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LIFE HISTORY STUDIES OF THE LAHONTAN REDSIDE, *RICHARDSONIUS EGREGIUS*, IN LAKE TAHOE[1]

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Lahontan redsides occur in Lake Tahoe in greatest numbers along the rocky shoreline and around piers during the summer. Few redsides were taken in water more than 40 ft deep or in areas of extensive sandy habitat. The redsides apparently spend the winter in a torpid state at depths of 10 to 50 ft. Spawning begins in early June, reaches maximum activity during late June, and continues at a slow rate through July and into August. Redsides form large aggregations and spawn over gravel and rocks along the shoreline and in tributaries. Males on the spawning grounds outnumber females. For 16 specimens the estimated average number of eggs per female was 1,125. A pronounced bilateral variation was evident in weight of the ovaries and number of eggs. The average lengths of males at annuli I, II, III, and IV were 33, 48, 65, and 73 mm, respectively. The corresponding lengths of females were 35, 52, 68, and 78 mm. The summer diet consisted mainly of surface foods (especially adult Diptera, Coleoptera, and Hymenoptera), chironomid larvae and pupae, and crustaceans. Hybrids between all three of the cyprinids in Lake Tahoe were discovered.

INTRODUCTION

The Lahontan redside, *Richardsonius egregius* (Girard), is a small cyprinid endemic to the Lahontan drainage system in western Nevada and adjacent northeastern California. Information on the ecology and life history of this species is rather scarce. Snyder (1917) offered a few notes on its distribution, spawning, and food habits. As part of his study on Lake Tahoe fishes, Miller (1951) considered food habits and some aspects of distribution and reproduction. This report considers the age and growth, food habits, reproduction, distribution, and movements of the Lahontan redside (Figure 1) in Lake Tahoe.

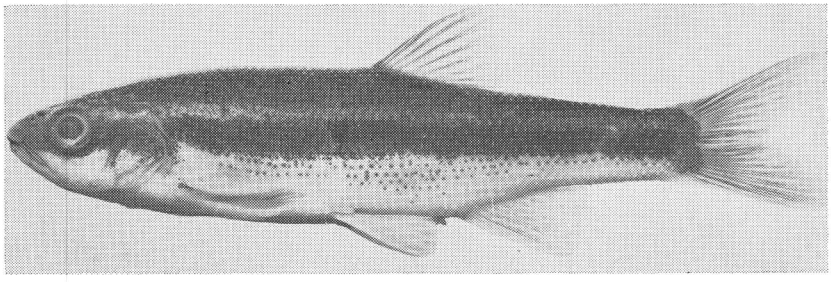

FIGURE 1—The Lahontan redside, *Richardsonius egregius* (male; 65.7 mm SL). *Photograph by Scientific Photographic Laboratory, University of California, Berkeley.*

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Lake Tahoe is situated in the Sierra Nevada at an elevation of 6,225 ft above sea level (for a map of Lake Tahoe see Cordone and Frantz, 1966). It is 21.6 miles long and 12 miles wide, and has a mean depth of about 1,027 ft and a maximum depth of 1,645 ft. It is an oligotrophic lake, and Secchi disk readings average about 90 ft (range 50 to 135 ft; McGauhey et al., 1963). Lake Tahoe has a single outlet, the Truckee River, which empties into Pyramid Lake, a remnant of pluvial Lake Lahontan.

Food habit studies (Miller, 1951, and Lake Tahoe Fisheries Study, unpubl. data) indicate that the redside is a minor component in the diet of Tahoe game fishes. It is insignificant in the diet of lake trout (*Salvelinus namaycush*), the principal game species (Weidlein, Cordone, and Frantz, 1965), and only moderately important in the diet of rainbow trout (*Salmo gairdnerii*).

METHODS

Redsides were collected by several techniques, including traps, gill nets, trawls, seines, and rotenone. The California and Nevada Fish and Game Departments conducted year-round fish collections as part of their study of Lake Tahoe fishes. Bottom gill nets were set monthly from July 1962 through July 1964 at various depths from 25 to 500 ft, with occasional sets made in deeper water. These nets consisted of multifilament nylon panels, which were 100 to 200 ft long by 11 ft deep. Each net contained panels of $\frac{5}{8}$-inch and 1-inch meshes (stretch measure), suitable for taking redsides, plus a number of larger meshes. In addition, gill nets made of monofilament nylon were fished in the limnetic zone of the lake throughout 1964. The panels were 50 ft long by 22 ft deep, and mesh sizes were 1 inch and larger. These nets were usually set in pairs, one at the surface, the other at either 50 or 100 ft.

Small, cylindrical, wire minnow traps ($8\frac{1}{2}$ x 17 inches) and large, rectangular traps (36 x 18 x 18 inches) were used to collect redsides. The large traps were usually set with the bottom gill nets. Traps were also set for a period of 4 or 5 days each month during parts of 1963 and 1964 at the Tahoe Boat Company pier (Tahoe City) and Obexer's pier (Homewood). Various baits were used in the traps, including bread, cheese, and canned dog food.

A 25-ft semiballoon otter trawl was used for bottom trawls at depths from 100 to 500 ft, conducted regularly during 1963, 1964, and part of 1962. Rotenone was used in selected shoreline stations from 1963 through 1966. The sample areas were encircled with long seines prior to the application of the rotenone; Baker (1967) gives additional details on sampling with rotenone.

