ASPECTS OF THE LIFE HISTORY OF THE MOHAVE CHUB, <u>GILA BICOLOR MOHAVENSIS</u> (SNYDER) FROM SODA LAKE, CALIFORNIA

A Thesis
Presented to the
Faculty of
California State University
Fullerton, California
By
Charles E. Vicker
September 1973

ASPECTS OF THE LIFE HISTORY OF THE MOHAVE CHUB, *GILA BICOLOR MOHAVENSIS* (SNYDER) FROM SODA LAKE, CALIF.

A Thesis

Presented to the

Faculty of

California State University, Fullerton

In Partial Fulfillment

of the Requirements for the Degree

Master of Arts

in

Biological Science

---

by

Charles E. Vicker

September 1973

ASPECTS OF THE LIFE HISTORY OF THE

MOHAVE CHUB, GILA BICOLOR MOHAVENSIS

(SNYDER) FROM SODA LAKE, CALIF.

A Thesis

Presented to the

Faculty of

California State University, Fullerton

---

by

Charles E. Vicker

Approved by:

Michael H. Horn — 18 June 1973

Committee Chairman — Date

Bayard H. Brattstrom — June 18, 1973

Member — Date

Kenneth A. McWilliams — 18 June 1973

Member — Date

ABSTRACT

Several aspects of the life history of *Gila bicolor mohavensis*, an endangered desert cyprinid isolated in several ponds at Soda Lake, California, were investigated from March 1969 to February 1973. The fish are not active during December and January, and the few individuals collected during those months were in a torpid state. *G. b. mohavensis* first spawns at age 1+. Spawning activity begins in February, reaches a maximum by the first of April, and declines in May. The calculated mean fecundity for 5 individuals was 5,255. Two specimens (2.26%) in the sample used for age determination were in the 4+ age-group. A preliminary food habit analysis indicates that mature chubs feed primarily on immature insects and waste food thrown into the pond by the residents of Zzyzx Mineral Springs Resort. One instance of probable intraspecific predation by a large individual was recorded.

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF TABLES

ACKNOWLEDGMENTS

My appreciation goes to Dr. D. W. Greenfield (presently at Northern Illinois, University, DeKalb) under whose supervision this study was initiated as graduate research toward an M.A. degree in Biological Science. I want to thank my adviser Dr. Michael H. Horn and the other members of the thesis committee, Dr. Bayard H. Brattstrom and Dr. Ken L. McWilliams, for their evaluation of the completed paper. I am grateful to the California Department of Fish and Game for permission to collect specimens of the Mohave chub for completion of this study. Also, I want to thank M. C. Vicker and K. Vicker for their assistance with the field work.

INTRODUCTION

The Mohave chub, Gila bicolor mohavensis (Figure 1), is a desert cyprinid originally native to the Mojave River, San Bernardino County, California. This chub, first described as Siphateles mohavensis by Snyder (1919), was later placed in the genus Gila by Uyeno (1960), who reduced Siphateles to a subgenus. Miller (1973) has not been able to discover characters that will separate the Mohave chub specifically from all other populations of Gila bicolor in the Lahontan basin and thus has reduced Gila (Siphateles) mohavensis to a subspecies, Gila bicolor mohavensis (Snyder).

Mass hybridization occurred between G. b. mohavensis and G. orcuttii apparently as a result of cohabitation of these native fishes in isolated sections of the Mojave River after the Pluvial period of the Quaternary (Hubbs and Miller, 1943). Subsequent collections by Miller (1968) have verified that G. b. mohavensis as a distinct subspecies has been eliminated from the river system through introgressive hybridization. A small population of G. b. mohavensis, restricted to several ponds at Zzyzx Mineral Springs Resort on the west shore of Soda Lake, California (Figure 2), is the only remaining natural population.

The California Fish and Game Commission (1971) listed the Mohave chub as an endangered and rare fish. As a result

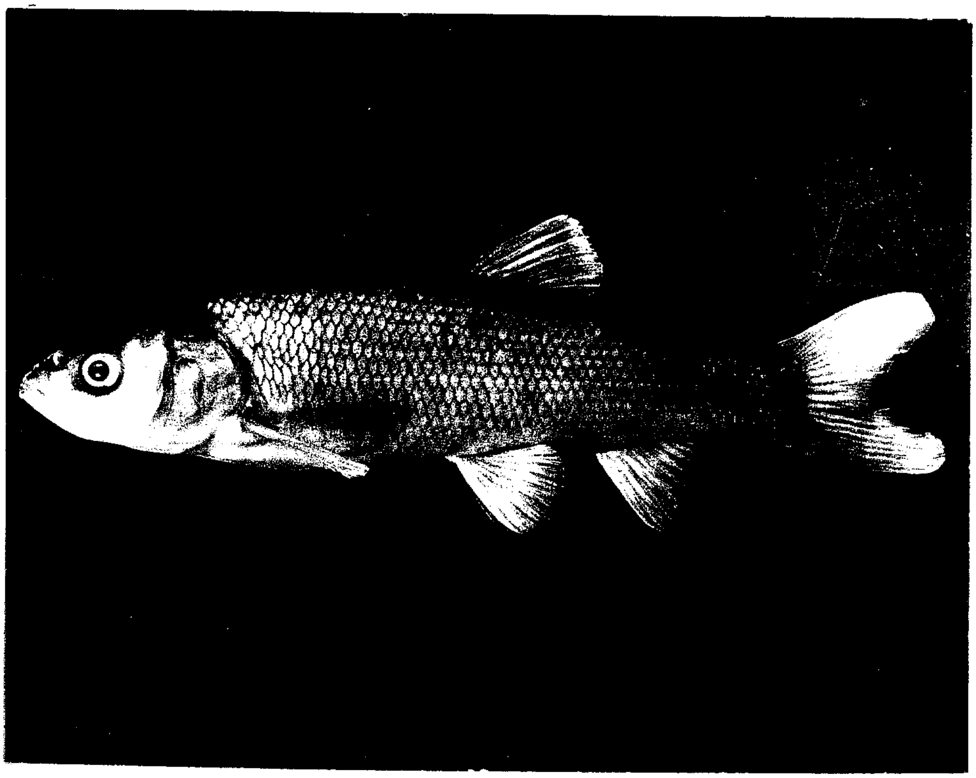

FIGURE 1. The Mohave chub, *Gila bicolor mohavensis* (female; 130 mm SL). Photographed by H. Christian.

