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AGE, GROWTH, AND FOOD HABITS OF TUI CHUB, *GILA BICOLOR*, IN WALKER LAKE, NEVADA

James J. Cooper¹

ABSTRACT.—At Walker Lake, Nevada, tui chub were collected 1975–1977 for analysis of age, growth rate, and food habits. The fork length (FL)–scale radius (SR) relationship was linear and described by the equation $FL = 4.44 + 3.17(SR)$. Age I, II, III, and IV chub were 116, 176, 218, and 242 mm fork length, respectively. Maximum longevity was six years. The length weight relationship was defined by the log transformed linear equation $\log \text{weight} = -4.65 + 2.93(\log FL)$. Chub collected from pelagic regions ate mostly zooplankton, whereas chub collected from littoral areas had a diet of zooplankton and benthic organisms.

Tui chub, *Gila bicolor*, is the most abundant of the three species of fish currently found in Walker Lake, Nevada. It is common to the Walker, Carson, Truckee, and Humboldt river systems of the Lahontan basin (La Rivers 1962). Various subspecies of tui chub occur in other endorheic basins in the drainages of pluvial lakes Railroad, Toiyabe, and Dixie, and lakes in the White Mountains in west central Nevada. Other forms occupy lake basins in California, southeastern Oregon, and southeastern Washington (Hubbs et al. 1974). In Walker Lake tui chub are an important component of the ecosystem bioenergetics and are preyed upon heavily by the piscivorous Lahontan cutthroat trout, *Salmo clarki henshawi* (Cooper and Koch, 1984). The vast number of fish-eating birds that annually visit the lake are also predators of tui chub.

Most of the life history information reported in the literature for the Lahontan form of tui chub has been collected from Eagle Lake, California, and Pyramid Lake, Nevada. Kucera (1978) and Kennedy (1983) studied the reproductive biology and growth of Pyramid Lake tui chub. Kimsey (1954) described the life history of the Eagle Lake tui chub population. Cooper (1978, 1982), working on Walker Lake, described various aspects of tui chub life history. Notes on the species can be found in other articles (Snyder 1917, La Rivers 1962, Vigg 1978, 1980, 1981, Galat et al. 1981, Galat and Vucinich 1983a, 1983b). The objectives of this study are to present data on the age, growth rate, and diet of tui chub from Walker Lake.

STUDY AREA

Walker Lake, a remnant of pluvial Lake Lahontan, is in west central Nevada 209 km southeast of Reno. The lake has a surface area of 15,000 ha, is 25 km long and 9 km wide, and has a maximum and mean depth of 33 and 20 m, respectively. It is the second largest remnant of Lake Lahontan. The lake's drainage basin is endorheic and receives water from the eastern Sierra Nevada via the Walker River. Because Walker is a terminal lake, it has a relatively high total dissolved solids (TDS) content of 12,500 mg/l that has increased rapidly in historic times. During the past 45 years the lake has had an average increase in TDS of 152 mg/l per year, and the cutthroat trout sport fishery appears to be in jeopardy. The primary factor responsible for the increasing salinity has been surface evaporation exceeding tributary inflow; since 1915 the lake's elevation has dropped at an average rate of 0.58 m per year (Cooper and Koch, 1984). Agricultural and urban diversion of the Walker River is hastening desiccation of the lake.

METHODS

The scale method was used to analyze the age of tui chub at various sizes (Ricker 1971, Everhart et al. 1975). Scales were taken from the left side of the body above the lateral line and below the dorsal fin. In the laboratory scales were placed between two plastic slides and run through a roller press to form an impression. Scales were read using an Eber-

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TABLE 1. Mean calculated fork length and mean calculated annual growth increments for tui chub collected June–November 1976, Walker Lake, Nevada.

Age class	No. of fish	Calculated fork length at end of each year of life (mm)			
		1	2	3	4
I	46	113			
II	16	124	187		
III	31	117	172	220	
IV	8	111	165	214	242
Grand mean		116	176	218	242
Increments of growth		116	60	42	24
Number of fish		101	55	39	8

bach microprojector and the distance from the focus to each annulus and from the focus to the scale radius recorded. All age and growth calculations were performed using the computer program SHAD II (Nelson 1976).