Fecundity estimates were made from the ovaries of preserved specimens. A sample of each ovary was removed from three different regions, and comprised approximately one-fourth of the whole ovary. The eggs in the sample were counted, and the total number of eggs in the ovary was calculated by simple proportion. All weights were measured to the nearest 0.005 g. An actual egg count of the eggs in one pair of ovaries was made. The estimated numbers of eggs were 288 and 705 compared with actual counts of 293 and 664, respectively.

All scale samples were taken from preserved specimens and were consistently removed from the area below the origin of the dorsal fin and above the lateral line on the left side of each specimen. Scales were dry-mounted between two glass slides held together with cellophane tape and examined with a projection apparatus. The annuli, focus, and edge of each scale were marked on tagboard strips placed along the anterior field. A nomograph was used to estimate body lengths at each annulus. Since the relationship between standard length and length of the anterior field of the scale was found to be linear (although points on the graph were widely scattered), the length estimates were used without correction. In using the nomograph, the focus marked on the tagboard strip was set at 17, since scale formation occurred at a standard length of about 17 mm, as shown by staining a series of young specimens with alizarin red.

Food habit studies were based on the contents of the first of the three loops of the gut, since a distinct stomach is absent in the redside. Initial attempts at weighing the gut contents proved inadequate because of the small quantities involved. Consequently, a grid placed beneath the container on the microscope stage was used to make an estimate of the total volume of the ingested material and of the volume of each category after sorting. The material was distributed to a uniform depth and density in each case.

DISTRIBUTION

Spatial Distribution

Lahontan redsides inhabit the littoral zone of Lake Tahoe, primarily areas where the substrate is rocky, or where cover is afforded by piers. Traps set in rocky areas generally took many redsides, whereas traps set in sandy habitat took few or none. Observations made while free diving (mask, fins, snorkel) revealed an absence of redsides in sandy habitat, even where such areas were adjacent to rocky shoreline. Redsides predominated around piers, and were the most common minnow taken in fishermen's traps. Hence, the species serves as the primary bait used by deepline anglers fishing for lake trout.

Extensive trappings revealed that redsides were most abundant in shallow water to depths of 30 or 40 ft. Futhermore, of 112 sets with bottom gill nets and 75 sets with open-water gill nets, only 11 caught redsides. One redside was caught 4 ft below the surface in an open-water set made 300 yards offshore where the depth was 180 ft. The remaining 10 sets were bottom sets, 9 of which were made at depths of 25 ft or less. One set caught six redsides at a depth of 115 to 120 ft, the greatest depth at which redsides were taken in Tahoe. This set was made in the northwest part of the lake.

Only two trawl hauls caught redsides. Both of these were made in 1962, one at a depth of 15 to 20 ft, the other at 65 to 100 ft. No redsides were taken in 109 trawls made in 1963 and 120 trawls in 1964.

Daytime observations made while free diving indicated that redsides which congregated near the shoreline to depths of 4 or 5 ft formed very loose aggregations. Over deeper water, the schools were much more distinct and generally were found within a few ft of the surface. In such schools, I often observed surface feeding, as individuals would dart to the surface and immediately return to the school.

Seasonal Distribution

Redsides were abundant around piers and rocky shores from late spring to early fall, but were very scarce during the remainder of the year. The monthly minnow trappings at the piers reflect seasonal abundance (Figure 2). Redsides became relatively numerous in mid-May, coincident with a rise in surface temperatures from the high 40's to the low 50's (F). Peak numbers occurred during the months of June, July, and August, tapering off to low activity by late November, when temperatures dropped to the high 40's. Since the traps have several inadequacies as a sampling tool, the seasonal pattern described should be regarded as a rough approximation of the overall situation in the lake. A notable exception to the pattern seen at the piers was a collection made on April 10, 1962, in which two traps set for 4.5 hr in 30 ft of water took 338 redsides at Zephyr Cove (water surface temperature 46 F).

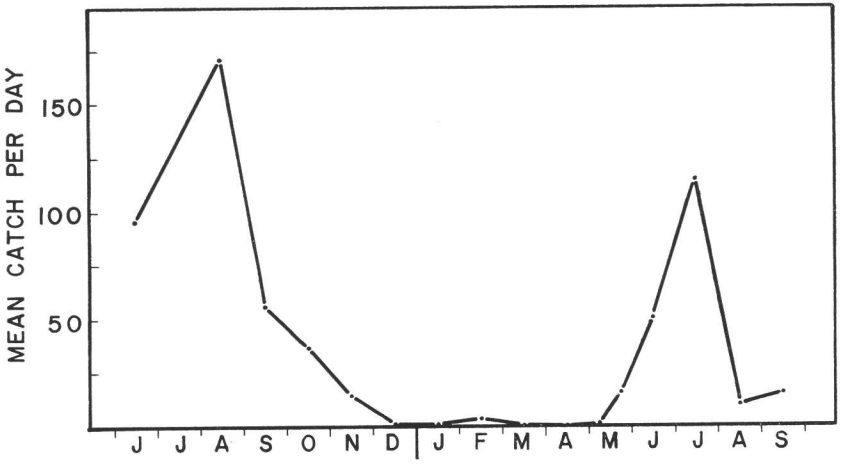

FIGURE 2—Seasonal variation of Lahontan redsides caught in traps set at piers in Lake Tahoe from June 1963 through September 1964.

