lowe in 1954 (see below), were "indistinguishable from *C. insignis*...." It is therefore obvious that *C. bernardini* and *C. insignis* are closely related, perhaps at the subspecific level, and data on this problem are being compiled to be presented elsewhere. Specimens at the University of Arizona referred to by Miller and Lowe (1967) have not again been found, and are therefore not listed in Appendix B (see, however, site 122a in the Appendix).

Catostomus spp.
(Fig. 16)

Catostomus sp. — Miller 1959.

Pantosteus plebeius — Meek 1902, 1904 (mis-identification, *fide* Miller 1976a).

We recognize two undescribed species of *Catostomus* in northwestern México. The first is in the uppermost Río de Bavispe drainage, at high elevation (mostly greater than 2,000 m) in Arroyo Moctezuma (Plate V), Arroyo de la Norteña, Río Negro, and Arroyo San Antonio. It is distinctive, with short head and caudal fin, stocky body, and large lips. Fish from clear water were blackened, with breeding males displaying a bright red, lateral band. In turbid streams both sexes were drab, grayish-brown in coloration. The

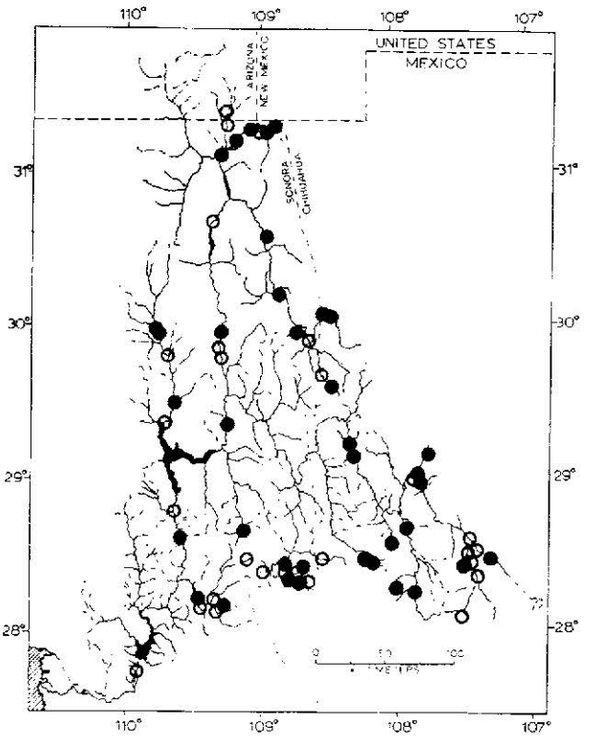

Figure 15. Distribution of Yaqui sucker *(Catostomus bernardini)* in the Río Yaqui basin.

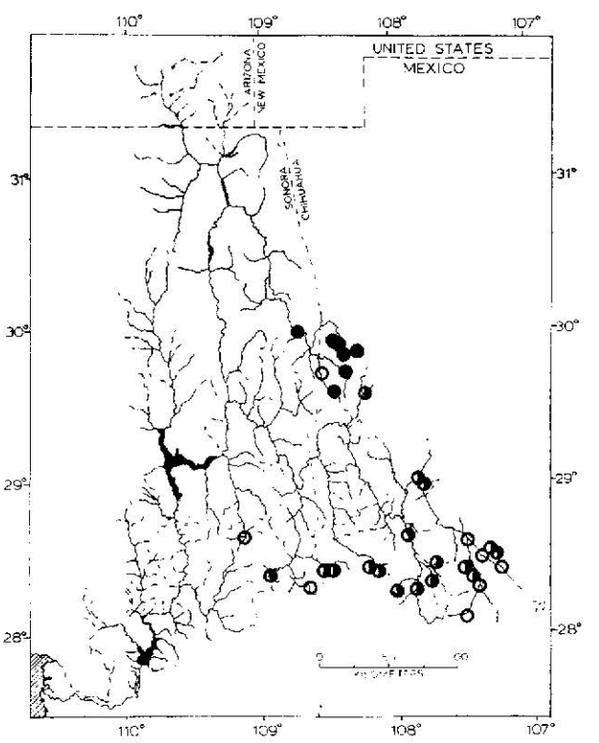

Figure 16. Distribution of two undescribed species of *Catostomus* in the Río Yaqui basin. Darkened circles are for the Río Gavilán form and half-darkened circles denote localities for the southeastern basin form. Open circles are for literature or museum records for each within their respective ranges.

species is syntopic with Rio Grande mountain-sucker, *Pantosteus plebeius* (Baird and Girard), in Arroyo Moctezuma. It was the only catostomid collected in arroyos de la Norteña and San Antonio, and occurred with Yaqui sucker in the Río Negro. Habitat was typically in larger pools with abundant cover in the form of boulders or undercut banks, and over clean gravel or coarse sand bottom. In the Río Negro, however, a series was caught from a deep pool in open water in association with a thick deposit of decaying leaf litter.

The second undescribed species of *Catostomus* is in southern and southeastern headwaters of the Río Yaqui system, where it occurs widely between 1,500 and 2,135 m. It is distinguished from the last form in having a more terete, elongated body and head, and smaller lips. No reddening of breeding males was noted, with body coloration typically a mottled brown or black over a lighter ground color. It inhabits pools, and is broadly sympatric with Yaqui sucker. It was rare in larger streams, however, where it avoided currents of the channel.

Relationships of these two suckers are not apparent at present. The first also is represented in high montane tributaries of the Río Casas Grandes, Chihuahua (Miller 1959), and the second occupies some upper tributaries of the Río Mayo drainage immediately south of the Río Yaqui.

Catostomus wigginsi Herre and Brock
Opata sucker

Catostomus wigginsi is known from the Río Yaqui in a single sample taken in 1941 from the Río Moctezuma near Cumpas, Sonora (site 114a). The species is common in the Río Sonora, immediately west of the Río Yaqui watershed (Miller 1959).

Pantosteus plebeius (Baird and Girard)
Rio Grande mountain-sucker (Fig. 17)

Catostomus (Pantosteus) plebeius — Smith 1966; Moore 1968; Eddy 1969.

Pantosteus plebeius — Miller 1976a.

Meek's (1902, 1904) record for *P. plebeius* from Miñaca was based on a composite of *Catostomus* sp. and *C. bernardini* (Miller 1976a). Authors prior to Smith (1966) generally followed that error and included Río Grande mountain-sucker in the Río Yaqui fauna.

The species is remarkably restricted in distribution in the Río Yaqui basin, occurring only in the uppermost Río Gavilán drainage (Río de Bavispe system) above 2,000 m. Smith's (1966) records for the same drainage, although not precisely located, are certainly above

1,800 m, and several intensive collections between 1,400 and 1,700 m in that system failed to capture the species. In the adjacent Piedras Verdes basin (Ríos Casas Grandes system), *P. plebeius* ranges from high-elevation headwaters to well below 1,400 m. Perhaps the presence of two small, *Pantosteus*-like *Catostomus* in the Río Yaqui headwaters, along with *C. bernardini*, has impeded further invasion of the system by mountain-suckers.

The species was abundant in a small *represo* at the upper Arroyo Moctezuma and in the stream below, where it occurred with the unnamed *Catostomus* discussed above. It tends to occupy pools, and appeared to move into riffle areas at night and in early morning. Adults were in high breeding condition in May and June, with males displaying a jet-black lateral band and milky-white bellies, and high degree of tuberculation of the pelvic and anal fins. Young were abundant along the margins of pools and riffles in June and July at Arroyo Moctezuma.

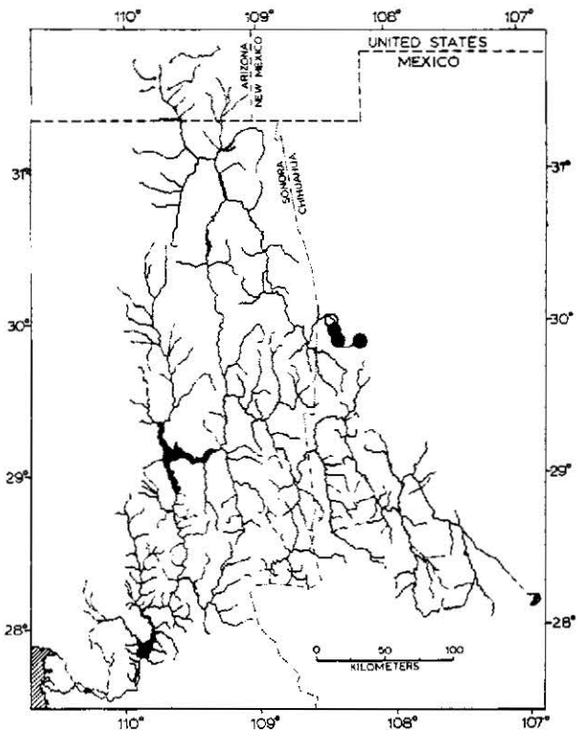

Figure 17. Distribution of Río Grande mountain-sucker *(Pantosteus plebeius)* in the Río Yaqui basin.

ARIIDAE

Arius caerulescens Günther and *A. liropus* (Bristol)

Galeichthys spp. – Miller 1959.

Arius liropus – Branson *et al.* 1960.

These marine catfishes enter the mouth of the Río Yaqui (sites 101b and d, 102a, and 156a), from the Sea of Cortez. *Arius caerulescens* ranges along the Pacific Coast from Sonora, México, to Guatemala, entering lagoons (Miller 1966), and *A. liropus* is known only from coastal waters of Sonora (Jordan *et al.* 1930).

ICTALURIDAE

Ictalurus furcatus (Lesueur) and *I. punctatus* (Rafinesque)

Blue and channel catfishes

These two catfishes were rare in our collections, presumably being stocked in recent years with other non-native species in reservoirs, from which they moved into rivers. Three large specimens (greater than 50 cm) of blue catfish were gill netted at Huásabas between Presa La Angostura and Presa Novillo, and others were observed after being caught by residents for use as food. A single specimen of channel catfish was caught on pole and line from the Río Yaqui at Tónichi, below Presa Novillo.

Ictalurus pricei (Rutter)

Yaqui catfish (Fig. 18)

Villarius pricei – Rutter 1896 (original description, San Bernardino Creek, Sonora); Jordan and Evermann 1898.

Ameiurus pricei – Meek 1902.

Amiurus pricei – Meek 1904.

Haustor pricei – Jordan *et al.* 1930; De Buen 1940, 1947.

Ictalurus pricei – Eddy 1957, 1969; Moore 1957, 1968; Miller 1959, 1972b; Miller and Lowe 1964, 1967; Minckley 1969a, 1971, 1973; McNatt 1974; Deacon *et al.* 1979.

Yaqui catfish was taken from 250 m to *ca.* 1,400 m elevation in our collections from the basin; it is known from the Río Yaqui Delta (site 102a) and from Miñaca at 2,100 m (Meek 1902, 1904). None was taken from artificial reservoirs, although the species occurs in substantial numbers above and below them. The species was most common in larger rivers, in areas of medium to slow current over sand/rock bottom. In small streams at higher elevations, however, it lived in quiet, clear pools with abundant macrophytes, over gravel/sand substrate. The absence of the species from collections in the upper Papigochic system in recent years (Appendix B) may indicate a reduction in its range. Its presumed extirpation from the United States (McNatt 1974) resulted from desiccation of San Bernardino Creek and associated waters. An introduced population of *I. pricei* in the Santa Cruz River basin, Arizona, also is extinct (Minckley 1973). The status of ***Ictalurus meeki*** (Regan) (Regan 1907) from the upper Río Papigochic is uncertain, and the taxon is tentatively included as a synonym of *I. pricei*.

The presence of introduced, riverine species of *Ictalurus* (blue and channel catfishes) will likely effect changes in populations of Yaqui catfish in coming years, and this should be watched for in future work in the basin.

Ictalurus melas (Rafinesque)

Black bullhead

Amiurus melas catulus – Miller and Winn 1951.

Ictalurus melas – Branson *et al.* 1960; Minckley 1973; McNatt 1974.

This introduced catfish appears widely distributed in the Río Yaqui system at middle to low elevations. It was usually taken in disturbed habitats, or artificial ones such as stock tanks, reservoirs, or streams below reservoirs. It is known from similar habitat in the Río Yaqui basin in Arizona, where it was introduced as early as 1943 (sites 116a-b).

CYPRINODONTIDAE

Cyprinodon sp.

Whitefin pupfish (Fig. 19)

Cyprinodon elegans – Meek 1902, 1904.

Cyprinodon bovinus bovinus – De Buen 1940, 1947.

Cyprinodon bovinus – Alvarez 1950.

Cyprinodon sp. – Miller 1976a.

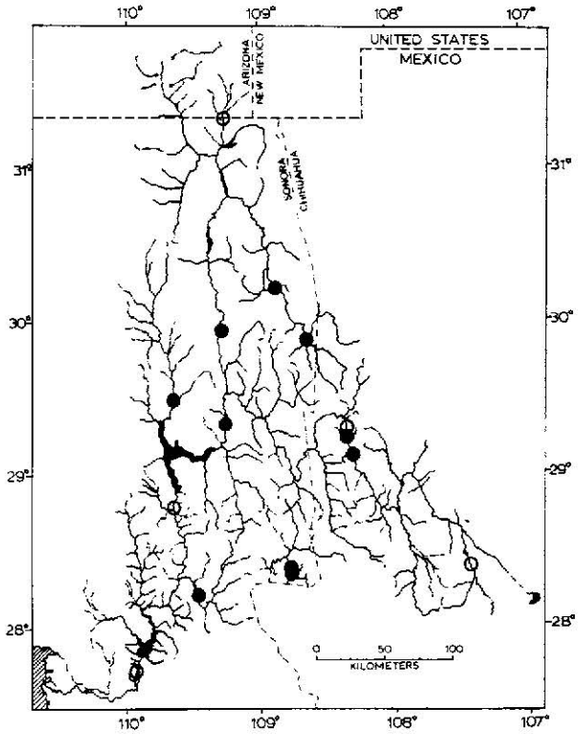

Figure 18. Distribution of Yaqui catfish *(Ictalurus pricei)* in the Río Yaqui basin.

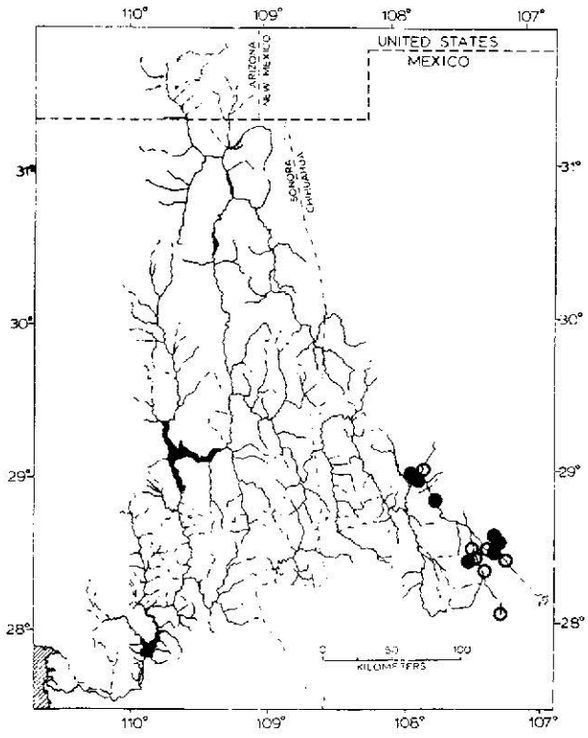

Figure 19. Distribution of whitefin pupfish *(Cyprinodon* sp.) in the Río Yaqui basin.

This distinctive, undescribed pupfish inhabits the high, montane valley of the uppermost Río Papigochic in Chihuahua. It has broad ecological tolerances, occurring in headsprings, along sand and gravel bars of large streams and in slower parts of tributaries, and abundantly in cutoff pools along all kinds of watercourses. As is typical of pupfishes, juveniles and females are closely associated with algae and higher aquatic plants, but territorial males occupy more open places along shorelines. Lek formation by males (Arnold 1972, Kodric-Brown 1977) is marked, beginning shortly after sun impinges on the water, and continuing throughout daylight hours. Some territorial males were in relatively swift water of the outlet of El Ojo de Yepómera in June, and pairs were observed spawning in dense beds of *Chara* on the bottom where currents exceeded 0.4 m/second. Itzkowitz (1969) described similar spawning in swift water by *C. elegans* Baird and Girard in a canal leading from Phantom Cave, Texas.

Relationships of this undescribed *Cyprinodon* seem to be to the east, presumably with the *C. eximius* Girard group as defined by Miller (1976b). The closest apparent relative, based mostly upon shared color features of breeding males (milky-white dorsal fin, thinly edged in black), is an undescribed species from the Río Santa María drainage of northern Chihuahua. The high-altitude range of the whitefin pupfish is unusual for the genus, and may have resulted from regional uplift.

POECILIIDAE

Gambusia affinis (Baird and Girard)

Mosquitofish

Mosquitofish was introduced into Arizona in the 1920s (Miller and Lowe 1967), and has since spread to occupy essentially all permanent water in that state (Minckley *et al.* 1977). Surprisingly it had not been recorded from the Río Yaqui basin prior to our collections. We caught the species in 3 collections at 2 localities in the Mexican part of the drainage where it occurred syntopically with Sonoran topminnow, *Poeciliopsis occidentalis sonoriensis* (Girard), and was relatively rare. It was not taken in the United States' portion of the watershed until December 1979. Mosquitofish and *P. o. occidentalis* (Baird and Girard), interact to the detriment of the latter in the Gila River basin of Arizona, as will be discussed below. It seems inconceivable that mosquitofish had not before been introduced into the Río Yaqui basin. Perhaps *P. o. sonoriensis* resists incursions of this exotic.

Poeciliopsis prolifica Miller

Poeciliopsis prolifica — Miller 1960b; Rosen and Bailey 1963.

This species is distributed from the lower Río Yaqui (site 101c), south along the coastal plain to San Blas, Nayarit, in fresh and brackish water (Miller 1960b). It was not taken in the present survey.

Poeciliopsis occidentalis (Baird and Girard)
(Fig. 20)
Sonoran Topminnow[3]

Girardinus sonoriensis — Girard 1859 (original description, Río San Bernardino, tributary to the Río Yaqui); Günther 1866; Jordan 1878.
Girardinus occidentalis — Jordan and Gilbert 1883.
Poecilia occidentalis — Garman 1895; Rutter 1896; Meek 1904.
Heterandria occidentalis — Jordan and Evermann 1896.
Poeciliopsis occidentalis — Hubbs 1926; Jordan *et al.* 1930; De Buen 1940, 1947; Hubbs and Miller 1941a; Alvarez 1950, 1970; Eddy 1957, 1969; Moore 1957, 1968; Branson *et al.* 1960; Anonymous 1966, 1968, 1973; Schultz 1971; Miller 1972b; Moore *et al.* 1970; Vrijenhoek *et al.* 1977; Deacon *et al.* 1979.
Poeciliopsis sp. — Miller and Simon 1943; Miller 1959.
Poeciliopsis "F" — Miller and Schultz 1959; Schultz 1961.
Poeciliopsis sonoriensis — Miller and Lowe 1964, 1967; McNatt 1974.
Poeciliopsis occidentalis sonoriensis — Minckley 1969b, 1971, 1973; Constantz 1974; Schoenherr 1977.

This species is widely distributed below 1,300 m elevation in the Río Yaqui basin, and often was the only fish persisting in smaller, intermittent, hot, low-desert streams, or it occurred in such habitat with longfin dace. Prior to de-watering of southern Arizona, topminnow and longfin dace also were closely associated in desert streams of that area (Hubbs and Miller 1941a), where they comprised a distinctive element of the Sonoran Desert fauna. Sonoran topminnow also is associated with an all-female topminnow, *Poeciliopsis monacha-occidentalis*, in the southwestern part of the Río Yaqui basin (see below).

