68. Although Harry Baldwin recalled that he was facing west at a point ten feet north of the Spanish inscription when he made his own inscription; letter, Baldwin to Nusbaum, June 4, 1940.

69. Harry L. Baldwin to Gilbert Grosvenor, *loc. cit.*

70. Tom Sharpe, *Albuquerque Journal—North*, November 25, 1995.

71. Walter Briggs, *loc. cit.*

72. Just as is the inscription by William Clark in Montana, likewise the only one known to have been left by members of that expedition.

73. Herbert Bolton, "Escalante Way, an Opportunity for the National Park Service," *American Planning and Civic Annual*, 1939, pp. 266–73, reproduced by Bannon, *loc. cit.*, pp. 296ff.

Frederic Morton Chamberlain's 1904 Survey of Arizona Fishes, with Annotations

W. L. MINCKLEY

Figure 1. Portrait of Frederi Morton Chamberlain taken ca. 1905 (from Jennings 198

Historic documents form much of the basis for our knowledge of natural landscapes and biotic communities before development of the American Southwest by Western Europeans. This kind of information is strongest for terrestrial ecosystems and plant communities and far weaker in documenting past conditions for aquatic environments and their inhabitants. Even when the scattered entries in diaries of adventurers, notes of physicians doubling as natural historians when assigned to various explorations, and military accounts are included, few data may be found that deal specifically with Southwestern streams and their biotas before the turn of the present century. It was not until 1904 that a *bona fide* aquatic biologist, Frederic Morton Chamberlain (1867–1921), studied Arizona fishes in some detail.

From 1897 to 1914, Chamberlain (fig. 1) was an assistant with the U.S. Fish Commission (after 1903 called the U.S. Bureau of Fisheries, evolving over time into part of the present U.S. Fish and Wildlife Service). His assignments were diverse and geographically widespread (Jennings 1987); surveys of freshwater fishes in rivers tributary to the Gulf of Mexico, exhaustive studies of salmon and salmon fisheries in California and Alaska, collection of thousands of oceanographic records and biological specimens while assigned as a naturalist on the *U.S.S. Albatross* in the north and central Pacific, and assessing fur seal populations in the Pribilof Islands. In 1904, Dr. Barton Warren Evermann, then director of the Division of Scientific Inquiry, U.S. Bureau of Fisheries,

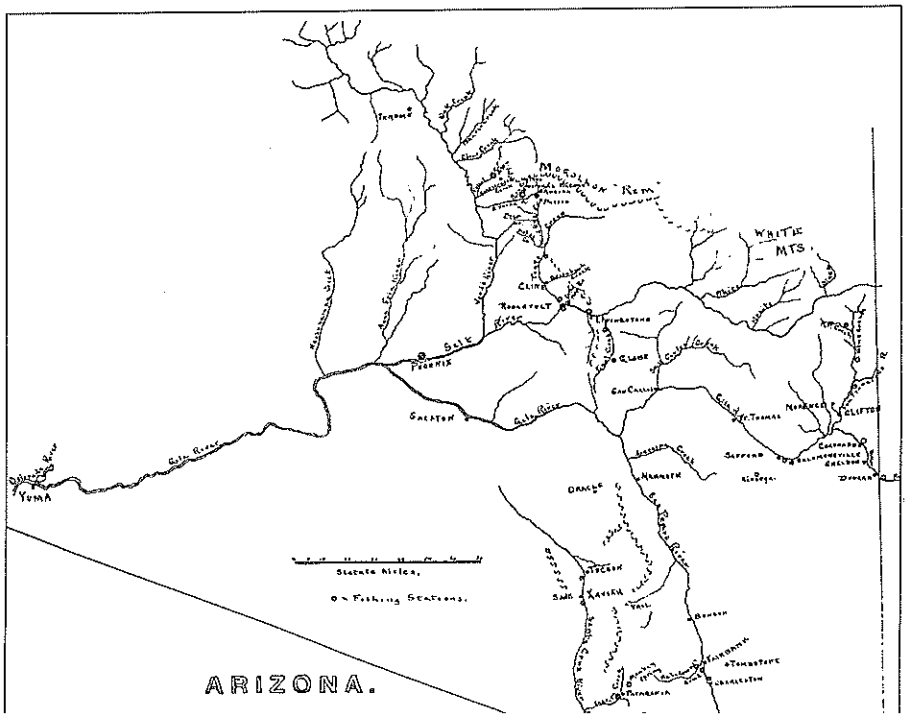
W. L. MINCKLEY *is professor of biology at Arizona State University, Tempe.*

and Chamberlain's former mentor at Indiana State Normal School (now Indiana State University, Terre Haute), commissioned him to perform a survey of fishes in the Arizona Territory.

The resulting excursion from 15 January to 28 April included about 30 days in the field, concentrated in the Gila River basin. Chamberlain's collecting sites are shown in figure 2. Most were in well-traveled parts of the territory, likely because of insufficient time to access more remote areas. He nonetheless made collections and natural history observations at more than 20 locales, reported in a handwritten, fifty-two-page manuscript housed in the Smithsonian Institution Archives, Washington, D.C. (Record Unit [RU] 7258, Accession No. 16447); it is reproduced here with permission.

My reasons for publishing Chamberlain's manuscript are threefold. First, it is a historic document meriting general availability. It has already proven valuable in documenting early conditions in regional aquatic systems and their biotas. Miller (1961), Miller and Lowe (1964, 1967), Miller, Hubbs, and Miller (1991), and myself (Minckley 1965, et seq.; Minckley, Meffe, and Soltz 1991, Minckley et al. 1991) all used it in formulating interpretations of habitat and ichthyofaunal changes. His voucher specimens, housed in the U.S. National Museum of Natural History (USNM), have further served as comparative materials for many studies of natural history, systematics, and evolution of regional fishes (e.g., Miller 1950, 1972; Miller and Hubbs 1960; Minckley 1973, 1985, 1991b, 1999a).

Figure 2. F. M. Chamberlain's map, traced from an unknown source, depicting most of the Gila River basin and indicating sites mentioned in text and places or stream reaches where he made fish collections and observations in 1904. I enhanced open circles penciled on the map by Chamberlain to indicate sampling sites; all of which are mentioned in text. Information obtained from a station marked near the old town of Livingstone on the Salt River mainstem was apparently combined with that obtained from the same stream near Roosevelt (Station XXI).



