REPRINT FROM
Calif. Fish and Game, 56(3) ; 166-179.1970.

SOME ASPECTS OF THE LIFE HISTORY OF THE SANTA ANA SUCKER, CATOSTOMUS *(PANTOSTEUS)* SANTAANAE (SNYDER)[1]

DAVID W. GREENFIELD,[2] STEPHEN T. ROSS[3] and GARY D. DECKERT[4]
Department of Biology, California State College, Fullerton

The life history of *Catostomus* santaanae, a small fluviatile species of the subgenus *Pantosteus* occurring in the Santa Clara River, California, was studied from April 1968 to August 1969. Peak spawning activity occurred during *May* and June with a few individuals spawning as early as March and at least as late as July. Fecundity in six individuals ranged from 4,423 to 16,151. The fertilized ova are demersal and adhesive. C. santaanae matures at 1+ with only a few individuals reaching the 3+ age-group. A vertebral deformity was observed in up to 3.47% of the individuals in the monthly samples. However, this apparently did not result in a selective disadvantage in terms of survival. The species is well adapted for survival in streams subject to heavy flooding, both in its ability to withstand rapid currents and also in its ability to repopulate rapidly following the loss of a large percent of the population.

INTRODUCTION

The Santa Ana sucker, *Catostomus santaanae* (Figure 1), is the only native catostomid found in the coastal drainages of southern California and is one of the three native primary freshwater fishes in this area. The other two species are the speckled dace, *Rhinichthys osculus*, and the arroyo chub, *Gila orcuttii.* While investigating the systematic relationships of *Gila orcuttii* (Greenfield, MS) and the unarmoured threespine stickleback, *Gasterosteus aculeatus williamsoni* (Ross, 1969), we were able to collect large numbers of *C. santaanae* in the Santa Clara River, Los Angeles County at Soledad Canyon. The purpose of this report is to describe some aspects of the life history of the Santa Ana sucker, which has not been previously investigated.

C. santaanae was first described by Snyder as *Pantosteus santa-anae* from the Santa Ana River near Riverside, California (Snyder, 1908). Smith (1966) amended the specific name to eliminate the hyphen and relegated *Pantosteus* to a subgenus of *Catostomus.* Although the number of individuals in southern California rivers has been greatly reduced by the effects of man (Miller, 1961), *C. santaanae* may still be collected in the Santa Ana River, Orange County, the San Gabriel and Big Tujunga rivers, Los Angeles County, and the Santa Clara River, Ventura and Los Angeles counties.

Miller (1968) suggested that *C. santaanae* was not native to the Santa Clara River ; however, this supposition was based on only negative evidence. *C. santaanae* in the Santa Clara River has been influenced in the past by genes from the Owens Valley sucker, *Catostomus* sp. (Hubbs, Hubbs and Johnson, 1943 and Smith, 1966). Thus it is pos-

[1] Accepted for publication January 1970.
[2] Present address : Dept. Biol. Sci., Northern Illinois University, DeKalb, Illinois.
[3] Present address: Dept. Zoology, University of South Florida, Tampa, Florida.
[4] Present address: Dept. Biol. Sci., Northern Illinois University, DeKalb, Illinois.

sible that the following information on the life history of *C. santaanae* might differ from that of populations in other drainages.

METHODS AND MATERIALS

Specimens were collected monthly from April 1968 to December 1968, with the exceptions of May and August, and from February 1969 to August 1969, with the exception of July, at two separate stations on the Santa Clara River (Figure 2), totaling 3,359 individuals. The first station was located 1 1 miles east of the Antelope Valley Freeway offramp on Soledad Canyon Road, just west of Bee Canyon. The river here is from 3 to 6 ft wide and generally less than 1 ft deep during most of the year. The bottom is composed of rock and sand, with very

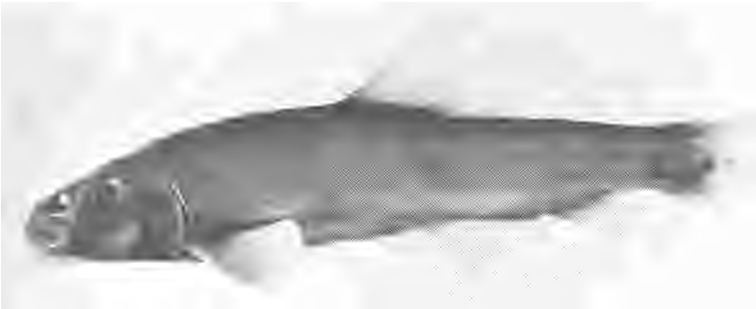

FIGURE 1. The Santa Ana sucker, *Catostomus* santaanae (male; 77.2 mm SL). Photography by S. Ross.

little aquatic vegetation. Seasonal water temperatures varied from 10 to 26 C. The second station was located 4 miles upstream from the first station on Soledad Canyon Road at a U.S. Forest Service Campsite, and was similar to the first station with the exception of increased streamside vegetation.