Stomach contents were analyzed two ways: percent occurrence and percent composition. In the former the number of stomachs in which each item occurred was recorded and expressed as a percentage of the total number examined. In the second method a representative sample of a stomach content was placed in a Sedgewick Rafter counting chamber and strip counts made of individual food items at 40X magnification. Percent composition of each food item identified in the counts were calculated for the total sample. Comparisons were made between the feeding habits of fish collected from pelagic surface (midlake) areas versus collections from littoral (< 5 m) regions of the lake. Tui chub stomachs appear as an enlargement in the anterior portion of the digestive tract, and it was at this point the contents were removed for food analysis. Fish were collected using multipaneled experimental gill nets with meshes of 3.8, 5.1, 6.4, 7.6, 8.9, and 10.2 cm stretched mesh measure. A more complete description of the methods is given in Cooper (1978).

RESULTS AND DISCUSSION

Age and Growth

Scale samples from 101 tui chub were examined for age and growth determinations. The fork length (FL) - scale radius (SR X 24) relationship was linear (Fig. 1) and described by the regression equation $FL = 4.44 + 3.17(SR)$ ($r = 0.93$). Scale formation begins to occur in Walker Lake tui chub between 25 and

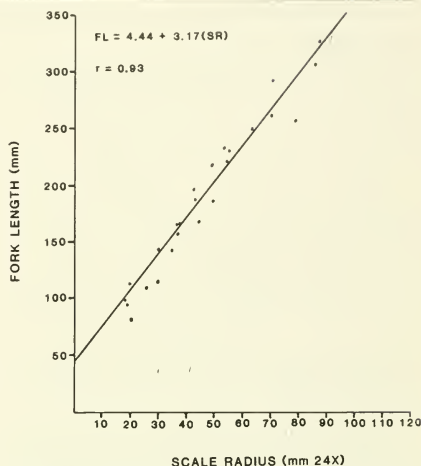


Figure 1. Fork length–scale radius relationship for Walker Lake, Nevada, tui chub.

30 mm in length. Kimsey (1954) reported that scale formation occurred in tui chub from Eagle Lake, California, when the fry reached 20 to 25 mm in length.

Annual growth of tui chub were analyzed from summer hatch to four years (Table 1). The major growth in length is achieved during the first year of life. Young of the year chub captured in late August at approximately 2 to 3 months of age ranged in length from 72 to 115 mm and averaged 91 mm. Kucera et al. (1978) reported that by two months of age Pyramid Lake chub were 48 mm long and by September had attained a length of 122 mm. Eagle Lake young of the year only reach a length of 22–41 mm by September (Kimsey 1954). Following this rapid growth during the first year of life, annual growth increments become progressively smaller.

TABLE 2. Tui chub growth rates in five selected waterbodies.

Location	Fork length at end of each year of life (mm)				Reference
	1	2	3	4	
Walker Lake, Nevada	116	176	218	242	This study
Pyramid Lake, Nevada	123	172	215	259	Kucera et al. (1978)
Eagle Lake, California*	74	125	187	242	Kimsey (1954)
Big Sage Reservoir, California	58	103	140	157	Kimsey and Bell (1955)
East Lake, Oregon	43	75	114	149	Bird (1975)

* Standard length converted to fork length by a factor of 1.12

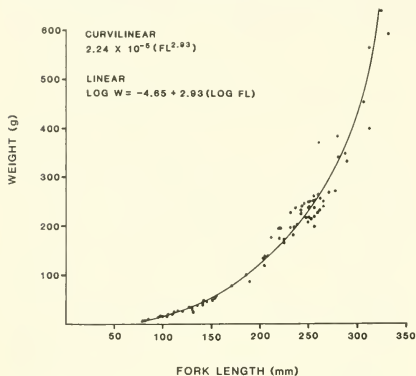


Figure 2. Length-weight relationship for Walker Lake, Nevada, tui chub.

Maximum growth at an immature age can be explained by the fact that this age group does not contend with reproduction and thus all energy is expended in growth. Furthermore, maximum growth in length at an early age with a subsequent decline could be advantageous because most Lahontan cutthroat trout can only ingest smaller sized chub.