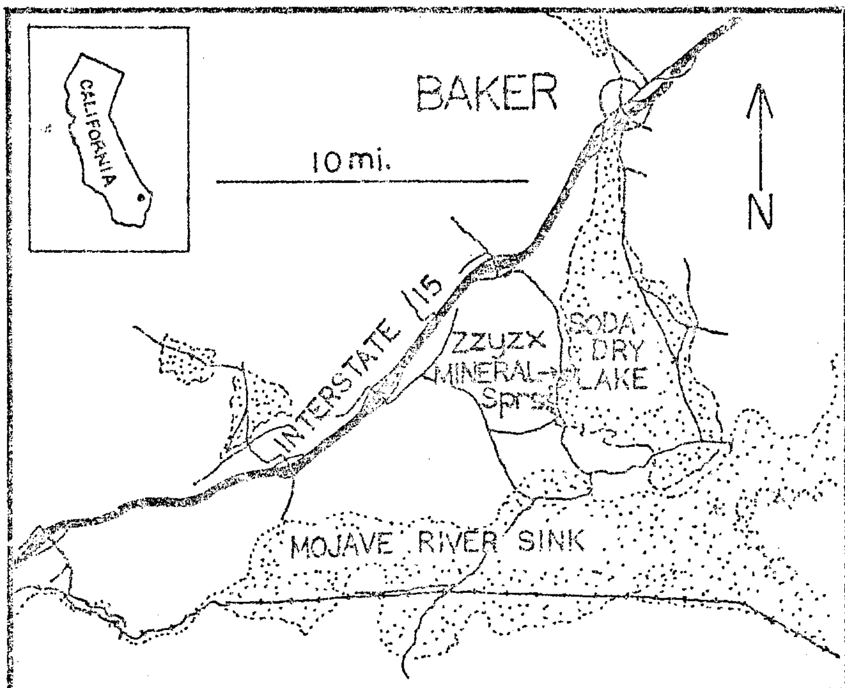

FIGURE 2. Map showing proximity of study area to Soda Lake and the Mojave River Sink.

of a symposium at Furnace Creek, Death Valley, Calif. (November 18 and 19, 1969), plans to preserve G. b. mohavensis in the existing natural habitat and to establish other refugiums are in progress. James Deacon (University of Nevada, Las Vegas) and Dale Lockard (Nevada Fish and Game) are observing an established population of the Mohave chub at Paradise Spa near Las Vegas, Nevada (Pister, 1969).
St. Amant and Sasaki (1971) reported the introductions of the Mohave chub into Piute Springs northwest of Needles, Calif. (December, 1969), into a pond at South Coast Botanic Garden, Palo Verdes, Calif. (January, 1970), and into Two-hole Spring east of Lucerne Valley, Calif. (August, 1970). As of 1971 G. b. mohavensis was still present in Piute Springs Creek. The plant at Two-hole was unsuccessful, and another attempt to introduce the chub at this location will be made by the Calif. Dept. of Fish and Game. The population of chubs at South Coast Botanic Garden spawned in 1970, but had to be rescued after the pond developed a leak. The rescued chubs were put into ponds at the Chino Fisheries Base, Calif., into a pond at Lion Country Safari, Orange County, Calif., and into a pond on the China Lake Naval Weapons Center, Calif. (Fisk, 1972, personal communication).

The endangered status of the Mohave chub has made an understanding of its biology necessary for the survival of this fish. The purpose of this report has been to investigate several aspects of the life history of G. b. mohavensis including; the habitat, distribution, reproduction, age and growth, and food habits.

METHODS

Investigation of the Mohave chub was begun in March 1969 and continued until February 1973. Specimens were collected during each month of the year except December and January, and were primarily from the main pond, Lake Tuendae, at Zzyzx Mineral Springs Resort (Figure 2a).

A 1 m by 1.5 m one-man seine with 2.5 mm mesh, a 2 m by 7 m seine with 5 mm mesh, and a wire-basket fish trap baited with bread were used in the collections. Except for live chubs returned for laboratory observation all specimens were fixed in 10% formalin and preserved in 40% isopropyl alcohol. The stomachs of chubs used in food habit analysis were injected with formalin.

The shoreline of the main pond was measured with a steel tape; depths at specific locations in the pond were measured with meter sticks on a pole. The bottom composition, hydrology, and flora and fauna of the habitat were investigated. Seasonal and daily distribution of the chub population in the main pond were determined from observations and collections. Surface water temperatures were recorded on certain visits to the study area.

The age of earliest spawning was established by determining the maturity of eggs and the number of scale annuli from a large number of chubs of a wide size range.