Second, historic documents are profitable avenues for research in their own right. Their appearance and availability in published form stimulates others to search out additional information that may lead to new and valuable baselines for future examination of ecological and societal change. Chamberlain's observations and reports of firsthand testimony on failing springs, declining water tables, and floodplain incision are pertinent to environmental alterations later documented and detailed by Hastings (1959, 1963), Hastings and Turner (1965), Turner (1974), Cooke and Reeves (1976), Dobyns (1981), Humphrey (1987), Hendrickson and Minckley (1985), Bahre (1991, 1995), Minckley and Brown (1994), and others. His attribution of environmental deterioration to the collective abuses of overgrazing and other unwise agricultural practices, overcutting of forests and woodlands, and pumping of groundwater, along with mining and possible climatic change, was shared even then by people he interviewed. Sadly, essentially all the same environmental stressors remain in effect today (Minckley and Kubly 1995).

Last, my annotations to Chamberlain's report help to reset partially previous baselines of understanding to the present, placing the aquatic environments and fishes he studied in a contemporary context. Perhaps its most significant single contribution is to dramatize the magnitude of change. Many recognize the vastness of environmental alterations in the American Southwest, yet only a few specialists seem to appreciate the disparate severity of impacts on its original aquatic systems. More than half the sites and stream reaches (14 of 22) visited by Chamberlain in 1904 are now dry except in flood or otherwise so drastically modified that native fishes are significantly reduced in numbers and diversity, or extirpated.

The localities Chamberlain examined seem to have been largely predetermined by previous work on fishes of the region. It was not by chance he visited sites where 12 of the 15 native fishes then recognized from the Gila River basin had been originally described (a total of 18 freshwater species now is known; see table 1). "Topotypes," specimens from the same populations upon which scientific names of species are based, were then as now of considerable value. He succeeded in securing eight taxa of the twelve he must have sought at or near places of their original description, caught five others described from Arizona at other than their type localities, and obtained three more species unrecognized at that time by science.

Native fish occurrences are summarized in table 1 as follows: (1) historically, insofar as is known or can be estimated; (2) as represented in Chamberlain's notes and collections; and (3) based on samples in the 1990s. An average of 5.7 natives (1 to 11) was recorded or was to be expected at sites or stream reaches he visited. He caught or noted an average of 3.2 kinds (1 to 10) at sites he physically sampled (as opposed to simply observing). An average of only 2.3 species (0 to 5) remained in the very same localities and stream reaches when sampled by myself and others in the 1990s.

It is significant that he collected or reported only seven non-native species (table 2). His sampling thus predated the vast influx of alien taxa accompanying regional development, resulting in more than 40 non-native fishes presently known from the Gila River basin alone (unpubl. data). In Arizona as a whole, 84 translocated fish species were tallied by Fuller, Nico, and Williams (1999) when both non-natives and natives moved about within their natural ranges were included. I consider predatory and competing alien species the most important factor in the continuing decline and disappearance of native fishes in the American Southwest (Minckley 1991b).

Of the 16 native species Chamberlain caught, one is extinct and eight are listed as Threatened or Endangered by the U.S. Department of the Interior (U.S. Fish and Wildlife Service [USFWS] 1996). Eleven also are formally listed by the Republic of Mexico (SEDESOL 1994), and most of the remainder are considered imperiled by state agencies or private conservation groups and may soon be proposed for listing. The terms "Threatened," "Endangered," "Rare," etc., when capitalized in text and footnotes, are for official categories under the U.S. Endangered Species Act of 1973 (as amended) or other classifications (e.g., "Rare," as applied in Mexico).

EXPLANATION AND RATIONALE OF PRESENTATION

It is clear from the letter of transmittal (fig. 3) that Chamberlain submitted his report as a preliminary draft. The manuscript is nonetheless lucid and to the point, and is therefore reproduced essentially verbatim and unedited, excepting punctuation added without comment, items of clarification and new information given in text in brackets [ ], or comments included as consecutive footnotes.

A few items appear often, however, and are best dealt with collectively. First, most of Chamberlain's collecting sites were located relative to nearby communities, some of which were abandoned and disappeared. Towns still in existence and appearing on available maps are not specifically dealt with. If not found on current maps, brief descriptions and a location are provided by Township (T) and Range (R) (Barnes 1988). Second, Chamberlain recorded all water temperatures in degrees Fahrenheit, often but sometimes not indicated by "° F" in the original; this was not converted. Last, stream flow (discharge volume) was reported in "miner's inches," commonly stated as "inches" or "inches of water." Although varying locally (Gove 1986), a miner's inch equals about 1.5 cubic feet of water passing a measurement point per minute. Thus, miner's inch(es) × 0.025 was used as a conversion to cubic feet per second (cfs), the present standard for discharge volume in the United States.

Table 2 provides the common and scientific names Chamberlain applied to fishes he collected or discussed, matched with those applied today (mostly from Robins et al. 1991). Modern common names also are provided in text in brackets, when deemed appropriate. When he used a name repetitively, such as "carp" for common carp, "*Agosia*" for longfin dace, or "*Poecilia*" for Sonora topminnow, the modern name was omitted where obvious from prior use.

Chamberlain's fish identifications were generally accurate to taxonomy of the day. Discrepancies were corrected when specimens were examined by Professor Robert Rush Miller (University of Michigan Museum of Zoology, pers. comm.) in 1944 and reconfirmed by myself in 1992. The few reidentifications are noted in table 2 and in text. Fishes were reported secondhand by Chamberlain for a number of sites; unless pertinent to other perspectives of past or present habitat or faunal conditions, these sites were neither assigned station numbers (see below) nor were the sites or fishes commented upon. Chamberlain adhered closely to his forte as an aquatic biologist for both the survey and