As noted earlier, northern populations of *P. occidentalis* in the Gila River system, Arizona and New Mexico, have been essentially eliminated by drying of watercourses, or in places with permanent water, through direct predation by the introduced mosquitofish (Minckley *et al.* 1977). Our few records of mosquitofish in the northernmost basin strongly imply invasion from the United States. If the species is just establishing itself in the Río Yaqui system, and our speculation that Sonoran topminnow may resist mosquitofish is incorrect, it seems likely that Sonoran topminnow will begin to decline. Some populations of Gila topminnows were decimated by the mosquitofish in a few months or years (Miller 1961; Minckley 1973; Schoenherr 1977), while others persist for longer periods in special habitats afforded by headwaters or springs (Minckley *et al.* 1977). In all documented instances, however, the topminnow has finally disappeared. A detailed study contrasting habits of the two topminnows relative to their susceptibility to this predator would be pertinent to management of the native forms.

Poeciliopsis monacha-occidentalis
(Fig. 21)

Poeciliopsis "F_x" — Miller and Schultz 1959; Schultz 1961.
Poeciliopsis monacha-occidentalis — Moore *et al.* 1970; Schultz 1977.

This unisexual form of *Poeciliopsis* is believed to be of hybrid origin, arising from a cross of *P. monacha* Miller and *P. occidentalis* in the Río Mayo basin (Schultz 1977). This hybrid is dependent on *P. occidentalis* males for its unusual mode of reproduction, hybridogenesis (Schultz 1969). The all-female offspring exhibit characters of both parental forms. The original female *P. monacha* genome is clonally maintained by exclusion of the paternal genome from ova in oogenesis and a new paternal *(P. occidentalis)* genome is incorporated in each generation. The sex-determination mechanism which produces only female offspring is not fully understood (Schultz 1973, 1977).

[3]The name "Sonoran" topminnow is proposed as preferable to "Gila" and "Yaqui" topminnows for *P. o. occidentalis* and *P. o. sonoriensis*, respectively, to emphasize the general distribution of this species in the Sonoran Desert region.

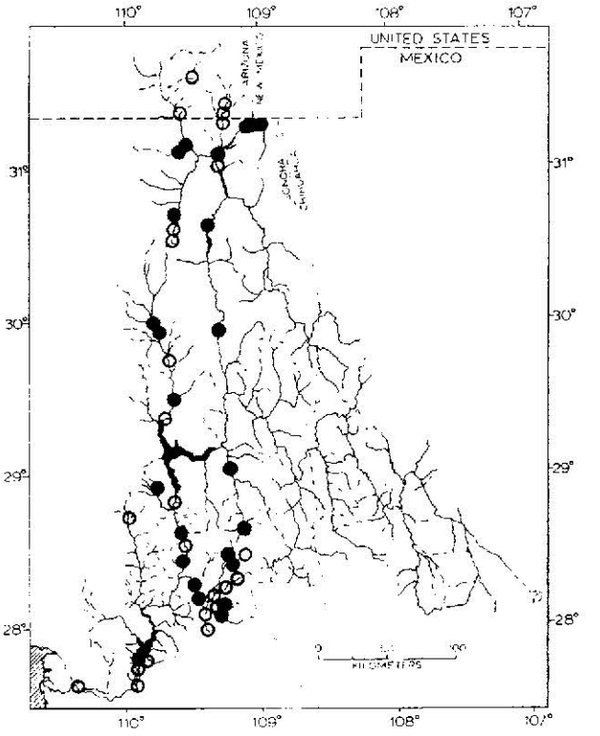

Figure 20. Distribution of Sonoran topminnow *(Poeciliopsis occidentalis)* in the Río Yaqui basin.

Moore *et al.* (1970) reported on the distribution of this form in northwestern México, including numerous collection sites within the Río Yaqui basin. They found a general trend of decreasing proportions of *P. monacha-occidentalis* in topminnow populations with increased latitude. The largest proportion of *P. monacha-occidentalis* in the Río Yaqui basin was 38% at a southern locality, and none has been taken in Arizona.

P. monacha-occidentalis may be reliably separated from the Soronan topminnow only on the basis of structure of the jaw teeth. Since most collections we made in the Río Yaqui system have been sorted only to the point of recognition of presence or absence of the all-female fish, no data are available on proportions of the two species.

MUGILIDAE
Agonostomus monticola (Bancroft)
Mountain mullet

Aganostomus monticola — Contreras 1972.

This primarily-marine species enters fresh waters of both slopes of North and Middle America, and has been recorded from the lower Río Yaqui on a number of occasions (sites 101a-b, 102a-b, 115).

Mugil cephalus Linnaeus and *M. curema* Valenciennes
Striped and white mullets

Mugil curema — Branson *et al.* 1960.

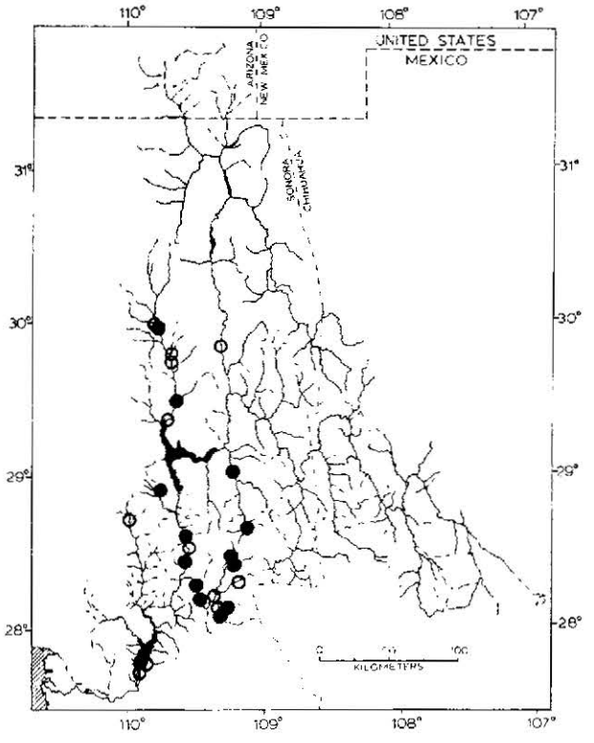

Figure 21. Distribution of the all-female topminnow (*Poeciliopsis monacha-occidentalis*) in the Río Yaqui basin.

We have been unable to find records for striped mullet from the Río Yaqui, but it must penetrate the river at least on the delta. The species ascends the Colorado River as far upstream as Palo Verde Irrigation Diversion (Minckley 1979), more than 300 km by river from the sea. *Mugil curema* has been recorded on the Río Yaqui delta (sites 101d, 156a). According to local testimony, mullet are fished extensively for use as food by use of throw and gill nets. The local name for the species near Ciudad Obregón is *lisa*. A similar fishery and the same local name are present along the lowermost Colorado River (Minckley 1979).

CENTROPOMIDAE

Centropomus nigrescens Günther and *C. robalito* Jordan and Gilbert
Snooks and robalo

Centropomus sp. – Miller 1959.

Centropomus nigrescens – Miller 1966.

Centropomus robalito Miller 1966.

Both these species were collected near the mouth of the Río Yaqui in 1940 and 1960 (sites 101b and 103). They share a geographic distribution from the Río Yaqui south to Perú, and both often enter rivers (Miller 1966). One or both of these fishes may be a species reported to us by Alejandro Suarez, fishery manager at Presa Alvaro Obregón, as *robalo*, and said to attain weights of 12 kg in that reservoir and in the river below.

LUTJANIDAE

Lutjanus novemfasciatus Gill
Pargo amarillo

Neomaenis novemfasciatus – Branson *et al.* 1960.

A single specimen of this snapper was caught by Branson *et al.* (1960) from the Río Yaqui due north of Ciudad Obregón (site 156). The species is distributed from the Sea of Cortez to the Galápagos, and young often enter the tidal zone of rivers (Thompson *et al.* 1979).

CENTRARCHIDAE

Micropterus salmoides (Lacepede)
Largemouth bass

Micropterus salmoides – McNatt 1974.

Largemouth bass are rare in streams of the Río Yaqui watershed. We caught them at three localities on the Río de Bavispe, and in and below Presa Alvaro Obregón. The species has been recorded before from ponds on the San Bernardino Ranch, Arizona (site 116f; McNatt 1974), and from the Río Papigochic in association with a small reservoir near Guerrero, Chihuahua (site 129a). Bass are reportedly common (as *Lobina*) in La Angostura and Novillo reservoirs, and are obviously so in Presa Alvaro Obregón, where they were stocked to develop a sport fishery.

Lepomis cyanellus Rafinesque
Green sunfish

Green sunfish were first taken from the southern part of the Río Yaqui basin, from an irrigation system near Nuri, Sonora (site 140). They now are abundant in hot, pool-riffle streams of that region, but remain relatively rare elsewhere. In the Río Chico system near Nuri, green sunfish are syntopic with Sinaloan cichlid, *Cichlasoma beani* (Jordan), which is similar in size and body shape. Active interactions between males of the two species were noted, and study of such an alien co-occurrence of two aggressive species should prove interesting. Both were successfully reproducing in the same pools of the Río Chico near the town of Río Chico, Sonora.

Lepomis megalotis (Rafinesque) and *L. microlophus* (Günther)
Longear and redear sunfishes

Specimens of these fishes from the Río Yaqui basin are new records of introductions into northwestern México. Six specimens of longear sunfish were seined from the Río Papigochic at Guerrero, and a single redear sunfish was gill-netted from Presa Novillo.

Lepomis macrochirus Rafinesque
Bluegill

Lepomis macrochirus purpurescens – Miller and Winn 1951; Branson *et al.* 1960.

Lepomis macrochirus – Minckley 1973; McNatt 1974.

Bluegill are present in mainstream reservoirs on the Río Yaqui, and have been locally established in Arizona, and in headwaters of the Río Papigochic and Río Gavilán. In the last drainage, we were told that a local individual had stocked "*mojarra*" to establish a fee fishery. The species proved to be bluegill, introduced and reproducing well at an elevation of 2,150 m.

Pomoxis annularis Rafinesque and ***P. nigromaculatus*** (Lesueur)
White and black crappies

Pomoxis sp. – Branson *et al.* 1960

White crappie were gill-netted in presas Novillo and Alvaro Obregón in substantial numbers, and black crappie are established on the San Bernardino Ranch, Arizona (site 116h).

CICHLIDAE

Cichlasoma beani (Jordan)
Sinaloan cichlid (Fig. 22)

Cichlasoma beani – Miller 1959; Branson *et al.* 1960.

Sinaloan cichlids occur only in the southernmost part of the Río Yaqui basin, in pools of warm, algae-rich streams of lowlands (Plate

II) and in adjacent highlands of relatively low relief. The species was taken in 1950 in the mainstream Río Yaqui on the delta (site 102a) in company with a number of marine fishes and big-river forms such as *Ictalurus pricei* and *Gila robusta*. Common associates in smaller streams were *Campostoma ornatum* and *Agosia chrysogaster* in flowing parts, *Poeciliopsis* spp. along margins, and *Catostomus bernardini* plus introduced river carpsucker and green sunfish in pools (see above). The species ranges from the Río Yaqui southward to the lower Río Ameca, Nayarit.

ELEOTRIDAE

Dormitator latifrons (Richardson)

Dormitator – Miller 1959.

Dormitator latifrons – Branson *et al.* 1960.

This sleeper, distributed from southern California to Perú (Miller 1966), often enters the sluggish mouths of streams. It has been taken from the lowermost Río Yaqui (sites 101c-d, 103).

Eleotris picta Kner and Steindachner

Spotted sleeper

Eleotris picta, distributed generally as described for *D. latifrons*, also has been taken from the delta (site 101c). This species may move far inland in larger rivers, since Hubbs (1953) recorded an individual from an irrigation drain of the Colorado River near Yuma, Arizona, more than 150 km from the sea.

Gobiomorus maculatus (Günther)

Gobiomorus maculatus – Miller 1966.

The Río Yaqui (sites 102a, 103) is the most northern record for the species (Miller 1966), which ranges south to Perú.

GOBIIDAE

Awaous transandeanus (Günther)

Awaous transandeanus – Miller 1966.

The Río Yaqui also marks the northern limit of range for this goby, which is otherwise in coastal waters south to Perú (Miller 1966). It has been taken three times on the delta (sites 101b, 102a-b), and twice far inland, near Movas (site 110) and almost to Presa Novillo in the Río Yaqui at Soyopa (site 115).

SOLEIDAE

Trinectes fonsecensis (Günther)

Trinectes – Miller 1959.

Trinectes fonsecensis – Miller 1966.

This species was taken along with *Dormitator latifrons*, *Eleotris picta*, and the topminnow, *Poeciliopsis prolifica*, at site 101c, which is the northern limit of its geographic range (Miller 1966).

QUANTITATIVE ASPECTS OF THE FAUNA. – Relative abundances of various fishes in habitats depicted in Plates I-X provide some insight into ecological relations and general condition of the fauna, and are presented in Tables 2-4. Determination of relative or absolute abundances of fishes was not, however, a goal of this survey, and diversity of habitats sampled along with a variety of equipment used as conditions dictated, provide data of obviously questionable value. Furthermore, rare species such as *Gila purpurea* receive an inordinate percentage of effort, whereas common forms such as *Campostoma ornatum* often were released after a series representative of the local population was secured. Uncommon forms should therefore be considered rarer than our data indicate, while the most abundant species, or those of little interest such as carp, were undoubtedly underestimated. Some kinds, such as the undescribed *Catostomus* from the upper Río de Bavispe system, also are obviously too numerous in over-all collections, just as a Snowy Owl would be overrepresented in bird counts by overly zealous persons at lower latitudes (MacArthur 1960).

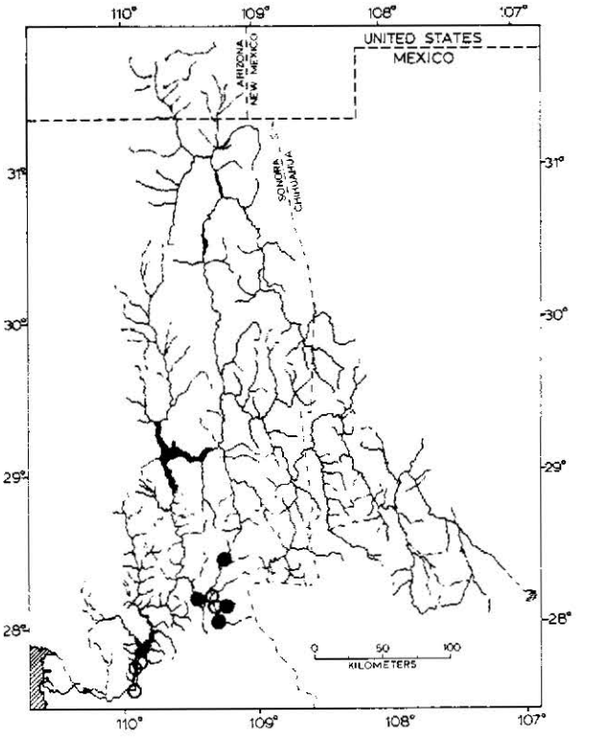

Figure 22. Distribution of Sinaloan cichlid *(Cichlasoma beani)* in the Río Yaqui basin.

Collections from "big-river" segments of the ríos Sirupa-Aros System, here defined as canyon reaches downstream from the Plateau Section of the Sierra Madre Occidental (Fig. 1), produced only three native fish species (Table 2). Of these, only *Catostomus bernardini* remained dominant in the mainstream of Río de Bavispe. Both *Gila robusta* and *Ictalurus pricei* remained as major parts of the Río de Bavispe fauna, but smaller, native fishes such as Mexican stoneroller, beautiful shiner, and topminnows also were common. The abundance of introduced fishes, especially *Carpiodes carpio*, reflected the greater percentage of pool habitat in the Río de Bavispe (as did the abundance of *C. bernardini*), plus the presence of artificial lentic habitat in the form of Presa La Angostura. Lowland riverine habitat was dominated by topminnows, *Poeciliopsis occidentalis* and *P. monacha-occidentalis*. Actual abundance of these small fishes along margins of the river may have been accentuated, however, by difficulties in collecting deep, swifter areas. Few fishes other than topminnows were obtained from the mainstream Río Yaqui (Table 2). Topminnows also were the most abundant fishes in or adjacent to mainstream reservoirs, based upon our collections, with few other native fishes being common. Longfin dace achieved their indicated abundance in reservoirs only because we included a collection from flowing water of the Río de Bavispe below the high-water mark of Presa La Angostura.

Table 2. Relative abundance in percent of various fishes in big-river habitat and mainstream reservoirs in the Río Yaqui basin, Mexico, spring and summer 1978.

Species	Río Sirupa-Aros	Río de Bavispe	Lower Río Yaqui	Reservoirs[1]
Dorosoma smithi	–	– –	– –	1.4
Salmo sp.	– –	1.2	– –	– –
Cyprinus carpio	– –	0.5	0.1	3.2
Pimephales promelas	–	– –	– –	0.7
Notropis formosus	-	1.9	Tr.	– –
Codoma ornata	–	0.2	– –	– –
Campostoma ornatum	– –	4.9	– –	– –
Agosia chrysogaster	– –	– –	– –	5.2
Gila robusta	30.3	4.1	0.2	– –
Carpiodes carpio	- -	7.6	0.1	17.1
Catostomus bernardini	54.2	71.5	0.4	0.2
Gambusia affinis	– –	– –	– -	1.2
Poeciliopsis spp.	– –	4.2	98.8	61.1
Ictalurus melas	-	– –	– –	0.5
Ictalurus punctatus	– –	– –	0.1	– –
Ictalurus furcatus	-	0.7	–	
Ictalurus pricei	15.5	1.7	0.1	– –
Lepomis macrochirus	– –	-	– –	2.0
Lepomis microlophus	– –	– –	- –	Tr.
Lepomis cyanellus	-	1.2	0.1	1.6
Pomoxis annularis	– -	– –	– –	4.0
Micropterus salmoides	-	0.3	– –	1.8
Total fishes	251	590	2,653	1,480

[1]Includes riverine habitats below high water mark in reservoirs (Presa La Angostura) and immediately below Presa Alvaro Obregón.

Yaqui sucker, roundtail chub, Mexican stoneroller, and longfin dace dominated the fauna of smaller streams at lower elevations in the Río Papigochic system. No introduced fishes were taken (Table 3). The same four species, plus topminnows, prevailed in tributaries of the Río de Bavispe, but abundance shifted strongly toward longfin dace with the general reduction in pool habitat and an increase in desert conditions such as high summer water temperatures. This tendency was even more evident in the ríos Moctezuma-Nacozari system, where shallow, warm, sandy-bottomed habitats supported 60% longfin dace and more than 20% topminnows (Table 3). The more tropical topminnows obviously were enhanced in pool-riffle tributaries of the southern Río Yaqui, and Sinaloan cichlids were present in significant numbers in that area. Mexican stoneroller, longfin dace, Yaqui sucker, and the undescribed *Catostomus* of that region all were present in substantial proportions. With the exception of topminnows, low-elevation tanks in the Río Yaqui basin yielded mostly introduced fishes. *Notropis formosus* was present in one such habitat.

Higher elevation streams in the system were essentially devoid of non-native fish species (Table 4). In the Río Papigochic sub-basin, *Codoma ornata* and Mexican stoneroller were clearly the most abundant species, followed by whitefin pupfish, Yaqui sucker, and the undescribed *Catostomus* of that region. The Río de Bavispe fauna lacked *Codoma ornata*, but Mexican stoneroller dominated, followed by the undescribed *Catostomus*, *Notropis formosus*, *Catostomus bernardini*, *Gila robusta*, and *Pantosteus plebeius*. Trout were relatively common (Table 4). Tributaries in mountains of the southern Río Yaqui had a fauna remarkably balanced in relative numbers among the five species collected. *Gila robusta* was common, comprising almost 37% of the total, followed by longfin dace, Mexican stoneroller, Yaqui sucker, and the undescribed *Catostomus*. A tendency for well-developed pools separated by distinct runs and riffles apparently produced this assemblage. High-elevation tanks in the basin were generally occupied by native fishes, with the exception of bluegill introduced near Chuhuichupa, Chihuahua.