All specimens were collected with a .087 inch mesh minnow seine, 3 ft by 4 ft long, or a bag seine, 6 ft deep and 20 ft long with inch stretch mesh wings and a .087 inch mesh bag. They were preserved in 10% formalin and later transferred to 40% isopropyl alcohol. Standard length was measured to the nearest 0.1 mm, using dial calipers.

Annuli were not well defined on the scales and were not used for aging. Otoliths were removed from 50 fish and cleaned in xylene. Otoliths allowed satisfactory age determination for approximately 20% of those examined. The results were related to the length-frequency diagrams. Dry otolith weight for 20 specimens (29-90 mm) was determined using a Mettler balance.

The time of spawning was determined using three techniques : increase of mean *egg* diameter throughout the season, the maturity index, and the first major appearance of young.

Fecundity estimates were made from samples of ovaries from six fish ranging in size from 77.8 to 158.2 mm. Weight of the fish, standard length, and weights of both the left and right ovaries were recorded. The ovaries were weighed after excess fluid and adhering foreign tissue

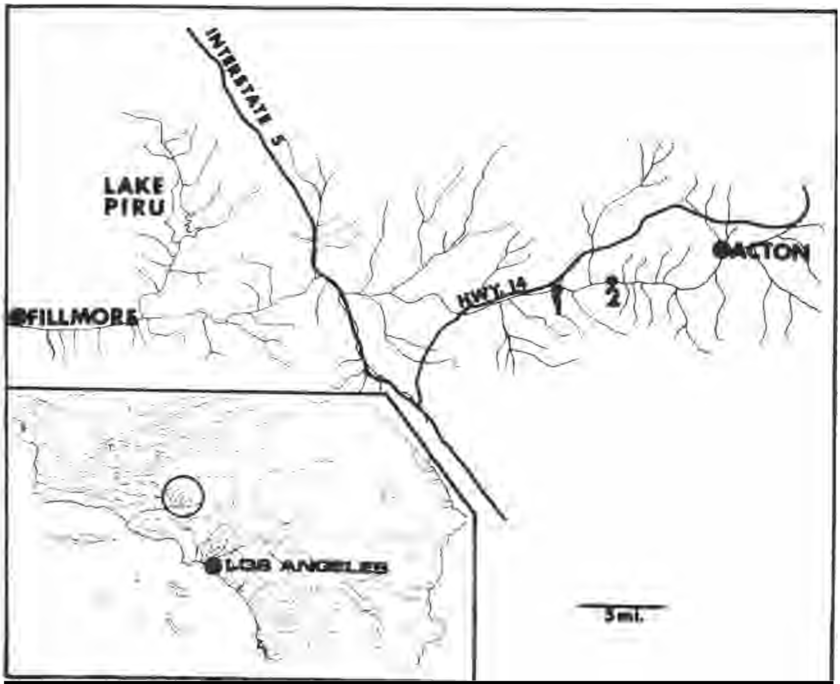

FIGURE 2. Map of study area, showing station 1 and 2 on the Santa Clara River.

were removed. Samples of eggs were removed at random from each ovary and separated into groups of 150, 100 and 50, while submerged in alcohol to prevent drying. Each of the three samples was dried on absorbant paper prior to weighing to remove excess alcohol. Each sample was weighed on a Mettler balance and the number of eggs per gram computed. An average number of eggs per gram was calculated from the three samples to determine the number of eggs per ovary.

The mean egg diameters for December 1968 and February, March and May 1969 were determined by randomly removing 20 ova per fish from the left ovary of several of the largest females. The ova were arranged in a straight line irrespective of size and viewed with a dissecting microscope equipped with an ocular micrometer.

Thirty-four specimens from the period of June 1968 to May 1969 were utilized to calculate the seasonal trend in the gonadal-somatie, or maturity index $\left(\frac{\text{ovary weight X 100}}{\text{body weight}}\right)$ (James, 1946). The left ovaries were removed, dried for 4 min on absorbent paper, and weighed. The average maturity index for each month was then calculated and plotted against time to show the progressive increase in relative ovary size up to a peak just prior to spawning.

Stomach contents were obtained from 48 suckers, 27 to 57 mm, collected on October 4, 1968. All specimens were injected with 10% formalin and returned to the laboratory for analysis. The posterior limit of the stomach was arbitrarily chosen as the middle of the first reverse bend (MacPhee, 1960). Stomach contents were removed to this point and a total wet weight was obtained on the Mettler balance. The organisms were sorted, identified to family, and again weighed according to category. The percentage contribution of each food category to the total weight of the stomach contents was then computed.

Ripe female and male specimens of C. *santaanae* were collected on April 17, 1968, at Station 2, and artificially spawned at 1800 hours. The fertilized ova were brought to the laboratory and hatched in a one-quart jar at 13C. Samples of the various developmental stages were preserved and photographed.