Table 1. Native fishes at sites collected by Chamberlain in 1904.*

Species	Sampling Stations																			
	I	II	III	IV	V	VI	VII–VIII[1]	IX[2]	X, XV, & XVI[1]	XI	XII[1]	XIII[1]	XIV	XVII	XVIII	XIX	XXa–b	XXI	XXII
Agosia chrysogaster	—	x/x/o	x/x/o	x/x/x	x/x/x	—	x/x/x	x/x/x	x/x/x	—	p/o/x	p/x/x	—	—	p/o/o	p/o/x	p/x/x	p/x/o	p/o/x
Gila elegans	x/x/o	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	p/x/o	—
G. intermedia	—	x/x/o	x/x/o	x/x/o	p/o/o	x/x/o	x/x/o	x/o/x	—	x/x/o	—	—	—	—	—	—	—	—	—
G. nigra[3]	—	—	—	—	—	—	—	—	—	—	—	—	—	x/x/x	—	p/x/x	p/x/x	—	—
G. robusta	x/o/o	—	—	—	—	—	x/o/o	—	x/o/o	—	p/o/o	—	—	—	—	—	—	p/x/o	—
Meda fulgida	—	—	—	—	—	—	x/x/o	—	—	—	p/o/o	—	—	—	—	—	p/o/o	p/x/o	—
Plagopterus argentissimus[4]	x/o/o	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—	—
Ptychocheilus lucius	x/n/o	—	—	—	—	—	—	—	p/n/o	—	—	—	—	—	—	—	—	p/x/o	—
Rhinichthys osculus	—	—	—	—	p/o/x	—	p/x/o	x/o/o	p/o/o	—	p/o/o	p/o/x	p/o/x	x/x/x	p/o/x	p/x/x	p/o/x	p/o/o	p/x/o
Tiaroga cobitis	—	—	—	—	—	—	p/x/o	—	p/o/o	—	p/o/o	p/o/x	—	—	—	—	—	—	—
Catostomus insignis	—	p/o/o	p/x/o	p/o/o	x/x/o	—	x/x/o	x/o/x	p/o/x	—	p/o/x	p/o/x	—	—	p/o/x	p/o/x	p/x/x	p/x/o	p/o/o
C. latipinnis	x/o/o	—	—	—	—	—	p/o/o	—	p/o/o	—	—	—	—	—	—	—	—	p/x/o	—
Pantosteus clarki	—	p/o/o	p/x/o	p/x/x	x/x/x	—	x/x/x	x/o/x	p/o/x	—	p/o/x	p/o/x	p/o/x	x/x/x	p/x/x	p/x/x	p/o/x	p/x/o	p/o/x
Xyrauchen texanus	x/x/o	—	—	—	—	—	p/o/o	—	p/o/o	—	—	—	—	—	—	—	p/o/o	p/x/o	—
Oncorhynchus apache[3]	—	—	—	—	—	—	—	—	—	—	—	—	x/x/o	—	—	—	—	—	—
Poeciliopsis occidentalis	p/o/o	x/x/o	x/x/o	x/x/x	x/x/x	x/x/x	—	—	—	—	p/o/o	—	—	—	—	—	p/x/o	p/x/o	—
Cyprinodon sp.[3]	—	—	—	—	—	x/x/o	—	—	—	—	—	—	—	—	—	—	—	—	—
C. macularius	x/o/o	—	—	—	x/o/o	—	p/o/o	—	—	—	—	—	—	—	—	—	—	—	—

*Data arranged with pre-1904 status (x = known, p = probable [if caught later or known in the vicinity]) separated by a slash (/) from his record (x) or notation (n), separated by a second slash (/) from its presence (x) or absence (o) in the 1990s. Dashed lines indicate known or probable absence of a taxon from a reach or locality. "Sampling Stations" are those I assigned to his collection and observation stations.

1. Chamberlain's somewhat disjointed account of sampling the San Pedro River in the Charleston-Fairbank area, along with data for cataloged specimens in USNM from places he failed to specify collecting (e.g., USNM 129973 and 129974, from 1½ miles above Fairbank) as well as a rambling account of the Gila River above Safford, Arizona, indicate he practiced opportunistic sampling while en route from one place to another. Therefore, at least some of Chamberlain's sites were not firmly fixed and "stations" can be reasonably combined in this summary.

2. Chamberlain's lack of intense sampling here is difficult to understand. It was a known collection site during the U.S. and Mexican Boundary Survey and the type locality for speckled dace, extirpated there before the 1950s (R. R. Miller, pers. comm.).

3. Species not taxonomically recognized at the time of Chamberlain's collections.

4. Woundfin was historically taken only at two places in the lower Colorado River basin, in the mainstream near Yuma and in the Salt River at Tempe, both in the 1800s. It survives today only in the Virgin River, Arizona, Nevada, Utah, and is listed as Endangered (USFWS 1996).

Table 2. Identifications and present-day common and scientific names of plants and animals in Chamberlain's original text.*

Chamberlain's Name(s)	Present-day Vernacular	Scientific Names
Native Fishes		
Agosia	longfin dace	[b]*Agosia chrysogaster* Girard
bonytail, bony-tail	bonytail	[c]*Gila elegans* Baird & Girard[1]
bonytail suckers	flannelmouth sucker	*Catostomus latipinnis* Baird & Girard
Catostomus or sucker(s) (all except "bonytail suckers")	Sonora sucker	[b]*Catostomus insignis* Baird & Girard
Cyprinodon(s)	Monkey Spring pupfish	†*Cyprinodon* sp.[2]
Gila	roundtail chub	[b]*Gila robusta* Baird & Girard[3]
humpback sucker, humpback(s), Xyrauchen, "buffalo"	razorback sucker	[c]*Xyrauchen texanus* (Abbott)
killifish	Sonora topminnow	[c]*Poeciliopsis o. occidentalis* (Baird & Girard)
chub(s) or red-finned, chub, "dace," *Leuciscus* (part), *Leuciscus intermedius*, Lisa	Gila chub	[c]*Gila intermedia* (Girard)[4]
Leuciscus (part)	headwater chub	*Gila nigra* Cope[5]
Meda	spikedace	[a]*Meda fulgida* Girard
Pantosteus or sucker(s)	desert sucker	*Pantosteus clarki* (Baird & Girard)
Poecilia	Sonora topminnow	[c]*Poeciliopsis o. occidentalis* (Baird & Girard)
salmon	Colorado squawfish	[c]*Ptychocheilus lucius* Girard
Tiaroga (San Pedro River)	loach minnow	[c]*Tiaroga cobitis* Girard
Tiaroga (all but San Pedro River)	speckled dace	[b]*Rhinichthys osculus* (Girard)
trout or yellow trout	Apache trout	[a]*Oncorhynchus apache* (Miller)
Non-native Fishes		
crappie	crappie	*Pomoxis* sp.[6]
carp	common carp	*Cyprinus carpio* L.
catfish (Yuma)	black bullhead	*Ameiurus melas* Rafinesque
catfish, cat	bullhead	*Ameiurus* sp.[7]
catfish (Monkey Spring)	Yaqui catfish	*Ictalurus pricei* (Rutter)[8]
black bass or bass	largemouth bass	*Micropterus salmoides* (Lacepède)
rainbow trout or trout	rainbow trout	*Oncorhynchus mykiss* (Walbaum)
Amphibians		
black tadpoles	most likely toads	*Bufo* spp.
large tadpoles	leopard frogs	*Rana* spp.[9]
frogs	leopard frogs	*Rana* spp.[9]