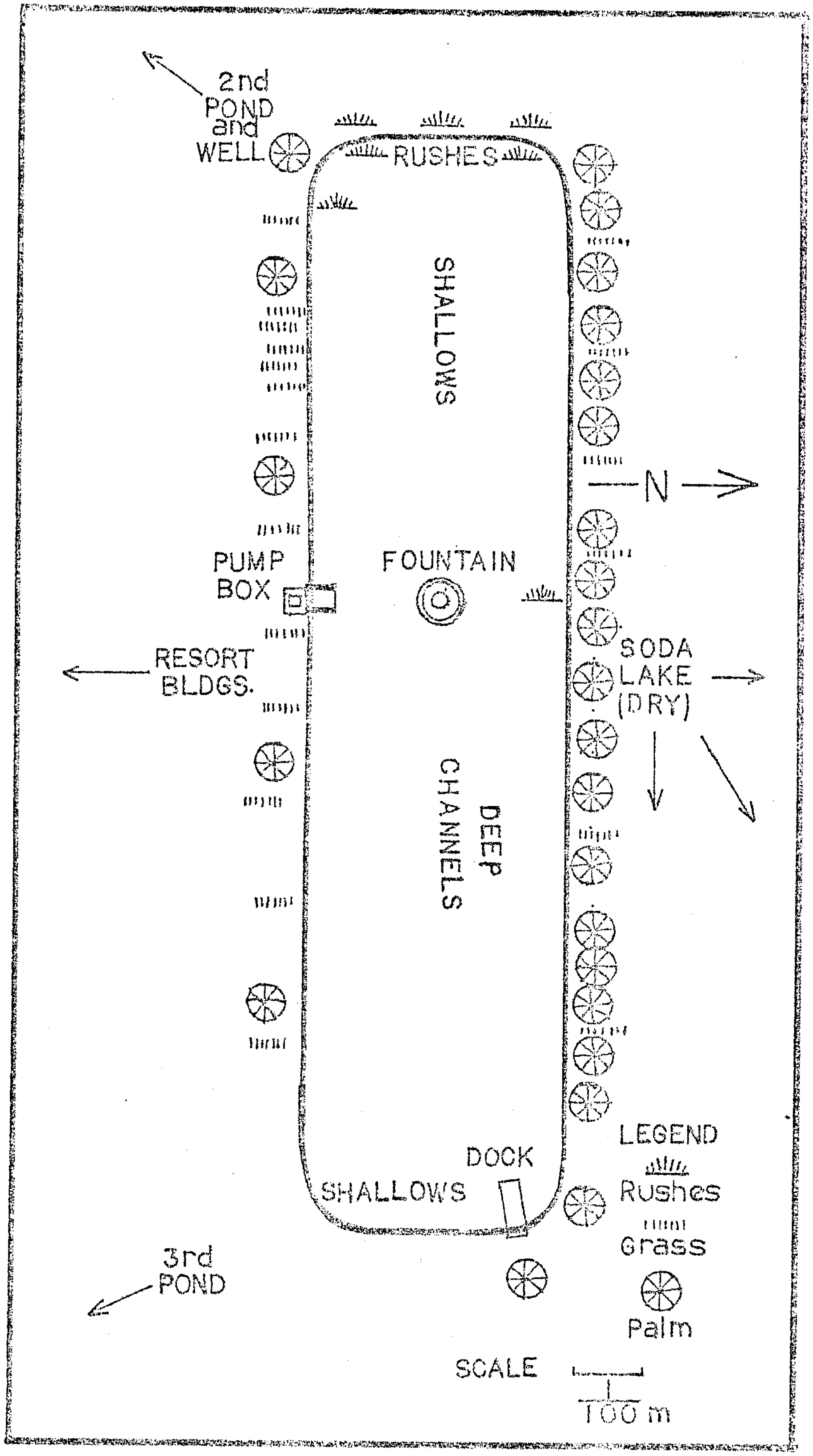

FIGURE 2a. Map of habitat, the main pond (L. Tuendae).

Large spherical, yellow eggs at least 1 mm in diameter were considered to be ripe. The spawning period and maximum spawning activity were determined from the following criteria: spawning behavior, appearance of the first large schools of young, presence of easily extruded milt and eggs from live chubs, and the developmental state of eggs of females collected in various months. Several attempts at inducing spawning in the laboratory and collecting fertile eggs in the habitat were unsuccessful.

The ovaries of 5 mature specimens were selected for fecundity estimates. Standard lengths (mm) and weights (g) of the chubs were measured with dial calipers and a Mettler balance, respectively. The fecundity of the largest chub collected was also calculated as an indication of maximum egg production in the population. Both ovaries of each specimen were removed and loose tissue was cut away. They were dried on filter paper and weighed to the nearest 0.005 g. Groups of 50 and 100 eggs from .5 to 1 mm in diameter were taken at random from each ovary and stored in alcohol. Each group of eggs was dried and weighed. The number of eggs in each ovary was estimated by calculating the mean number of eggs per gram in the samples (Greenfield, Ross, and Deckert, 1970).

An investigation of age and growth of _G_. _b_. _mohavensis_ was made on 113 specimens collected in the spring of 1970 (Appendix I). Age was determined from scale annuli. Opercular bone and otolith year marks were used to substantiate the age of several of the largest fish. A binocular stereomicroscope was used to examine the scales, opercular bones, and otoliths. A minimum of 5 scales were selected from an area on each specimen above the lateral line and anterior to the dorsal fin. Scales were dried to eliminate distortions caused by the preservative solution. Although discontinuous ridges, relative approximation of circuli, and clear narrow streaks were considered, the "cutting-over" or cutting across the unfinished ends of the outcurved circuli on resumption of new ridge growth was the primary criterion used to identify an annulus. Age groups were established from year-mark data and the month the collections were made. The standard length (mm) and the number of chubs by sex from a large random sample of specimens collected on the same date were used to compute length-frequency distribution (Lagler, 1956).

Preinjected stomachs from 60 specimens of various sizes were examined. The contents of the stomach from the esophageal-cardiac junction to the first reverse turn were removed. Most of the stomachs were either empty or contained no identifiable organisms. The organisms found in the other stomachs were identified.

HABITAT

The main pond is a 37 m x 159 m man-made expansion of a natural pool (Figure 2a). The existing water table in the adjacent playa of Soda Lake is about 1 m below the surface, and is dependent primarily upon seasonal variations in the flow of the subterranean Mojave River. The study area and Soda Lake are located within the Mojave River Sink (Figure 2). The water table, which regulated the level of water in the original pool, does not provide sufficient seepage for the larger pond. The present tenant of Zzyzx Mineral Springs Resort pumps water into the pond from a nearby well. The white encrusted soil and plants in the study area indicate the high concentrations of mineral salts in the ground water.

A maximum depth of 125 cm was recorded in the northeast corner of the pond on March 15, 1969. A shallow shelf with a sand bottom extends across the east end. The eastern half of the pond contains several deep channels with hard bottoms. The entire west end is a shallow mud bottom zone with a mean depth of about 50 cm (Figure 2a). Water in the pond remains turbid at depths greater than about 50 cm.

Floating algae, aquatic grass, and rushes occur in high density in the west end from spring through early fall. Adult and immature aquatic insects, primarily in the orders Odonata, Coleoptera and Diptera were observed and collected in the vegetation and above and on the surface. A species of desert pupfish, *Cyprinodon salinus*, was successfully introduced into the pond from Salt Creek, Death Valley, California by Miller (1968) in 1939 and 1940. *C. salinus* appears to inhabit the shallow areas of the pond.

The study area also included a second smaller pond which is southwest of the main pond and adjacent to the pump and well. A third pond, which is no more than a hole filled with seepage water, is located about 800 m southeast of the main pond. The two ponds were excavated by the tenant of the resort (Figure 2a). Both ponds have introduced and breeding populations of *G. b. mohavensis*.

DISTRIBUTION AND ACTIVITY

A population on the order of 5,500 to 6,000 G. b. mohavensis occurs in the main pond from mid-March to October. The estimation of population size is based on the number of individuals observed and collected at several sites around the pond on visits when the chubs were active. During periods of activity surface water temperatures range from 15°C (mid-March), to about 29°C (July), and down to 21°C (October). By mid-February schools of young chubs occupy the west end of the pond. No activity was seen in any area of the pond during December and January. Water temperature on January 31, 1970 (10:30 A.M.) was 8°C. Surface ice occurred at the edge of the pond until late morning on several winter days. Bottom seine hauls in December and January either captured no chubs or only small groups of 5 to 10 individuals under the aquatic grass. The specimens that were collected were in the deepest water and appeared to be in a torpid state. Chubs that made no attempt to escape when captured were considered to be in a torpid state. Traps set in the same locations did not catch any chubs.