Data from traps set in winter and sampling with rotenone in March 1966 suggest that the redsides spend the winter offshore at depths from 10 to 50 ft in rubble and boulder areas. Such areas commonly grade into sand at 25 to 30 ft but in some parts of the lake extend out much farther. It seems clear that the redsides are inactive during the winter, since extensive efforts to trap them met with slight success. Crossman (1959) proposed that the redside shiners (*R. balteatus*) of Paul Lake, British Columbia, spend the winter offshore at depths of about 30 ft; during mid-May they move onto the shoals.

Distribution of Young

Young redsides were observed in shallow and quiet water along the lake margins and in pools at the mouths of creeks. They were most numerous where there were accumulations of organic debris.

Many young and some adult redsides were collected in shoreline rotenone sampling from 1963 through 1966 (summarized by Baker, 1967). Redsides were second in importance to Lahontan speckled dace (*Rhinichthys osculus robustus*). "Overall, 70.1% of the fish were dace, 14.7% Lahontan redside . . . , 7.1% Piute sculpin (*Cottus beldingii*), 3.9% Tahoe sucker (*Catostomus tahoensis*), 3.2% rainbow trout (*Salmo gairdnerii*), and the remaining 1.0% tui chub (*Siphateles bicolor*) [now *Gila bicolor*], brown trout (*Salmo trutta*), mountain whitefish (*Prosopium williamsoni*), and eastern brook trout (*Salvelinus fontinalis*)."

Large concentrations of immature redsides and other species were observed off Lake Forest, a marshy area on the north shore of the lake. I made several collections here using a one-man seine. Of 337 fishes collected on July 1, 1964, 63% were dace, 22% suckers, 8% redsides, and 7% chubs. The species varied in abundance at different times. On July 17, 1964, I collected 462 fishes, of which 33% were redsides, 32% suckers, 22% dace, and 13% chubs. Later in the summer these populations were much reduced. By mid-August young-of-the-year were evident in great numbers, and most of the larger fishes had left the area.

I also collected in Truckee Marsh, located at the mouth of the Upper Truckee River on the south shore of the lake. Here in July and August of 1964, I collected six species: 66 tui chubs, 52 brown bullheads (*Ictalurus nebulosus*; 25-81 mm FL), 49 golden shiners (*Notemigonus crysoleucas*; 20-76 mm FL), 29 Tahoe suckers, 10 redsides, and 8 dace. The golden shiner and brown bullhead seem to be established in Truckee Marsh; presumably they were introduced by bait fishermen.

REPRODUCTION

Spawning Season

Spawning begins in early June. In 1964, redsides were first noted spawning on June 12 at Agate Bay but only casual observations were made before that date. On June 4, 1966, spawning and redside embryos were observed in Taylor Creek. It seems possible that spawning might begin as early as the end of May in years of exceptionally warm springs. Maximum spawning activity occurred in the third and fourth weeks of June in 1964. By the second week of July, activity had declined sharply. However, spawning continued at a slow pace for a few more weeks. A ripe female was taken as late as August 6, 1964, at Pebble Beach. At that time, only small numbers of fish were present on the spawning grounds.

Throughout the spawning period, samples of redsides were collected from the spawning grounds and tested for ripeness. Fish were considered ripe if gametes flowed freely from the vent when gentle pressure was applied to the sides of the living specimen. Nearly all males were ripe throughout the spawning season, but often females which were not ripe were found. Presumably, the unripe females either were not yet ready to spawn, or were spawned out, depending on whether it was early or late in the season.

Murphy (1963) conducted a study of trout survival in Taylor Creek, one of the larger tributaries located near the southern end of Lake

TABLE 1

Collections Made at Redside Spawning Sites in Lake Tahoe

Date	Time	Surface temp. (F)	Number of redsides						Associated species		
			Males (mean SL; range SL)		Females (mean SL; range SL)		Total no.	Males:females	Chub	Dace	Sculpin
Agate Bay (collections made with traps)											
June 12, 1964	11 a.m.	55	24	66.2; 54–75	2	73.0; 71–76	26	12:1	0	5	0
June 12, 1964	2 p.m.	57	46	67.3; 61–75	1	85.0	47	46:1	0	43	0
June 19, 1964	2 p.m.	58	--		--		24	--	0	233	0
June 29, 1964	4 p.m.	62	8	66.2; 63–69	0		8	--	0	11	0
July 5, 1964	11 a.m.	59	6	65.8; 61–70	12	75.3; 63–88	18	0.5:1	3	10	0
July 10, 1964	5 p.m.	--	12	65.7; 58–78	5	74.2; 65–85	17	2.4:1	0	26	0
July 30, 1964	1 p.m.	65	4	60.0; 54–65	0		4	--	0	1	0
Aug. 10, 1964*	5 p.m.	70	4	57.8; 48–67	13	71.3; 58–88	17	0.3:1	0	7	0
Sept. 9, 1964*	3 p.m.	66	7	60.5; 42–73	9	63.3; 49–79	16	0.8:1	0	15	0
Homewood (collection made with seine)											
June 25, 1965	9 p.m.	52	14	63.4; 56–71	11	61.0; 57–77	25	1.3:1	3	0	14
Pebble Beach (collections made with seine)											
July 9, 1964	4 p.m.	62	325 for 73:	65.4; 54–78	3		328	108:1	17	20	1
July 19, 1964	6 p.m.	65	262 for 191:	64.3; 50–77	25	63.2; 55–71	287	10.5:1	4	0	6
June 23, 1965	10 p.m.	56	192	66.7; 56–78	13	65.9; 59–75	205	14.8:1	1	6	0
June 24, 1965	8 p.m.	56	25	64.7; 58–74	4	72.0; 69–80	29	6.3:1	0	0	6
June 24, 1965	10 p.m.	54	138		11		149	12.5:1	168	1	0
June 25, 1965	10 p.m.	53	50	65.6; 59–78	7	66.2; 56–75	57	7.1:1	100	1	0
Taylor Creek (collections made with seine)											
June 14, 1964	2 p.m.	59	16	68.5; 64–77	1	70.0	17	16:1	0	0	0
June 14, 1964	5 p.m.	60	8	67.3; 63–74	4	62.1; 59–67	12	2:1	0	0	0
June 14, 1964	5 p.m.	60	16	67.5; 57–74	29	66.6; 60–81	45	0.6:1	0	0	0
July 18, 1964	2 p.m.	72	26	63.0; 51–76	4	69.4; 65–75	30	6.5:1	0	4	0
June 25, 1965	10 a.m.	56	130	64.7; 55–77	26	63.4; 54–79	156	5:1	0	1	0
June 25, 1965	11 a.m.	57	155	64.0; 56–75	10	58.8; 52–71	165	15.5:1	0	0	0
Burton Creek (collections made with seine and trap)											
June 2–5, 1965	--	--	29	66.7; 59–78	75	74.9; 56–90	104	0.4:1	0	65	0
June 24, 1965	6 p.m.	56	16	64.7; 57–75	3	62.7; 55–69	19	5.3:1	0	2	0