Table 2. *Continued*

Chamberlain's Name(s)	Present-day Vernacular	Scientific Names
Reptiles		
turtle, hardshell turtle	Sonoran mud turtle	*Kinosternon sonoriense* LeConte
softshell	spiny softshell	*Apolone spinifera* (Lesueur)[10]
Birds		
crane	unidentified	most likely a heron, family Ardeidae
killdeer	killdeer	*Chadrius vociferus* L.
teal	likely green-winged teal	*Anas carolinensis* Gmelin
woodcock	likely common snipe	*Capella gallinago* (L.)
Mammals		
Jackrabbit	blacktail jackrabbit	*Lepus californicus* Gray
Algae and Lower Plants		
algous vegetation, "algous," "green algous slime"	likely bluegreen & diatomaceous benthic films	Cyanobacteria & Bacillariophyceae
Chara	skunkgrass	Charophyta, Charales, *Chara* spp.
columbine	columbine	*Aqualegia* spp.
liverwort	liverwort(s)	Marchantiomorpha
Mimulus	monkey flower	*Mimulus* spp.
moss	true moss(es)	Bryopsida
Nitella	Charophyta, Charales	*Nitella* spp.
Oedegonium	filamentous Chloro--phycea (algae)	*Oedegonium* spp.
Spirogyra	filamentous Chloro--phycea (algae)	*Spirogyra* spp.
Vaucheria	filamentous Chryso--phycea (algae)	*Vaucheria* spp.
Higher Plants		
cedar(s)	junipers	*Juniperus* spp.
cottonwood	Fremont cottonwood	*Populus fremontii* Wats.
duckweed	duckweed	*Lemna* spp.
maple	likely boxelder	*Acer negundo* L.
mesquite	mesquite	*Prosopis* spp.
Myriophyllum	parrot-feather	*Myriophyllum* sp.
oak	oak	*Quercus* sp.
paloverde	paloverde	*Cercidium* spp.
pine	pine	*Pinus* spp.
pondweed(s)	pondweed	*Potamogeton* spp.

Table 2. *Continued*

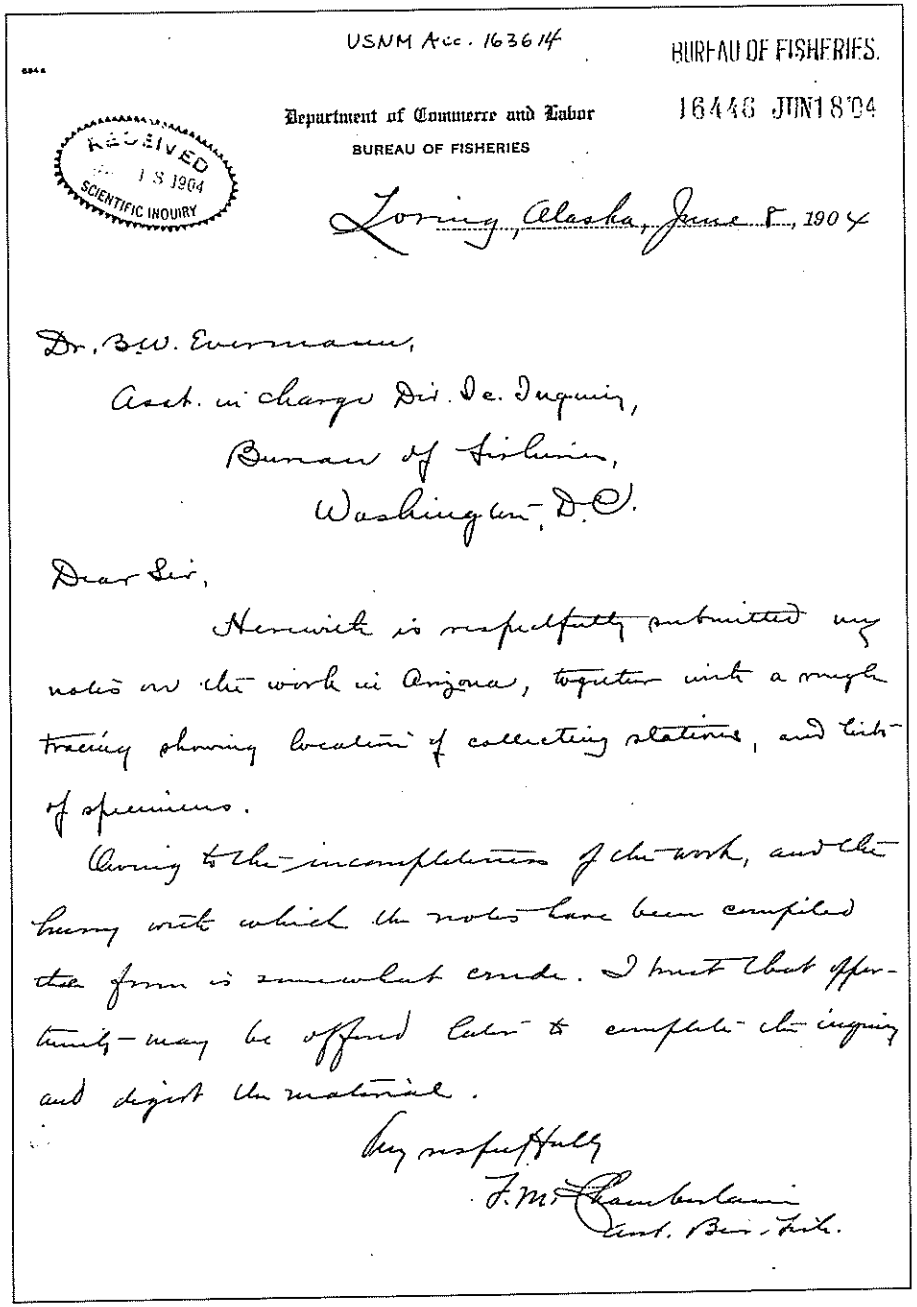
Chamberlain's Name(s)	Present-day Vernacular	Scientific Names
Roripa nasturtium	watercress	*Nasturtium officinale* R. Br.
Salix nigra	Goodding willow	*Salix gooddingii* Ball
sycamore	Arizona sycamore	*Platanus wrightii* Wats.
water cress	watercress	*Nasturtium officinale* R. Br.
willow(s)	Goodding and likely coyote willow, plus (likely) seep willow	*Salix gooddingii* Ball, *S. exigua* Nutt. and *Baccharis salicifolia* Pers.