DEVELOPMENT

Development from fertilization until hatching took 360 hours at 13 C. The fertilized ova were demersal and adhesive, averaged 2.2 mm in diameter, and had a transparent egg membrane with a light yellow yolk. The perivitelline space was about one-fifth the diameter of the yolk. Two hours after fertilization the blastodisc had formed and covered approximately one-fifth the diameter of the yolk. At 45 hours after fertilization, epiboly had continued so that the germ ring was slightly less than one-half of the way down the yolk. The embryo was clearly visible at 123 hours and extended three-fourths of the distance around the yolk. The myomeres were visible at 148 hours, and by 171 hours the caudal segment had lifted from the yolk and the embryo exhibited considerable movement. The eyes were pigmented by 315 hours at which time the auditory vesicles were visible. At hatching (360 hours) the prolarva was approximately 7 mm in total length, with the head still bent forward. The pectoral buds were present at this stage. At 26 hours after hatching, the head had straightened out and the dorsal fin fold was visible more anteriorly, originating anterior to the midpoint of the body (Figure 3). A 14.8 mm prejuvenile collected on

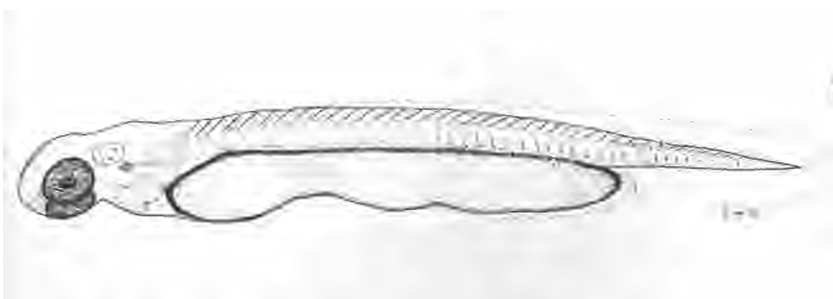

FIGURE 3. Prolarvae 26 hours after hatching (8.9 mm TL). The head has straightened out and both the dorsal and anal fin folds have advanced anteriorly.

June 12, 1968 had remnants of both the dorsal and ventral fin folds still present (Figure 4). The dorsal, caudal and pectoral fins were developed ; however, the anal fin was only partially developed and the pelvic fins were represented only by fin buds. The mouth was still terminal. The mouth becomes subterminal at about 16 mm. Pigmenta-

FIGURE 4. A prejuvenile C. *santaanae*, 14.8 mm SL. The dorsal, caudal, and pectoral fins are developed while the anal fin is only partially developed, and the pelvic fins are rudimentary.

tion was heaviest along the dorsal surface, with a diamond shaped concentration of melanophores above the eyes. A line of pigmentation was located laterally at the level of the vertebral column.

FECUNDITY

The total fecundity of six specimens ranged from 4,423 (8.57 g and 77.8 mm) to 16,151 (69.35 g and 158.2 mm) (Figure 5). A linear relationship between body weight and number of eggs was observed. No females under a length of 49 mm or 2.05 g contained eggs.

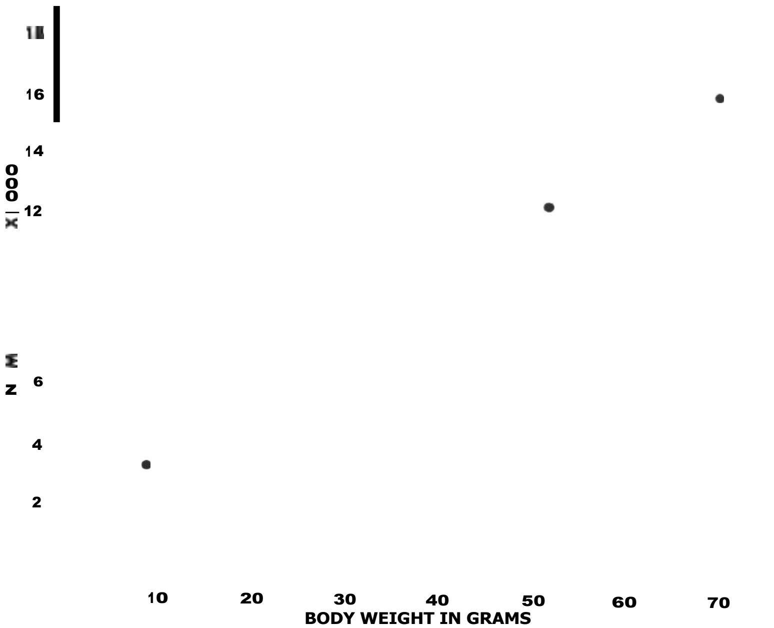

FIGURE 5. The relationship of egg number to body weight for C. *santaanae*.

TIME OF SPAWNING

From our observations the peak of spawning occurred during late May and through June, with the first major appearance of young in early June. The mean egg diameter for December 1968 was 0.10 mm and increased to 1.25 mm in May 1969 (Figure 6). The maturity index was low from June 1968 to December 1968 with a sharp increase after