DISCUSSION AND CONCLUSIONS. – The fish fauna of the Río Yaqui basin is a composite of freshwater species derived from adjacent basins (32%) and a marine and coastal component (68%). Headward erosion of Pacific coastal streams into the Sierra Madre Occidental captured numerous sub-basins, and exchanges over low divides east of the Sierra completed integration of the system. The

Table 3. Relative abundance to percent of various fishes in lower-elevation streams and artificial tanks tributary to the ríos Papigochic, Bavispe, and Yaqui, México, spring and summer 1978.

Species	River or tributary systems[1]: Río Papigochic	Río de Bavispe	Río Moctezuma Nacozari	Lower Río Yaqui	Tanks
Cyprinus carpio	– –	– -	– –	– –	4.7
Pimephales promelas	-	1.7	1.0	– –	9.5
Notropis formosus	-	– –	0.4	0.9	1.8
Codoma ornata	3.3	-	– –	– –	– –
Campostoma ornatum	20.5	22.3	7.0	4.0	– –
Agosia chrysogaster	9.9	40.4	60.2	3.8	– –
Gila purpurea	– –	– –	0.1	- -	– –
Gila robusta	24.6	2.5	– –	– -	–
Carpiodes carpio	– –	Tr.	Tr.	0.3	– –
Catostomus bernardini	41.2	16.5	9.9	2.8	– –
Catostomus sp.[2]	– –	– –	– –	5.0	– –
Gambusia affinis	– –	1.2	– –	– -	- -
Poeciliopsis spp.	– –	15.3	21.3	82.6	81.9
Ictalurus melas	– –	Tr.	– –	- -	2.1
Ictalurus pricei	0.5	– –	Tr.	0.1	–
Lepomis cyanellus	-	– –	– –	1.0	– –
Cichlasoma beani	– –	– –	– –	4.6	– –
Total fishes	7,733	4,862	2,949	3,887	896

[1]Lower-elevation tributaries are defined as below 1,400 m in the ríos Papigochic and de Bavispe systems, and below 1,250 m in tributaries to the southern Río Yaqui; tanks included here all were below 1,400 m.

[2]Undescribed species from tributaries to the Río Papigochic and lower southern Río Yaqui.

Table 4. Relative abundance in percent of various fishes in higher-elevation streams and artificial tanks tributary to the ríos Papigochic, Bavispe, and Yaqui, México, spring and summer 1978.

Species	River or tributary systems[1] Río Papigochic	Río de Bavispe	Lower Río Yaqui	Tanks
Salmo sp.	0.9	5.5		0.2
Pimephales promelas	0.2	– –	– –	– –
Notropis formosus	0.7	10.7		17.5
Codoma ornata	36.8	..		8.1
Campostoma ornatum	29.2	44.9	20.3	22.2
Agosia chrysogaster	– –	0.2	26.4	– –
Cila pulchra	1.7	. –		
Gila robusta	1.2	7.4	36.7	– –
Catostomus bernardini	9.3	8.2	11.6	– –
Catostomus sp.[2]	– –	14.9	– –	– –
Catostomus sp.[3]	5.1	– –	5.0	
Pantosteus plebeius	.	7.0	– –	48.2
Cyprinodon sp.	14.1	- –	– –	– –
Lepomis macrochirus	0.7	1.1	– –	3.7
Lepomis megalotis	0.1	– –	– –	– –
Total fishes	9,066	1,211	1,094	657

[1]High-elevation tributaries are defined as above 1,400 m in the ríos Papigochic and de Bavispe systems, and above 1,250 m in tributaries to the southern Río Yaqui; tanks included here all were above 1,500 m.

[2]Undescribed species from the uppermost Río de Bavispe system.

[3]Undescribed species from tributaries to the Río Papigochic and lower Río Yaqui.

basin supports 16 native families, the largest number of any western river treated by Miller (1959), and with 35 native fishes has the richest ichthyofauna of any drainage in the American Southwest (Table 5).

Genera that attest to integration of parts of the Río Grande system into the present Río Yaqui drainage are *Campostoma*, *Notropis*, and *Codoma*, among minnows, and *Pantosteus*, *Ictalurus*, and *Cyprinodon*, all of which presumably entered from the Río Grande system or its connectives. The genus *Gila* includes *G. robusta*, with obvious relationships to the Colorado River basin. *Gila pulchra* and *G. purpurea* are among a number of thick-bodied, large-scaled species of that genus that are distributed along the Mexican Plateau north to coastal streams of California (Barbour and Miller 1978), so their zoogeography in the Río Yaqui basin is conjectural. *Gila pulchra* occurs both in the Río Conchos and Río Yaqui as well as in the ríos Mayo and Fuerte systems, and *G. purpurea* is in the ríos Yaqui, Sonora, and Matape of northern Sonora (Table 6). Their respective distributions on the periphery of the Río Yaqui system support movements over drainage divides, and directions of the transfers seem academic at present. Species of nearby river basins that may well be involved in questions concerning the last two fishes are *G. intermedia* to the north (Rinne 1976), *G. ditaenia* Miller (1945) to the west, *G. nigrescens* (Girard) and *G. pandora* (Cope) to the north and east, and perhaps *G. conspersa* (Garman) or its relatives to the south (in part, Miller 1978, Barbour and Miller 1978). If one assumes

Table 5. Summary of native and introduced fish taxa in the Río Yaqui drainage, México and U.S., 1978.

Family	Native Genera	Native Species	Introduced Genera	Introduced Species
Primary (I)				
Cyprinidae	5	7	3	3
Catostomidae	2	5	1	1
Ictaluridae	1	1	1	3
Centrarchidae		–	3	7
Secondary (II)				
Cyprinodontidae	1	1	–	–
Poeciliidae	1	3[1]	1	1
Cichlidae	1	1	–	–
Others				
Elopidae (III)	1	1	–	–
Clupeidae (III)	2	2	–	–
Salmonidae (III)	1	1(?)	2	2
Ariidae (III)	1	2	–	–
Mugilidae (III, V)	1	2	–	–
Centropomidae (III)	1	1	–	–
Lutjanidae (V)	1	1	–	–
Eleotridae (V)	2	3		–
Gobiidae (V)	3	3	–	–
Soleidae (III)	1	1		–
TOTALS	25	35	22	27

NOTE: I = Primary, obligate freshwater fishes; II = Secondary, euryhaline species; III = Diadromous fishes; and V = Complementary fishes, marine species that often enter freshwaters.

[1]Includes *Poeciliopsis monacha-occidentalis*, an all-female "species."

conspecificity or at least close relationships of *Catostomus bernardini* with *C. insignis* to the north and *C. conchos* (Meek) to the east (Miller 1976a), a similar northwest-to-southeast-oriented pattern of dispersal to that of the last-mentioned *Gila* species may be indicated.

The genus *Agosia*, naturally distributed from the Bill Williams River of Arizona south through the Río Yaqui basin and into Sinaloa, México, must have dispersed through north-south connections of structurally-controlled rivers in deserts west of the Sierra Madre Occidental. Similar paths must have been used by *Poeciliopsis* in northward movement through the Río Yaqui into the Gila River basin of southern Arizona, and by *Cichlasoma* and *Dorosoma* northward into the Río Yaqui system. These last three genera are, however, capable of dispersal through euryhaline situations provided by coastal estuarine habitats.

Endemism in the Río Yaqui is low. Among the minnows, the nominal *Campostoma pricei*, *Gila minacae*, and *Notropis mearnsi* have been synonymized with *C. ornatum*, *G. robusta*, and *N. formosus* (or *N. lutrensis*; Contreras 1978), respectively (Miller 1976a, 1978). The Yaqui sucker, *Catostomus bernardini*, is scarcely separable from *C. insignis* of the Gila River basin (see above and p. 76) and two new species of *Catostomus* from the Río Yaqui system

Table 6. Zoogeographic relations of freshwater (primary and secondary) fishes of the Río Yaqui basin, MEXICO AND U.S., to those of adjacent river basins. Drainages surrounding the Río Yaqui are arranged clockwise, north-east-south-west. A question-mark (?) indicates a suspected, but conjectural, relationship, or when underlined (?) a lack of information.

	Gila River[1]	Río Casas Grandes[2]	Río Santa María[2]	Río del Carmen[2]	Laguna de Bavicora[3]	Río Conchos[4]	Río Fuerte	Río Mayo	Río Matape	Río Sonora
Campostoma ornatum	-	x	-	x	-	x	x	x	?	x
Notropis formosus	-	x	x	x	x	-	-	-	-	-
Pimephales promelas[5]	-	x	x	x	-	x	-	-	-	-
Gila pulchra	-	-	-	-	?	x	x	x	-	-
Gila robusta	x	-	-	-	-	-	?	?	-	-
Gila purpurea	-	-	-	-	-	-	-	-	x	x
Agosia chrysogaster	x	-	-	-	-	-	x	x	?	x
Codoma ornata	-	-	-	-	-	x	x	-	-	-
Catostomus bernardini	x[6/]	-	-	-	-	x[6/]	-	-	-	-
Catostomus sp.	-	x[7/]	-	-	-	-	-	-	-	-
Catostomus sp.	-	-	-		-	-	-	x[7/]	-	-
Catostomus wigginsi	-	-	-	-	-	-	-	-	-	x
Pantosteus plebeius	-	x	x	x	-	x	x	-	-	-
Ictalurus pricei	-	-	-	-	-	-	-	-	-	-
Cyprinodon sp.	-	-	x	-	-	-	-	-	-	-
Poeciliopsis occidentalis	x	-	-	-	-	-	x	x	x	x
Poeciliopsis monacha-occidentalis	-	-	-	-	-	-	x	x	x	x
Poeciliopsis prolifica	-	-	-	-	-	-	x	x	-	-
Cichlasoma beani	-	-	-	-	-	-	x	x	-	-

[1]Colorado River basin; [2]closed basin, collectively the Guzmán system; [3]Independent closed basin; [4]Río Grande basin; [5]Probably introduced (see p. 75); [6]relationships true only if *C. insignis* and *C. conchos* are considered conspecific (see p. 76); [7]northern (Río de Bavispe) and southern forms, respectively.

also are known from other river basins (p. 77 and Table 6). The catfish *Ictalurus pricei* appears to be confined to the Pacific slope of northwestern México (Miller 1978), and therefore may represent a true endemic to the Río Yaqui system. Even the new species of *Cyrinodon* from the Río Papigochic sub-basin (p. 79), a member of a genus notorious for local endemism (Miller 1976b), appears to be represented in the Río Santa María system of northern Chihuahua (Table 6).

Despite logging, grazing, mining, and other human uses of the region, much of the Río Yaqui watershed seems, to our eyes, relatively undisturbed. Of course, our view is biased by experience in the overly-exploited arid zones of the American Southwest in which we live and work, where human populations and their vast supporting technology have caused major environmental degradation.

Lumbering and grazing are extensive in the watershed, but logging is still accomplished by men and horses, so damage from heavy machines is minimal. No clear cutting was observed. Grazing was severe adjacent to communities, but far less evident in remote areas. Highlands were especially devoid of livestock, and ranges appeared in fair to good condition in spite of summer drought.

Mining operations influenced streams such as the Río Nacozari through discharges of toxic materials and dumping of spoil. Yet this was an exception, and influences of mines seemed insignificant.

Road construction and other increased emphasis on advanced technology, plus increased interest in development of the interior of the basin, point toward rapid and extensive expansion of development of the region in the immediate future. Direct modification of rivers consists at present of three mainstream reservoirs. Sophistication in operations of these reservoirs has yet to be developed -- they are not under daily regimes of discharge to provide such things as "peaking power" to satisfy demands of distant consumers. The dams are occasionally closed when irrigation demands cease, and downstream reaches become intermittent. The river basin is, however, so vast and complex that major tributaries provide continuing discharge and flooding that maintain heterogeneity despite the stabilizing factor of dams.

Major impacts on fishes of the Río Yaqui basin, at present and in the near future, will likely come from expansion of introduced fish populations as more lentic habitat becomes available with increasing numbers of reservoirs. Little is known of the interactions of native and introduced fishes in western drainages, despite the volume of literature that has accumulated on their supposed "competitive" and other interrelations. Stream habitats appear to resist most introduced species in the American Southwest and this trend seems to hold true for the Río Yaqui basin (Tables 2-4). About 30% of the fish species taken from the Río Yaqui basin were introduced, and with the exception of the riverine catfishes (*Ictalurus punctatus* and *I. furcatus*) and carpsucker (*Carpoides carpio*), all are lentic-adapted.

Of fishes recorded from the United States' portion of the Río Yaqui system - *Gila purpurea*, *Campostoma ornatum*, *Notropis formosus*, *Agosia chrysogaster*, *Catostomus bernardini*, *Poeciliopsis occidentalis*, and perhaps *Gila robusta* and *Ictalurus pricei* – only the first seems rare in the Mexican portion of the basin. *Notropis formosus* is highly local in distribution, and often uncommon, but populations of all other species are widespread and abundant at the present time. Immediate dangers are: 1) interactions of *Peociliopsis occidentalis* with introduced *Cambusia affinis*, which have been demonstrated to result in disappearance of the former in the Gila River basin (Minckley *et al.* 1977); 2) potential interactions of blue and channel catfishes with the native *I. pricei*, which may reduce its populations; and 3) potential introduction of *Notropis lutrensis* as bait, which might well result in genetic swamping of *N. formosus*.

Plate II. Locality 10, Río Chico. 250 m.

Plate III. Locality 4, Río Moctezuma near Cumpas. 750 m. This is the only locality in the Mexican basin where we collected *Gila purpurea*.

Plate IV. Locality 15, Río Sahuaripa. 690 m.

Plate V. Locality 32, Arroyo Moctezuma. 2,130 m. Habitat of *Pantosteus plebeius* and the northern *Catostomus* sp.

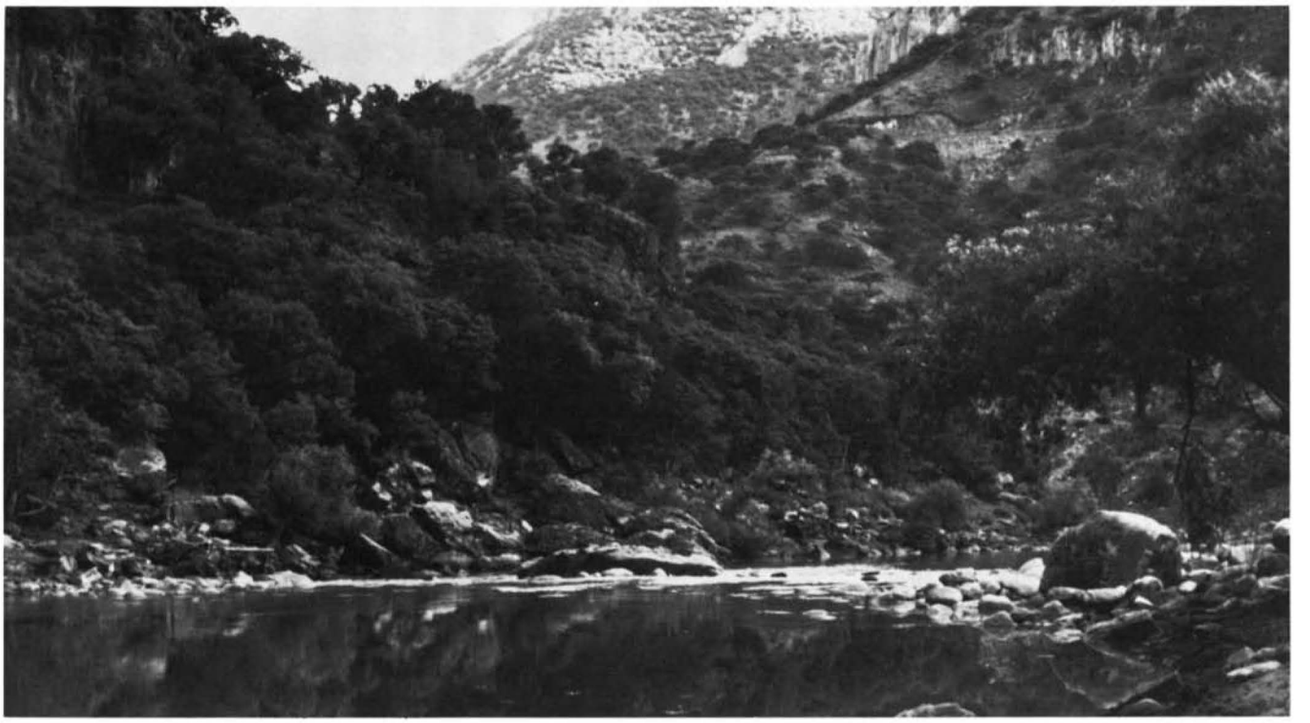

Plate VI. Locality 69, Río Sirupa. 1,300 m. This large river or *barranca* habitat is dominated by *Catostomus bernardini*, *Gila robusta* and *Ictalurus pricei*.

Plate VII. Locality 54, Arroyo Ahumado. 2,000 m. This small stream contained the most diverse, totally native fish fauna encountered by us in the basin.

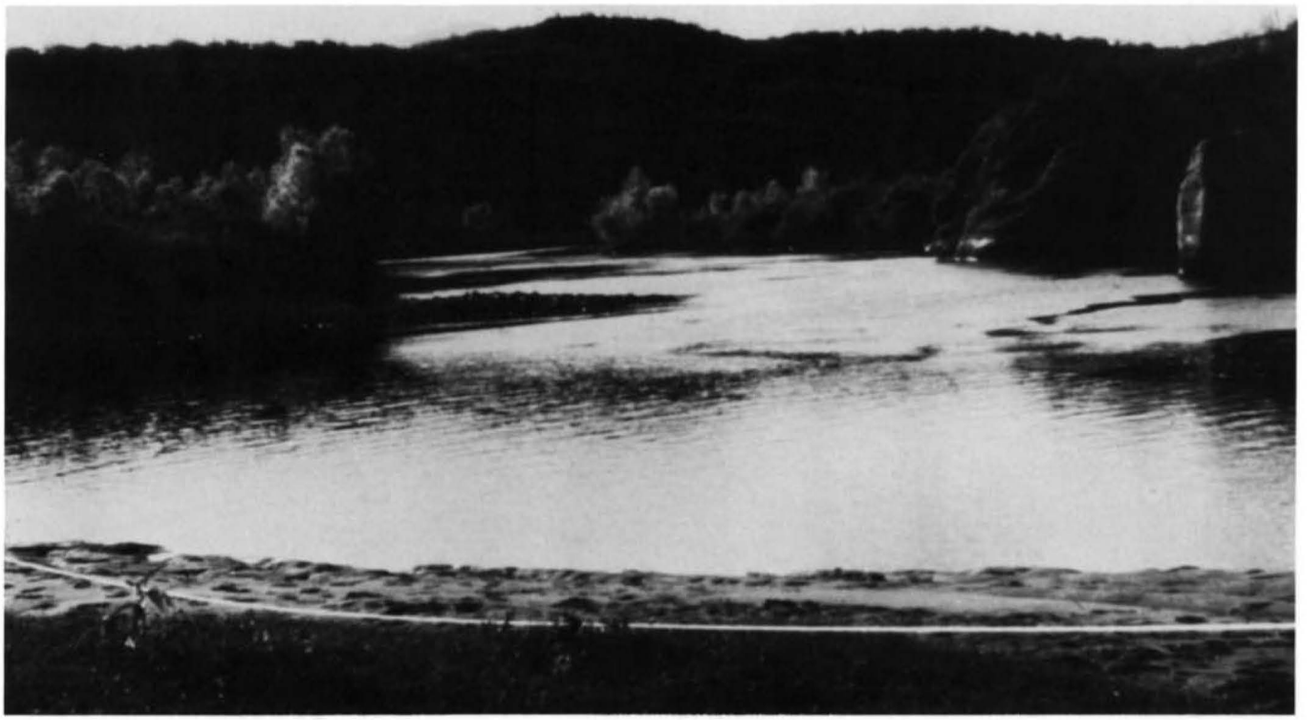

Plate VIII. Locality 8, mainstream Río Yaqui. 210 m. Although flow is regulated downstream of Presa Novillo, the native, large-river fish fauna persists alongside introduced species.

