AN ABSTRACT OF THE THESIS OF

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Title: A DWARFED POPULATION OF CATOSTOMUS RIMICULUS (CATOSTOMIDAE: PISCES) IN JENNY CREEK, JACKSON COUNTY, OREGON

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Abstract approved: ______________________
Carl E. Bond

The population of *Catostomus rimiculus* from Jenny Creek basin is identified as a dwarfed derivative of the normally much larger *C. rimiculus* from the Klamath and Rogue River systems. *C. rimiculus* in Jenny Creek basin are separated from those in the Klamath by a series of 3-10 m waterfalls resulting from a Pleistocene lava flow. *C. rimiculus* in Jenny Creek basin can be distinguished from the Rogue River stock by number of scales above the lateral line, number of pectoral fin rays, number of caudal vertebrae, number of post-Weberian vertebrae and size of the lips. Stocks from Jenny Creek basin and the Klamath can be distinguished on the basis of number of caudal vertebrae. The suckers from Jenny Creek basin mature at approximately 130 mm SL at age II. Only one specimen was older than III. Growth rate appears to be similar in all three stocks of suckers despite the young age of maturity of Jenny Creek suckers. Age at maturity is IV or V for Klamath and Rogue River *C.*

rimiculus. The largest sucker collected from the Jenny Creek basin was 210 mm SL whereas many specimens 250-390 mm SL were collected in the Rogue and Klamath River systems. I hypothesize that fish colonized the Jenny Creek basin by headwater capture in the Skookum-Rocky Creek area.

Jenny Creek suckers are opportunistic omnivores. Segregation of foods in the intestine indicate discriminative feeding. Jenny Creek suckers were found in most habitat types in the lower reaches of Jenny, Beaver, Corral, Keene and Johnson Creeks in summer 1979. Sampling throughout the year established a pattern of migration upstream to spawn in spring and movement downstream in fall.

A Dwarfed Population of *Catostomus rimiculus* (Catostomidae: Pisces) in Jenny Creek, Jackson County, Oregon

by

David Berry Hohler

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Introduction

Within the genus Catostomus there are about 22 species of fishes divided into two subgenera, Pantosteus and Catostomus. The members of the subgenus Pantosteus are referred to as mountain suckers, have a horny scraping sheath on the jaws, and typically inhabit faster, cooler streams of the western United States. Fishes of the subgenus Catostomus are more generalized, without modified sheaths on the jaws, inhabit slower, larger streams, and are referred to as "typical" suckers (Smith and Koehn 1971; Moyle 1976). Catostomus rimiculus, the Klamath smallscale sucker, usually regarded as a "typical" sucker, was described by Gilbert in 1898. It is found in the Klamath, Trinity, and Rogue River systems (Moyle 1976). C. rimiculus appears to be intermediate between C. tahoensis (subgenus Catostomus) and C. columbianus (subgenus Pantosteus) (Smith and Koehn 1971). The largest specimen on record is 410 mm (Gilbert 1898). The form of Catostomus found in Jenny Creek was identified by Dr. James K. Andreasen (unpubl. ms.) as a dwarf derivative of C. rimiculus. The Jenny Creek form appears to be much smaller than found elsewhere, sexual maturity being reached at 115 mm SL or less. Other than knowledge of the small size and relationship to C. rimiculus, very little was known about this sucker at the beginning of this study. This is the only known dwarf sucker known in the Pacific Northwest, and possibly the only true dwarf representative of a normally larger species west of the Rocky Mountains.

Dwarfism in suckers has been reported several times but it is not common (Scott and Crossman 1973). The most famous work on dwarfism among suckers was probably that of Kendall and Dence (1929) and later Dence alone (1931) on a dwarf subspecies of the common sucker, *C. commersoni utawana*. Subsequent investigators have arrived at a different conclusion, stating that in their opinion it is not a distinct subspecies or a dwarf but rather smaller males singled out by sampling technique (Beamish 1970; Beamish and Crossman 1977).