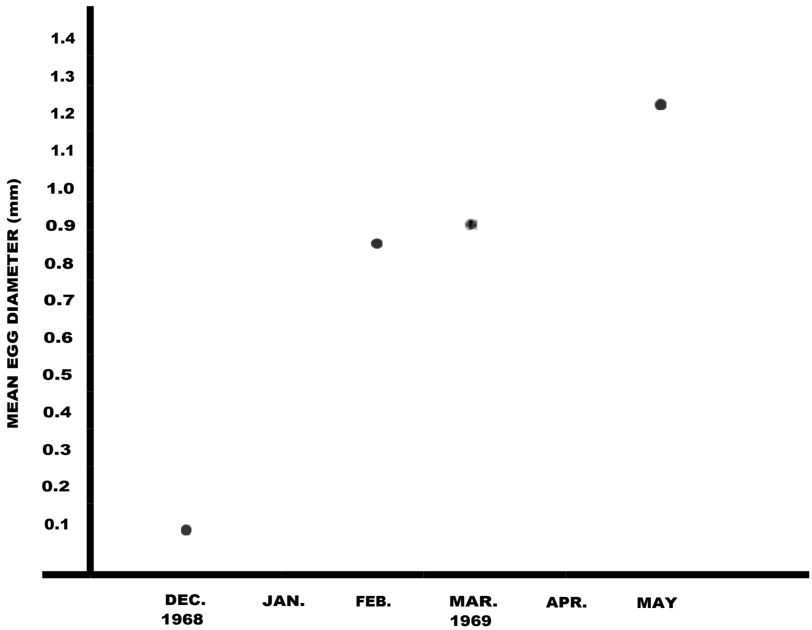

FIGURE 6. The increase in mean egg diameter over a 6-month period.

January 1969 (Figure 7). Only one size group of eggs was found in each ovary. The wide range of variability in the maturity index for February indicates that ova development in some individuals was well advanced at this time. Also, the presence of a few fish 25 mm in April and 31 mm in May of 1968 indicates that some fish had spawned as early as the first week in April. Young fish (10-11 mm) were still present in the July 21, 1968 sample, indicating that spawning had taken place as late as early July. The presence and distribution of breeding tubercles in both the males and females is discussed by Smith (1966).

AGE AND GROWTH

Length frequency data from April 1968 through August 1969 are presented in Figure 8. The 0+ age-group of the 1968 year class was followed from June through December (Figure 9). The mean length of the 0+ age-group in December was 44 mm.

Following Hubbs (1943), the 0+ age-group then becomes the 1+ age-group as of January 1, 1969. Due to the small sample size and the overlap of the size ranges in the 1+, 2+ and 3+ age-groups, mean length values were not determined.

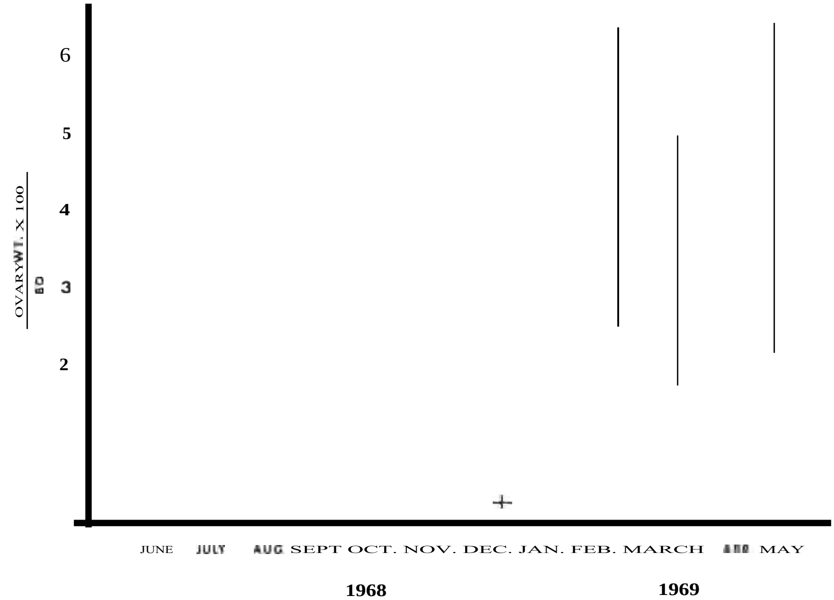

FIGURE 7. The maturity index for a 12-month period beginning after the termination of the 1968 spawning season.

Although scales were unreliable for age assessment due to the lack of conspicuous annuli on even the largest specimens, scale width increased in a linear relationship to standard length (Figure 10), thus allowing an estimation of age from scale width for scales which may be recovered from the stomachs of piscivores.

Otolith growth rings were observed in only 10 out of 50 specimens examined, because the otoliths are extremely small in the Ostariophysi, and they rapidly become spherical with increasing age, thereby inhibiting reading. Age determinations based on otoliths correlated well with expected ages from the length frequency distribution. Specimens 26, 36, 42, and 51 mm from October 1968 were read as being in the 0+ age-group. A specimen 61.5 mm from October 1968 was read as being in the 1+ age-group, while individuals 77 and 83 mm from October 1968 and one 110 mm from December 1968 were in the 2+ age-group. Two large specimens, 141. and 153 mm, collected in February 1969, were members of the same age-group, but since it was past January 1, would be classified as age-group 3+. The relatively large range for the 2+ age-group, 77 to 110 mm, is most likely the result of the prolonged spawning season.