Plate IX. Locality 6, Presa Novillo. 350 m.

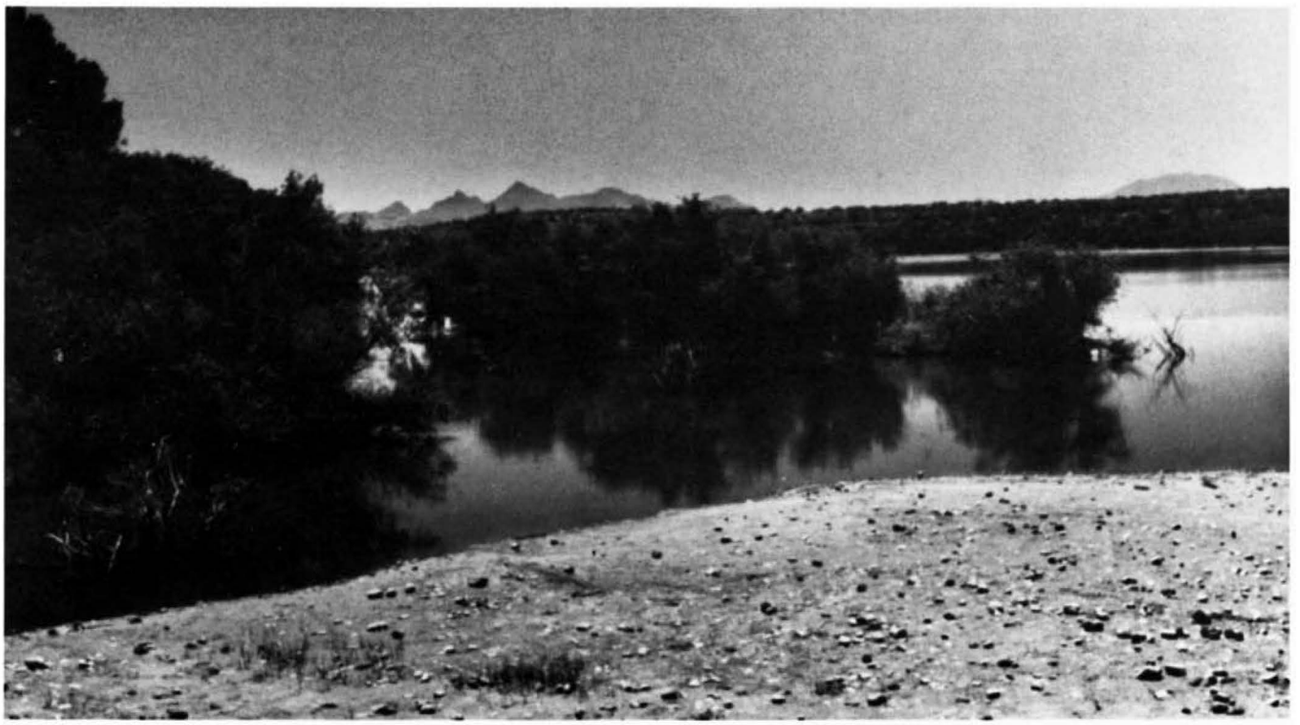

Plate X. Locality 81, La Presa de Hacienda Cuchuta. 1,160 m.

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APPENDIX A: Itineraries of Collecting Trips

27 April – 7 May 1978 (Hendrickson and Thomas O. Clark)

27 April. – Entered México at Douglas-Agua Prieta. First water municipal sewage lagoons draining into Río de Agua Prieta after primary treatment; fishless. Road from Agua Prieta to Nacozari (in part under construction) paralleled 1 km W Río de Agua Prieta. Watercourse lined with gallery of cottonwood and sycamore trees near Rancho San Antonio; no public access. Irrigated fields on river terraces. Tributary of Río de Agua Prieta, Arroyo Cabullonas (Arroyo El Fresnal) near Ejido Cabullonas, mostly dry with short stretch of surface flow. Broad, sand/gravel channel marked by extensive recent flooding. Excavated pool 300-400 m^2, maximum depth of 1.75 m, with clear water; some oil from pump in use by construction crew forming "slick" on downwind side. Shallow flow (< 0.01 m^3/sec) seeped through gravel embankment. Dense algal mats in stream, but no aquatic plants in pool. Flow returned into substrate after 50 m (locality 1).

28 April. – Inquiries in Cabullonas indicated Arroyo El Fresnal as only local, permanent, surface water. Irrigation canal fishless. Fishes observed in Arroyo El Fresnal above Cabullonas. Toward Nacozari, north-flowing arroyo along road from Fronteras and Esqueda with small, clear, gravel/sand-bottomed stream. Water most permanent downstream from crossing where aquatic macrophytes (mostly *Marsilea* sp.) choked pools (locality 2). Near Nacozari, Arroyo de Nacozari contaminated by copper wastes. 9.7 km S on road to Moctezuma stream partially recovered. Water clear, discharge 0.03 m^3/sec over bed of angular rock and gravel. Conductance high as indicated by electrofishing gear. Mostly riffle, with shallow pools. No aquatic vegetation (locality 3). Arroyo Moctezuma 1.6 km SSW Cumpas with permanent flow rising 1 km above in broad, sand/gravel bed. Discharge 0.1 m^3/sec. Pools to 1.0 m deep, with undercut, grassy banks. One pool deepened by rock-gravel diversion moving water into irrigation canal (locality 4).

29 April. – From Moctezuma route W to Huásabas then S toward Diversaderos. From Colonia Norelia de Divisaderos local residents guided to El Ojo de Agua Salada, tiny, sulfurous seep impounded for medicinal bathing; fishless. Approaching Divisaderos, detoured 9.7 km NE to reservoir under construction. Stream with tadpoles and dense algae; also fishless. Residents reported stream ephemeral. Passing through Divisaderos and Tepache, Arroyo Tepache, discharging 0.03 m^3/sec, fishless at crossing. S, Río Moctezuma extensively used for irrigation (especially in Cumpas-Moctezuma area). Discharge at Rancho La Junta equal or slightly less than at Cumpas; stream bed predominately sand. Algal mats highly developed. Channel wide and open; extensive riparian stands of *Acacia* (locality 5). From Rancho La Junta, rough dirt road to Presa Novillo. Bottom of large, fluctuating reservoir consisted of 15-20 cm of soft mud over harder base in flooded cornfields near shore (locality 6).

30 April. – Residents reported *lobina (Micropterus salmoides)* and catfish other than that collected (ranging to 60 cm long) taken by sportsmen. NW direction around lake; Río Moctezuma and Arroyo Coronado dry at confluence with reservoir, and extensive irrigation upstream on each. Route passed through San Pedro de la Cueva, Matape, Nacori Grande (erroneously on map as Nacori Chico), Mazatán, to Presa Rebeico.

1 May. – Seepage pool below Presa Rebeico densely vegetated by *Potamogeton* sp., rising from deep, gray, reducing mud bottom (locality 7). Reservoir small, deep, and steep-sided; not sampled. Crossed Río Yaqui at Soyopa. Inquired in Tónichi on status of springs. Told pumping at Ojo El Sasachi (28° 47' N, 109° 27' W) dried source. Pond at Rancho Tarango once contained fishes; also dried. Ojo Agua Caliente (29° 38' N, 109° 30' W) produced small, natural stream of high mineral content and temperature. Stream canalized after 1 km. Along upper km, marshes and riparian zone sheltered diversified avifauna. Small dam at origin of canal formed 1,500 m^2 pool; populated by abundant invertebrates, but fishless. Returned to Tónichi. Río Yaqui large, 50 m wide and 0.6 m deep at ford. Bottom of large, rounded cobble and rock on riffles, with some gravel and sand. Large pool *(remanso)* 0.5 km downstream from ferry with sand bottom; mud and rock at lower end. Depth varied to > 3.0 m. Discharge dropped overnight, lowering pool 0.5 m (locality 8).

2 May. – From Tónichi, passed through Onabas and Río Chico. Río Chico intermittent near Rancho Alamos, 8.0 km by road S of town of Río Chico. Pools choked with algae and *Potamogeton* sp.; frogs (*Rana* sp.) and tadpoles abundant (locality 9).

3 May. – 5.6 km N Movas by road discharge of Río Chico 0.03 m^3/sec over rocky riffles; pools to 1.25 m deep, with mud, sand and gravel bottoms. Water clear (locality 10). Riparian vegetation willows (*Salix* spp.) and large *Acacia* sp. Surrounding terrain with Sinaloan thornscrub. Irrigation ditch discharged more water than adjacent stream channel. From Movas route SE to Nuri. Río de Nuri (above Nuri) with scattered, isolated, large pools in rock/gravel channel. Mainstream supported heavy algal growths, while permanent pool of spring-fed tributary densely vegetated with *Potamogeton pectinatus* (locality 11). Local informants reported *lobina*, *lisa* (*Gila* sp.), and *bagre* (catfish).

4 May. – From Nuri, road under construction toward Santa Rosa and Yécora not on 1:250,000 maps. Traveled through Palmarito, Tacupeto, and Curea, much beyond which numerous detours made actual route indiscernible. At place known as Salseda, on same arroyo that passes through San Nicolás, road forked, one road following permanent water upstream to San Nicolás, other downstream to town of Tepoca (not on maps). About 0.5 km above fork to Tepoca, stream flowed < 0.03 m^3/sec. Often diverted for riparian irrigation. Bottoms sand/gravel, algal mats present, and riparian community dominated by *Salix* sp. (locality 12). At Tepoca, arroyo locally known as Arroyo Tepoca (also Arroyo Milpillas) with long, isolated, shallow pools. Algal mats and *Chara* sp. dense. Bottom gravel and large rock. *Salix* sp. lined banks (locality 13). Arroyo Salseda (or Arroyo San Nicolás, tributary of Arroyo Tepoca) enters downstream. From Tepoca returned through Salseda, passing locality 12 and ascending that arroyo. Bridge for road to Yécora under construction over arroyo above locality 12 and below San Nicolás. Arroyo dry above San Nicolás, and followed for several km until climbing toward Santa Rosa. No water along road to Santa Rosa and Yécora.

5 May. – Arroyo El Toro through Yécora permanent for at least 6.0 km above town. Water clear, flowing 0.06 m^3/sec over gravel/boulder bottom. *Potamogeton pectinatus*, *Chara* spp., and algal mats in scattered beds. Sedimentary bedrock locally exposed, developing deep pools with undercut ledges, separated by shallow riffles and runs. Tributary mouths with deep pools and backwaters. Banks grassy. Little or no riparian shrubs and trees. Surroundings cultivated, with oak-juniper woodlands and pine forest on slopes (locality 14).

6 May. – Returned from Yécora to Santa Rosa. Rock pool *(tinaja)* along road 1.75 m deep and 10 m long in bedrock below fall; fishless. N toward Guisamopa from Santa Rosa, water in isolated pools 7.6 km from Santa Rosa fishless. Río Sahauripa 23.6 km from Santa Rosa flowing 0.03 m^3/sec. Clear water over sand bed in large pools and large rounded rock in riffles. Conglomerate cliffs bordered one side, inducing formation of long, deep (to 1.5 m) pools, with undercut, rocky shelves (locality 15). Riparian vegetation sparse; water exposed to full sun. Sinaloan thornscrub on surrounding slopes. Local residents reported stream dwindling in summer to isolated pools. Channel dry from Cajón de Onapa to Sahuaripa. Agriculture on terraces from Tacupeto downstream must use pumpage; irrigation canal at Arevechi contained no fishes. Shallow (< 15 cm) pool isolated in sandy bed of Río Sahuaripa at S edge Sahuaripa with extensive algal mats (locality 16). New road (not on maps) leaves Sahuaripa, proceeds E then N crossing Arroyo Los Otales and Chipajora (both dry at fords), eventually arriving at ferry crossing on Río Yaqui; 2.4 km upstream an eddy had 1.0 - 1.5 m of water over clean sand. Channel with occasional outcroppings of bedrock; water turbid. Rapids deep (1.0 to 1.5 m) and fast (1.0 m/sec) over large boulders (locality 17).

7 May. – Road toward Dividaderos, with water 23 km from ferry supporting abundant snails and other invertebrates; no fishes. Field party returned directly from Divisaderos to Tempe, Arizona.

11-14 May 1978 (Hendrickson and Sherry Hendrickson)

11 May. – entered México at Douglas-Agua Prieta. Proceeded SE toward Colonia Morelos, crossing Río San Bernardino at Hacienda Cuchuverachic. Discharge 0.06 m^3/sec through braided, narrow channels within 50-m-wide gravel bed. Large cottonwoods lined margins; no shading of water (locality 18). From Hacienda Cuchuverachic secondary road paralleled S side Arroyo de Los Embudus for 8 km, crossed, and continued to Arroyo Cajón Bonito at Ejido Oquita Monte Negro (formerly Rancho La Cieneguita). Slow-flowing stream over sand/gravel substrate with substantial pools 0.75 to 1.5 m deep and to 15 m long, separated by 5-15 m riffles. Deeply undercut roots common; dense gallery of cottonwood, sycamore, and other large trees shaded water. Flood felled many trees in August 1977; segment of stream nearly permanent, dries occasionally, the last being 5-7 years ago (local testimony; locality 19).

12 May. – From Ejido Oquita Monte Negro road led N connecting with Agua Prieta-Janos road. E on road to Janos, Arroyo de Guadalupe flowed several hundred meters; fishless. Water next at Cajón Bonito near Rancho El Diablo. Flow slightly greater than downstream; stream bed with more gravel/rock than sand/gravel. Riparian vegetation as at previous locality, shading stream (locality 20). Evidence of beaver; residents reported occasional individuals. 8.1 km upstream similar to below; more enclosed by canyon walls (locality 21). Tributary of 0.03 m^3/sec discharge entered from S, falling over steep, pool-waterfall series through dense, high, riparian canopy. Avifauna dense and diversified, including pair of black hawks. Tree squirrels abundant in riparian forest.

13 May. – 4.8 km upstream. Backwater area at base conglomerate cliff with bottom of sand, mud, and clay, and undercut bank with overhanging roots (locality 22). Upstream, road followed Arroyo Agua Blanca, which at time supplied 30% discharge Cajón Bonito below Rancho Nuevo. Riparian vegetation changed to oak-grassland; ciénega near headwaters of system, fishless. Road crossed Animas Valley, passed through W Río Casas Grandes watershed to Janos, Chihuahua. From Janos, SW through Buenos Aires, E to Rancho Los Novillos, into Sonora and upstream in Arroyo Carretas to Río Yaqui watershed.

14 May. – Río de Bavispe 3.2 km downstream from San Miguelito clear over sand/gravel bottoms in long (50 m), deep (to 2.0 m) pools separated by rocky riffles. Discharge 0.4-0.6 m^3/sec. Riparian vegetation dominated by low willow and large, scattered cottonwoods (locality 23). Route followed river to Colonia Morelos. Diversions from Río de Bavispe and Río Batepito along road near Colonia Oaxaca and Colonia Morelos. No fishes in inspected irrigation canals. Returned to Tempe, Arizona.

19-26 May 1978 (Hendrickson and Siebert)

19 May. – Entered México at Douglas-Agua Prieta. S through Fronteras and Esqueda, E at Km Post 99 on La Angostura road. Arroyo de Esqueda (locality 2 in May) reduced to isolated pools. Road ended on narrow dam of Presa La Angostura. Access to water impossible in narrow precipitous canyon. 20 m below high-water mark; turbidity high (water red-brown). Returned to Rancho El Alamo.

20 May. – Proceeded S to Villa Hidalgo (formerly Oputo on 1:250,000 map). Intense construction activity 12.8 to 16.1 km S. Workers explained 76 cm pipeline to convey water from La Angostura to La

Coloradita copper mine (visible near peak SW Presa). Water to be returned to Río de Bavispe. Headwaters Arroyo de Hacienda de Juriguipa in area of Mina La Coloradita; absence of fishes in stream that discharged 0.03 m³/sec may result from contamination, but no indications of pollution visible. Road followed Río de Bavispe, which was flooding. Strong currents inundated riparian trees. Similar circumstances downstream at Huásabas. Bottoms gravel/rock in 1.0 m water and currents approached 1.0 m/sec; submerged terrestrial grasses in quieter places (locality 24). River crossed by ferry. No surface water except stock tanks NE between Huásabas and Huachinera. Río de Bavispe at Rancho El Picacho discharging 0.3 m³/sec of clear water over gravel/rock substrate in riffles and sand in pools (to 1.5 m deep). Riparian gallery of cottonwood and sycamore lined reaches of bank. Sedimentary rock formed cliffs on S side. Diatoms abundant in riffles, no rooted aquatic plants (locality 25). Drove to Bavispe for vehicle parts, Río de Huachinera below town of same name with slight surface discharge. Considerable land under irrigation between Huachinera and Bavispe along terraces. Returned to Huachinera, road SE through Cebadilla rose rapidly into Sierra Madre Occidental, approaching 2,500 m elevation between Cebadilla and Colonia Mesa Tres Ríos.

21 May. — Torrential stream near Cebadilla fishless. Tributary Arroyo San Antonio, unnamed on available maps (locally Arroyo Cuartel) discharged about 0.03 m³/sec over rocky bottom (locality 26). Sycamore on banks. Most surrounding vegetation pine, some oak and juniper. 7.0 km by road toward Colonia Mesa Tres Ríos from last site, Arroyo San Antonio at Rancho San Antonio discharged 0.05 m³/sec. Stream physically similar to locality 26, but lesser gradient (locality 27). Inquiry in Colonia Mesa Tres Ríos as to roads indicated new construction through La Cueva de Tres Ríos, crossing Río Negro then on to Chuhuichupa. Took road to Nuevo Casas Grandes. Below confluence of ríos Negro, Chuhuichupa, del Gavilán, and de la Cueva, at Rancho Tres Ríos, large quiet pool had gravel/rock bottom and outcrops of bedrock. Water clear, no macrophytes or algal mats. Diatoms on rock riffles; films relatively thin (locality 28). Occasional large sycamore on banks, but riparian vegetation sparse; surrounding hills oak-grassland community.

22 May. — Arroyo del Juicle along road to Nuevo Casas Grandes (at abandoned sawmill, Rancho Los Chales) had frequent, large pools. Little surface flow; sharp thermal stratification in deeper (➢3.0 m) water. Aquatic macrophytes and algae absent; diatoms as films on stony riffles (locality 29). Sycamore constituted sparse riparian vegetation. Río del Gavilán at Rancho El Gavilán passed through open, grassy meadows with sparse pine and juniper. Discharge 0.06 m³/sec; near minimum flow according to Alvin Whetten (owner). Trout no longer common (formerly abundant prior to sawdust pollution). Populations remained low with closure of sawmills (locality 30). To his knowledge, no trouts introduced in Río del Gavilán watershed, although aware of stockings in Río Grande drainage further E in Chihuahua.