Three suckers have evolved a small adult size in the West. *C.* (subgenus *Catostomus*) *microps*, the Modoc sucker of the Pit River system in California, rarely grows larger than 150 mm. The small size that *C. microps* attains may be an adaptation for the small, sometimes intermittent, streams they inhabit (Moyle 1976). *C.* (*Pantosteus*) *santaanae* of 4 coastal Southern California streams rarely exceeds 160 mm (Greenfield 1973), and *C.* (*Pantosteus*) *plebius* of the southwest rarely exceeds 140 mm (Minckley 1980).

This research was the beginning of a life history and ecological status study of the dwarfed form of *Catostomus rimiculus* in the Jenny Creek system. The objectives were:

1. Determine the distribution of dwarf suckers in the Jenny Creek system.

2. Determine whether suckers of normal size exist within the system.
3. Determine the taxonomic relationships among the populations of suckers present in Jenny Creek basin, the Klamath River basin other than Jenny Creek, and the Rogue River drainage.
4. Determine population densities of dwarf suckers in selected stream areas.
5. Explain habitat preference, age and growth, and other life history characteristics as possible.

Very little work has been done on *Catostomus rimiculus* even though it inhabits three large river systems in northern California and southern Oregon. Snyder (1908) noted only slight differences between stocks in the Rogue and Klamath Rivers. Moyle (1976) reported ages of a sample of *C. rimiculus* from the Klamath.

Description of Jenny Creek Basin

Physical setting

Jenny Creek flows south out of Howard Prairie Reservoir in southwestern Oregon for approximately 37 kilometers before emptying into Iron Gate Reservoir on the Klamath River in northern California. Jenny Creek and its tributaries are separated from the Klamath River by a 10 m waterfall. The waterfall was the result of a lava flow approximately 5 million years ago (M. Elliot, personal communication). The Jenny Creek basin drains an area of 546 km^2 (California Dept. of Water Resources).

The study area is divided into almost equal halves by Jenny Creek. On the east is a Pleistocene fissure flow of andesite and basalt, stretching from just south of Crater Lake to the Modoc Plateau in California and east into Idaho and Nevada. This relatively new rock is laid over early Miocene rock of the same composition. It is the flowing of this newer sheet of rock over the older, highly dissected sheet that has shaped much of the drainage and formed the falls over which both Jenny and Fall Creeks travel to the Klamath River.

Jenny Creek has cut down through this Pleistocene flow creating the lower canyon stretching from Agate Flat to Iron Gate Reservoir and the middle canyon between stream km 18.5 and 21. The middle canyon was created as Jenny Creek cut through an arm of the Pleistocene flow around which Keene Creek flows.

The headwaters of Grizzly Creek drain a broad plain between Brush Mt. to the east and Breast Mt. to the west. It is the lower end of this plain known as Howard Prairie that has been dammed to form Howard Prairie Reservoir. The northwest edge of the plain drains into the Rogue basin via Dead Indian Creek. The waters of Grizzly Creek and Dead Indian Creek are separated by 3 to 4.5 m vertically and 0.4 km horizontally.

Johnson Creek drains Johnson Prairie, a bowl shaped area of approximately 142 km^2. This is the east side of the basin and carries water from Brush, Surveyor and Buck Mountains to Jenny Creek. Johnson Creek is intermittent and flow was subgravel in many places during August and September 1979.

Keene Creek, along with Beaver and Corral Creeks, drains much of the mountainous west side of the drainage. The upper two thirds of Keene Creek connects a series of reservoirs built to help move water over the ridge to Talent Irrigation District. The resulting water control fluctuates water levels below Hyatt reservoir from torrents to puddles. The lower third (stream km 7.25 and below) of Keene Creek is stabilized by the presence of numerous springs. Feeder creeks Mill and Lincoln are characterized by very low summer flows reducing the streams to ribbons of water connecting pools in which only resident rainbow trout persist.