Apparently most fish die while in the 2+ age-group, with a few carrying on into the 3+ age-group. The age and length at maturity data show that spawning first occurs during the spring following hatching at age 1+, and that males and females then spawn a second time the next year while in age-group 2+.

Otolith weight exhibited a curvilinear relationship to standard length, so that it apparently becomes less accurate as an estimate of age after a standard length of about 65 mm (Figure 11).

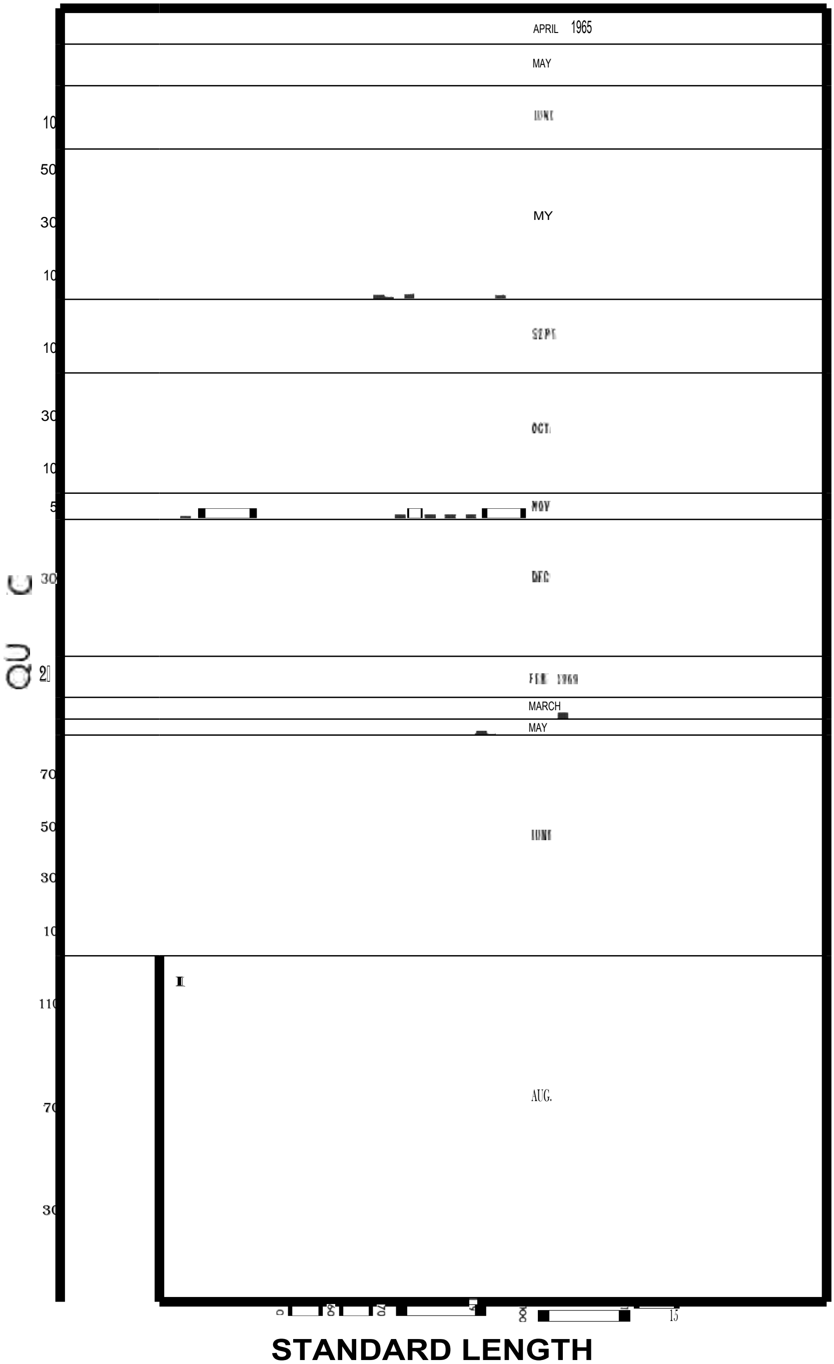

FIGURE 8. Length-frequencies (mm SL) of C. santaanae from Soledad Canyon, Santa Clara River from April, 1968 to August, 1969.

Indication of differences in growth rates between the males and females was not found. The sex ratio remained 1: 1 throughout their life history.

STOMACH CONTENTS

The stomach contents of the 48 suckers examined indicated that 97.53% of the stomach contents by weight consisted of detritus, algae and diatoms, 1.16% of hydrophilid larvae, and the remaining 1.31% larval Plecoptera, Odonata, Helodidae, Hydraenidae, Hydroptilidae, Rhyachophilidae, Empididae and Culicidae, as well as miscellaneous fish scales and eggs. A trend towards an increase in the number of aquatic insect larvae with size was noted.