During peak activity periods from spring through fall young chubs up to 50 mm SL remained in shallow areas in the western half and east end of the pond. Schools of the young chubs were active throughout the day and frequently took shelter in the aquatic grass. Chubs ranging in size from 50-180 mm traveled in large schools along the south and east shore lines in about 45 cm of water. As water temperatures increased in the late morning the larger chubs moved to the bottom of deeper channels and returned to the shore line in the late afternoon. Fish-trap collections on the bottom in 80 to 100 cm of water also indicated the occurrence of diurnal migrations. The largest chubs (about 180 mm +) were observed and collected as solitary fish on the north side of the pond. A 215 mm female was collected by seine on March 15, 1969, in about 80 cm of water.

SPAWNING

Three specimens, collected on March 14, 1970 from a school of spawning chubs, were found to be the smallest individuals (53.7, to 55.0, and 58.2 mm SL) with large numbers of ripe eggs. These chubs had one annulus on their scales which indicates that G. b. mohavensis first spawns at age 1+.

The appearance of larval and juvenile chubs in large numbers and the presence of milt in several males on February 11, 1972 indicated spawning activity. Spawning activity was near a peak on March 14, 1970, when the temperature of the water was 18°C (11:00 A.M.). Most of the mature fish collected extruded milt or eggs easily. The largest schools of young were observed on this date. Although most of the males collected on May 13, 1970 (water temperature 24°C; 2:00 P.M.) released milt, only one female released ripe eggs. Therefore spawning begins in February, reaches a maximum by the first of April, and declines in May. The presence of chubs as small as 19 mm on October 19, 1968 (water temperature 21°C; 1:00 P.M.) indicated a probable resumption of spawning in the early fall although no spawning activity was observed.

During spawning mature chubs mill around in compact groups of about 100 to 200 individuals. The chubs move across the aquatic grass about 40 cm below the surface, brush against each other, but do not appear to form pairs. Although oviposition was not observed, it was assumed that the eggs adhere to the vegetation and do not sink into the deep silt on the bottom. Kimsey (1954) showed that in the Eagle Lake tui chub (G. b. obesus X G. b. pectinifer) only those eggs attached to plants or otherwise kept off of the bottom and out of the mud will develop normally.

A rust color appears on all the fins of both males and females during the spawning season and is absent at other times of the year. Kimsey (1954) described a reddish tinge on the fins of spawning Eagle Lake tui chubs similar to the rust color on the fins of spawning G. b. mohavensis.

FECUNDITY

The left ovaries in the five specimens examined for fecundity had a higher mean number of eggs than the right ovaries (Table 1). The total fecundity of the five chubs ranged from 3,393 to 8,964 (Table 1); and the relationship between body weight and the number of eggs was nearly linear (Figure 3). The largest chub collected in this study (474.4 g and 215 mm SL) had an egg number of 49,847 (Table 1 and Figure 3). The ovaries of chubs as small as 53.7 mm SL contained ripe eggs.

TABLE 1

Calculated Number of Eggs in the Ovaries of 5 Mohave chubs and the Largest Mohave chub collected in the study

Standard length (mm)	Total weight of fish (g)	Number of eggs		
		Total	Right	Left
Date of sample: March 14, 1970				
130.0	55.67	8,964	3,750	5,214
113.0	41.18	5,079	2,460	2,619
112.0	35.79	4,462	1,936	2,526
104.0	27.32	4,377	2,165	2,212
98.5	25.44	3,395	1,722	1,673
Means (of 5 Mohave chubs)		5,255	2,407	2,849
Date of sample: March 15, 1969				
215.0	274.40	49,847	26,013	23,834
Means (of 5 Mohave chubs and largest chub)		12,687	6,341	6,346

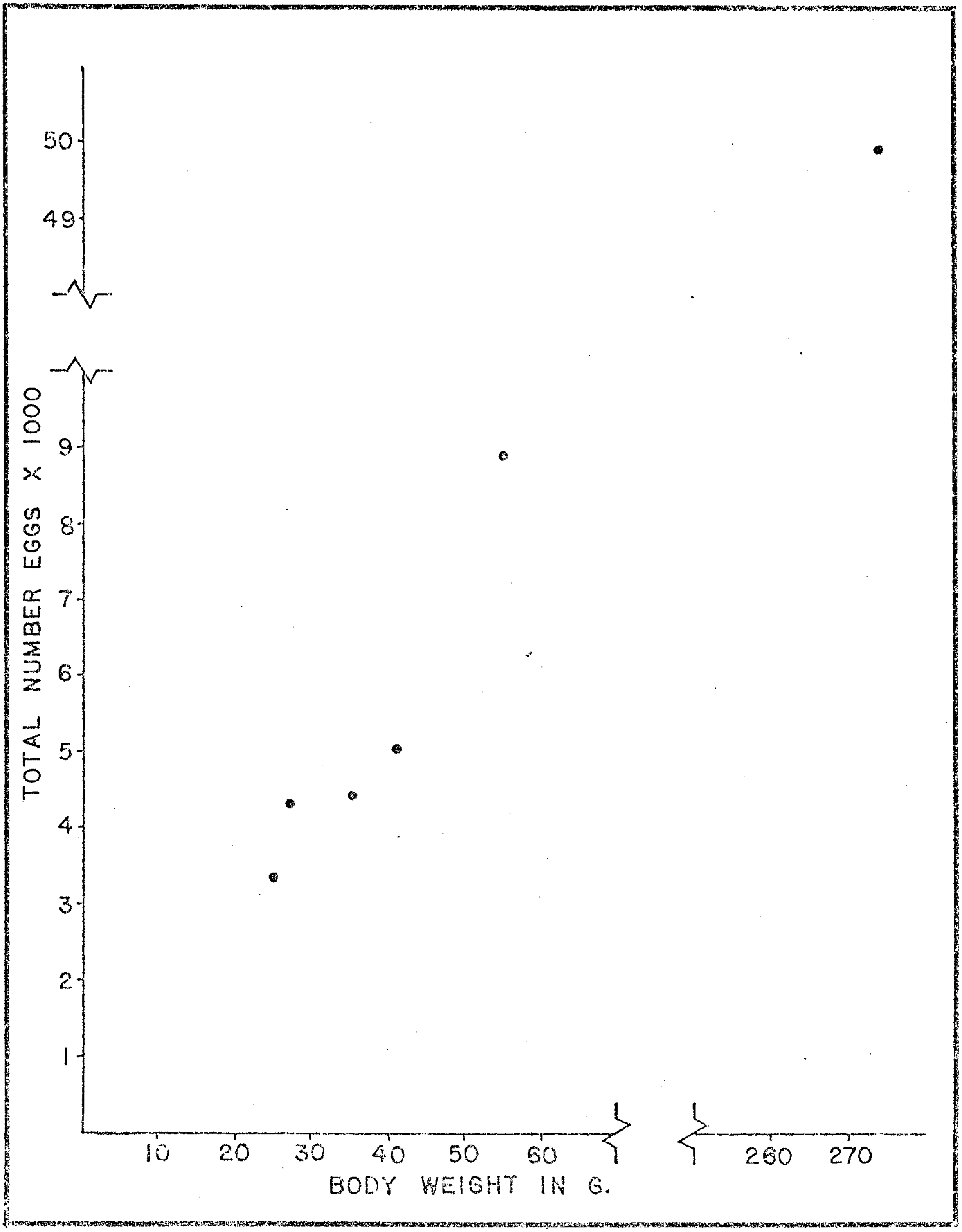

FIGURE 3. Body weight-egg number relationship for *G. b. mohavensis*.