Beaver and Corral Creeks drain the south and west flanks of Little Chinquapin Mountain and the west flank of Chinquapin Mountain respectively and flow together one-quarter mile before flowing into

Figure 1. Map showing study area. Dashed line outlines drainage area of Jenny Creek basin. Numbers in parentheses indicate number of sampling stations. Letters denote streams as follows:

a = Jenny Creek (28)

b = Grizzly Creek (2)

c = Willow Creek (2)

d = Hoxie Creek (1)

e = Cottonwood Creek (2)

f = Johnson Creek (9)

g = Keene Creek (10)

h = Beaver Creek (4)

i = Corral Creek (2)

j = Lincoln Creek (1)

k = Mill Creek (2)

l = Skookum Creek (dry)

m = Spencer Creek (10)

n = Dead Indian Creek (2)

o = Fall Creek (6)

p = Camp Creek (3)

q = Rocky Creek (1)

r = Dutch Oven Creek (1)

s = Klamath River

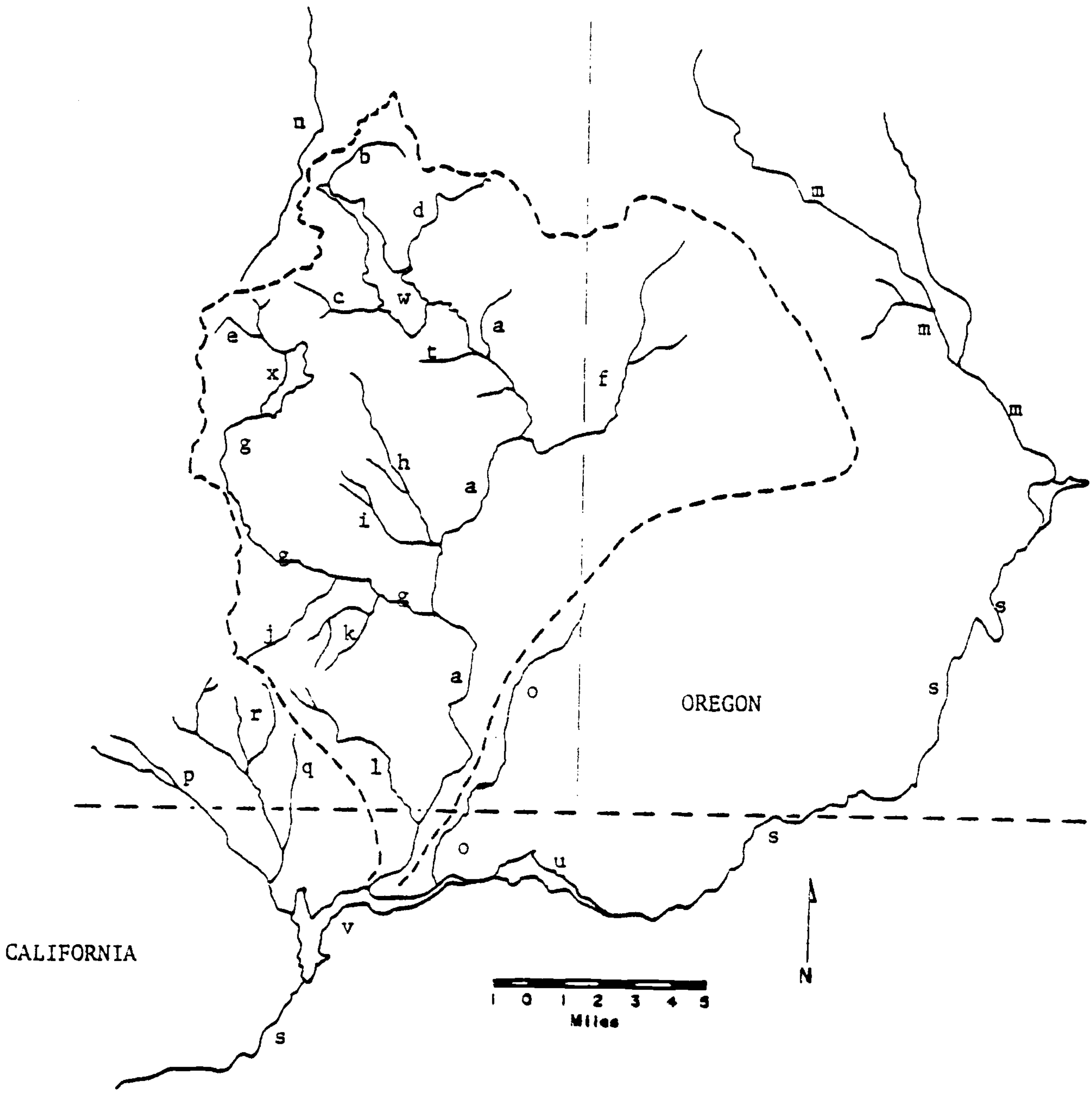
t = Soda Creek (4)