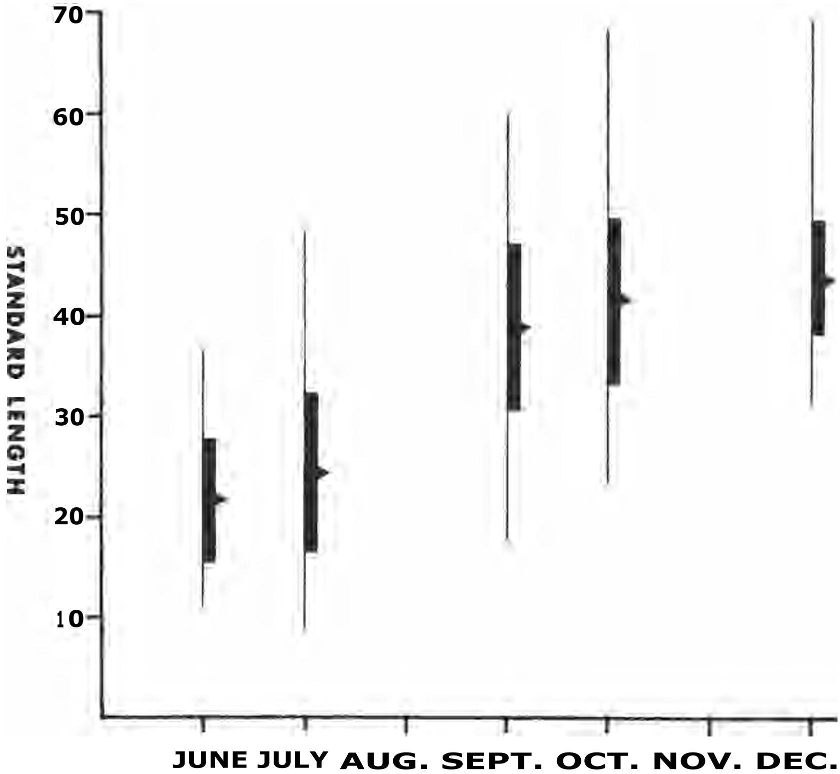

FIGURE 9. Growth curve of the 0+ age-group (mm SL), 1968 year class, of C. santaanae from the Santa Clara River. Triangles indicate mean, heavy bars one standard deviation on each side of the mean, and lines, the range.

EFFECTS OF FLOODING ON POPULATION LEVELS

During the winter of 1969 the Santa Clara River flooded in late January and once again in mid-February. One week after the first flood, hour of sampling at each of the two stations yielded 120

C. santaanae as compared to 225 in December. The specimens 141 and 153 mm that were taken in the February 1969 sample were larger than any previously collected. They apparently escaped from a private recreational lake during the first flood. The fact that these two individuals belonged in the same age-group as fish 40 mm shorter suggests that the growth of the river population is slower than that of the pond population.

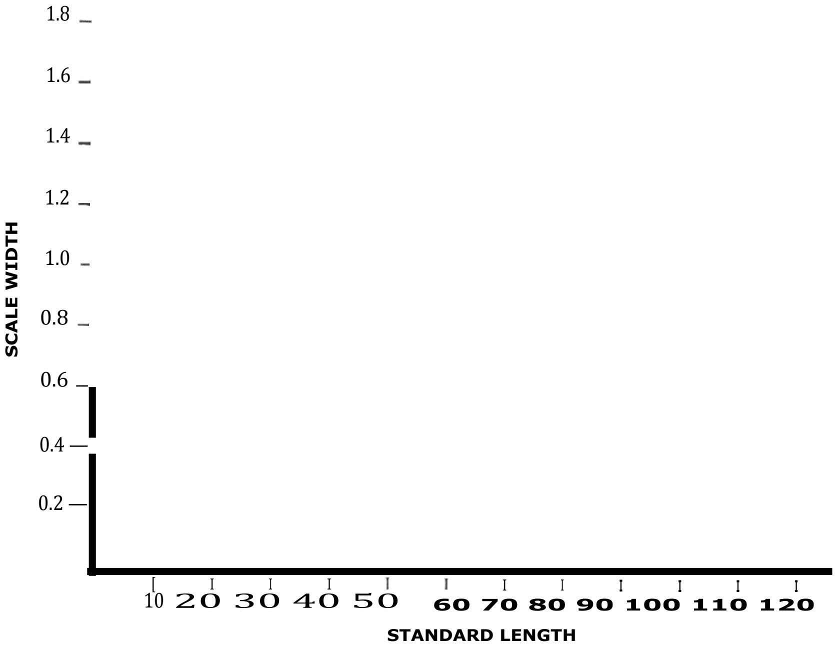

FIGURE 10. Relationship of scale width (mm) to standard length (mm) for C. santaanae.

There was a considerable reduction in the numbers of *Gila orcuttii* and *Gasterosteus aculeatus williamsoni* following the floods. The mosquito fish, *Gambusia affinis,* present prior to flooding, has not been collected since the first flood. Numbers of all species remained low until June 1969 (Table 1).