AGE AND GROWTH

Annuli were well defined in most of the scales examined from 113 specimens collected on March 14, 1970, and were considered the most reliable criterion for assigning age-groups. Resumption of circuli growth near the scale margin confirmed formation of the new annulus shortly before the collection of the sample. Chubs hatched since January 1st and not having formed an annulus, were classified in age-group 0+ following the method of Hubbs (1943). The chubs in age-group 0+ were spatially isolated from the older population of chubs in the habitat. All of the age-groups except 0+ were collected together in the samples. Scales of six specimens ranging from 26.5 to 41.8 mm SL were found to have no annulus. These six juveniles in age-group 0+ were correlated with other age-groups although the sample size may not be representative.

Specimens ranging from 53.7 to 85.2 mm (51 individuals) were assigned to age-group 1+. Age-group 2+ ranged from 76.1 to 120.5 mm (48 individuals). Six specimens (116 to 137.8 mm) were classified in age-group 3+. Age-group 4+ was composed of 2 females (161 and 179.5 mm). A scale of the larger chub in age-group 4+ (Figure 4) shows 4 annuli. (One other chub, a 215 mm female, collected on March 15, 1969, was also in age-group 4+). Age-group 1+, 2+, and 3+ have a wide range and an overlap of standard lengths (Figures

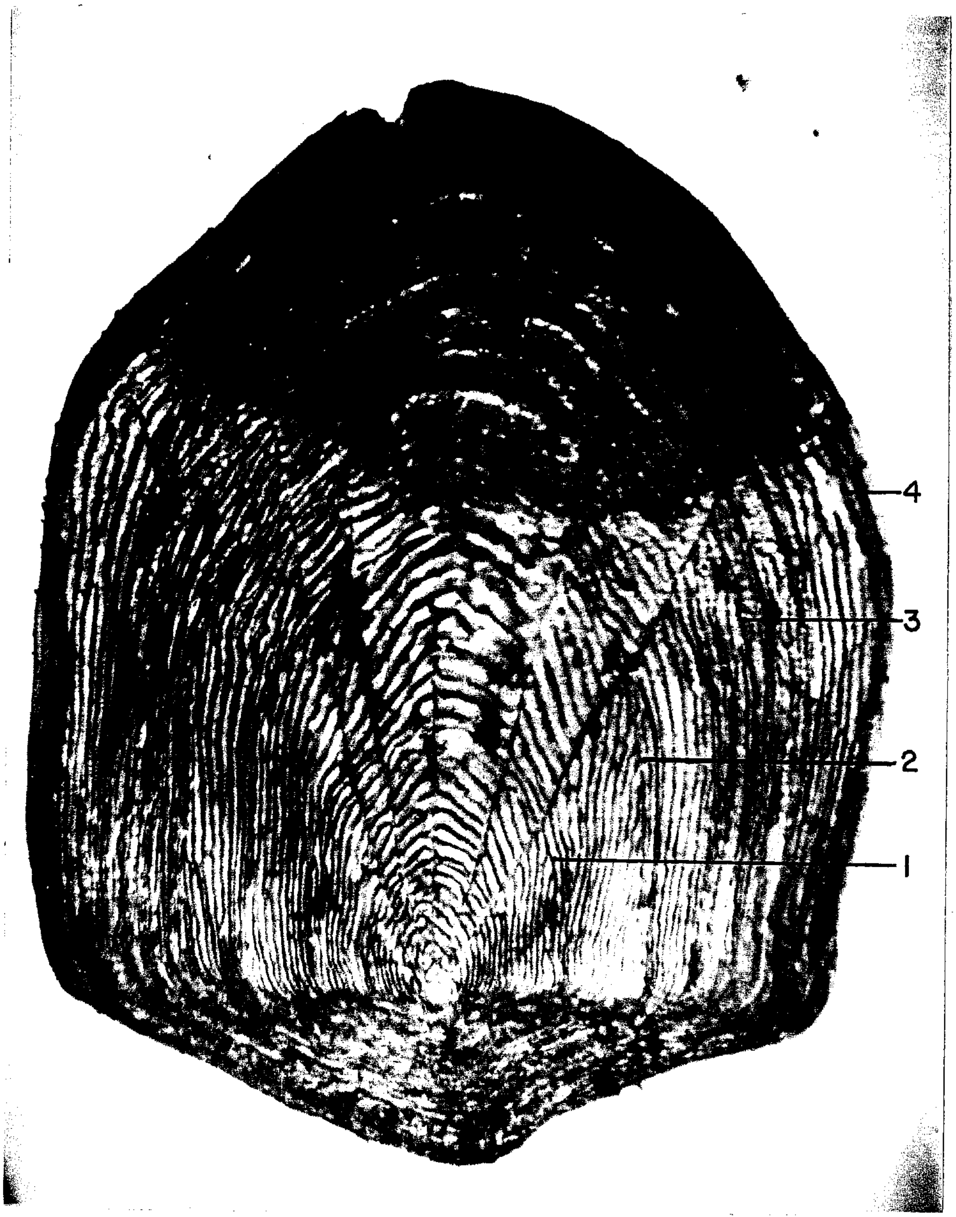

FIGURE 4. Scale of a Mohave chub in the 4+ age-group (female; 179.5 mm SL). Photographed by H. Christian.

5 and 6). The growth rate for G. b. mohavensis is nearly linear (Figure 5).

The sudden reduction in the number of individuals from age-group 2+ to 3+ (48 to 6) indicates that most chubs die in the 2+ age-group. Very few fish survive to the 4+ age-group.

Length-frequency distributions did not isolate groups of chubs by age, except in the 0+ and 4+ age-groups (Figure 6). The distributions show that females tend to be larger than males.