* These collections were made after the spawning season was apparently over.

Tahoe, during the summer of 1940, using screens to fence off a section of the stream. He reported that the redside, ". . . breeds all through the summer or at least to the end of August . . . . They suffered a tremendous mortality of adults during August; scores of dead were washed against the screens on some days and many dead were on the stream bottom." I never observed more than a few dead redsides in the stream, but I did not use a screen or other device.

Spawning Habitat

Throughout the breeding season a few lake and stream spawning sites were investigated repeatedly (Table 1). An important spawning site was located in Agate Bay at a spot 0.7 miles west of the Tahoe Vista Post Office. The substrate consisted largely of silt-free gravel and rubble up to 3 or 4 inches in diameter. The gradient was gradual; at a distance of several ft from shore the depth was 2 ft. Spawning was observed over a 40-ft section of this shoreline. No spawning activity was noticed in adjacent areas which were deeper and deficient in the smaller sizes of rock and rubble.

At Pebble Beach, between Ward and Blackwood Creeks, the substrate consisted almost entirely of rounded stones 2 to 3 inches in diameter; no silt was present. The gradient was steeper than at Agate Bay. At a distance of 7 ft from shore the water depth was about 3 ft.

No attempt was made to locate all spawning sites around the lake. The great size of Lake Tahoe and the difficult accessibility of much of the shoreline made it nearly impossible to do so, but there are many shoreline areas which are similar in substrate and water characteristics to those described above. Cordone and Frantz (1968) discuss the shoreline habitat of Lake Tahoe.

In Taylor Creek the redsides usually spawned over the upsloping bottom at the downstream end of pools, where the substrate consisted largely of sand and gravel. Larger stones occurred in some spawning sites, and very little silt was found in any of them. Spawning activities and the eggs of redsides were also observed in Burton Creek. During the breeding season, redsides were noticed in Third and Meeks Creeks. These two small streams appeared to have suitable spawning sites, but no eggs were found in the substrate. Since I examined the streams only briefly, evidence of spawning may have been overlooked.

Sexual Dimorphism and Coloration

The most striking feature of a redside in spawning condition is the red-orange lateral stripe. Breeding males are more colorful than females. Males possess a bright red stripe and brassy coloration just before and behind the base of the pectoral fins and in the suborbital area, which is sometimes streaked with red. The skin over the first pectoral ray is very dark in the males. The pectoral rays of breeding females are not as dark, and the red stripe is generally not as intense as in the male; the brassy coloration is usually absent. Sexual dimorphism also exists in the length of the pectoral fins (Figure 3), and to a lesser extent in the length of the pelvic fins. The pectoral fins of the male reach or nearly reach the base of the pelvic fins when the former are

depressed. When the pelvic fins of the male are depressed, they extend to the vent. The females generally have shorter pectoral and pelvic fins. The females have a bulging abdomen when in spawning condition, and the region around the vent is more distended than in the male. The females tend to be longer than males. During the breeding season, both sexes develop nuptial tubercles. In the male the tubercles appear over most of the body and on the head, opercles, and pectoral fins. The tubercles of the female are not as large as those of the male and are fewer in number, being restricted largely to the body and head.