TABLE 1

Numbers of Fishes Collected in the Santa Clara River Subsequent to the 1969 Winter Floods

Date	*Catostomus santaanae*	*Gila orcuttii*	*Gasterosteus aculeatus williamsoni*	*Gambusia affinis*
March 8, 1969 - - - - - - - - - - - - - - -	37	0	0	0
April 8, 1969 - - - - - - - - - - - - - - - -	1	1	0	0
May 13, 1969 - - - - - - - - - - - - - - - -	10	0	0	0
June 20, 1969 - - - - - - - - - - - - - - - -	316	15	1	0
August 22, 1969 - - - - - - - - - - - - - -	1,308	9	14	0

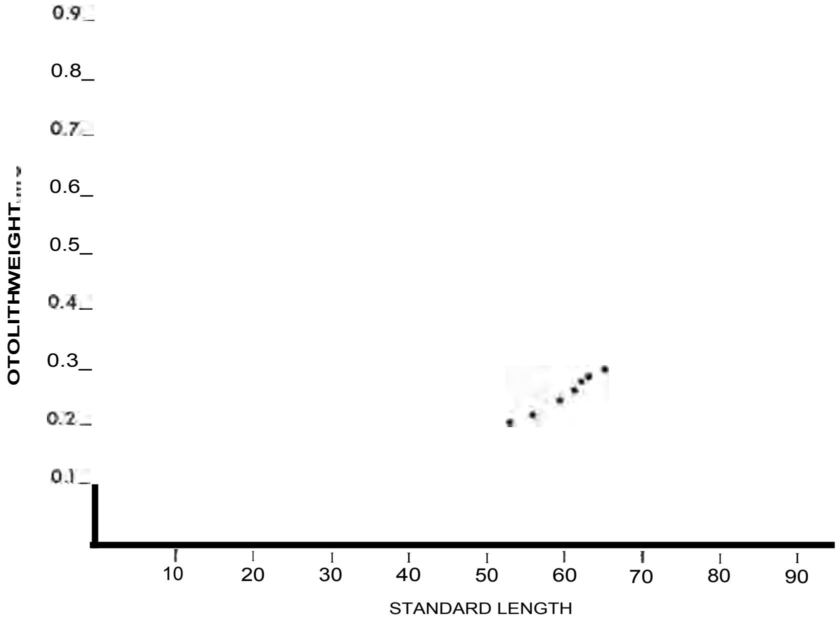

FIGURE 11. Relationship of otolith weight to standard length (mm) for C. santaanae.

DEFORMED VERTEBRAE

Throughout the study various individuals were collected which exhibited a vertebral deformity, kyphosis, consisting of an upturn of the vertebral column in the region of the posterior trunk and anterior caudal vertebrae. The percentage occurrence of deformed individuals taken during sampling ranged from 0 to 3.47% (Table 2). In over 60% of the deformed individuals, the centra were crowded and shortened (Figure 12). No difference existed in the number of post-weberian vertebrae between normal and deformed individuals. The counts fell within the range of 39 to 42 presented by Smith (1966) with a median

FIGURE 12. Radiograph of C. santaanae (37.2 mm SL) showing typical vertebral deformation.

number of 40. The lack of deformed fish for several months is most likely the result of smaller sample sizes. It is interesting that this deformity was in members of various year classes, indicating that it has been in the population for a number of years.

Amin (1968) reported vertebral kyphosis for *Catostamus insignis* and, to a lesser extent, for *C. clarkii* from the Lower Salt River, Tempe, Arizona. A suggestion was made that a high pesticide concentration might be responsible. However, data on the presence of pesticides in the Santa Clara River are not available. Hubbs (1959) linked vertebral deformities with high water temperatures, a situation which would apply to *C. santaanae* larvae hatched during the latter part of the breeding season. Patten (1968) reported greatly reduced swimming ability in fish with fused or compressed vertebrae. He also stated that increased mortality of the deformed individuals with age was not apparent for *Rhinichthys osculus.* Deformed *C. santaanae* as large as 54 mm were collected in August 1969, indicating that they were able to withstand the flooding conditions. This would indicate that the deformed individuals are not selected against, at least in respect to maintaining themselves in rapid currents. The percentage of deformities for August (1.52) is not significantly lower than other percentages in months prior to the flooding.

TABLE 2

Percentage Occurrence of Deformed Vertebral Columns in Catostomus santaanae From the Santa Clara River, California

Date	Number deformed	Total number in collection	Percentage deformed
September 15, 1967	0	24	0
March 27, 1968	0	6	0
April 17, 1968	0	84	0
June 27, 1968	5	144	3.47
July 21, 1968	1	463	0.22
September 3, 1968	5	201	2.45
October 4, 1968	1	262	0.43
November 11, 1968	1	64	1.56
December 18, 1968	4	267	1.49
February 12, 1969	0	21	0
March 8, 1969	0	37	0
May 13, 1969	0	10	0
August 22, 1969	20	1,308	1.52

DISCUSSION

The Santa Ana sucker, *C. santaanae,* seems well adapted to life in small southern California rivers which experience periodic flooding. The rapid repopulation of the Santa Clara River following severe flooding in the winter of 1969 indicates that the relatively few individuals remaining after the flooding were, as a result of their prolonged spawning period and high fecundity, able to return to previous population levels in a single breeding season. The prolonged breeding season would tend to reduce the competition between larval forms and thus more efficiently utilize the available food resources, resulting in an increase in larval survival. The ability to spawn while in the 1+ age-group contributes to the high intrinsic rate of increase for the population.