23 May. — From Rancho El Gavilán S toward La Mesa del Huracán. Isolated pools in Arroyo Punta de Agua at ranch of same name 1.5 m² and 30 cm deep. Heavily overgrown with algae; rocky stream bed densely shaded by riparian trees (locality 31). One km N El Colorado road paralleled upper Río del Gavilán (locally Arroyo Moctezuma), which flowed between grassy, meadow-like terraces bordered by pines. Bottoms, sand, gravel, and boulder. Discharge ➢ 0.03 m³/sec through shallow pools and riffles (locality 32). Toward La Mesa del Huracán water in Arroyo San Juan and again in unnamed arroyo at N edge of town; both fishless. S toward Madera, Río Chico crossed at dark. Camped at Arroyo Tres Fierros; fishless despite small flow.

24 May. — Río de Nueva Madera carefully inspected, fishes rare. In Madera received information that Presa de Madera supported large *truchas* (trouts) and *lisa* (*Gila* sp.). Proceeded directly to Rancho Huápoca W Madera.

25 May. — Arroyo Calandria on Rancho Huápoca discharged 0.03 m³/sec and contained trout stocked three years earlier from native population elsewhere in Río Yaqui basin (Stonoff, personal communication). Water clear; dense beds of *Chara* sp. over rock/gravel/sand bottom (locality 33). Arroyo Los Alisos N Arroyo Calandria on Rancho Huápoca infiltrated rock/gravel bed about 100 m upstream from road, had isolated pools and small surface flow, then became warm, isolated pools with dense algal growths downstream (locality 34).

26 May. — Río Sirupa (= Río Papigochic) near Rancho Huápoca headquarters consisted of long, narrow, deep, sand-bottomed pools (200-300 m, 20-30 m, and to 4.0 m, respectively) against steep canyon walls on W bank. Gradient 0.4% over approximately 25 km stretch centered on ranch. Pools separated by rapids to 1.0 m deep and 10-15 m wide. Water with gray-green turbidity, with obvious, fine, particulate load. Diatoms thick on boulders at ends of pools and quieter rapids (locality 35). Route to Madera, SE to Yepómera. El Ojo de Yepómera, large spring serving as municipal water supply, fenced, creating enclosure of 0.3 ha. Rooted macrophytes dense at spring head, removed by residents at intervals. About half of discharge canalized, remainder flowing over natural rock/gravel bottom. *Chara* sp. and *Nasturtium officinale* in dense beds in channel (locality 36). From Yepómera, direct route followed through Gómez Farías, Nuevo Casas Grandes, Janos, Palomas, to Tempe, Arizona.

7-21 June 1978 (Hendrickson, W. L. and Robert L. Minckley, R. R. and Frances H. Miller, Siebert, Patricia L. Haddock, James E. Johnson, Jay Schnell, and Ron Ogan)

8 June. — Entered México at Nogales, through Cananea to Agua Prieta then S. Arroyo El Fresnal SW Cabullonas discharging 0.03 m³/sec of clear water through braided channels over broad, sand/gravel bed (locality 37). New highway S Cabullonas paralleled stream. From Cabullonas along main highway through Fronteras, Esqueda, and Nacozari. Arroyo Moctezuma near Cumpas (3.2 km downstream from locality 4) with habitat similar to before; bottom sand/gravel, with long shallow runs and marginal pools that provided little cover. Deepest water ➢0.6 m against conglomerate cliffs in bends. Well developed, tall, riparian gallery of sycamore, cottonwood, and other trees, affording little shading for broad channel (locality 38).

9 June. — Río de Bavispe 0.8 km N Huásabas near ford on road to Huachinera with discharge far lower than at time of May collection (same as locality 24). Presa La Angostura apparently closed. Water clear and currents slow. Deep, quiet pools where bank-full conditions formerly produced strong, rapid-like currents. 1.8 m pool along vertical bank cut in mesquite bosque with sharply defined thermal stratification at 1.4 m (locality 39).

10 June. — Next destination Tónichi on Río Yaqui below Presa Novillo. Most direct route left Río Yaqui watershed through Mazocahui, Mazatán, and San Jose de Pimas. Arrived Tónichi at nightfall; discharge of river high.

11 June. — At Tónichi grasses and other terrestrial vegetation submerged along flooded shorelines. River deep, swift, and cool; phytoplankton bloom evident (locality 40). At Rancho Recodo river still high and swift in rapids above large eddy (locality 41). Río Chico at same site as locality 10 similar to earlier description. Water temperatures elevated (➢ 30°C), increased density of algae in pools, and less discharge (sample 42). Passed through Movas, Rosario de Tezopaco, and Los Hornos to Presa Alvaro Obregón.

12 June. — Shoreline devoid of terrestrial or aquatic vegetation below high-water mark; substrates loose porous lavas and gravel. Water clear, with phytoplankton density limiting visibility to one meter (locality 43). Alejandro Suarez H., fishery manager, informed us of *robalo* in reservoir and river below, described as snook-like (Centropomidae ?) which may attain 12 kg. Recreational park below dam adjacent to powerhouse. Lagoon system formed in backwater of river. Hydrogen sulfide odor evident, indicating deoxygenation of hypolimnion in reservoir. No fishes near powerhouse. Substrate mud/gravel, some *Scirpus* sp. along shorelines (locality 44). Bullfrogs *(Rana catesbeiana)* abundant. Retraced path through Rosario de Tezopaco, then through Nuri. Unnamed tributary Río Chico N Nuri on road to Yécora reduced to isolated pools of clear, warm water, with plentiful algal growth on boulders scattered over gravel /sand substrate. Banks lined with willow and other riparian vegetation (locality 45). High sediment loads noted in ephemeral arroyo 16 km E Curea. Light precipitation in area of slash/burn agriculture resulted in erosion of denuded slopes.

13 June. — Passed through Santa Rosa toward Yécora; small, probably ephemeral streams and rock pools (*tinajas*) supported larvae of *Ambystoma* sp. and tadpoles and adults of two species of *Rana*. Arrived Yécora; upstream on Arroyo El Toro to site of locality 14; stream as before (locality 46).

14 June. — Proceeded toward Maicova. Discrepancies between ground and maps made location difficult; reference to local names necessary. Isolated pools in Arroyo El Toro, 22.5 km E Yécora. Bedrock forced water to surface for short distances, producing deep (➢ 1.0 m), sand-bottomed pools to 5.0 m diameter. Clear and unvegetated (locality 47). One km before small town of El Trigo, road to Maicova forks left at ranch on permanent stream. Discharge ≪ 0.03 m^3/sec through narrow channel with little pool development. Substrate sand/gravel (locality 48). El Trigo not on 1:250,000 maps or 1:1,000,000 World Aeronautical Charts (located only as 25.1 km from Yécora on road to Maicova). Large arroyo 38.6 km from Yécora on same road tributary of Arroyo Talayote; long pools to 2.0 m deep lying 50 m along base of steep conglomerate/igneous cliffs. Substrate in pools sand/gravel; scattered large boulders in pools and riffles. Discharge ≪ 0.03 m^3/sec, subsurface water movement probably great; water clear, no aquatic vegetation (locality 49). Arroyo Talayote crossed 40.2 km from Yécora. Surface flow small, but large, deep pools of clear water separated by shallow riffles over coarse substrate. Pools usually ≪ one meter deep, 2 deeper than 2.0 m. Substrate in pools coarse gravel, grading to sand in deep areas. Rooted,submergent macrophytes profuse (locality 50).

15 June. — Orchard being irrigated by water pumped from drying pools in Arroyo Maicova, 3.0 km by road upstream from Maicova at Rancho Casa Blanca. Few pools remained, none ➢ 0.6 m deep or ➢ 4.0 m diameter; all in sandy substrate (locality 51). Near Maicova, bound for Yepáchic, road construction encountered and traffic diverted to new road not on available maps. The following locality data as distances from towns, with coordinates and elevations approximated as interpreted from route of new road. Tributary of Río Yepáchic 18.3 km from Maicova had no surface flow between pools in gravel streambed. One large pool one meter deep against sharply cut bank at base of large pine. Bottom hard, coarse gravel overlain by sand and mud. High turbidity and brown color in pool due to leachate from leaf litter and disturbance of lower end by construction. Clear water in small, shallow pools upstream (locality 52). In Yepáchic, Río Yepáchic at highway bridge clear over coarse gravel and small boulder bed. Little pool development; deeper water along rocky banks. Stream obviously organically loaded from town, as well as detergents from laundry use near bridge (locality 53). Surroundings in agriculture.

16 June. — A few km E Yepáchic, road to La Junta crosses divide to Río Mayo watershed, passing through Basaseachic and returning to Río Yaqui drainage to follow tributary (locally termed Arroyo Ahumado) of Río Tomóchic. Along Basaseachic-Tomóchic highway, 21.8 km by road upstream from Tomóchic, stream with abundant cut banks had overhanging willows, gravel/bedrock riffles, rocky banks, and long, slow-flowing pools. No macrophytes in stream; diatoms formed continuous growth over bedrock riffles (locality 54). Río Tomóchic, 2.2 km upstream from highway bridge at Tomóchic flowed through broad and frequently scoured bed on rock and coarse gravel in riffles. Large pools (to ➢ 40 m long and 2.5 m deep) with mud/gravel bottoms, grading to sand/silt at lower ends (locality 55). Field party separated into three groups, one continuing E toward La Junta, another NE toward Matachic, and a third to Ciudad Cuauhtémoc for equipment repair. Arroyo de Vallecillos, 2.0 km upstream from confluence with Río Tutuaca at Tutuaca, cold, clear, with essentially no surface discharge between large, 0.5- to 1.5-m-deep pools. Banks steep and rocky, and bottoms rock/gravel (locality 56). Between Tomóchic and Ciudad Cuauhtémoc, Río Verde (upstream from locality 59; see below) at bridge on Basaseachic-La Junta highway averaged 4.0 m wide and 1.0 m deep. Current slight to none and pools to 10 by 60 m. Vegetation included *Ranunculus* sp. and *Potamogeton* sp. in dense beds. Bottoms ranged from boulder through gravel to silt and some mud in pools (locality 64). Río de los Triguitos had bottoms of boulder and rock; scarce pockets of gravel. Beds of algae and *Ranunculus* sp., and axolotls (*Ambystoma* sp.) abundant (locality 65). Arroyo Tonachic (also known as Río Bahuerachic) 18 km W La Junta at crossing of new highway to Basaseachic provided locality 66.

17 June. — Río Tutuaca 2.0 km downstream from Tutuaca flows through extensive, gently sloping meadowlands used for grazing and agriculture. Surrounding hills with conifers. Stream open, with little or no riparian vegetation excepting scattered stands of 2.0 m, willow-like shrubs. All water ≪ 1.0 m deep. Pools scarce, stream flowing over open, large, loose, gravel/rubble substrate or short reaches of bedrock. Water clear and cool (locality 57). Dynamite used by local fishermen. Road conditions dictated return to Vallecillos, through Tosanochic and then to Matachic. Tributary of Río Sirupa below Tosanochic small, with slight but evident gray turbidity attributable to laundry use. Small pools; riffles predominated. Depths nowhere ➢ 50 cm. Pools with large boulders and undercut, rocky shorelines. Water noticably warm (locality 58). Río Verde at bridge between Tosanochic and Matachic large and slow-flowing, discharging little on surface relative to obvious capacity (0.06 m^3/sec, and clear). 20 by 100 m pool ranged to 3.0 m deep, with narrow, vertical-walled channels cut in bedrock, and ridges of stone rising to one meter of the surface. Substrate otherwise gravel, sand, and mud in deepest parts, with sandbar vegetated by *Ranunculus* sp. sloping to form S bank and vertical, 30 m rock wall on N. Sharp thermal stratification at 1.5 m, and pool obviously green with phytoplankton. Conductance lower than most streams of region, judged by low efficiency of electrofishing (locality 59). Arroyo de Agua Caliente at Rancho La Boquilla near La Junta discharged ≪0.03 m^3/sec in channel 2-20 m wide; pools associated with boulders and outcroppings of bedrock. Bottoms bedrock/gravel, with some sand/silt in pools. Aquatic vegetation abundant; *Lileopsis* sp., *Ranunculus* sp., *Potamogeton* sp., *Chara* sp., *Lippia* sp., and *Justicia* sp. in dense beds. *Azolla* sp. also common, densely covering surface in quieter water (locality 61). Same stream a short distance above and near source in town of Agua Caliente with obvious organic pollution by man and livestock; deep organic deposits overlying gravel/sand substrate. Water gray; bluegreen algae and *Spirogyra* abundant. Sparse willow riparian community. Discharge slightly greater than downstream (locality 62). 1.0 km SE La Junta, Arroyo de La Junta ranged from 3-12 m

wide and to 2.0 m deep, flowing over gravel/boulder bottom overlain by mud in pools (locality 63). *Ranunculus* sp., *Najas* sp., and *Potamogeton* sp. abundant. First and third parties camped on Río Papigochic at Rancho de San Pedro near Miñaca. River flowed < 0.3 m³/sec over short riffles connecting large pools to 100 m long and 2.0 m deep. Bottoms gravel/rock, with dense diatoms and some macrophytes in pools (locality 60).

18 June. – Returned to El Ojo de Yepómera (former locality 36). Fished main pool over spring boil (locality 67). *Gila* sp. (likely *G. pulchra*) observed but not caught in clear water directly over spring boil. Stream site locally known as El Salto de Yepómera, popular bathing locality a short distance from Yepómera, with low waterfall (locally Arroyo Yepómera or Arroyo de La Concha). Pool below 1.0 m fall, 2.5 m deep, with rock and coarse gravel bottom. Waterfall about 10 m across and pool equivalent in diameter, bounded by 6.0 m cliff on N side and opposite, sloping gravel bar. Small backwater downstream with abundant emergent and submergent vegetation, and riffle below pool flowing 0.05 m³/sec (locality 68). Pool frequently fished with dynamite (local information). Party again split into groups, one to Río Sirupa W Madera and second to extreme SE part Río Papigochic system. Río Sirupa large, with deep (>3.0 m) quiet pools. River cut deeply in relatively narrow canyon, maintains highly erosive character; most bottoms of boulder and coarse rock, with large gravel in pools (locality 69). Intentions of continuing W thwarted by inaccessibility much beyond W rim of Río Sirupa Canyon. Second party visited upper end Presa Los Alamos, a muddy reservoir. Depths ranged slightly more than a meter over hard clay bottom covered by 10 cm mud (locality 70).

19 June. – Arroyo El Alamo near Ciénega Ojos Azules clear and supporting beds of *Potamogeton* sp. and *Ranunculus* sp. Salamanders (*Ambystoma* sp.) and turtles (*Kinosternon* sp.) also present (locality 71). Río Papigochic at Guerrero similar to stream described at locality 60 (locality 72). Small, spring-fed pool in Matachic resembled El Ojo de Yepómera, and yielded sample 73. Mainstream Río Papigochic just S Temósachic was similar to stream at locality 60 (locality 73). Field parties rejoined at Río Sirupa.

20 June. – Retraced route to Madera then N through La Mesa del Huracán. Río Chico near Rancho Río Chico with bed of rock and coarse gravel, little perennial riparian vegetation save for large conifers; dense growth of annual plants on terraces attested to heavy scour of channel. Discharge <0.06 m³/sec of clear water (locality 74). Through La Mesa del Huracán, camped at Arroyo Moctezuma near previous locality 32.

21 June. – Arroyo Moctezuma similar to description for locality 32 (locality 76). Headwaters of Arroyo Moctezuma impounded at Moctezuma near downstream end of large meadow. Shallow reservoir choked with beds of filiform *Potamogeton* sp. on mud bottoms to about 20 m from shore; to 1.5 m deep (locality 77). Part of party proceeded to Colonia García, across Piedras Verdes drainage (Río Casas Grandes basin) to Nuevo Casas Grandes. Personnel traveling by highway stopped at tributary of Río Papigochic 35.2 km S Madera (Río La Concha). Bottom of gravel, rock, sand, and silt; aquatic vegetation abundant (*Nasturtium* sp., *Ranunculus* sp., fine-leafed *Potamogeton* sp., and *Ceratophyllum* sp.; locality 78). From Nuevo Casas Grandes, personnel returned *via* paved highway to International Boundary at Palomas, then to Tempe, Arizona.

18-25 July 1978 (Hendrickson, Minckley, James P. Collins and Robert W. Clarkson)

18 July. – Entered México at Douglas-Agua Prieta. Arroyo El Fresnal near Cabullonas flooded since June, silting many pools. Discharge similar to before; water temperature in shallow, sandy exposed channel far higher, 30°C or more (locality 79). S to Esqueda, E to Rancho La Playa at upper end Presa La Angostura. Reservoir at low water and distant from ranch. River bed below high water mark to 20 m wide with depth of 0.5 m over clean, shifting sand. Depths of > 1 m rare. Water turbid, high sediment load imparting brown color. No aquatic plants, terrestrial grasses locally submerged (locality 80).

19 July. – Retraced route to Esqueda; spring at Rancho Virginia fishless. 4.8 km S Esqueda turned W through Cuchuta on road from Río Yaqui to Río Sonora drainage. Small reservoir at Cuchuta impounded by earth-filled dam. Hard gravel bottom overlain by deep silt. *Typha* sp. in large clumps along shore and in some open areas. Large cottonwood along one shore (locality 81). 1.5 km above Rancho Mababi two springs rose and flowed across an open, grassy meadow (oak-grassland). As they left meadow, streams lined with cottonwood, sycamore, walnut, and wild cherry. Water clear, over gravel and supporting stands of *Chara* sp., watercress, *Nitella* sp., *Polygonum* sp., *Lileopsis* sp., and *Eleocharis* sp.; *Batrachospermum* sp. in upper 500 m of streams (locality 82).

20 July. – Above Rancho Mababi crossed into Río Sonora basin through La Volanta, Bacoachi, and Cananea; returned to Río Yaqui basin near Agua Prieta. From Agua Prieta road to Janos *via* Cajón Bonito for more intensive survey for *Gila purpurea*. None taken in localities 83-86, very near localities 18-20 made on earlier trip. Discharge of stream slightly less than before, other conditions same. Arroyo Agua Blanca supplied 50% discharge for Cajón Bonito. Ciénega-like area near headwaters dry. Río Yaqui basin left at Arroyo Agua Blanca; passed through Janos and Gómez Farías and crossed bed of Laguna de Bavicora.

21 July. – Entered Río Yaqui drainage at Vallecillos enroute to La Mesa del Huracán. Reservoirs at Vallecillos contained only *Ambystoma* sp. Arroyo Tres Fierros again proved fishless, but discharge far greater with advent of summer monsoon. Next arroyo crossed on road was dry on previous trips, now flowed 0.03 m³/sec. Rock pools 50 m above road contained *Ambystoma* sp. and *Rana* sp.

22 July. – Proceeded SW from La Mesa del Huracán to Chuhuichupa. 1.0 km S earth-fill dam formed large pond. Beds of *Chara* sp. and *Potamogeton* sp. grew from clay/mud bottom; dense bloom of filamentous algae in progress (locality 87). Arroyo de La Norteña 3.0 km NW El Norte flowed through broad, grassy meadow along road to Colonia Mesa Tres Ríos. Stream in spate from heavy rainfall and water turbid, 1.5 m deep in places (average 0.5 m), and 4-5 m wide. Substrate mostly gravel/rock, with beds of clay. Banks clay, typically cut, with scattered gravel/rock bars. Riparian vegetation absent; *Potamogeton* sp. rare (locality 88). Numbers of springs, seeps, and ciénegas in meadow in short-grass-sedge area 0.5 to 2.0 km above.