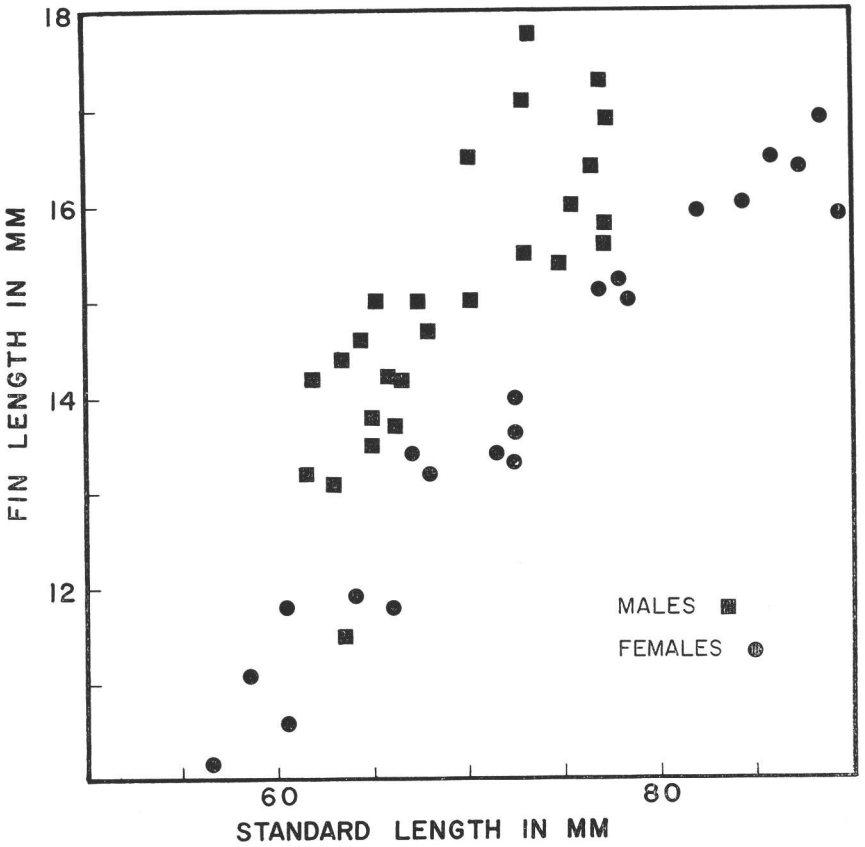

FIGURE 3—Sexual dimorphism in pectoral fin length of Lahontan redsides from Lake Tahoe.

The best external characters for distinguishing the mature sexes during nonbreeding periods are the pectoral and pelvic fin lengths. Nonbreeding individuals lack the brassy coloration, and the red stripe may be absent or nearly so.

Sex Ratios

Generally there were many more males than females on the spawning sites (Table 1). The variation in sex ratios, with females predominating

in some collections, may reflect a tendency for the sexes to school separately at times. Three collections were made in Taylor Creek on June 14. In one area the sex ratio was 16 males to 1 female, while in two other areas the ratios were 2:1 and 0.6:1.

In contrast with the situation found on the spawning sites, collections of redsides made at piers during the breeding season regularly contained more females than males. As the season progressed and breeding activity declined, an increasing proportion of males appeared at the piers.

This information suggests that the males move to the spawning sites in large numbers at the beginning of the breeding season and remain on these sites, and in breeding condition, for a long period of time. The females apparently move to the spawning sites as they ripen, returning to the piers and other habitat after they spawn. The period of time which individual spawning females remain on the sites could not be determined.

Spawning Behavior

Observations of the spawning behavior of redsides were conducted on several occasions. Preparations of the spawning gravel did not occur. Pairing did not take place, but instead large, dense groups of redsides moved rapidly over the substrate in shallow water.

At the Agate Bay site, large aggregations were observed during the height of the spawning season, but actual breeding behavior occurred in groups of approximately 20 to 100 fish. The fish swam over the rubble in water 3 to 15 inches deep, staying close to the bottom. Much chasing and crowding was evident, and groups changed direction every few seconds. Often the erratic chasing would cease, and the fish would appear to force themselves against the substrate, pressing into nooks and crevices between the rocks. It was not possible to observe actual oviposition, but it probably accompanied this behavior.

At Pebble Beach the pattern of behavior was similar. Much spawning took place at the edge of the shoreline in water so shallow that the dorsal parts of the fish were exposed. When moving along the shoreline, the redsides often traveled at a distance of 3 to 4 ft from the beach, returning to shallow water to resume spawning. Stream spawning observed at Taylor Creek was similar, but movement over the gravel was much less extensive.

At Agate Bay and Pebble Beach, day-to-day fluctuations in the numbers of spawners were noted. To some extent, this variation was due to the weather. On windy days wave action was heavy, and the redsides moved from the shallow water. On a couple of such occasions, I set traps in the rocks beyond the spawning area at depths of 10 ft or more and caught redsides. Sometimes they were absent or scarce when the weather did not seem to be a factor.

No indication of diurnal variation in the intensity of spawning activity was apparent from superficial observations. Spawning was observed throughout the day until darkness, when visual observation was no longer possible. Seine hauls made after dark took ripe redsides on the spawning grounds.

Other cyprinids were often collected with the redsides on the spawning sites (Table 1), but only at Agate Bay were interactions between species observed. Speckled dace were often seen with the redsides, though the two species tended to group separately. The dace and redsides frequently came in contact with each other. On a few occasions, the redsides appeared to be chasing the dace. I examined some of these dace and found them to be ripe, but since no dace eggs were found in the substrate, I am not certain they were spawning at this time.

Suckers and redsides shared many of the gravel bars at Taylor Creek, and eggs of both species were found together in the substrate. In some areas of the stream, dace were found with the redsides. I did not see aggressive behavior between the species. Snyder (1917) mentioned redsides following female suckers and feeding on their eggs.

Fecundity

Fecundity estimates were made from preserved specimens which had been collected just before the beginning of the spawning season. Only mature eggs, distinguished by their large size, rounded shape, and yellowish color, were counted.