*His names are arranged alphabetically under each major category. Thirteen of the 16 native fishes he collected are listed in some category of special concern by the U.S. Fish & Wildlife Service (ᵃ) (USFWS 1996), the Republic of México (ᵇ) (SEDESOL 1994), or both (ᶜ), or is extinct (†).

1. See text note 5.
2. Extinction of the Monkey Spring pupfish was detailed by Minckley et al. (1991).
3. Roundtail chub has declined precipitously in the last decade and is presently almost extirpated from much of its former range in the Gila River basin.
4. Gila and headwater chub populations persist today in isolated, typically headwater situations, throughout much of the Gila River basin (Minckley 1999a).
5. Headwater chub was only recently elevated to specific rank by Minckley (1999a).
6. Two species of crappie, *Pomoxis annularis* Rafinesque and *P. nigromaculatus* (Lesueur), are introduced in Arizona. The former has not been collected for a number of years and may well be extirpated.
7. See text note 6.
8. See text note 8.
9. See text note 13.
10. See text note 34.

report, mentioning terrestrial plants or animals only in passing; these also are identified in table 2 insofar as possible.

Chamberlain's penmanship was clear and readable in all but a few places. The text moves along well and contains little redundancy, with only a few minor idiosyncrasies interrupting the flow. There is a tendency toward telegraphic style, as might be expected in a preliminary report. Interchangeable use of written numbers and numerals is common, as is alternating abbreviations with complete words (e.g., "ft." vs. foot or feet, "#" or "lbs." vs. pounds). All were retained as in the original. He was apparently enamored of and consistently used the Spanish word *cañon* for "canyon," with or without the tilde (thus "canon"); it was corrected to *cañon*. He was inconsistent in underlining (italicizing) scientific names and some underlining on the manuscript was clearly by later workers. I applied italics to all scientific names and non-English words for consistency, but otherwise ignored the few marginal notes clearly added by others.



USNM Acc. 163614

BUREAU OF FISHERIES.

16446 JUN 18 '04

RECEIVED J S 1904 SCIENTIFIC INQUIRY

Department of Commerce and Labor
BUREAU OF FISHERIES

Loring, Alaska, June 8, 1904

Dr. B.W. Evermann,
Asst. in charge Div. of Inquiry,
Bureau of Fisheries,
Washington, D.C.

Dear Sir,

Herewith is respectfully submitted my notes on the work in Arizona, together with a rough tracing showing location of collecting stations, and lists of specimens.

Owing to the incompleteness of the work, and the hurry with which the notes have been compiled the form is somewhat crude. I trust that opportunity may be offered later to complete the inquiry and digest the material.

Very respectfully
F. M. Chamberlain
Asst. Bio. Insp.

Figure 3. Copy of F. M. Chamberlain's letter of transmittal.

Any confusion resulting from Chamberlain's frequent, interchangeable use of common and scientific names may be minimized by referring to table 2. Confusion also may result from his presentation of information for some collecting stations in an order other than that in which they were visited. This last feature prompted me to designate collection-station numbers as boldface Roman numerals (**Stations I–XXII**). Minor additional editing on my part included addition of headings in brackets where obviously missing or deemed necessary, use of boldface for headings, and combining with a preceding paragraph some short sentences or phrases apparently added almost as an afterthought to the ends of major sections. Footnotes emphasize comparison and contrast of conditions of habitat, faunal, or species status in 1904 with those of today. I also explain in footnotes some features of ichthyological fieldwork that may be unfamiliar to non-professionals. ✣

ACKNOWLEDGMENTS

I thank all who helped over the long period from my initial acquisition of Chamberlain's manuscript until now. R. R. Miller, University of Michigan, provided me a partial copy in the 1960s. M. E. Douglas, Arizona State University, arranged in the 1980s for a photocopy of the manuscript and associated documents (e.g., daily logs and expense accounting) that were provided by J. D. Felley of the Smithsonian Institution. W. C. Starnes hosted a visit to USNM in 1992 to re-examine Chamberlain's specimens then in his care. R. Hershler, USNM, helped complete the project by obtaining photocopies of a misplaced page and clean copies of Chamberlain's map and letter of transmittal reproduced as figures 2 and 3. He was assisted by B. Kirby of the Smithsonian Institution Archives, who also arranged for permission to publish the contribution. R. M. Turner, formerly of the U.S. Geological Survey, provided paired photographs comprising figures 4 to 6. Finally, I am indebted to students and colleagues for impromptu help in deciphering some of Chamberlain's handwriting and to M. J. Sredl (Arizona Game and Fish Department) and P. Jenkins and C. Mason (University of Arizona) for assisting with details in footnotes. Project completion was partially funded by the U.S. Bureau of Reclamation through the efforts of R. M. Clarkson.