u = Copco Reservoir

v = Iron Gate Reservoir

w = Howard Prairie Reservoir

x = Hyatt Reservoir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Jenny Creek at Pinehurst. The lower 2.4 km of Corral Creek flows through a moderate canyon (average gradient 3%) after dropping precipitously (average gradient 10%) for the first mile. Beaver Creek is steep (average gradient 9%) throughout all but its last kilometer.

Jenny Creek can be divided into ten reaches on the basis of instream gradient, riparian vegetation density, and upslope topography. Table 3 summarizes the reach characteristics. It shows that Jenny Creek is essentially made up of zones of canyon and flat areas in between.

Climate

The climate of Jenny Creek is generally one of cold winters and warm summers. The mean temperature varies from -4°C in January to 16.4°C in July (Table 1). Precipitation is moderate, about 830 mm/year, the majority of which falls in the form of snow during winter and early spring.

Air and water temperatures for the periods July 28 - September 6, 1979 and March 23 - April 23, 1980 are shown in Table 2. Water temperatures at Agate Flat varied from a low of 2.7°C in March to 23.75°C in August. Results from the three thermographs indicated that water temperatures generally followed the same diel regime with the upper section 0 to 2°C cooler during the summer period.

Table 1. Air and water temperature in degrees Centigrade for Jenny Creek basin for the periods 7/28/79 - 9/7/79 and 3/22/80 - 4/23/80. Air temperatures taken at Howard Prairie Dam. Water temperatures taken near Jenny Creek bridge, stream kilometer 8.