The average number of eggs contained in both ovaries of 16 females was 1,125, with a range of 180 to 1,695 (Table 2). The left ovary had an average number of 350 eggs (0–918), compared with an average of 775 eggs (600–1,371) in the right ovary. In 4 cases out of 16, the left ovary was much reduced, and in 2 cases the left ovary contained no mature eggs. This pronounced bilateral variation was reflected in ovary weights. Based on 25 samples, the right ovary comprised an average of 5.6% of the total body weight, compared with a mean of 2.5% for the left ovary.

TABLE 2

Estimated Number of Eggs in Ovaries of 16 Female Redsides

Standard length (mm)	Number of eggs		
	Total	Left	Right
83.0	1,236	43	1,193
79.5	1,695	918	777
78.0	1,113	193	920
76.5	1,556	909	647
75.5	711	267	444
74.5	1,523	704	819
73.0	1,371	0	1,371
72.0	1,278	243	1,035
71.5	1,235	635	600
71.0	1,096	433	663
70.0	845	0	845
68.5	993	288	705
67.5	937	189	748
67.0	1,135	642	493
64.5	1,091	28	1,063
54.5	180	107	73
Averages	**1,125**	**350**	**775**

Seasonal Cycle in Gonad Weight

The gonad weights of 196 males and females collected at various times of the year were expressed as a percentage of body weight. Ovaries varied seasonally from about 3 to 11%, and testes varied from 0.5 to 3.5%. The gonads increased in weight during the months of March, April, and May.

HYBRIDIZATION BETWEEN LAKE TAHOE CYPRINIDS

In the course of the life history study, hybrids between all three of the cyprinids in Lake Tahoe were discovered. Specifically, these hybrids are *Richardsonius egregius* × *Gila bicolor*, *Rhinichthys osculus* × *R. egregius*, and *R. osculus* × *G. bicolor*.

The *R. egregius* × *G. bicolor* hybrid was noted many years ago. Snyder (1917) described it as a new species, *R. microdon*, but Hubbs and Miller (1943) subsequently identified it as a hybrid. Miller (1951) reported the *R. osculus* × *R. egregius* hybrid from Lake Tahoe, and Calhoun (1940) reported it from Five Lakes, Placer County, California. Hopkirk and Behnke (1966) reported the *R. osculus* × *G. bicolor* hybrid from Lake Tahoe, based on specimens collected during this study.

Hybrids may be distinguished by coloration, proportion of body parts, and gill raker number. A manuscript dealing with the morphometry of these hybrids, frequency of occurrence, and possible causes of hybridization is in preparation by the author (in collaboration with J. D. Hopkirk).

AGE AND GROWTH

Difficulty was encountered in discerning annuli, and the estimates given here should be regarded as preliminary findings. The most reliable indication of an annulus was the cutting across of incomplete circuli by other circuli upon the resumption of growth. Assigning ages to the scales was difficult because cutting over and incomplete circuli sometimes occurred in what appeared to be nonannular regions of the scales.

The scales of 119 specimens were examined, but 16 were discarded as unreadable. The average standard lengths (mm) at each annulus were estimated as follows (number of specimens in parentheses).

Annulus	I	II	III	IV
Male	33.3 (42)	48.4 (33)	65.0 (20)	73.3 (4)
Female	35.1 (61)	52.4 (53)	67.5 (44)	77.8 (13)
Combined	34.4 (103)	50.9 (86)	66.7 (64)	76.7 (17)

Females averaged slightly larger than males, although the magnitude of the difference was not consistent between year classes, and sample sizes were small. The difference in length at annulus I was not expected. Annulus formation seems to be completed in May.

Length-frequency distributions were not useful in determining age classes (Figure 4). However, they do show that females average somewhat larger in size than males.

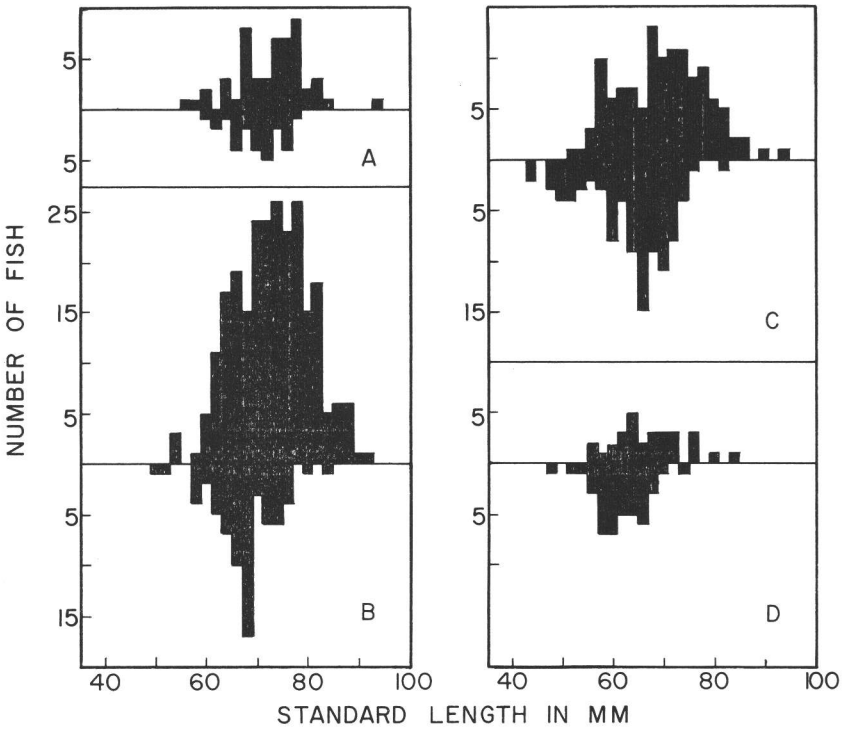

FIGURE 4—Length-frequency distributions of Lahontan redsides in four of the samples taken at piers in Lake Tahoe (females above line, males below). A, May 25–29, 1964; B, June 15–22, 1964; C, July 17–24, 1964; D, September 23–25, 1964.