Chamberlain's Report "Notes on Work in Arizona 1904"

ITINERARY

Reach Yuma, Ariz., Jan. 15.
  Work on Alaska Report to Feb. 26.
  Fish Colorado River at Yuma, Feb. 27.
  Reach Tucson, Feb. 29.
  Work on Alaska Report to Mch. 26.
Fish Santa Cruz River at San Xavier, Mch. 27 and 29.
Leave for Patagonia, Apr. 1.
Fish Sonoita Creek and Monkey Spring, Apr. 2.
Visit Monkey Spring, Apr. 3.
Fish Santa Cruz River at Nogales, Apr. 4.
Fish San Pedro [River] at Fairbank, Apr. 5.
Fish San Pedro River at Charleston and Babacomari [= Babocomari] Creek, Apr. 6.
Reach Safford, Apr. 7.
Fish Sienega [= *ciénega*] and visit Gila River at Safford, Apr. 8.
Reach Clifton, Apr. 9.
Fish San Francisco River, Apr. 11
Fish K.P. Creek, Apr. 12.
Fish Blue Creek, Apr. 13.
Fish Gila River above Duncan at the "box," Apr. 14.
Fish Gila [River] above Duncan and at Coronado, Apr. 15.
Reach Globe, Apr. 16.
En route to Payson, Apr. 18 and 19.
Fish Tonto Creek at *cañon*, Apr. 20.
En route to Fossil Creek, Apr. 22.
Fish Pine Creek at Natural Bridge and East Verdi [= Verde] River at Angora, Apr. 23.
En route to Cline, Apr. 24.[1]
Fish Salt River at Roosevelt and Tonto Creek near mouth, Apr. 25.
Fish Pinal Creek, Apr. 26.
Reach Tucson, Apr. 27.
Leave for Alaska, Apr. 28.

ready to spawn (Feb. 13). They will take almost any bait, are very slow to bite, but rather gamey when hooked. Capt. Mellon reports seeing a fish from the lower Colorado, which placed on a pole through the gill openings and the pole on the shoulders of two tall Indians, did not quite clear the ground. Such a fish would easily weigh 100 lb.[10]

SANTA CRUZ RIVER [BASIN]

Tucson, Mch 24 and later [**Station II**] [18, 25–26 March].
San Xavier Mission, Mch. 27 and 29 [**Station III**].
Nogales, Apr. 4 [**Station IV**].
Sonoita Creek, Patagonia, Apr. 2 [**Station V**].
Monkey Spring, Richardson's Ranch, Apr. 2 and 3 [**Station VI**].

[Santa Cruz River]

The Santa Cruz rises in eastern Santa Cruz County, describes a short curve into old Mexico, and flows north by Nogales to Tucson, thence northwest only toward the Gila [River], reaching it in times of heavy rain.

The uppermost point examined is near Nogales [**Station IV**], about 6 mi. in a general easterly direction from the town, at the crossing of the Camp Washington road [Camp Washington is a now-long-abandoned mining camp near the present international boundary, T24S, R16E, Santa Cruz County]. At this point the channel is about 100 ft. average width and six to eight feet below the level of the banks. The water, Apr. 4, about 100 to 150 miner's inches [= 2.5 to 3.75 cfs] in volume, occupied a width of 4 to 20 ft., and a depth of a few inches to 2 ft., the average 5 to 10 ft. wide and ankle deep. Temperatures in afternoon 62°. The bed is sandy or with fine gravel up to the size of a hen's egg—coarser than at Tucson. Little vegetation is present except algous, which is abundant in places, forming a blackish slime on the bottom; all other plants were doubtless trampled and eaten by cattle.

Most of the water is taken for irrigation. That in the ditch[11] alongside the river at this point was 68° in temperature. No dams were seen in the short extent examined, but the dams used are doubtless similar to those described later.

There was a rather abundant growth of cottonwood along the banks. The surrounding country is hilly with a good deal of oak timber.

The seine was not operated, the fishes taken were caught with a dipnet. *Agosia* [= longfin dace] is abundant. Perhaps in consequence of the dark bottoms they are darker than the Tucson specimens, the bronze lateral band or stripe being quite indistinct. *Poecilia* [= Sonora topminnow] is quite scarce, not over a half a dozen were seen, those scattered. One *Pantosteus*(?) [= desert sucker] was seen.[12] Frogs plentiful.[13]

The river appears to furnish water for irrigation at Calabassas [*sic*; the town of Calabasas, now abandoned, was in T22S, R13E, Santa Cruz County] near which point it is joined by Sonoita Creek. Immediately below this it is said to sink again. It rises a short distance above San Xavier.[14]

At San Xavier, 9 miles from Tucson [**Station III**], the river was examined Mch. 27 and 29. The main channel is here some 30 to 40 ft. wide with steep banks of 10 to 15 ft. height. The stream about 1/3 the width of the channel narrows in places to very few feet. The bottom is sand or adobe. In the course are a number of small pools two to four feet in depth. The water is said to rise about 2 1/2 mi. above the mission. I examined it only about two-thirds that distance. About a mile above the mission a dam diverts the entire current to an irrigation ditch and no water rises again in the channel until about 3 miles below the mission. It flows over a rocky bed said to be impracticable to seine. It is entirely used for irrigating.

The river running for the most part over a shallow bottom varies in temperature as the atmosphere. It was 78° F Mch. 29. The water is alkaline to the extent of showing incrustations [= encrustations] on the banks. In many places the banks are springy. Water cress (*Roripa nasturtium*, identified by Prof. Thornber of the A. S. [= Arizona State] University[15] grows abundantly along the margins and in the current in suitable places. It was just beginning to flower the last of March. The growth of algae was less abundant than nearer Tucson. About the same amount of water as at Nogales. The pool back of the dam varies up to 5 or 6 ft. deep, is about 300 yd. long, and 15 to 20 ft. wide. Logs and snags prevent seining in the lower pond, the upper 100 feet was seined.

The most abundant species here is the dace, *Leuciscus intermedius* (?) [= Gila chub],[16] known locally as "red finned chub" in allusion to the orange breeding colors. All I obtained were small, but occasional individuals of 12 to 14 in. have been seen in former years. The smaller individuals resemble *Agosia* in color very closely, but are readily distinguished by the decurved lateral line and by the black stippling of the

lower sides. The lateral dark streak is not very distinct in life. A narrow bronze streak lies above the dark and ends in an orange blotch at the upper edges of the gill opening. Orange (almost scarlet in some) in front of the opercle and margin of preopercle, maxilary [*sic*] with orange stripe running across to cheek. Axil of pectoral and ventral [fins] orange, base of anal [fin] similar (one fish with entire ventral [body] scarlet). Back between orange streaks an apple green—almost translucent in the small ones. Larger ones more generally grayish, sides darker and coloring in fins less marked.

Agosia much less abundant than near Tucson, the bronziness less marked, the bellies silvery rather than bronze, otherwise similar to the Tucson specimens; commonly confused with the dace [= Gila chub].