	Air		Water			Air		Water	
Date	low	high	low	high	Date	low	high	low	high
7/28/79	7.8	29.4	15.5	22.5	3/22/80	-5.0	1.66	3.25	7.5
7/29/79	4.4	28.9	15.0	22.5	3/23/80	-1.66	7.22	3.5	7.25
7/30/79	4.4	26.7	15.0	23.0	3/24/80	-5.0	6.67	2.7	7.2
7/31/79	5.0	31.1	15.5	23.25	3/25/80	-5.0	7.22	3.75	7.5
8/01/79	8.3	32.2	16.0	23.75	3/26/80	-2.78	7.78	3.6	7.0
8/02/79	8.3	29.4	16.0	23.75	3/27/80	-3.33	6.67	3.25	7.1
8/03/79	6.7	31.6	15.25	23.0	3/28/80	-6.7	5.6	2.9	7.0
8/04/79	6.1	28.9	15.0	22.0	3/29/80	-6.1	12.2	3.5	7.2
8/05/79	5.0	27.8	15.0	22.0	3/30/80	-5.0	12.8	3.0	8.0
8/06/79	5.0	25.6	14.75	22.0	3/31/80	-4.4	6.7	3.4	4.7
8/07/79	4.4	28.3	15.0	22.25	4/01/80	-3.3	2.2	3.5	6.5
8/08/79	6.7	27.8	14.75	22.25	4/02/80	-7.8	2.8	2.75	6.75
8/09/79	6.7	28.9	14.25	22.5	4/03/80	-7.8	7.2	3.5	5.5
8/10/79	6.7	28.9	15.0	21.0	4/04/80	-3.9	5.0	3.9	5.8
8/11/79	12.2	27.2	14.5	21.5	4/05/80	-0.6	5.6	3.8	6.5
8/12/79	8.3	26.1	14.5	21.5	4/06/80	-2.2	6.1	2.3	6.0
8/13/79	8.3	26.7	15.5	16.75	4/07/80	-6.1	4.4	3.0	6.5
8/14/79	7.2	17.8	14.25	18.0	4/08/80	-5.6	6.1	4.0	6.75
8/15/79	6.1	20.0	14.0	20.25	4/09/80	0.0	8.3	4.75	6.9
8/16/79	6.1	23.9	14.25	20.25	4/10/80	-1.7	7.8	4.1	9.25
8/17/79	6.7	23.3	14.0	21.0	4/11/80	-3.3	9.4	3.5	9.6
8/18/79	5.0	23.9	14.0	20.5	4/12/80	-1.7	15.0	4.1	11.5
8/19/79	5.6	24.4	14.75	15.5	4/13/80	-1.1	22.2	5.25	10.0
8/20/79	7.8	16.1	14.25	18.75	4/14/80	1.1	18.3	6.0	7.9
8/21/79	4.4	18.9	13.5	18.5	4/15/80	-2.2	11.7	4.9	11.5
8/22/79	3.3	20.0	13.0	19.25	4/16/80	-1.7	17.8	5.5	12.3
8/23/79	3.3	21.7	14.0	19.25	4/17/80	1.7	21.7	6.0	11.5
8/24/79	3.9	19.4	13.25	19.75	4/18/80	-1.1	19.4	5.5	12.5
8/25/79	5.0	24.4	14.0	20.5	4/19/80	0.6	18.9	7.0	12.25
8/26/79	6.1	22.2	14.0	20.5	4/20/80	2.2	19.4	8.25	8.5
8/27/79	6.7	23.8	14.0	18.0	4/21/80	-1.7	10.0	6.5	8.5
8/28/79	6.7	20.0	14.74	16.75	4/22/80	-1.1	3.9	6.8	9.75
8/29/79	7.2	20.0	14.75	15.25	4/23/80	0.6	8.9	7.5	--
8/30/79	8.3	17.2	14.0	14.25					
8/31/79	8.3	15.0	12.0	18.25					
9/01/79	3.8	13.8	14.0	15.5					
9/02/79	4.4	22.8	13.75	15.25					
9/03/79	8.8	20.0	13.25	16.25					
9/04/79	7.2	21.1	13.5	18.5					
9/05/79	7.8	17.2	13.0	18.5					
9/06/79	3.3	26.1	13.25	--					
9/07/79	3.3	21.1	--	--					

Table 2. Climatological data taken at Howard Prairie Dam from NOAA climatological data for Oregon.

Month	Air Temperature Mean (°C)	Mean min. (°C)	Mean max. (°C)	Max. (°C)	Precipitation (mm)	Snow depth (mm)	# of days <0°C	# of days >32°C
January 1979	-4.0	-9.6	1.6	7.2	148	483	30	0
February 1979	-0.8	-5.2	3.6	9.4	108	584	27	0
March 1979	3.2	-3.4	9.7	17.8	56	584	29	0
April 1979	4.6	-1.35	10.8	17.8	95	0	24	0
May 1979	9.9	1.7	18.0	31.1	94	0	2	0
June 1979	13.0	3.7	22.2	29.4	25	0	3	0
July 1979	16.4	6.4	26.4	33.3	2	0	1	5
August 1979	15.0	6.6	23.7	32.2	19	0	0	1
September 1979	14.6	4.9	24.3	31.7	9	0	0	0
October 1979	9.7	2.9	16.3	28.9	130	51	9	0
November 1979	1.2	-3.7	6.1	12.2	138	457	3	0
December 1979	0.1	-4.3	4.4	11.1	103	635	8	0
January 1980	-1.4	-6.3	3.4	10.6	128	508	28	0
February 1980	2.4	-1.9	6.7	11.1	120	279	20	0
March 1980	1.4	-3.8	6.7	13.3	80	229	31	0
April 1980	5.4	-1.5	12.3	23.9	56	178	22	0
May 1980	7.9	0.6	15.3	27.2	46	76	15	0
June 1980	-	-	-	-	-	-	-	-
July 1980	16.7	6.7	26.7	35.0	6	0	0	5
August 1980	14.8	4.8	24.8	31.7	0	0	0	0
September 1980	13.0	3.5	22.6	38.3	20	0	3	0
October 1980	9.4	1.3	17.5	30.0	45	0	13	0