23 July. – From Arroyo de La Norteña attempted again to penetrate W into central Río Yaqui basin through Chuhuichupa. Río Negro and small tributary visited where crossed road from Chuhuichupa to sawmill at Huaynopa. Not shown on map (1:250,000), dirt road said to continue W crossing Río Bonito and Río Aros. Río Negro clear, with rocky bottom and occasional sand-bottomed pools with accumulated leaf litter. Discharge 0.06 m³/sec through pine, spruce, and aspen forest. Small fields near road, but area otherwise undisturbed (locality 89). Tributary W of Río Negro with high gradient, flowing 0.05 m³/sec over gravel and sharp rock. Clear water of low conductance; productivity low, no visible diatoms on rocks and sparse invertebrate fauna (locality 90). Series of tanks and other lentic habitats along road on return to Chuhuichupa fishless (occupied by *Ambystoma* sp. and *Rana* sp.) Weather conditions deteriorated with advance of monsoon.

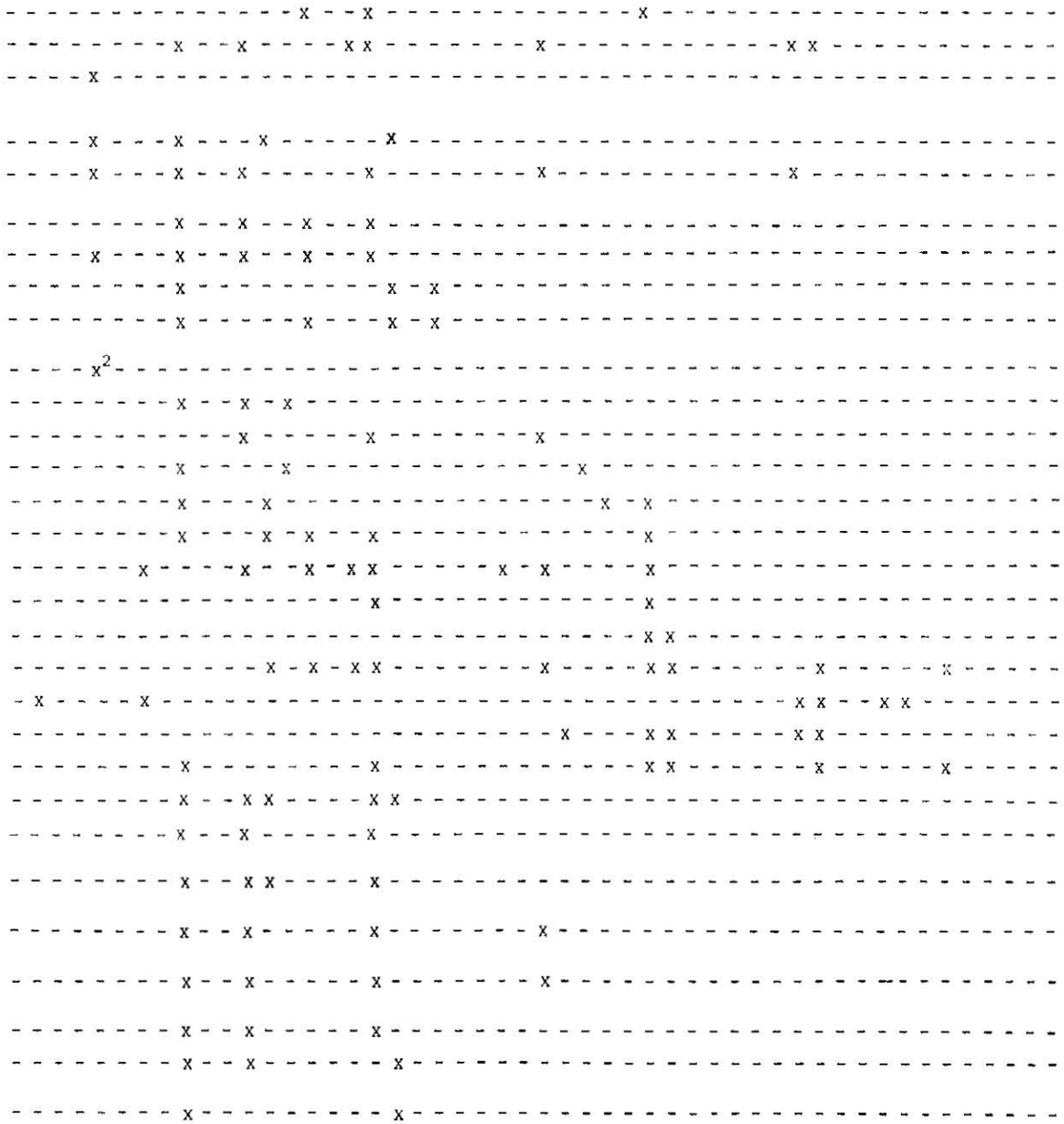
24-25 July. – Live fishes from Río Moctezuma, Presa Moctezuma, El Ojo de Yepómera, and Río de La Concha near Yepómera collected and transported directly through Gómez Farías, Zaragosa, Nuevo Casas Grandes, to Palomas. Declared through U.S. Customs and delivered to U.S. Fish and Wildlife Service personnel in Demming, New Mexico. Field party returned to Tempe, Arizona.

APPENDIX B: Locality and collection data for fish collections made during this survey (localities 1-90) and compiled from museum catalogs and the literature (sites 101a-173).

Locality numbers are plotted in Figure 3 and museum and literature sites in Figure 4, with the exception of 169-173 for which information was too vague to allow plotting. Literature and museum collections from the same site or from within a limited geographic area are assigned the same number and differentiated by consecutive letters of the alphabet. Localities and sites are designated by states only. All Arizona collections are from Cochise County. Coordinates of survey localities are based on maps cited in Methods and Materials. Those estimated on the ground are marked with an asterisk (*). Species collected are identified by X in the appropriate column. Specimens identified in catalogs to generic level only and not inspected by the authors are indicated by two or more ? in columns of each possible congener. In some cases where only *P. monacha-occidentalis* was recorded, *P. occidentalis* was assumed present and so indicated (see text p. 80).

Locality	*Lile stolifera*	*Dorosoma smithi*	*Elops affinis*	*Salmo gairdneri*	*Salmo* sp.	*Salvelinus fontinalis*	*Cyprinus carpio*	*Carassius auratus*	*Campostoma ornatum*	*Gila purpurea*	*Gila pulchra*	*Gila robusta*	*Agosia chrysogaster*	*Codoma ornata*	*Notropis formosus*	*Pimephales promelas*	*Carpiodes carpio*	*Catostomus bernardini*	*Catostomus* spp.	*Catostomus wigginsi*	*Pantosteus plebeius*	*Arius caerulescens*	*Arius liropus*	*Ictalurus furcatus*	*Ictalurus punctatus*	*Ictalurus pricei*	*Ictalurus melas*	*Cyprinodon* sp.	*Gambusia affinis*	*Poeciliopsis prolifica*	*P. occidentalis*	*P. monacha-occidentalis*	*Agonostomus monticola*	*Mugil curema*	*Centropomus nigrescens*	*Centropomus robalito*	*Lutjanus novemfasciatus*	*Micropterus salmoides*	*Lepomis cyanellus*	*Lepomis megalotis*	*Lepomis microlophus*	*Lepomis macrochirus*	*Pomoxis nigromaculatus*	*Pomoxis annularis*	*Cichlasoma beani*	*Dormitator latifrons*	*Eleotris picta*	*Gobiomorus maculatus*	*Awaous transandeanus*	*Trinectes fonsecensis*
1. Sonora, Arroyo Cabullonas, 500 m N church in Cabullonas, 31°09' N, 109°32' W, 1,070 m; 27-IV-78.									X				X																		X																				
2. Sonora, headwaters Arroyo de Esqueda at crossing to La Angostura, near Rancho Milpita (airport), 30°29' N, 109°38' W, 1,500 m; 28-IV-78.																X																																		
3. Sonora, Arroyo Nacozari, 9.6 km S Nacozari by road to Moctezuma, 30°19' N, 109°41' W, 975 m; 28-IV-78.									X				X																																					
4. Sonora, Arroyo Moctezuma, 0.8-1.6 km SSW Cumpas, 29°58' N, 109°46' W, 750 m; 28-IV-78.									X	X			X		X			X													X	X																		
5. Sonora, Río Moctezuma at Rancho La Junta, 29°27' N, 109°38' W, 450 m; 29-IV-78.									X				X		X		X	X								X					X	?[1]																		
6. Sonora, Presa Novillo, 29°12' N, 109°37' W, 350 m; 30-IV-78.		X					X										X										X														X	X	X							
7. Sonora, seepage pool below dam at Presa de Rebeico, 28°56' N, 109°45' W, 450 m; 1-V-78.																															X	X																		
8. Sonora, Río Yaqui, *ca.* 0.5 km downstream from ferry at Tónichi, 28°36' N, 109°34' W, 210 m; 2-V-78.							X				X				X	X								X						X	X						X											
9. Sonora, Río Chico, *ca.* 8 km S. Pueblo Río Chico along road to Movas, 28°17' N, 109°29' W, 190 m; 2-V-78.																															X	X																		
10. Sonora, Río Chico, *ca.* 5.6 km (road to Tónichi) N Movas, 28°12' N, 109°28' W, 250 m; 3-V-78.															X		X	X								X					X	?[1]						X						X					
11. Sonora, Río Nuri, *ca.* 4 km (road to Cuba) above town of Nuri, 28°05' N, 109°19' W, 490 m; 3-V-78.									X				X		X																X	X						X						X					
12. Sonora, Arroyo Salseda, *ca.* 7 km W San Nicolás on road from Nuri to Yécora, 28°24' N, 109°12' W, 6-700 m; 4-V-78.													X																		X	X																		
13. Sonora, Arroyo Tepoca (locally Arroyo Milpillas) at Tepoca, 28°25' N, 109°14' W, 5-600 m; 4-V-78.									X																						X	X						X						X					
14. Sonora, Arroyo El Toro, 2.4 km upstream from Yécora, 28°22' N, 108°56' W, 1,550 m; 5-V-78.									X			X	X					X																																	
15. Sonora, Río Sahuaripa at crossing 23.6 km from Santa Rosa on road to Guisamopa, 28°38' N, 109°07' W, 690 m; 6-V-78.									X				X					X														X	X							X									
16. Sonora, Río Sahuaripa at S edge Sahuaripa, 29°02' N, 109°13' W, 460 m; 6-V-78.									X																						X	X																		
17. Sonora, Río Yaqui, *ca.* 2.4 km upstream from ferry, road from Sahuaripa to Divisaderos, 29°21' N, 109°14' W, 430 m; 7-V-78.							X				X		X	X		X	X								X																								
18. Sonora, Río San Bernardino at Hacienda Cuchuverachic, 31°07' N, 109°17' W, 960 m; 11-V-78.									X				X					X													X																		
19. Sonora, Cajón Bonito at Ejido Oquita Monte Negro, 31°10' N, 109°13' W, 1,030 m; 11-V-78.									X				X					X									X																							
20. Sonora, Cajón Bonito at first road crossing from Agua Prieta to Janos, near Rancho El Diablo, 31°17' N, 109°03' W, 1,230 m; 12-V-78.									X				X					X													X																		
21. Sonora, Cajón Bonito, *ca.* 9.3 km downstream from Rancho Nuevo, 31°17' N, 109°00' W, 1,300 m; 12-V-78.									X				X					X																															
22. Sonora, Cajón Bonito, 4.8 km downstream from Rancho Nuevo, 31°16' N, 108°51' W, 1,320 m; 13-V-78.												X					X	X																															
23. Sonora, Río de Bavispe, *ca.* 3.2 km downstream from San Miguelito (near Bavispe), 30°33' N, 108°57' W, 995 m; 14-V-78.							X				X		X				X	X																				X											

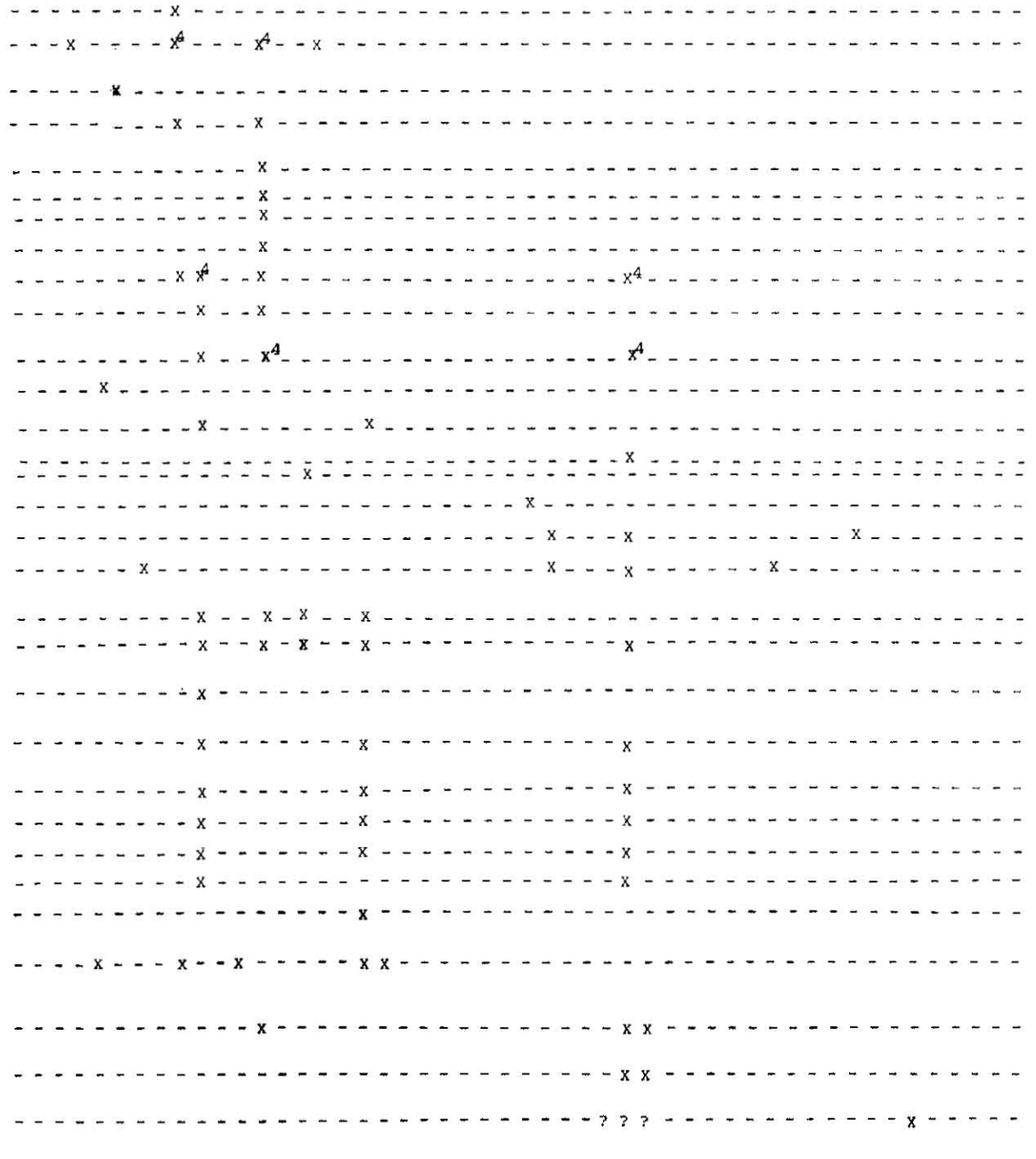
24. Sonora, Río de Bavispe, *ca.* 1.5 km N. Huásabas at ford to Huachinera, 29°56' N, 109°17' W, 560 m; 20-V-78.
25. Sonora, Río de Bavispe at Rancho El Picacho, 7.2 km W Huachinera, 30°12' N, 108°52' W, 1,090 m; 20-V-78.
26. Sonora, Arroyo Cuartel, tributary to Arroyo San Antonio, *ca.* 13.1 km (road to Cebadilla and Huachinera) from Colonia Mesa Tres Ríos, 29°52' N, 108°48' W, 1,900 m; 21-V-78.
27. Sonora, Arroyo San Antonio at Rancho San Antonio, 29°52' N, 108°44' W, 1,600 m; 21-V-78.
28. Sonora, Río de Bavispe at Rancho Tres Ríos, 17.9 km E Colonia Mesa Tres Ríos by road to Nuevo Casa Grandes, 29°53' N, 108°38' W, 1,390 m. 21-V-78.
29. Sonora, Arroyo del Juicle, tributary Río Gavilán, at Rancho Los Chales, 30°04' N, 108°32' W, 1,600 m; 22-V-78.
30. Chihuahua, Río Gavilán at Rancho El Gavilán, 30°05' N, 108°30' W, 1,700 m; 22-V-78.
31. Chihuahua, Arroyo Punta de Agua at Rancho Punta de Agua, 29°55' N, 108°26' W, 2,000 m; 23-V-78.
32. Chihuahua, Río Gavilán (locally Arroyo Moctezuma) between Rancho Punta de Agua and El Colorado, 29°53' N, 108°24' W, 2,130 m; 23-V-78.
33. Chihuahua, Arroyo Calandria on Rancho Huápoca, *ca.* 50 km W Madera, 29°06' N, 108°16' W, 1,500 m; 25-V-78.
34. Chihuahua, Arroyo Los Alisos on Rancho Huápoca, *ca.* 50 km W Madera, 29°07' N, 108°16' W, 1,450 m; 25-V-78.
35. Chihuahua, Río Papigochic (locally Río Sirupa) at Rancho Huápoca, 29°09' N, 108°18' W, 1,330 m; 26-V-78.
36. Chihuahua, El Ojo de Yepómera, 29°03' N, 107°51' W, 1,900 m; 26-V-78.
37. Sonora, Arroyo El Fresnal, SW Cabullonas, 31°08' N, 109°35' W, 1,100 m; 8-VI-78.
38. Sonora, Arroyo Moctezuma, *ca.* 5 km downstream from Cumpas, 29°58' N, 109°46' W, 750 m; 8-VI-78.
39. Sonora, Río de Bavispe, *ca.* 1 km N Huásabas at ford to Huachinera, 29°56' N, 109°17' W, 560 m; 9-VI-78.
40. Sonora, Río Yaqui at Tónichi, 28°36' N, 109°34' W, 210 m; 11-VI-78.
41. Sonora, Río Yaqui at Rancho Recodo, 28°25' N, 109°33' W, 180 m; 11-VI-78.
42. Sonora, Río Chico, 5.6 km N Movas, 28°12' N, 109°28'W, 250 m; 11-VI-78.
43. Sonora, Presa Alvaro Obregón near dam, 27°49' N, 109°52' W, 90 m; 12-VI-78.
44. Sonora, backwater in park immediately below Presa Alvaro Obregón, 27°49' N, 109°54' W, 60 m; 12-VI-78.
45. Sonora, unnamed tributary of Río Chico, *ca.* 6 km N Nuri on road to Yécora, 28°10' N, 109°18' W, 380 m; 12-VI-78.
46. Sonora, Arroyo El Toro, 2.4 km upstream from Yécora, 28°22' N, 108°56' W, 1,550 m; 14-VI-78.
47. Sonora, Arroyo El Toro, *ca.* 22.5 km E Yécora along road to Maicova (*ca.* 1.5 km W Rancho de Bono), 28°22' N, 108°46' W, 1,250 m; 14-VI-78.
*48. Sonora, tributary of Arroyo El Toro, *ca.* 25 km E. Yécora on road to Maicova (near El Trigo), 28°22 N, 108°45' W, 1,300 m; 14-VI-78.
*49. Sonora, tributary of Arroyo Talayote, *ca.* 38 km E Yécora on road to Maicova, 28°22' N, 108°47' W, 1,250 m; 14-VI-78.
*50. Sonora, Arroyo Talayote at crossing 40 km E Yécora on road to Maicova, 28°22' N, 108°43' W, *ca.* 1,250 m; 14-VI-78.
51. Sonora, Arroyo Maicova at Rancho Casa Blanca, 3 km W Maicova, 28°22' N, 108°40' W, 1,500 m; 15-VI-78.
52. Chihuahua, tributary of Río Yepáchic at highway crossing 18.2 km E Maicova on road to Yepáchic, 28°22' N, 108°30' W, 1,600 m; 15-VI 78.
53. Chihuahua, arroyo in town of Yepáchic at highway bridge, 28°25' N, 108°23' W, 1,790 m; 15-VI-78.