Growth rates of tui chub in Walker and Pyramid lakes are higher than other nonterminal lakes (Table 2). First-year growth in the two terminal lakes is over three times that of the relatively unproductive, high elevation East Lake, Oregon (Bird 1975). Eagle Lake chub exhibit slow growth their first year but by year IV are the same size as Pyramid and Walker fish. This too may be related to the lake's trophic state because Walker and Pyramid are the more productive (Huntsinger and Maslin 1976, Cooper and Koch 1984, Galat et al. 1981). Temperature may also be a factor because winter temperatures are about 6 C warmer in Pyramid and Walker, which do not experience ice cover.

Longevity of tui chub from Walker Lake is probably near four or five years of age. Maximum age of 102 fish collected for age examination was one six-year-old individual. This is similar to data collected from Pyramid Lake, where a sample size of 322 produced six age five, one age six, and one age seven (Kucera et al. 1978).

The length-weight relationship can best be described by the linear log transformed equation $\log W = -4.65 + 2.93 (\log FL)$, where W = weight in grams and FL = fork length in millimeters (Fig. 2). Chub used for length-weight analysis ranged in size from 72 to 324 mm in length and 6.3 to 636.8 g in weight. The largest individual caught was a female (324 mm, 636.8 g) that had a young-of-the-year tui chub in its stomach.

Walker tui chub are heavier in weight per unit length than Pyramid chub (Kucera et al. 1978), although there was only a slight difference in length at any given age. This was corroborated by the higher mean coefficient of condition (K) of Walker (1.51) versus Pyramid (1.31) fish. Kimsey (1954) reported a mean K value of Eagle Lake tui chub of 1.92, the highest of all three lakes.

Food

Food items identified from 103 stomachs revealed Walker Lake tui chub to be omnivorous and highly opportunistic. Zooplankton was the most important item in the diet of chub captured in pelagic water by both occurrence (97.4%) and composition (94.4%) (Table 3). Fish captured in littoral regions also fed on zooplankton but took significant quantities of benthic material. The attached alga (*Cladophora*), Chironomidae larvae, and the gammarid *Hyalella azteca* were evidence of benthic feeding activity in the littoral catch. Zooplankton were the most important organ-

TABLE 3. Food of tui chub by percent frequency of occurrence and percent gut composition collected from two habitats in Walker Lake, Nevada, in 1976 and 1977*.

Food item	Occurrence %		Composition %	
	Pelagic	Littoral	Pelagic	Littoral
Zooplankton	97.4	63.9	94.4	30.6
<i>Cladophora</i> sp.	10.3	88.5	2.5	44.5
Chironomidae	5.1	29.5	0.5	12.9
<i>Hyalella azteca</i>	0	0	0	2.9
Bottom substrate	0	27.9	0	9.1
<i>Gila bicolor</i>	2.6	0	2.6	0

* Pelagic n = 41
Littoral n = 62

isms in the diet of these fish, probably due to the small amount of littoral habitat in Walker Lake.

These findings are consistent with the literature in categorizing tui chub as opportunistic omnivores (Kimsey 1954, La Rivers 1962, Bird 1975, Langdon 1979, Galat and Vucinich 1983b), although the data suggest zooplankton may be more important in the diet of Walker Lake fish. Gill raker counts of Walker chub indicate an abundance of the fine-rakered *pectinifer* form, with only a small representation of an intermediate between *pectinifer* and the course-rakered *obesa* form (Cooper 1978, Vigg and Cooper, unpublished data). In Pyramid Lake both forms are abundant and exhibit differences in feeding behavior (Langdon 1979, Galat and Vucinich 1983a); fine-rakered chub consume more zooplankton and course-rakered chub more macroinvertebrates. However, as in this study, Langdon (1979) found little similarity in the diet of *pectinifer* sampled at the surface and bottom. It seems that *obesa* is more dependent on a bottom-feeding strategy than *pectinifer* is on pelagic feeding. This theory is supported by Pyramid Lake data showing that only *pectinifer* are found in open water, but both forms can be caught inshore on the bottom (Vigg 1978, Langdon 1979). Although there is little gill raker variation in Walker Lake chub, for whatever reason, *pectinifer* appear to have successfully filled the trophic niche unoccupied by *obesa*. When compared to lakes supporting *obesa* populations, Walker chub are, in general, feeding on the same food items and can modify their feeding strategy in accordance with food availability. This suggests that feeding strategy in lentic Great Basin chub populations may be just as dependent on

behavioral and ecological characters as it is on morphological variation.

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