Methods and Materials

The primary method of collection was electrofishing with a type VII Smith-Root backpack electroshocker. Small numbers of suckers were held overnight in live cars at the first few sampling stations. No deaths were observed in these instances. Fyke nets and seines were used in Jenny and Johnson Creeks in areas where water was too deep for use of the backpack shocker.

Sampling during the period from June 16 to July 30, 1979 was primarily to determine the distribution of C. rimiculus both within Jenny Creek basin and outside in the Klamath and Rogue drainages and to obtain specimens for taxonomic work (Appendix 2). All streams shown in figure 1 were sampled and the number of sampling stations on each stream is shown by number in parentheses.

The stations sampled during the first part of the summer were at least 33 m (108 ft) long, the majority being closer to 100 m. These stations were sampled less intensively than those for habitat preference. They were sampled once, the fish collected were identified, enumerated and general habitat conditions noted.

After distribution patterns were determined, stations for more intensive sampling were selected and sampled from July 31 to September 6, 1979. These sampling stations were located at approximately each stream mile (1.6 km) on each stream within the Jenny Creek basin that was inhabited by suckers. Additional sites within a stream mile were sampled when time and personnel allowed. The additional sites were located 0.25 mi (0.4 km) above or below the original site selected and were indicated by an A following the station number if 0.25 mi above or B if 0.25 mi below the original site. There were 28 sampling stations on Jenny Creek with the first at the Oregon-California border. Station numbers in Table 8 were named for number of stream miles from the California border. Relative proportions of each habitat type within a stream mile were estimated and these same proportions were reflected in the length of each station.

Each sampling station was at least 33 m (108 ft) in length with some variation due to sampling feasibility. The upper and lower ends of the station were blocked with 10 mm mesh nets to prevent escape of fish. Transect lines were used at 6.2 m (20 ft) intervals within stations. Along each transect line two points were selected and water depth, velocity, bottom substrate, vegetation effective cover and shade were measured. Water depth was measured to nearest cm with a meter stick. Velocity was estimated by floating a partially water filled film can for a distance of 3 m (10 ft) and timing to the nearest second. Bottom particle size was measured to nearest 25 mm, unless under 25 mm and then was characterized as sand, mud, or silt and estimated to nearest millimeter. For calculation of mean particle size the lower limit was set at 2 mm and the upper limit of particle size at 406 mm to reduce bias of particles at extremes of size range.

Aquatic vegetation and effective cover were considered together but noted as to contribution. Effective cover was arbitrarily specified to be aquatic vegetation, debris, overhanging terrestrial

Table 3. Characterization of Jenny Creek by stream reach.

Reach	Stream kilometer	Character	Average instream gradient	Native species*
I	0 - 4.0	canyon	4.5%	RBT, S, SD, Sc, FH
II	4.0 - 7.25	canyon	1.5%	RBT, SD, S
III	7.25 - 16.0	open flats	< 1.0%	RBT, SD, S
IV	16.0 - 18.5	forested hills	1.0%	RBT, SD, S
V	18.5 - 21.0	canyon	1.5%	RBT, SD, S
VI	21.0 - 25.0	willow flats	< 1.0%	RBT, SD, S
VII	25.0 - 26.5	canyon, shaded	2.0%	RBT, SD, S
VIII	26.5 - 28.0	flat; shaded beaver ponds	< 1.0%	RBT, SD, S
IX	28.0 - 32.6	canyon, shaded	1.4%	RBT, SD, S
X	32.6 - 34.6	canyon, shaded	9.0%	RBT, SD