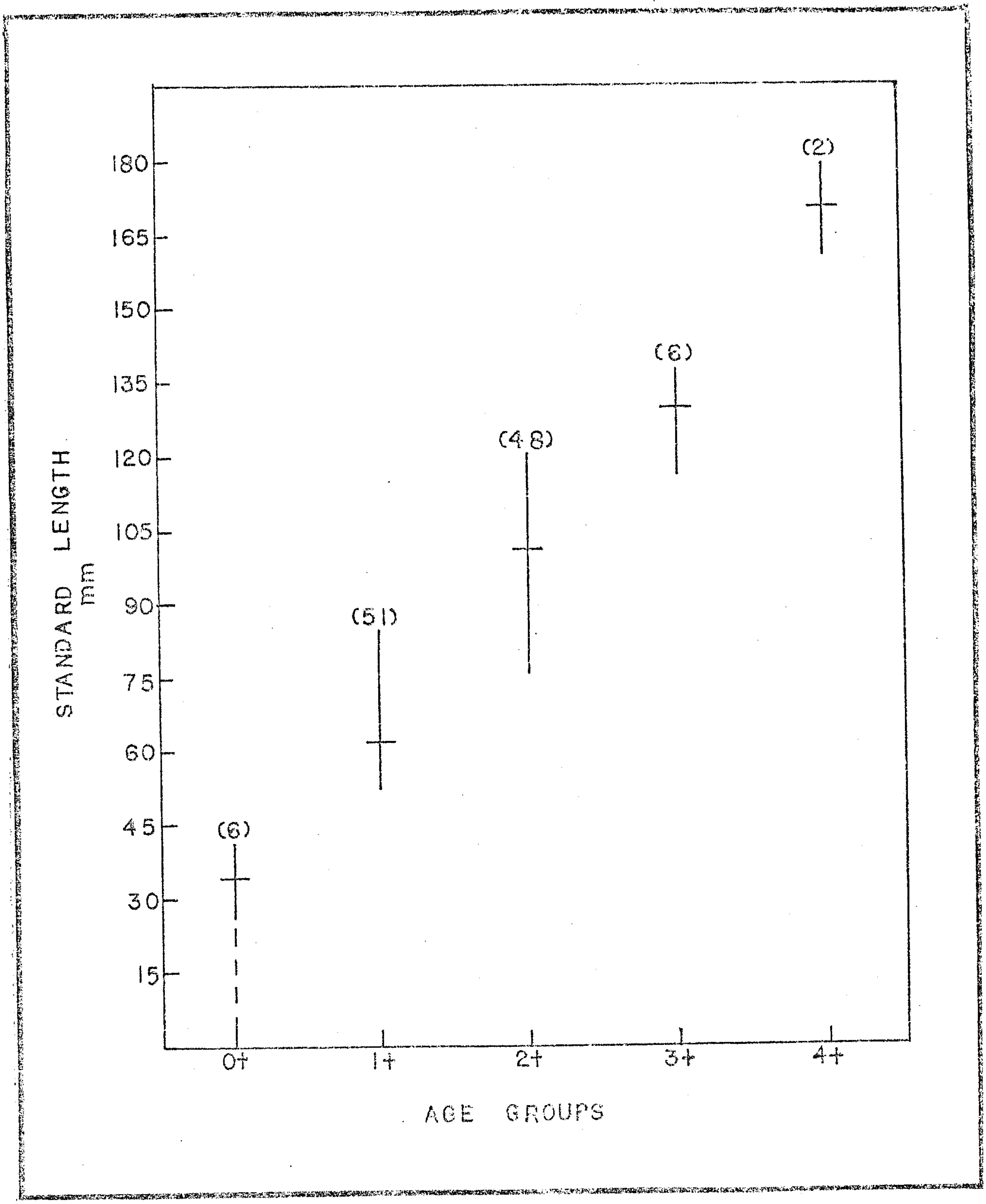

FIGURE 5. Growth rate of G. b. mohavensis based on a sample of 113 specimens collected on March 14, 1970. Vertical lines indicate the range, horizontal lines the mean, and the number in parentheses the sample size. The broken vertical line represents lengths of chubs in age-group 0+ not included in the sample.

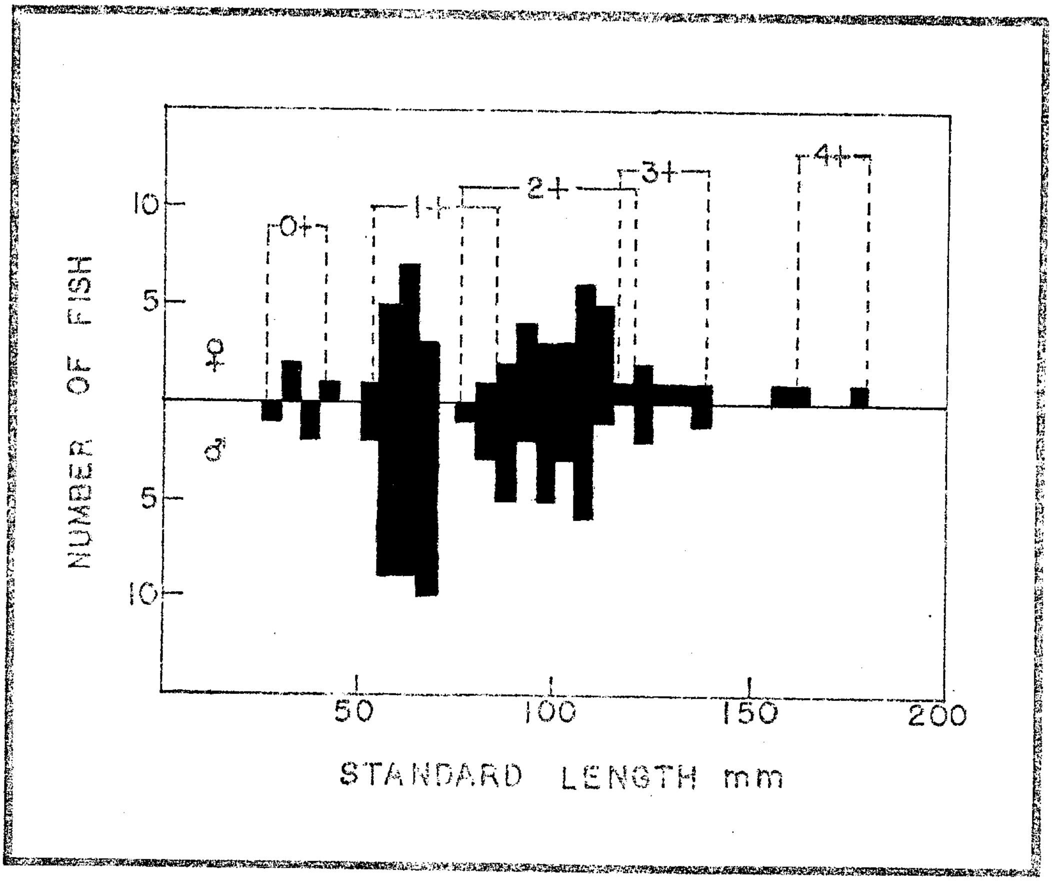

FIGURE 6. Length-frequency distribution of G. b. mohavensis collected on March 14, 1970 (females above line, males below). Ranges of age-groups indicated by distances between vertical broken lines.