Locality	*Lile stolifera*	*Dorosoma smithi*	*Elops affinis*	*Salmo gairdneri*	*Salmo* sp.	*Salvelinus fontinalis*	*Cyprinus carpio*	*Carassius auratus*	*Campostoma ornatum*	*Gila purpurea*	*Gila pulchra*	*Gila robusta*	*Agosia chrysogaster*	*Codoma ornata*	*Notropis formosus*	*Pimephales promelas*	*Carpiodes carpio*	*Catostomus bernardini*	*Catostomus* spp.	*Catostomus wigginsi*	*Pantosteus plebeius*	*Arius caerulescens*	*Arius liropus*	*Ictalurus furcatus*	*Ictalurus punctatus*	*Ictalurus pricei*	*Ictalurus melas*	*Cyprinodon* sp.	*Gambusia affinis*	*Poeciliopsis prolifica*	*P. occidentalis*	*P. monacha-occidentalis*	*Agonostomus monticola*	*Mugil curema*	*Centropomus nigrescens*	*Centropomus robalito*	*Lutjanus novemfasciatus*	*Micropterus salmoides*	*Lepomis cyanellus*	*Lepomis megalotis*	*Lepomis microlophus*	*Lepomis macrochirus*	*Pomoxis annularis*	*Pomoxis nigromaculatus*	*Cichlasoma beani*	*Dormitator latifrons*	*Eleotris picta*	*Gobiomorus maculatus*	*Awaous transandeanus*	*Trinectes fonsecensis*
54. Chihuahua, tributary of Río Tomóchic (locally Arroyo Ahumado), 21.8 km from Tomóchic along road to Basaseachic, 28°21' N, 107°58' W, 2,000 m; 16-VI-78.	-	-	-	-	X	-	-	-	X	-	X	-	-	X	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
55. Chihuahua, Río Tomóchic, 2.2 km upstream from highway bridge at Tomóchic, 28°20' N, 107°51' W, 1,910 m; 16-VI-78.	-	-	-	-	-	-	-	-	X	-	X	X	-	X	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
56. Chihuahua, Arroyo Vallecillos (tributary to Río Tutuaca), *ca.* 2 km upstream from Tutuaca, 28°28' N, 108°11' W, 1,900 m; 16-VI-78.	-	-	-	-	X	-	-	-	X	-	-	X	-	X	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
57. Chihuahua, Río Tutuaca, *ca.* 2 km downstream from Tutuaca, 28°29' N, 108°11' W, 1,850 m; 17-VI-78.	-	-	-	-	X	-	-	-	X	-	-	X	-	X	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
58. Chihuahua, tributary of Río Sirupa at Tosanochic, 28°32' N, 108°00' W, 1,990 m; 17-VI-78.	-	-	-	-	-	-	-	-	X	-	X	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
59. Chihuahua, Río Verde at crossing of road from Tosanochic to Matachic, 28°38' N, 107°54' W, 1,710 m; 17-VI-78.	-	-	-	-	-	-	-	-	X	-	-	X	-	X	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
60. Chihuahua, Río Papigochic at Rancho de San Pedro near Miñaca, 28°24' N, 107°26' W, 2,100 m; 16-17-VI-78.	-	-	-	-	-	-	-	-	X	-	X	-	-	X	-	-	-	X	X	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-
61. Chihuahua, Arroyo Agua Caliente, 6 km NE Baje de Agua (Rancho La Boquilla), 28°31' N, 107°13' W, 2,130 m; 17-VI-78.	-	-	-	-	-	-	-	-	X	-	X	-	-	X	X	-	-	-	X	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
62. Chihuahua, Arroyo Agua Caliente in town of Agua Caliente, 28°33' N, 107°13' W, 2,135 m; 17-VI-78.	-	-	-	-	-	-	-	-	X	-	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
63. Chihuahua, Arroyo de La Junta, 1 km SE La Junta, 28°28' N, 107°19' W, 2,075 m; 17-VI-78.	-	-	-	-	-	-	-	-	X	-	X	-	-	X	X	-	-	X	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
64. Chihuahua, Río Verde, 55 km W La Junta on new road to Basaseachic, 28°20' N, 107°45' W, 2,100 m; 16-VI-78.	-	-	-	-	-	-	-	-	X	-	-	X	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
65. Chihuahua, Río de los Triguitos, 45.5 km W La Junta on new road to Basaseachic, 28°26' N, 107°40' W, 2,100 m; 16-VI-78.	-	-	-	-	-	-	-	-	X	-	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
66. Chihuahua, Arroyo Tonachic, tributary to Río Papigochic, 18 km W La Junta on new road to Basaseachic (locally Río Babuerachic), 28°23' N, 107°28' W, 2,100 m; 16-VI-78.	-	-	-	-	-	-	-	-	X	-	X	-	-	X	-	-	-	X	X	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-
67. Chihuahua, El Ojo de Yepómera, 29°03' N, 107°51' W, 1,900 m; 18-VI-78.	-	-	-	-	-	-	-	-	X	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
68. Chihuahua, Arroyo Yepómera, 29°03' N, 107°52' W, 1,880 m; 18-VI-78.	-	-	-	-	-	-	-	-	X	-	-	-	-	X	X	-	-	X	X	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
69. Chihuahua, Río Sirupa W Madera, 29°11' N, 108°19' W, 1,300 m; 18-19-VI-78.	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	X	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
70. Chihuahua, Presa Los Alamos at upper end, 38.4 km by road SSW Cuidad Cuauhtemoc, 12.2 km W Ojo de Agua, 28°11' N, 107°07' W, 2,090 m; 18-VI-78.	-	-	-	-	-	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
71. Chihuahua, Arroyo El Alamo, 1.9 km by road E. Ciénega Ojos Azules, 28°04' N, 107°01' W, 2,090 m; 19-VI-78.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
72. Chihuahua, Río Papigochic at Guerrero, 28°32' N, 107°29' W, 2,048 m; 19-VI-78.	-	-	-	-	-	-	-	-	X	-	-	-	-	X	X	X	-	X	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	X	-	X	-	-	-	-	-	-	-	-
73. Chihuahua, spring-fed pond at Matachic, 28°51' N, 107°45' W, 1,880 m; 19-VI-78.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
74. Chihuahua, Río Chico at Rancho Río Chico, 29°36' N, 108°10' W, 2,000 m; 20-VI-78.	-	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
75. Chihuahua, Río Papigochic, *ca.* 1 km S Temósachic on road from Guerrero to Madera, 28°57' N, 107°49' W, 1,860 m; 19-VI-78.	-	-	-	-	-	-	-	-	X	-	-	X	-	X	X	-	-	X	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
76. Chihuahua, Arroyo Moctezuma, *ca.* 1 km upstream from El Colorado, 29°51' N, 108°24' W, 2,180 m; 21-VI-78.	-	-	-	-	-	-	-	-	X	-	-	X	-	-	X	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
77. Chihuahua, Presa de Moctezuma at Rancho Moctezuma, 29°53' N, 108°16' W, 2,360 m; 21-VI-78.	-	-	-	X	-	-	-	-	X	-	-	-	-	-	X	-	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
78. Chihuahua, Río La Concha, 6.7 km S of new road from Madera to Gómex Farías on paved road from Guerrero to Madera, below bridge, 35.2 km S Madera, 29°02' N, 107°53' W, 2,000 m; 21-VI-78.	-	-	-	-	-	-	-	-	X	-	-	-	-	X	X	-	-	X	X	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

79. Sonora, Arroyo El Fresnal SW Cabullonas, 31°08' N, 109°35' W, 1,100 m, 18-VII-78.
80. Sonora, Río de Bavispe at Rancho La Playa, 30°37' N, 109°23' W, 750 m; 18-19-VII-78.
81. Sonora, La Presa de Hacienda Cuchuta, *ca.* 5 km NNW Esqueda, 30°47' N, 109°36' W, 1,160 m; 19-VII-78.
82. Sonora, spring fed stream 1.6 km upstream from Rancho Mababi, 30°46' N, 109°48' W, 1,400 m; 19-VII-78.
83. Sonora, Cajón Bonito, *ca.* 1 km upstream from first crossing of road from Agua Prieta to Janos, 31°17' N, 109°03' W, 1,250 m; 20-VII-78.
84. Sonora, Cajón Bonito, *ca.* 9.3 km downstream from Rancho Nuevo, 31°17' N, 109°00' W, 1,300 m; 20-VII-78.
85. Sonora, Cajón Bonito, 4.8 km below Rancho Nuevo, 31°16' N, 108°59' W, 1,320 m; 20-VII-78.
86. Sonora, Arroyo Agua Blanca, 1 km upstream from Rancho Nuevo, 31°15' N, 108°56' W, 1,400 m; 20-VII-78.
87. Chihuahua, presa, *ca.* 1 km S Chuhuichupa, 29°36' N, 108°23' W, 2,150 m; 22-VII-78.
88. Chihuahua, Arroyo de La Norteña, *ca.* 3 km NW El Norte, 29°39' N, 108°24' W, 2,100 m; 22-23-VII-78.
89. Chihuahua, Río Negro, *ca.* 1 km above bridge on road from Chuhuichupa to Molino de Aserrar Huaynopa, 29°33' N, 108°25' W, 1,990 m; 23-VII-78.
90. Chihuahua, tributary of Río Negro at crossing of road from Chuhuichupa to Molino de Aserrar Huaynopa, 5.9 km SW crossing Río Negro, 29°33' N, 108°27' W, 2,090 m; 23-VII-78.
101a. Sonora, Río Muerto, 6 mi S and 1 mi W Vicam, near mouth of Río Yaqui, R. G. Miller and guide, 13-III-1940 (UMMZ).
101b. Sonora, Río Yaqui, 3.75 mi W Vicam, R. G. Miller and guide, 16-III-1940 (UMMZ).
101c. Sonora, Río Yaqui, *ca.* 5 mi W Potam (30 airline mi WNW Ciudad Obregón) on delta, R. R. Miller and J. T. Greenbank, 1-II-1955 (UMMZ).
101d. Sonora, distributary of Río Yaqui near hwy 15, 33 mi N Ciudad Obregón, 20-VII-1959 (Branson *et al.* 1960).
102a. Sonora, Río Yaqui, *ca.* 14 mi N Cocorit and 6 mi S Yaqui Dam, B. W. Walker and party, 25-I-1950 (UMMZ).
102b. Sonora, Río Yaqui, 10.2 mi NE Esperanza, R. G. Miller and guide, 14-III-1940 (UMMZ).
103. Sonora, Río Muerto drainage, ditches along RR tracks, *ca.* 4 mi S Mapoli, between Mapoli and Pitihaya, B. W. Walker and party, 26-I-1950 (UMMZ).
104a. Chihuahua, Río Gavilán, tributary Río Yaqui, 7 mi SW Pacheco, A. S. Leopold 21-VIII-1948 (UMMZ).
104b. Chihuahua, Río Gavilán, *ca.* 10 mi S Gavilancito sawmill, W. P. Knoch, 22-II-1953 (UMMZ; Smith 1966).
105. Sonora, Río Moctezuma, *ca.* 20 mi N Moctezuma, S. B. Benson, 1-VI-1936 (UMMZ).
106a. Sonora, Río Moctezuma at Moctezuma, S. B. Benson, 26-V-1938 (UMMZ).
106b. Sonora, Río Moctezuma *ca.* 2 mi N Moctezuma, R. C. Miller and F. Fierro, 16-III-1941. (UMMZ).
107. Sonora, (Nueve) Tapeche, 25 ± mi SSE Moctezuma Copsural, J. E. Simpson, 23-V-1938 (UMMZ).
108. Sonora, Río Yaqui, 3 mi S Granados, R. G. Miller and F. Fierro, 13-III-1941 (UMMZ).
109. Sonora, Río Yaqui, in drying channel at Granados, R. G. Miller and F. Fierro, 14-III-1941 (UMMZ).
110. Sonora, Río Chico, 2 mi W Movas, R. G. Miller and F. Fierro, 20-III-1941 (UMMZ).
111a. Chihuahua, Río Gavilán at Rancho Gavilán, W. Knoch and party, 10-II-1953 (UMMZ) (Burr 1978).
111b. Chihuahua, S Fork Río Gavilán at Gavilancito, W. P. Knoch and party, 20-II-1953 (UMMZ).
112a. Chihuahua, Río Papigochic at Miñaca (from Meek 1902, 1904, as reviewed by Miller 1976) (FMNH).
112b. Chihuahua, Río Papigochic, 5 mi W Miñaca on road to Pachera and Creel, R. R. Miller and family, 19-VI-1964 (UMMZ).

Locality	*Lile stolifera*	*Dorosoma smithi*	*Elops affinis*	*Salmo gairdneri*	*Salmo* sp.	*Salvelinus fontinalis*	*Cyprinus carpio*	*Carassius auratus*	*Campostoma ornatum*	*Gila purpurea*	*Gila pulchra*	*Gila robusta*	*Agosia chrysogaster*	*Codoma ornata*	*Notropis formosus*	*Pimephales promelas*	*Carpiodes carpio*	*Catostomus bernardini*	*Catostomus* spp.	*Catostomus wigginsi*	*Pantosteus plebeius*	*Arius caerulescens*	*Arius liropus*	*Ictalurus furcatus*	*Ictalurus punctatus*	*Ictalurus pricei*	*Ictalurus melas*	*Cyprinodon* sp.	*Gambusia affinis*	*Poeciliopsis prolifica*	*P. occidentalis*	*P. monacha-occidentalis*	*Agonostomus monticola*	*Mugil curema*	*Centropomus nigrescens*	*Centropomus robalito*	*Lutjanus novemfasciatus*	*Micropterus salmoides*	*Lepomis cyanellus*	*Lepomis megalotis*	*Lepomis microlophus*	*Lepomis macrochirus*	*Pomoxis annularis*	*Pomoxis nigromaculatus*	*Cichlasoma beani*	*Dormitator latifrons*	*Eleotris picta*	*Gobiomorus maculatus*	*Awaous transandeanus*	*Trinectes fonsecensis*
112c. Chihuahua, Arroyo Ancho, SW Miñaca, S. Contreras B. and party, 1964 (UANL).	-	-	-	-	-	-	-	-	X	-	?	?	-	X	-	-	-	X	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
112d. Chihuahua, Arroyo Ancho, SW Miñaca, S. Contreras B. and party, 1975 (UANL).	-	-	-	-	-	-	-	-	X	-	X	X	-	X	-	X	-	X	X	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
112e. Chihuahua, Río Papigochic, 0.3 mi below bridge at Rancho San Pedro, C. H. Lowe, J. Findley, D. W. Owens, and D. Constant, 15-XI-1975 (UA).	-	-	-	-	-	-	-	-	X	-	X	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	?	?	?	?	-	-	-	-	-	-	-	-
113. Chihuahua, tributary to Río Papigochic, 8 mi SSW Miñaca on road to Pachera, R. R. Miller and family, 19-VI-1964 (UMMZ).	-	-	-	-	-	-	-	-	X	-	X	X	-	X	-	-	-	X	X	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-
114a. Sonora, Río Moctezuma, 2 mi S Cumpas, R. G. Miller and F. Fierro 12-III-1941 (UMMZ).	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
114b. Sonora, Río Moctezuma, 3.2 km S Cumpas, J. Greenbank and party, 25-I-1951 (UMMZ).	-	-	-	-	-	-	-	-	X	X	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
115. Sonora, Río Yaqui, 1 mi from Soyopa, R. G. Miller and F. Fierro, 19-III-1941 (UMMZ).	-	-	-	-	-	-	-	-	-	-	-	X	X	-	X	-	-	X	-	-	-	-	-	-	-	X	-	-	-	-	X	X	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-
116a. Arizona, "west reservoir," San Bernardino Ranch, J. R. Simon, 10-IX-1943 (UMMZ).	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
116b. Arizona, "east reservoir," San Bernardino Ranch, J. R. Simon, 10-IX-1943 (UMMZ).	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-
116c. Arizona, San Bernardino Ranch, 17 mi E Douglas, small pond about 3/8 mi E ranch house, M. Frost, and J. Hendrickson, 8-VI-1944 (UMMZ).	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-
116d. Arizona, San Bernardino Ranch, 17 mi E Douglas, small stream from warm artesian well, *ca.* ½ mi E ranch house, M. Frost and J. Hendrickson, 8-VI-1944 (UMMZ).	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
116e. Arizona, artesian-fed holes and ditches on San Bernardino Ranch, 18 mi E Douglas, R. R. Miller and H. E. Winn, 24-IV-1950 (UMMZ).	-	-	-	-	-	-	-	-	-	X	-	-	X	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
116f. Arizona, pond on San Bernardino Ranch, 18 mi E Douglas, W. L. Minckley and party, 3-IX-1964 (ASU).	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-
116g. Arizona, E artesian pond and ditches, San Bernardino Ranch, 18 mi E Douglas, W. L. Minckley and W. E. Barber, 19-20-III-1965 (ASU).	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-
116h. Arizona, ranch house pond on San Bernardino Ranch, 18 mi E Douglas, W. L. Minckley and party, 3-IX-1964 (ASU).	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-
116i. Arizona, San Bernardino Ranch, artesian well ¼ mi E San Bernardino Creek, W. L. Minckley and party, 2-II-1974.	-	-	-	-	-	-	-	-	-	X[4]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X[4]	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
117a. Arizona, Whitewater Creek at hwy bridge just W Douglas, R. R. Miller and J. Davis, 13-VII-1939 (UMMZ).	-	-	-	-	-	-	X	X	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
117b. Arizona, Whitewater Creek near Douglas, 2 mi W and 1 mi N border, J. R. Simon, 12-VI-1943 (UMMZ).	-	-	-	-	-	-	X	X	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
117c. Arizona, Whitewater Creek, 2 mi W Douglas, J. R. Simon, 11-IX-1943 (UMMZ).	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
118a. Arizona, Rucker Canyon, Chiricahua Mountains, southern Arizona, Jordan and Thoburn, in Jordan and Evermann (1896) (SU).	-	-	-	-	-	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
118b. Arizona, Rucker Canyon (Rutter 1896).	-	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
118c. Arizona, Rucker Canyon, *ca.* 5 mi N CCC Camp, R. R. Miller and J. Davis, 14-VII-1939 (UMMZ).	-	-	-	X	-	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
118d. Arizona, Rucker Canyon, *ca.* ½ mi below USFS Campground, R. R., G. H., and F. L. Miller, 22-VI-1959 (UMMZ).	-	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
118e. Arizona, Rucker Canyon (John 1964).	-	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
118f. Arizona, Rucker Canyon at Cypress Picnic area, W. L. Minckley and party, 20-III-1965 (ASU).	-	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
118g. Arizona, Rucker Canyon, 12 mi SW Portal, A. Schoenherr, 1-VI-1969 (ASU).	-	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
118h. Arizona, Rucker Canyon, Chiricahua Mountains, W. L. Minckley and party, 28-IV-1974 (ASU).	-	-	-	-	-	-	-	-	X	-	-	-	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-