Spawning by the 1+ age-group is likely also to occur in several other species of the subgenus *Pantosteus* (Smith, 1966), and all species in this subgenus begin spawning at least by the 2+ or 3+ age-groups (Smith, 1966; Hauser, 1969). This is in marked contrast to the larger, more lacustrine suckers of the subgenus *Catostomus,* which generally do not mature until at least age-groups 4-5 (Bailey, 1969; Harris, 1962; Spoor, 1938).

Fecundity is well above the 990 (131 mm TL) to 3,710 (184 mm TL) range reported by Hauser (1969) for *C. pla,tyrhynchus,* also in the subgenus *Pantost ens.* Fecundity for *C. catostomus* was reported by Bailey (1969) to range from 14,000 (352.7 mm TL) to 35,000 (449.2 mm TL). Stewart (1926) reported fecundity for C. *commersonii* to be 31,200 in a 380 mm individual. Both of the above species are in the subgenus *Catostomus.*

The food habits of the smaller members of the 0+ age-group may also enable *C. santaanae* to rapidly repopulate a flooded area, since the young feed primarily on algae, diatoms, and detritus. Aquatic insects become a significant part of their food after they approach the 1+ age-group. The "top-feeding" behavior for prolarvae of *C. macrocheilus* (MacPhee, 1960) was not noted for *C. santaanac* since our food analysis utilized individuals 27 mm or larger, and the shift in feeding habits associated with the movement of the mouth from a terminal to subterminal position and the increased length of the digestive tract had already taken place.

The cause of the vertebral deformity noted in *C. sa.ntaanae* is unknown. The effects of predators as an agent in eliminating unfit individuals is also unknown, but there is a lack of larger predatory fish in this river.

The suggestion by Smith (1966) that there might be dual spawning in the spring and fall appears unfounded, while the alternate suggestion of protracted spawning is supported.

ACKNOWLEDGMENTS

We wish to thank all persons who helped with this study. In particular, R. Bagube assisted with the food analysis ; J. W. Wiley, R. H. Cornelius, T. Arambula and D. Wildrick helped with the field work. T. Arambula also typed the final manucript.

REFERENCES

Amin, O. M. 1968. Deformed individuals of two species of suckers, *Catostomus insignis* and *C. clarkii,* from the Gila River system, Arizona. Copeia 1968(4) : 399-401.

Bailey, M. M. 1969. Age, growth, and maturity of the longnose sucker *Catostomus catostomus,* of western Lake Superior. Jour. Fish. Res. Bd. Canada 26(5) : 1289-1299.

Harris, R. H. D. 1962. Growth and reproduction of the longnose sucker, *Catostomus catostomus* (Forster), in Great Slave Lake. Jour. Fish. Res. Bd. Canada 19(1) : 113-126.

Hauser, W. J. 1969. Life history of the mountain sucker, *Catostomus platyrhynchus,* in Montana. Trans. Amer. Fish. Soc. 98(2) : 209-215.

Hubbs, C. 1959. High incidence of vertebral deformities in two natural populations of fishes inhabiting warm springs. Ecology 40: 154-155.

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

Hubbs, C. L., L. C. Hubbs and R. E. Johnson. 1943. Hybridization in nature between species of catostomid fishes. Contr. Lab. Vert. Biol., Univ. Mich. 22: 1-76.

James, M. F. 1946. Histology of gonadal changes in the bluegill, *Lepomis macrochirus*, and the largemouth bass, *Huro salmoides*. Jour. Morph. 79(1) : 63–80.

MacPhee, C. 1960. Postlarval development and diet of the largescale sucker, *Catostomus macrocheilus*, in Idaho. Copeia 1960(2) : 119–125.

Miller, R. R. 1961. Man and the changing fish fauna of the American Southwest. Pap. Mich. Acad. Sci., Arts, and Letters. 46: 365–404.

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: 170–179.

Patten, B. G. 1968. Abnormal freshwater fishes in Washington streams. Copeia 1968 (2) : 399–401.

Ross, S. T. 1969. The systematics of *Gasterosteus aculeatus* Linnaeus in central and southern California. California State College at Fullerton, Master's Thesis, 87 p.

Smith, G. R. 1966. Distribution and evolution of the North American catostomid fishes of the subgenus *Pantosteus*, genus *Catostomus*. Misc. Publ. Mus. Zool., Univ. Mich., No. 129: 1–132.

Snyder, J. O. 1908. Description of *Pantosteus santa-anae*, a new species of fish from the Santa Ana River, California. Proc. U. S. Nat. Mus. 59: 23–28.

Spoor, W. A. 1938. Age and growth of the sucker, *Catostomus commersonnii* (Lacépède), in Muskellunge Lake, Vilas County, Wisconsin. Trans. Wis. Acad. Sci. Arts, and Letters 31: 457–505.

Stewart, N. H. 1926. Development, growth and food habits of the white sucker, *Catostomus commersonii* Lesueur. Bull. U. S. Bur. Fish. 42 : 147–184.

printed in CALIFORNIA OFFICE OF STATE PRINTING

80655-800 7-70 375
80722-250 7-70 700