FOOD HABITS

A quantitative analysis of stomach contents of all 60 Mohave chubs examined (range: 53.7 to 179.5 mm SL) was not possible, because of the small number of identifiable organisms found. The stomachs of 17 of the chubs were empty and in 37 stomachs the total volume consisted of waste food. The residents and guests of Zzyzx Mineral Springs Resort throw waste food (bread and other vegetable matter) into the pond every day. In 3 of the 6 stomachs containing material other than the waste food parts of Diptera and Coleoptera larvae, insect eggs and plant debris formed the total volume of contents (Table 2). In 2 of the remaining 3 chubs chironomid and gyrinid larvae were the only organisms complete enough to be identified. A 30.9 mm juvenile chub was the total stomach contents of the sixth chub (124.9 mm), a single record of apparent intraspecific predation (Table 2).

TABLE 2

The Stomach Contents of 6 Mohave chubs

Standard length (mm)	Date collected	Stomach contents	
		Identified organisms and % volume	% Organic debris
131.0	3-15-69	none	100%
124.9	3-15-69	(1) G. b. mohavensis 100%	none
114.4	3-15-69	gyrinid larvae 9%	90.9%
106.5	3-15-69	none	100%
161.0	3-14-70	chironomid larvae .6% gyrinid larvae 1.8%	97.5%
112.0	3-14-70	none	100%

DISCUSSION

The endangered status of *G. b. mohavensis* has resulted in a program to preserve this subspecies. The natural population of Mohave chubs at Zzyzx Mineral Springs Resort is in no immediate danger of extinction as long as the main pond is maintained by the present tenant. A management plan will be formulated by a committee appointed by the symposium on rare and endangered fishes of the Death Valley System (Pister, 1969) if the present tenant is evicted. The resort is located on an invalid mining claim which is being reviewed by the Federal Government. Introduction of the chub into other ponds in the study area and into refugiums in California and Nevada increases its chance for survival. *Cyprinodon salinus* has existed together with *G. b. mohavensis* in the main pond since the first introduction of *C. salinus* in 1939. Both species are still present in large numbers, and it would appear that apparent restriction of *C. salinus* to only the shallowest areas of the pond has in part contributed to the coexistence of both species. The high density of aquatic grass in the pond during the spawning season provides shelter for young chubs and a large surface area for attachment of developing eggs.

Collections and observations indicate that the chub population passes the winter months in a torpid state on the bottom of the pond. Evans (1969) reported that another cyprinid, the Lahontan redside (*Richardsonius egregius*), also spends the winter in an inactive state in deeper water of Lake Tahoe. *G. b. mohavensis* probably becomes inactive during the winter in response to decreased water temperatures. Kendeigh (1961) stated that seasonal variations in temperature may be great in ponds because of the small volume of water and that fish and other aquatic animals must become inactive to survive low water temperatures. The torpid state of the chubs during the winter when food organisms are also inactive is probably a survival factor. The solitary behavior of the largest individuals (180 mm +) during periods of activity may be a response to a difference in size with smaller chubs associated in schools. Since members of a school are about the same size (Marshall, 1966) the small number of large chubs (probably less than 15) apparently leave the schools of smaller chubs and move to the north central area of the pond.

The extended spawning season, apparent resumption of spawning in early fall, and the ability of chubs to spawn at age 1+ increase the probability for survival of this endangered subspecies. The long spawning period (February through May) of *G. b. mohavensis* should serve to decrease competition between larval fish and therefore result in a more effective use of the food supply insuring the survival of more young. Spawning at age 1+ reduces the time needed for chubs to populate other refugiums as well as to restore the natural population after a catastrophe. Greenfield, Ross and

Deckert (1970) attributed the survival of the Santa Ana Sucker (Catostomus santaanae) in small southern California rivers to its prolonged breeding season, early maturity and high fecundity.

There is an increase in egg number with age as well as with body size in G. b. mohavensis (Figure 3 and 5). Large numbers of ripe eggs in individuals in the 4+ age-group (one 215 mm specimen contained an estimated 49,847 eggs) indicate that some chubs are productive for at least 3 years as well as increasing in productivity with age.

The relationship between age and length was nearly linear. The wide range and overlap of standard lengths of G. b. mohavensis for age-group 1+, 2+, and 3+ may be the result of a long spawning season and probable spawning period in the fall. Kimsey (1954) suggested that a wide overlap of size ranges of year classes in the Eagle Lake tui chub were probably caused by the extended spawning period. The cause of the apparent death of a large number of chubs (reduction from 48 to 6) from the 2+ to the 3+ age-group is unknown and may affect the survival of this subspecies adversely. Death from old age is probably not a factor in the reduction of G. b. mohavensis in the 2+ age-group, since at least some of the Eagle Lake tui chubs, a subspecies related to the Mohave chub, live as long as 7 years (Kimsey, 1954).

A preliminary analysis of food habits indicates that mature Mohave chubs feed primarily on waste food, Diptera and Coleoptera larvae and insect eggs. Although adult and immature Diptera and Coleoptera and other aquatic insects are abundant in the shallow areas of the pond, the mature chubs spend most of their time in the deeper east end where the waste food is thrown. The large percentage of stomachs containing only waste food (61.6%) demonstrates that the chubs eat food that is most available and easiest to procure. Because the Mohave chub is apparently a generalized feeder the addition of waste food to the natural food supply of the pond probably increases its potential for survival. The single record of apparent intraspecific predation may be a factor in regulating the size of the population.

REFERENCES

California Fish and Game Commission. 1971. California Fish and Game Code, article 1, sections 900-903; 3511, 4700, 5050, and 5152 (Pursuant to the California Endangered Species Act of 1970 and sections 2050-2055 of the Fish and Game Code), Sacramento, Calif.

Evans, Douglas H. 1969. Life history studies of the Lahontan redside, Richardsonius egregius, in Lake Tahoe. Calif. Fish and Game, 55(3): 197-212.