Poecilia not so abundant as near Tucson. No males taken on account of large mesh of net,[17] but some were seen. Females well developed; cheek apple green—no other evanescent[?] markings.

Two species of suckers a *Pantosteus* [= desert sucker] and a *Catostomus* [= Sonora sucker] were taken in the pools in the upper part of the river. More in the pool back of dam. Six or eight of each were taken in a haul, mostly small, the largest were saved for specimens.

The carp has been introduced by Mr. J. M. Berger, Supt. of the Mission, from Silver Lake[18] near Tucson. I saw two about 14 in. long taken with a hook from the irrigating pool. They are said to be abundant in this pool, a statement which seems to me doubtful.

The hardshell turtle [= Sonoran mudturtle] is abundant but was not taken with the seine. Several frogs were secured, their large tadpoles abundant.

The *Agosia* was found mainly in the shallower water, on or near the riffles. Killifish [= Sonora topminnow] also was associated with these localities, but a good haul of them was made in the lower part of the irrigating pool. Dace [= Gila chub] were found throughout the pool and above, suckers in deeper pools above. The *Agosia* was probably about ready to spawn, though none of them were noted with ripe ova.

This little pool or irrigating pond, poor as it is, is more or less frequented by citizens of Tucson and the neighboring region for sport. The catch of a half dozen dace [= Gila chub] of six or eight inches length repays for the drive, and the fortunate capture of a carp of a pound weight is master angler for the day. Mr. Berger is desirous of planting the catfish to satisfy this demand.

Silver Lake two miles south of Tucson (figure 5) at one time furnished much recreation for Tucson people, boats and fishing tackle was [were] for rent and the carp taken were well appreciated. Were it not for the muddy floods it might be reestablished.

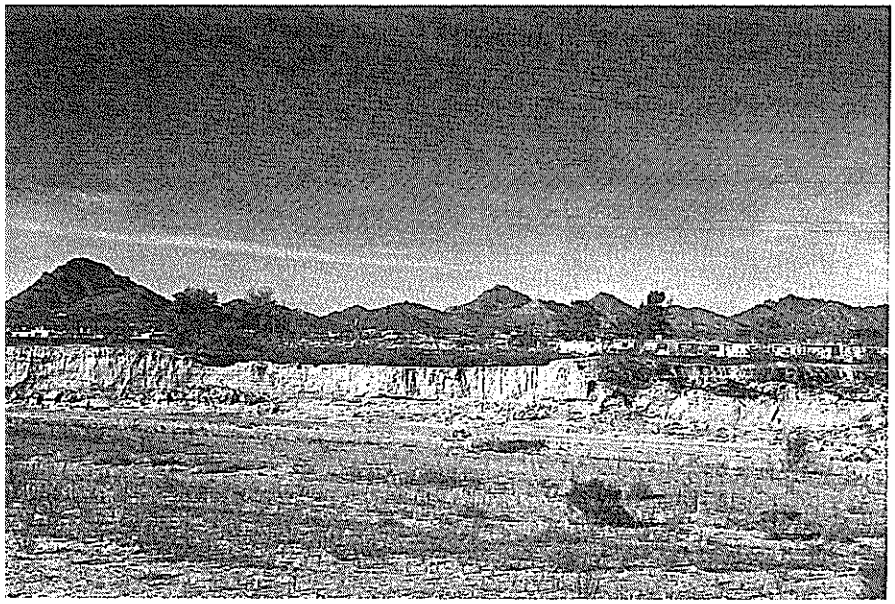
Another attempt at introducing game fishes was made in Rillito Creek(?) by Mr. D. J. Holsinger, who in the fall of 1901 or 1902 had 400 rainbow trout planted in Sabino *Cañon*.[19] So far as I could learn no results have come from this plant, possibly from poor judgment in choice of locality, or from the natural unfitness of the stream. I did not examine it as I was told the only water was a considerable distance back in the mountains.

At Tucson, or more strictly 2 mi. south of Tucson [**Station II**], the Santa Cruz was running about 100 inches [= 2.5 cfs] of water during March and April. The channel was about 100 ft. wide and 10 ft. deep, stream 3 to 30 ft. wide, mostly about 10 or 15, and two to six inches deep, with no pools over twenty inches or 2 ft. deep. Bottom is mostly sand, sometimes gravel or adobe. Temperature of the water varies closely with that of the air, figures from 68 to 72 were obtained. Alkali is shown by incrustations [*sic*] in the banks.

No irrigating dams are now operative above Silver Lake; the channel is too deep.[20] It was ditched within recent years, but the channel has deepened and the flow lessened till the ditches are no longer practicable. Irrigating is done by pumps in wells on the river bank. The water in these wells stands at about the river level, when the pumps are not working.[21] It falls about 20 ft. when the pumps are operating moderately; at this point the inflow equals the output. The temperature is constant at 71° to 72°. The lower figure is shown by the well higher up the valley, no variation was noted during March. The water is in a gravel stratum under some 6 or 8 ft. of adobe and gravel, with sand above. A well some distance back from the river showed several degrees lower temperature.

This water supply is an interesting problem. The wells remain at a constant temperature and almost constant volume while the river varies in both—but especially in temperature. It was stated, with what accuracy I cannot judge, that small frogs are sometimes pumped from these wells in numbers. It would seem that a large body of water must lie in the basin since beyond a certain level, perhaps governed by pressure required to force the water through the containing stratum, the pumps do not lower it, and their use, throwing a volume of water at least twice the amount running in the river, does not visibly affect that current.[22] It would be of interest to find if the level of the wells when not being used is the same at the interval of about two miles which separates the ex-

Figure 5. (Above) The Silver Lake Hotel on the Santa Cruz River, circa 1890.
Photo courtesy of the Arizona Historical Society.
(Below) Silver Lake, December, 1981. Photo by Ray Turner.



tremes. The fact that the well at the foot of the mesa, only about 40 rods [= 660 feet] further from the river, shows a lower temperature, complicates the question materially. The conditions found there may be closely connected with the rising and sinking of the rivers throughout the region, or it may be an artesian well proposition. The subsurface water level at Tucson is said to have fallen some 6 ft. during the last two or three years, and complaint is made of the same condition in the San Pedro Valley.[23]

Until a few years ago this part of the river contained pools; these were filled [with sediments] by a freshet and have not again formed, nor can they again form owing to the large amount of sand now carried in floods and the absence of bed rock to produce currents. Silver Lake, mentioned above, was an artificial pool made in the channel about 2 mi. south of Tucson. At one time it was abundantly stocked with carp and native fishes. The dam was cut three years ago, and at that time it was reported carp were found abundantly as far down the valley as Sacaton.[24]

As above San Xavier, water cress is abundant in suitable places along the margins of the stream. Another aquatic, not blooming and not identified, is also more or less abundant. Algae are everywhere in quantity: *Oedegonium*, *Vaucheria*, *Spirogyra*, and *Nitella* (Thornber). *Chara* is found in stagnant pools separated from the current. The willow (*Salix nigra*) is common on the banks, it reaches a diameter of over 2 ft.