The larger size of females is apparent from both the scale data and the length-frequency distributions. There is a regular increase in the number of assigned annuli as the length of fish increases, which supports the validity of the assignments.

A comparison of these growth estimates with the lengths of spawning redsides (Table 1) indicates that most of the spawners are 3 and 4 years old. The small size of some spawners suggests that some redsides reach sexual maturity when they are 2 years old.

The relationship between length and weight was examined graphically (Figure 5). Separate plots of males and females revealed very slight differences in the curves, so the sexes were combined.

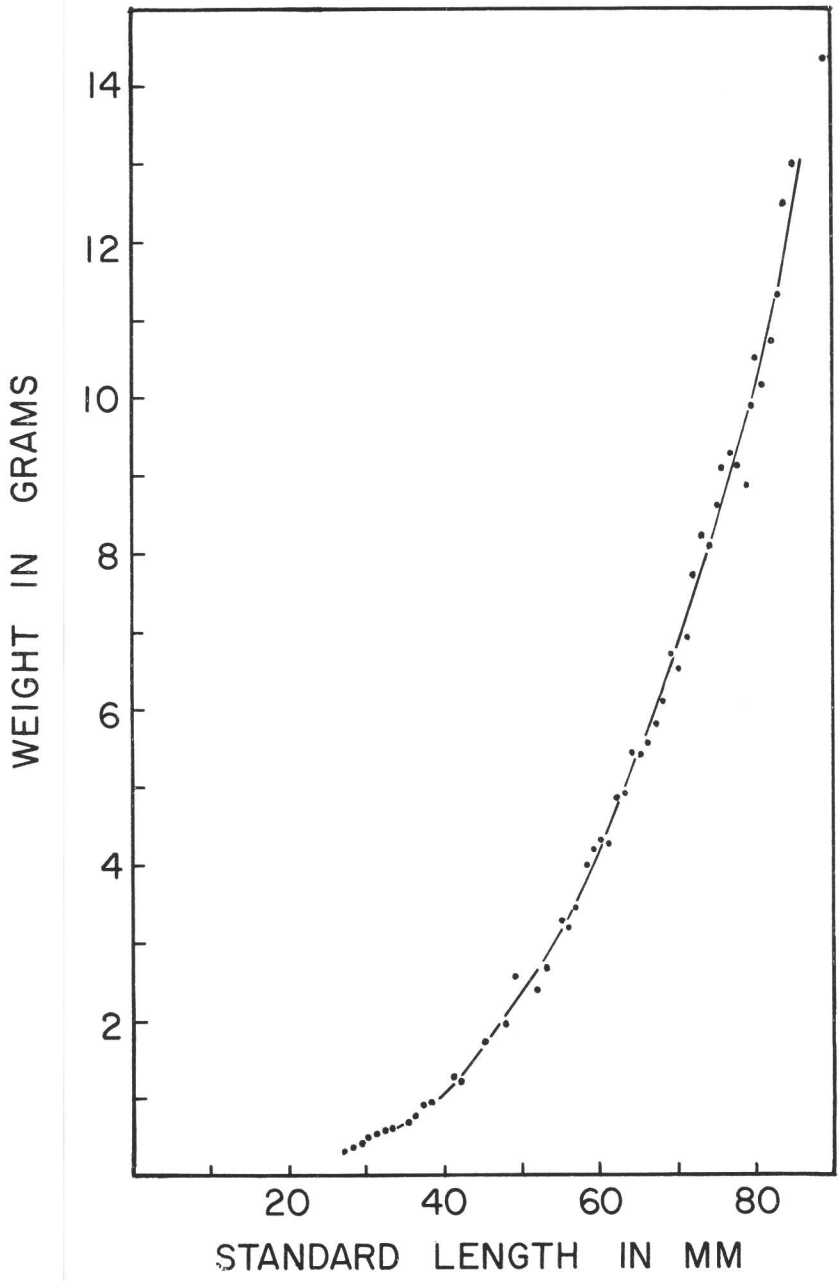

FIGURE 5—Length-weight relationship of 263 Lahontan redsides from Lake Tahoe (sexes combined; averaged at 1-mm intervals; curve fitted by inspection).

FOOD

The food of 102 specimens collected in the summer months was analyzed (Table 3). Diptera (mostly chironomids) constituted an average of 36% by volume of the diet, Coleoptera 7%, Hymenoptera 6%, and crustaceans 21%. Fragmented insect remains were identified on the basis of recognizable parts. However, a considerable amount of highly fragmented material which I could not identify often remained in the gut contents. In part, this fragmentation was due to the action of the pharyngeal teeth. In addition, many specimens were collected in minnow traps, and the bait had to be separated from the natural food items before analysis. Since the fish often were left in the traps for periods up to several hours before preservation in formalin, digestion in many cases was rather advanced.