118i. Arizona, Rucker Canyon, R. McNatt and party, 22-XII-1975 (ASU).
118j. Arizona, Rucker Canyon, SE ¼, Sec. 18, T19S, R 30E, W. L. Minckley, J. J. Landye, and W. Kepner, 17-IV-1976 (ASU).
118k. Arizona, Rucker Canyon, 2.1 mi above Rucker Canyon Lake, W. Frantz and party, 13-V-1977 (ASU).
118l. Arizona, Rucker Canyon, low-water bridge to 30 m upstream, W. Frantz, G. Ginnelly, and W. T. Silvey, 13-V-1977 (ASU).
119a. Arizona, Leslie Creek, 17 mi (airline N Douglas, K. R. John and F. M. Gorham, 30-VI-1960 (UMMZ).
119b. Arizona, Leslie Canyon (John 1964).
119c. Arizona, Leslie Creek, 8 mi E McNeal on Rucker Canyon road, W. L. Minckley and party, 20-III-1965 (ASU).
119d. Arizona, Leslie Creek, T 21S, R 28E, A. Schoenherr, 1-III-1970 (ASU).
119e. Arizona, Leslie Creek, 8 mi E McNeal, W. L. Minckley and party, 28-IV-1970 (ASU).
119f. Arizona, Leslie Creek (dam site), NW¼, SW¼, Sec. 21 - SE¼, SE¼, Sec. 20, T 21S, R28E, A. Essbach, W. Frantz, W. T. Silvey and party, 22-VIII-1974 (ASU).
119g. Arizona, Leslie Creek, W. L. Minckley and party, X-1976 (ASU).
120. Chihuahua, near La Mesa, *ca.* 50 mi due W Gómez Farías, B. Stonoff, 27-XII-1975 (ASU).
121a. Sonora, San Bernardino Creek, C. B. R., Kennerly (Girard 1857).
121b. Sonora, San Bernardino Creek (Girard 1859).
121c. Sonora, San Bernardino River, near boundary, E. A. Mearns, 1893 (Snyder 1915).
121d. Sonora, San Bernardino Creek, near N border of Sonora, W. W. Price, 1894 (Rutter 1896) (SU).
121e. Sonora, San Bernardino Creek, 1 mi S of border, J. R. Simon, 10-IX-1943 (Miller and Winn 1951).
121f. Sonora, pond ¼ mi S border and short distance W San Bernardino Creek, M. Frost and J. Hendrickson, 8-IV-1944 (Miller and Winn 1951).
121g. Sonora, San Bernardino Creek, from border to 2 mi S border, R. R. Miller and H. E. Winn, 24-IV-1950 (UMMZ).
122a. Arizona, San Bernardino Creek, *ca.* 2 mi above Mexican border, *ca.* 16½ mi E Douglas, J. R. Simon, 10-IX-1943 (Miller and Simon 1943) (UMMZ).
122b. Arizona, Black Draw, *ca.* 1-1½ m NE headquarters San Bernardino Ranch, C. H. Lowe and party, 19-20-II-1954 (ASU).
122c. Arizona, Astin Spring in Black Wash, 18 mi E, 1 mi N Douglas, W. L. Minckley and W. E. Barber, 20-III-1965 (ASU).
122d. Arizona, Astin Spring in Black Wash, W. E. Barber, J. E. Johnson, and R. K. Koehn, 2-I-1966 (ASU).
122e. Arizona, Astin Spring on San Bernardino Ranch, J. N. Rinne and N. Jensen, 27-III-1968 (ASU).
122f. Arizona, Astin Spring on San Bernardino Ranch, W. L. and R. L. Minckley, 28-VII-1968 (ASU).
122g. Arizona, Astin Spring on San Bernardino Ranch, A. Schoenherr, 31-V-1969 (ASU) (Schoenherr 1974, 1977).
123. Sonora, Río Bavispe (locally Río Aterra) at la Playa (= Pilares), 15 mi E Esqueda, B. Campbell, summer 1935 (UMMZ).
124. Chihuahua, Black Canyon at head of Río Bavispe, near Chuhuichupa, near border of Sonora and Chihuahua (Río Negro Canyones, Chihuahua), P. R. Needham and R. S. Rupp, 29-IV-1955 (CAS & UMMZ).
125. Sonora, Río Tecoripa at Tecoripa, 78 mi ESE Hermosillo from hwy 15 turnoff, R. R. Miller and R. J. Schultz, 28-III-1959 (UMMZ) (Moore *et al.* 1970).
126a. Sonora, Agua Caliente, tributary to Río Yaqui, on E side Presa Alvaro Obregón, *ca.* 80 km (airline) ENE Guaymas, A. C. Twomey, 5-V-1945 (UMMZ) (Moore *et al.* 1970).
126b. Sonora, Dique Agua Caliente, *ca.* 14 mi N Ciudad Obregón, A. A. Gardner, 26-I-1965 (UA).

Locality	*Lile stolifera*	*Dorosoma smithi*	*Elops affinis*	*Salmo gairdneri*	*Salmo* sp.	*Salvelinus fontinalis*	*Cyprinus carpio*	*Carassius auratus*	*Campostoma ornatum*	*Gila purpurea*	*Gila pulchra*	*Gila robusta*	*Agosia chrysogaster*	*Codoma ornata*	*Notropis formosus*	*Pimephales promelas*	*Carpiodes carpio*	*Catostomus bernardini*	*Catostomus* spp.	*Catostomus insignis*	*Pantosteus plebeius*	*Arius caerulescens*	*Arius liropus*	*Ictalurus furcatus*	*Ictalurus punctatus*	*Ictalurus pricei*	*Ictalurus melas*	*Cyprinodon* sp.	*Cambusia affinis*	*Poeciliopsis prolifica*	*P. occidentalis*	*P. monacha-occidentalis*	*Agonostomus monticola*	*Mugil curema*	*Centropomus nigrescens*	*Centropomus robalito*	*Lutjanus novemfasciatus*	*Micropterus salmoides*	*Lepomis cyanellus*	*Lepomis megalotis*	*Lepomis microlophus*	*Lepomis macrochirus*	*Pomoxis annularis*	*Pomoxis nigromaculatus*	*Cichlasoma beani*	*Dormitator latifrons*	*Eleotris picta*	*Gobiomorus maculatus*	*Awaous transandeanus*	*Trinectes fonsecensis*
127. Sonora, Río Fronteras, 1 mi S Turicachi, J. T. Greenbank and party, 23-I-1951 (UMMZ) (Moore *et al.* 1970).	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
128. Sonora, Río Moctezuma, 1 mi S Moctezuma, J. T. Greenback and party, 25-I-1951 (UMMZ) (Moore *et al.* 1970).	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
129a. Chihuahua, Río Papigochic, *ca* ¼ way (S) between Guerrero and the presa. J. Humphries and M. L. Smith, 14-VI-1976 (UMMZ).	–	–	–	–	–	–	–	–	X	–	–	–	–	X	X	X	–	X	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	X	–	–	–	X	–	–	–	–	–	–	–	–
129b. Chihuahua, Río Papigochic, just below Presa Abraham Gonzales, W. Miñaca, J. Humphries and M. L. Smith, 13-VI-1976 (UMMZ).	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
130. Sonora, Río Chico, 1.5 mi (by road) NE Nuri in stagnant pool. T. J. Cox, 30-VIII-1964 (UA).	–	–	–	–	–	–	X	–	–	–	–	–	X	–	X	–	–	X	–	–	–	–	–	–	–	–	–	–	?	?	?	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–
131. Sonora, Río Yaqui, Onovas, T. J. Cox, 28-XII-1964 (UA).	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
132. Sonora, Río Bajeca, 9.5 mi (road to Rosario de Tezopaco) SW Nuri. T. J. Cox, 30-VIII-1964 (UA).	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
133a. Sonora, Río Batepito, 24.3 mi (road to Bavispe) SE Agua Prieta, M. D. Robinson and D. R. Frost, 3-VII-1974 (UA).	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
133b. Sonora, Tributary to Río de Agua Prieta, J. Greenbank and party, 22-I-1951.	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
134. Sonora, Canyon del Pulpito (NE Colonia Oaxaca), 1 mi NE Rancho La Cueva, M. D. Robinson and D. R. Frost, 4-VII-1974 (UA).	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
135. Sonora, Arroyo Mesquite, 20 mi (road to Yécora) NE Nuri, M. D. Robinson and D. R. Frost, 10-VI-1974 (UA).	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	?	?	?	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
136a. Sonora, 1.2 mi (by road) W Yécora, M. D. Robinson and D. R. Frost, 11-VI-1974 (UA).	–	–	–	–	–	–	–	–	X	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
136b. Sonora, 1 mi (road to Santa Rosa) NW Yécora, M. D. Robinson and D. R. Frost, 12-VI-1974 (UA).	–	–	–	–	–	–	–	–	X	–	–	X	X	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
136c. Sonora, Yécora, above and below town, D. W. Owens, 27-III-1975 (UA).	–	–	–	–	–	–	–	–	X	–	–	X	X	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
137. Sonora, 1.1 mi (road by Sahuaripa) N Guisamopa, M. D. Robinson and D. R. Frost, 12-VI-1974 (UA).	–	–	–	–	–	–	–	–	X	–	–	–	X	–	–	–	–	?	?	–	–	–	–	–	–	–	–	–	?	?	?	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
138. Sonora, Río Nacozari, 6 mi (by road) SW Nacozari, M. D. Robinson and D. R. Frost, 16-VI-1974 (UA).	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
139. Sonora, 18 mi (by road) W Nuri (between Nuri and Tezopaco), bridge over Arroyo Carrizo, D. W. Owens, 24-III-1975 (UA).	–	–	–	–	–	–	–	–	X	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
140a. Sonora, Nuri, Tanque La Loma (irrigation canal), D. W. Owens, 25-III-1975 (UA).	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–	X	X	–	–	–	–	–	–	–	–	–	–	–	–	X	X	–	–	–	–	–	X	–	–	–	–	X	–	–	–	–	–	–
140b. Sonora, Río Nuri, *ca.* 1 km N Nuri ("Sabino"), D. W. Owens, 25-III-1975 (UA).	–	–	–	–	–	–	–	–	X	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	X	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–
141. Sonora, between Nuri and Tacupeto (just before the latter), D. W. Owens, 25-III-1975 (UA).	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
142. Sonora, 8 mi (by road) SW Tacupeto ("palm canyon"), D. W. Owens, 25-III-1975 (UA).	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
143. Sonora, 2 mi (road between Nuri and Yécora) S Santa Ana store, pool *ca.* 20 m from dry stream bed, D. W. Owens, 26-III-1975 (UA).	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
144. Sonora, *ca.* 3.2 mi (road between Nuri and Yécora) before Santa Rosa ("Arroyo El Morro"), D. W. Owens, 26-III-1975 (UA).	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
145a. Sonora, Rancho Trigo (de Colón) airstrip, D. W. Owens, 28-III-1975 (UA).	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
145b. Sonora, 1.5 mi (by road) past Rancho Trigo (de Colón) stream. D. W. Owens, 28-III-1975 (UA).	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
146. Sonora, "Río Peligroso," 9.8 mi (by road) W Maicoba, D. W. Owens, 28-III-1975 (UA).	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
147. Sonora, 5.3 mi (by road) E Rancho Trigo (de Colón), 12.5 mi (by road) W Maicoba, C. H. Lowe and R. L. Todd, 24-IV-1975 (UA).	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	?	?	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

148. Chihuahua, 19.3 mi (by road) E Maicoba, 3.5 mi (by road) E. Sonora state line, D. W. Owens, 29-III-1975 (UA).
149. Chihuahua, 4.8 mi (on road to Vallecitos) E Yepachic, D. W. Owens, 29-III-1975 (UA).
150. Chihuahua, 4.7 mi (by road) W. Tomochic on new, paved, La Junta - Basaseachic hwy, C. H. Lowe and R. L. Todd, 26-IV-1975 (UA).
151. Chihuahua, tributary Río Tomochic, 1.8 mi (by road) W Río Tomochic hwy bridge at Tomochic, C. H. Lowe, J. Findley, D. W. Owens, and D. Constant, 15-XI-1975 (UA).
152. Chihuahua, Río Tomochic at Ojo de Agua Caliente, between Tomochic and Basaseachic, C. H. Lowe, J. Findley, D. W. Owens, and D. Constant, 15-16-XI-1975 (UA).
153a. Sonora, tributary of Río Yaqui, 21 mi S Agua Prieta near Cabullonas, B. L. Branson and party, 14-VIII-1959 (Branson *et al.* 1960).
154a. Sonora, irrigation stream-artesian well, ½ mi N Calabasa, B. L. Branson and party, 15-VIII-1959 (Branson *et al.* 1960).
154b. Sonora, tributary to Río Bavispe, just S Turacachi and N Nacozari, 30°37' N, 109°35' W, J. J. Landye, 23-XI-1975 (ASU).
154c. Sonora, small artesian-well stream ½ mi N of Calabasas, B. L. Branson and party, 15-VIII-1959 (Branson *et al.* 1960)
155. Sonora, stream 8 mi S Calabazas, B. L. Branson and party, 15-VIII-1959 (Branson *et al.* 1960).
156a. Sonora, Río Yaqui, 6 mi N Ciudad Obregón on hwy 16, B. L. Branson and party, 20-VIII-1959 (Branson *et al* 1960).
156b. Sonora, Río Yaqui, 2 mi N of Obregón, J. Greenbank and party, 28-I-1951 (UMMZ).
157. Arizona, Morse Canyon, W. W. Price (Rutter 1896) (Willcox Playa drainage, specimens lost in 1906 San Francisco earthquake).
158a. Chihuahua, Arroyo de la Rincón, SW Yepómera, 29°03' N, 107°51' W, J. J. and S. T. Landye, 16-IV-1973 (ASU).
158b. Chihuahua, El Ojo de Yepómera, 29°03' N, 107°51' W, J. J. and S. T. Landye, 15-IV-1973 (ASU).
158c. Chihuahua, Rancho El Ojito Yepómera, 29°04' N, 107°51' W, J. J. and S. T. Landye, 16-IV-1973 (ASU).
158d. Chihuahua, Río Papigochic, Yepómera, T. Van Devender, 5-VII-1971 (ASU).
158e. Chihuahua, 1 mi NE Yepómera, small seepage ½ mi W Rancho El Ojito, near Arroyo de La Concha, T. Van Devender and R. H. Russell, 14-VIII-1971 (ASU).
158f. Chihuahua, Yepómera, river in Arroyo Rincón de La Concha, T. Van Devender, 30-VI-1971 and 11-VII-1971 (ASU).
158g. Chihuahua, El Cañon above Rancho San Ysidro, *ca.* 2 mi N Yepómera, T. Van Devender and R. H. Russell, 14-VII-1971 (ASU).
158h. Chihuahua, arroyo at N end of Temosachic, R. H. Russell, 13-VIII-1971 (ASU).
159a. Chihuahua, N fork Río Papigochic, ½ mi W La Junta, just below RR bridge and above ford, A. O. Flechsig and C. Moller, 26-VI-1953 (CAS).
159b. Chihuahua, Río Papigochic at La Junta, S. Contreras B. and party, 1964 and 1975 (UANL).
160. Chihuahua, middle fork Río Papigochic (ó Aros) just N Ciudad Guerrero, A. O. Flechsig and C. Moller, 27-VI-1953 (CAS).
161a. Chihuahua, headwaters middle fork Río Papigochic, 25 mi from Miñaca, 28°09' N, 107°18' W, A. O. Flechsig and C. Moller, 27-VI-1953 (CAS).
161b. Chihuahua, headwaters Río Papigochic (ó Aros), 23 mi up Pachera road from Miñaca, 28°11' N, 107°18' W, A. O. Flechsig and C. Moller, 28-VI-1953 (CAS).
162. Chihuahua, S fork Río Papigochic, on Miñaca -Creel road, 5.6 mi S Sigoyna, 28°06' N, 107°28' W, A. O. Flechsig and C. Moller, 29-VI-1953 (CAS).
163a. Sonora, Cajón Bonito, F. B. Cross and P. Gordon, 6-X-1953 (KU).
163b. Sonora, Cajón Bonito, P. Gordon, III-1954 (KU).
163c. Sonora, Cajón Bonito, P. Gordon, 15-16-VII-1955 (KU).

Locality	*Lile stolifera*	*Dorosoma smithi*	*Elops affinis*	*Salmo gairdneri*	*Salmo* sp.	*Salvelinus fontinalis*	*Cyprinus carpio*	*Carassius auratus*	*Campostoma ornatum*	*Gila purpurea*	*Gila pulchra*	*Gila robusta*	*Agosia chrysogaster*	*Codoma ornata*	*Notropis formosus*	*Pimephales promelas*	*Carpiodes carpio*	*Catostomus bernardini*	*Catostomus* spp.	*Catostomus wigginsi*	*Pantosteus plebeius*	*Arius caerulescens*	*Arius liropus*	*Ictalurus furcatus*	*Ictalurus punctatus*	*Ictalurus pricei*	*Ictalurus melas*	*Cyprinodon* sp.	*Gambusia affinis*	*Poeciliopsis prolifica*	*P. occidentalis*	*P. monacha-occidentalis*	*Agonostomus monticola*	*Mugil curema*	*Centropomus nigrescens*	*Centropomus robalito*	*Lutjanus novemfasciatus*	*Micropterus salmoides*	*Lepomis cyanellus*	*Lepomis megalotis*	*Lepomis microlophus*	*Lepomis macrochirus*	*Pomoxis annularis*	*Pomoxis nigromaculatus*	*Cichlasoma beani*	*Dormitator latifrons*	*Eleotris picta*	*Gobiomorus maculatus*	*Awaous transandeanus*	*Trinectes fonsecensis*
163d. Sonora, Cajón Bonita Cr. at road crossing 31 mi ESE of Agua Prieta, R. R. Miller and J. Greenbank, 7-IV-1955 (UMMZ).	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
164. Chihuahua, arroyo 38.7 km W Ciudad Cuauhtemoc, S. Contreras B., 1964 (UANL).	–	–	–	–	–	–	–	–	X	–	?	?	–	X	X	–	–	–	X	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
165. Chihuahua, Río Papigochic, *ca.* 25 mi W Madera, R. Stonoff, IX-1977 (ASU).	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
166. Sonora, Río Moctezuma, 3.2 km N Batuc, R. C. Miller and F. Fierro, 16-III-1941 (UMMZ).	–	–	–	–	–	–	–	–	X	–	–	–	X	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	X	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
167. Sonora, Río Bavispe at Tres Rios, W. P. Knoch and party, 21-II-1953.	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
168. Sonora, Río Fronteras at Fronteras, J. Greenbank and party, 23-I-1951.	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
169. México, Río Yaqui, F. Oposura (Rutter 1896).	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
170. México, Sonora, Rio Yaqui (Rutter 1896).	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
171. México, Sonora, Yaqui River, W. W. Price (no dates).	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
172. México, Sonora, F. Robinette (under Dr. C. Lumholtz) (Bean 1898).	–	–	–	–	–	–	–	–	–	–	–	X	–	–	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–
173.[8] Mexico, "...near the summit of the Sierra Madre Mountains in Chihuahua, near Colonia Garcia." Townsend and Barber (Evermann and Goldsborough (1902)).	–	–	–	–	–	–	–	–	X	–	–	–	X	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–	–

[1]Specimens accidentally mixed with another collection: *P. occidentalis* known present, possibly also *P. monacha-occidentalis*.
[2]Known introduced population. Stock from Rio de Bavispe sub-basin.
[3]Presumably in error (see page 75).
[4]Specimens not preserved.
[5]Catalogued as "6 fishes of 2 species." Specimens not seen by authors.
[6]Catalogued as *Notropis* sp. 1 and *Notropis* sp. 2. Other taxa, juveniles or females which might be mistaken for *Notropis* sp. are marked with a "?." It is assumed that *N. formosus* was taken.
[7]Locality not plotted in Figure 4 since locality is in the closed basin of Pluvial Lake Cochise (Wilcox Playa), Arizona.
[8]Two additional records of fishes are as follows:
México, Bavispe River, Lumholtz (1902), p. 42 in 1973 edition: "We got only five little fish -- one catfish, and four suckers, the largest six inches long."
Mexico, Tributary to Río Gavilán (6,620 feet elev.), mid-January, 1891, Lumholtz (1902) p. 51-52 in 1973 edition: "...immense quantities of fish, which had come up to spawn." "...big suckers...large Gila trout."