*Fish species are abbreviated as follows:

RBT - rainbow trout, *Salmo gairdneri*

S - Klamath smallscale suckers, *Catostomus rimiculus*

SD - speckled dace, *Rhinichthys osculus*

Sc - marbled sculpins, *Cottus klamathensis*

FH - fathead minnows, *Pimephales promelas* vegetation, boulders, undercut banks, or water depth of at least 75 cm. The proportion of transect segment with effective cover was estimated visually with aid of a meter stick. The relative proportion of that cover that was aquatic vegetation was noted. Percent of transect segment that had shade during the afternoon hours was estimated at the same time. The individual measurements at each point were used to calculate means of each character for that station. The means of width and depth were used to calculate mean cross sectional area for each section.

All stations were marked with aluminum identification plates to facilitate later recognition. Air and water temperatures were taken with a hand-held thermometer at each station at the time of sampling. Ryan recording thermographs were placed in representative sections of the upper, middle, and lower parts of Jenny Creek.

Population estimates were conducted by the Leslie depletion method (Seber 1973). An adequate number of passes is considered to be attained when the catch per unit effort is at least halved when compared to the previous pass. This requirement was usually met on the second pass during this study except on two stations that required a third pass. The method assumes that no fish are entering or leaving the sampling site during sampling efforts, that the probability of capture is equal for all fish and that probability of capture is proportional to the effort expended sampling. Fish smaller than 40 mm are assumed to be underrepresented in my results for two reasons. The first has to do with stress and mortality associated with electrofishing. Because larger fish have more body surface exposed to the electrical current they are most affected by the shocking. Stress and mortality from electrofishing occur from the combination of voltage used and duration of use. To reduce the deleterious effects of electrofishing on adult fish, care was taken to switch off the electroshocker while netting fish. This break in the field allowed smaller fish that recover very quickly to escape while larger fish remain stunned. The second reason is that the block nets had 10 mm mesh that allowed very small fish to leave the sampling site.

Several times efforts were combined with a BLM stream survey crew and 120 m stations were sampled. Fish density estimates are reported as the estimated number of fish of that species per 33 m segment of stream.

Fish species collected were identified and enumerated. All suckers were anesthetized and measured to the nearest mm standard length and weighed to the nearest gram. Scale samples were obtained from approximately 67 suckers. Subsamples of fishes were taken and preserved in 5% formaldehyde solution for later study including taxonomy, age and growth, and food habits.

The primary sampling period was June 16, 1979 to September 6, 1979. Sporadic sampling was continued for the next year and a half. Five stations, 0-1, 0-7, 0-13, 0-19 and K-2 were revisited during seasons when the others were inaccessible.

Food habits work was intended to be qualitative rather than quantitative. The entire intestine was removed and placed in a petri dish. The intestine was cut open and contents removed and examined. Components of the stomach contents were identified and the percentage of the volume of the intestine that that food category's original volume would have constituted was estimated (Van Oosten and Deason 1938). Categories were reported as percent of stomachs that each category appeared in and mean estimated original volume of those stomachs that category constituted.

Habitat preference was analyzed by calculation of Pearson product moment correlation coefficients at a 95% level using estimated fish densities and mean estimated habitat characters for each station in Table 9. Stations 0-16A, 0-17, 0-18 and 0-19 were not used for calculation of correlations with sucker density because of the presence of a barrier falls between stations 0-16M and 0-16A and the lack of suckers above the falls.

Counts and measurements in Table 4 were made on populations of <u>Catostomus rimiculus</u> from waters with direct access to the Klamath River, Rogue River, and Jenny Creek. Fish collections utilized in taxonomic analyses are retained at Oregon State University and the University of California at Davis.

Methods of counts and measurements follow the procedures of Hubbs and Lagler (1958) except as noted. Numbers of caudal, precaudal, and total post-Weberian vertebrae were counted from radiographs following Smith (1966). The hypural plate was counted as one vertebra. Number

Table 4. Meristic and morphometric characters examined in populations of *Catostomus rimiculus*.