TABLE 3

Food Habits of Lake Tahoe Redsides in Summer *

	Entire sample (N = 102; 22–88 mm SL)		Lake Forest sample (N = 29; 26–65 mm SL)	Excluding Lake Forest sample (N = 73)
	Percentage occurrence	Percentage volume	Percentage volume	Percentage volume
Cladocera	14	1.1	0.9	1.2
Copepoda	39	11.1	15.9	9.2
Amphipoda	4	1.1	1.5	0.9
Ostracoda	2	0.3	1.1	----
Crustacean debris	45	7.6	0.7	10.3
Arachnida	2	0.1	----	0.2
Thysanoptera	7	0.2	0.1	0.3
Hemiptera	12	0.6	1.1	0.3
Hymenoptera	15	5.7	0.4	7.8
Coleoptera	17	6.8	0.2	9.4
Diptera: adults	44	19.4	7.7	24.1
larvae and pupae	46	17.0	42.8	6.8
Insect debris	69	17.2	15.5	18.1
Animal debris	49	11.0	12.0	10.5
Sand particles	5	0.7	----	1.0
Plant matter	2	0.2	----	0.3

* Samples from June, July, August, and September 2.

Although sample sizes were inadequate to demonstrate definite size differences in food preferences, there was some indication that immature redsides depended on crustaceans and chironomid larvae to a great extent, whereas larger redsides seemed to feed more on adult Diptera (mostly chironomids), Coleoptera, and Hymenoptera. Many other adult redsides were examined, but the poor condition of the gut contents precluded detailed analysis. Fragments of Coleoptera and Hymenoptera were conspicuous, suggesting that these insects are more significant than indicated in the table. Thus, it appears that adult redsides depend heavily on flying insects as a food source. Miller (1951) found that surface foods comprised 38% by volume of the redside diet in Lake Tahoe; 28% consisted of bottom organisms, and 25% plankton. Another 8.3% he believed to be sucker eggs.

Specimens collected in the marshy area off Lake Forest showed some distinct differences from other collections (Table 3). Chironomid larvae and pupae comprised a large part (43%) of the diet of Lake Forest specimens, whereas surface foods (adult insects) were much less important. Miller (1951) also found considerable variation in redside diet in different areas of Lake Tahoe.

Small amounts of filamentous algae were found in the digestive tracts of two specimens and probably represent accidental ingestion. Cyprinid scales were found in four specimens. The size of the scales indicates that they came from fishes too large for redsides to swallow, and perhaps were ingested while the redsides were scavenging. Only one fish egg (cyprinid) was discovered.

Many specimens collected during other months of the year were examined, but the gut contents were unidentifiable because of advanced digestion and poor preservation. Three specimens (58–64 mm SL) collected on January 6 at Obexer's dock contained copepods (27% by volume), ostracods (9%), and animal debris (64%). A large part of the debris may have consisted of crustaceans, since no chitinous insect remains were evident. Redsides must derive some energy from stored fat in the winter, when insects and crustaceans are scarce. Cursory internal examination revealed accumulations of fat in the body cavities of redsides taken in late summer and fall. By spring the fat stores appeared largely depleted.

SUMMARY

Lahontan redsides in Lake Tahoe occur in greatest numbers along the rocky shorelines and around piers in the summer months. Few redsides were taken in water more than 40 ft deep or in areas of extensive sandy habitat. Redsides first become relatively numerous around the piers about the middle of May. They are most abundant in June, July, and August, but by the end of November they are scarce along the shores. They apparently spend the winter in an inactive state offshore at depths of 10 to 50 ft. Young redsides school separately from adults and are restricted to the shallow water adjacent to the shoreline in the summer. Large concentrations of young redsides and other species were found in a marshy area off Lake Forest.

Spawning begins in early June, reaches maximum activity in late June, and continues at a slow rate through July and into August. Redsides form large aggregations and spawn over gravel and rocks along the shoreline and in tributaries. Courtship and preparation of the spawning site were not evident. Males on the spawning sites outnumber females. Apparently, the males move to the spawning sites in large numbers at the beginning of the breeding season and remain there for a long time. Females move to the sites as they ripen and leave soon after spawning.

For 16 specimens, the estimated average number of eggs per female was 1,125 (range: 180–1,695). A bilateral variation in the ovaries was evident. Left ovaries averaged 350 eggs (0–918) and right ovaries 775 eggs (600–1,371). Left ovaries averaged 2.5% of body weight, compared with 5.6% for right ovaries. The main increase in weight of ovaries and testes occurred during March, April, and May.

Age and growth studies were conducted on 103 specimens. The average standard lengths of males at annuli I, II, III, and IV were 33, 48, 65, and 73 mm, respectively. The corresponding lengths of females were 35, 52, 68, and 78 mm.

Redsides taken in the summer had fed primarily on surface foods, (especially adult Diptera, Coleoptera, and Hymenoptera), chironomid larvae and pupae, and crustaceans. There was some indication that surface foods were most important in the adult diet, whereas crustaceans and chironomid larvae were primary food items of immature redsides. The diet varied in different areas of the lake.

Hybridization occurs between all three of the cyprinids in Lake Tahoe. The parental species involved are *Richardsonius egregius, Gila bicolor,* and *Rhinichthys osculus.*

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