Greenfield, David W., Stephen T. Ross, and Gary D. Deckert. 1970. Some aspects of the life history of the Santa Ana sucker, Catostomus (Pantosteus) santaanae (Snyder). Calif. Fish and Game, 56(3): 166-179.

Hubbs, C. L. 1943. Terminology of early stages of fishes. Copeia 1943 (4): 260.

Hubbs, C. L. and Robert R. Miller. 1943. Mass hybridization between two genera of cyprinid fishes in the Mohave Desert, California. Pap. Mich. Acad. Sci., Arts, and Let., 28: 343-378.

Kendeigh, Charles S. 1961. Animal Ecology. 3rd ed. Prentice-Hall, Inc., Englewood Cliffs, N. J. 468 pp.

Kimsey, J. B. 1954. The life history of the Tui chub, Siphateles bicolor (Girard), from Eagle Lake, California. Calif. Fish and Game, 40(4): 395-410.

Lagler, Karl. 1956. Freshwater Fishery Biology. 2nd ed. Wm. C. Brown Company, Dubuque. 421 pp.

Marshall, N. B. 1966. The Life of Fishes. The World Publishing Company, Cleveland and New York. 402 pp.

Miller, R. R. 1968. Records of some native freshwater fishes transplanted into various waters of California, Baja California, and Nevada. Calif. Fish and Game. 54(3): 170-179.

_____________ 1973. Two new fishes, <u>Gila bicolor snyderi</u> and <u>Catostomus fumeiventris</u> from the Owens River Basin, California. (in press, Copeia).

Pister, Edwin P. 1969. The rare and endangered fishes of the Death Valley system, a summary of the proceedings of a symposium relating to their protection and preservation. Calif. Dept. of Fish and Game (Memo. Report) Sacramento, 18 pp. (unpublished).

Snyder, John Otterbein. 1919. The fishes of the Mohave River, California. Proc. U. S. Nat. Mus. 54: 298.

St. Amant, James A. and Shoken Sasaki. 1971. Progress report on the reestablishment of the Mojave chub, <u>Gila mohavensis</u> (Snyder), an endangered species. Calif. Fish and Game. 57(4): 307-308.

Uyeno, Teruya. 1960. Osteology and phylogeny of the American cyprinid fishes allied to <u>Gila</u>. Doctoral dissertation, Univ. Mich., 174 pp.

APPENDIX I

AGE AND GROWTH

Date of sample: March 14, 1970

fish no.	sex	SL mm	no. of scale annuli	age-group
1	female	179.5	4	4+
2	female	161.0	4	4+
3	male	135.0	3	3+
4	female	130.0	3	3+
5	female	125.0	3	3+
6	female	116.0	3	3+
7	female	137.8	3	3+
8	male	124.2	3	3+
9	female	120.5	2	2+
10	female	112.0	2	2+
11	female	107.0	2	2+
12	male	120.0	2	2+
13	male	114.6	2	2+
14	female	120.0	2	2+
15	female	114.6	2	2+
16	female	113.0	2	2+
17	female	113.0	2	2+
18	male	109.0	2	2+
19	male	109.0	2	2+
20	female	108.0	2	2+
21	female	107.8	2	2+
22	male	107.2	2	2+
23	female	111.0	2	2+

AGE AND GROWTH

Date of sample: March 14, 1970

fish no.	sex	SL mm	no. of scale annuli	age-group
24	female	106.2	2	2+
25	male	107.6	2	2+
26	female	102.5	2	2+
27	male	105.0	2	2+
28	male	106.8	2	2+
29	male	102.7	2	2+
30	female	105.0	2	2+
31	female	105.3	2	2+
32	male	102.2	2	2+
33	female	101.5	2	2+
34	female	104.0	2	2+
35	female	98.9	2	2+
36	male	102.9	2	2+
37	male	97.9	2	2+
38	male	99.0	2	2+
39	female	99.7	2	2+
40	female	98.5	2	2+
41	male	95.9	2	2+
42	male	98.2	2	2+
43	female	94.9	2	2+
44	male	94.9	2	2+
45	male	95.7	2	2+
46	female	92.4	2	2+

AGE AND GROWTH

Date of sample: March 14, 1970

fish no.	sex	SL mm	no. of scale annuli	age-group
47	male	89.6	2	2+
48	female	93.8	2	2+
49	male	85.9	2	2+
50	female	90.4	2	2+
51	male	84.9	1	1+
52	male	91.4	2	2+
53	female	87.0	2	2+
54	female	84.6	1	1+
55	female	89.6	2	2+
56	male	85.2	1	1+
57	male	84.5	1	1+
58	male	82.2	1	1+
59	male	88.0	2	2+
60	male	85.0	2	2+
61	male	76.1	2	2+
62	female	69.6	1	1+
63	female	68.9	1	1+
64	female	68.5	1	1+
65	male	67.8	1	1+
66	male	67.6	1	1+
67	male	67.4	1	1+
68	male	66.4	1	1+
69	female	64.9	1	1+

AGE AND GROWTH

Date of sample: March 14, 1970

fish no.	sex	SL mm	no. of scale annuli	age-group
70	male	66.0	1	1+
71	male	66.8	1	1+
72	female	64.5	1	1+
73	male	68.0	1	1+
74	male	66.1	1	1+
75	male	65.9	1	1+
76	male	65.9	1	1+
77	male	64.7	1	1+
78	male	63.3	1	1+
79	female	64.9	1	1+
80	male	63.9	1	1+
81	male	61.1	1	1+
82	male	61.1	1	1+
83	male	61.3	1	1+
84	female	61.3	1	1+
85	female	61.3	1	1+
86	female	61.0	1	1+
87	male	62.5	1	1+
88	male	58.6	1	1+
89	male	60.8	1	1+
90	female	58.2	1	1+
91	male	60.0	1	1+
92	male	56.3	1	1+

AGE AND GROWTH

Date of sample: March 14, 1970

fish no.	sex	SL mm	no. of scale annuli	age-group
93	male	59.3	1	1+
94	male	59.2	1	1+
95	female	56.8	1	1+
96	female	55.0	1	1+
97	male	57.9	1	1+
98	male	57.1	1	1+
99	male	57.2	1	1+
100	female	60.7	1	1+
101	male	58.5	1	1+
102	female	56.9	1	1+
103	male	58.0	1	1+
104	female	55.3	1	1+
105	male	54.6	1	1+
106	female	53.7	1	1+
107	male	53.7	1	1+
108	female	41.8	0	0+
109	female	37.3	0	0+
110	male	35.0	0	0+
111	female	34.0	0	0+
112	female	31.1	0	0+
113	male	26.5	0	0+