Agosia is very abundant both in the shallow pools and in the riffles, schools of six to thirty adults in every quiet reach, with smaller schools in the shallows. Fry of 1/2 inch up are abundant along the margins even in the more barren places, they are apparently feeding on the algae and are more abundant in little pools. Adult females with eggs and males tuberculated indicate the spawning season, but no spawning was observed.

The sides and belly are bronzy, paling beneath, darkest is a stripe above the lateral dark stripe. This bronze stripe, as well as the dark more median stripe, is most distinctly seen when viewed from above. The bronze stripe continued in the cheek. The lateral dark stripe is more distinct in some individuals than others, most marked in the caudal region, merging into a small blotch at base of caudal [fin]. A narrow dark median dorsal stripe [is present]. Caudal and pectoral [fins] slightly orange, ventrals [= pelvic fins] and anal [fin] much paler. Tubercles [= granular organs formed on the skin of some breeding fishes, also called "pearl organs"] in male pale.

Poecilia is equally or more abundant than *Agosia*. The females and smaller individuals are found more in standing pools at the side of, but connected with, the current, among plant growths, the males more in the main stream, but also found with sexes associated and perhaps copulating in the warmer marginal waters.[25] The male in nuptial colors is almost wholly black, sometimes throat and breast pale, sides often with an emerald green iridescence. Caudal and base of anal and dorsal [fins] orange on membranes, paler distally. Females pale translucent green in life, markings unchanged in alcohol. They are not readily distinguished in the water from the minnows, but males are readily marked by color when black. These two are the only fishes found above Silver Lake and below San Xavier.

Few insect or crustacean forms were noted. There are few green frogs. One mass of frog spawn about 1/3 developed was noted Mch. 28. One crane and one heron were the only water birds seen. A pair of small ducks (teal?) were seen at San Xavier. Ducks are known to breed in small numbers throughout the region.

SONOITA CREEK

Examined [Sonoita Creek] Apr. 2 at Patagonia [**Station V**] where the water first rises about 1/2 mile below the railroad station. From this point it continues at the surface most of the way to Calabassas [*sic*, Calabasas]. Where examined it was flowing 50 to 70 inches of water [= 1.25 to 1.75 cfs], was 16 inches to 10 ft. in width, mostly in shallow sandy reaches similar to the Santa Cruz at Tucson. The channel is 60 to 100 ft. wide and 5 to 10 ft. deep. It is dammed at short intervals for irrigating. Small dams of sand and brush 2 to 3 ft. high were used.[26]

Abundant growths of [water] cress and a yellow flowered plant (*Mimulus*, #11) occur in the current and at the margins. The willow is common on the banks. Temperature of water 65 at 7 A.M., and showing the alkali inflorescence.

Agosia and *Poecilia* are very abundant, not so far advanced sexually as at Tucson, probably due to the greater elevation and consequent retardation of the season. Two small suckers, *Pantosteus* and *Catostomus* [= desert and Sonora suckers, respectively], were taken in a small pool, the only ones seen.

Frogs are not rare, some small black tadpoles seen, others half grown. Killdeer and woodcock were the only paludial birds noted.

MONKEY SPRING

This spring [**Station VI**] is located on Richardson's Ranch, about seven miles above Patagonia (figure 6). It has an elevation of some 4,500 ft. (see R.R. [= Southern Pacific Railroad] tables). It flows about 50 inches [= 1.25 cfs] of water at 80°, strongly impregnated with lime. The original waste ways show limy incrustations [*sic*] resembling lava streams. The water now enters a pond about 150 yd. long, 30 to 50 yd. wide and about 6 ft. deep at deepest point. This is an artificial pond supported by a dike upon which willows a foot in diameter are growing. There may have been a small pool naturally formed before the dam was built, which furnished a habitation for the small native fish.[27] The present pond is almost filled with a dense growth of *Chara* and another plant not identified. It is bordered by a tall growth of sedges.

A second reservoir about 40 yds. square lies on the hillside a quarter of a mile farther down and perhaps at 75 ft. lower level, and the same height above the valley. The original spring flow was quite steep into the *cañon* below, which has a width of 30 to 100 ft., with rocky walls at intervals. The water is now conducted by a ditch around the hill.

The upper pond is abundantly inhabited by *Poecilia* [= Sonora topminnow], *Cyprinodon* [= Monkey Spring pupfish], and *Leuciscus* [= Gila chub]. They were all native and have found lodgment here by natural means. In addition, a catfish [= Yaqui catfish] has been introduced. A hardshell turtle was seen. The longest *Leuciscus* seen was about 8 inches, only small ones were taken in the seine. In second reservoir only the *Poecilia* and a few Cyprinodons were seined. A few frogs.

The catfish were planted July 8, 1899. 14 fish, 8 to 12 inches in length were put in. They were obtained from a creek near Casitas, Mex[ico].[28] Secured by sinking a hole in the bank about 8 ft. from the edge, through which a Mexican boy caught them by hand. It seems that this stream at Casitas becomes dry during the dry seasons and at these times the fish find refuge in pools back under the banks. The Mexican small boy had these reservoirs located.

In October and November following this plant large schools of fry about 2 inches in length were noted in the pond. In 1903 good catches of fish of 2 and 3 lb. weight were made. In 1904 two of total weight 9 lb. were taken. I was unable to secure specimens.

There are two or three small tributaries of the Sonoita not far from Patagonia. One 3 or 4 mi. to the southwestward [an unknown locality] is said to contain numerous small fish, perhaps *Agosia* and *Poecilia*.