Standard length
Predorsal length
Head length
Head width
Head depth
Body width
Body depth
Caudal peduncle depth
Anal-caudal length
Dorsal fin length
Left pectoral fin length
Left pelvic fin length
Anal fin length
Snout length
Snout to nostril length
Orbit length
Internal mouth width
External lip width
Least fleshy interorbital distance
Least bony interorbital distance
Number of dorsal fin rays
Number of anal fin rays

Table 4. Continued.

Number of left pectoral fin rays
Number of left pelvic fin rays
Number of lateral line scales
Number of scales above lateral line
Number of scales below lateral line
Number of scales around caudal peduncle
Number of predorsal scale rows
Number of precaudal vertebrae
Number of caudal vertebrae
Number of total post-Weberian vertebrae
Number of gill rakers

of gill rakers is that of the external row on the left side. External lip width is the greatest distance between lateral edges of the lips and mouth width is the width of actual oral opening. Morphometric characters were measured to nearest 0.1 mm with dial calipers and reported in thousandths of standard length. Morphometric characters and number of gill rakers were analyzed for allometric growth by calculating product moment correlation coefficients for the standardized character for each fish and the respective standard length. If the correlation coefficient was significant at p = .05, allometry was indicated. To reduce the effects of allometry, only fish between 67 and 200 mm were utilized.

Selected characters were analyzed by the graphical methods of Hubbs and Hubbs (1953). In these figures the base line indicates the range, the vertical line mean, the sectioned rectangle two standard errors on either side of the mean and that plus the lightened rectangle indicate 0.675 standard deviations on either side of the mean. If the lightened rectangles of any two samples do not overlap that constitutes separation of 75% of the members of each of those samples. This is the minimum accepted value for subspecific separation of any two populations.

Results and Interpretation

Origin of fishes in the Jenny Creek basin

There are three native fish species in the Jenny Creek system above the falls: Klamath smallscale suckers, *Catostomus rimiculus*, speckled dace, *Rhinichthys osculus*, and rainbow trout, *Salmo gairdneri* or redband trout *Salmo* sp. The taxonomic status of the trout in the system above the falls is in doubt because trout resembling redband trout were collected during the course of this study in the headwaters of Johnson Creek. In addition to these, Pacific lamprey, *Lampetra tridentata*, fathead minnow, *Pimephales promelas*, and marbled sculpins, *Cottus klamathensis* occur below the falls.

The fishes above the falls could have gotten there in two ways and from either or both of the two adjacent systems. They could have been there since before the falls were formed, but if that were true marbled sculpins would be expected above the falls. Monty Elliot (Geology professor at SOSC, pers. comm.) stated that the falls could be up to 5 million years old. A greater degree of divergence would be expected between the populations above and below the falls if they had been separated for that length of time.

The second way would have been by stream capture of portions of the headwaters of Rogue or Klamath tributaries. The most logical place for this to occur seems to be at the northern end of Howard Prairie where the headwaters of Grizzly Creek (Jenny Creek basin) and

Dead Indian Creek (Rogue River basin) come within 3 meters vertically and 0.4 km horizontally.

The headwaters of Dead Indian Creek could have been where the suckers and/or trout got into Jenny Creek basin but since dace historically have been absent from the Rogue River basin (C. E. Bond, pers. comm.) the dace must have come in somewhere else. Other possible areas for stream capture are (1) between the lower part of Skookum Creek and the headwaters of Rocky and Dutch Oven Creeks draining Agate Flat and (2) the headwaters of Johnson Creek and Tunnel Creek to the east.

Five species of fishes have been introduced into the reservoirs in the Jenny Creek basin and have spread from there to the lower reaches. Four of them, rainbow trout, *Salmo gairdneri*, eastern brook trout, *Salvelinus fontinalis*, brown bullhead, *Ictalurus nebulosus*, and pumpkin seed sunfish, *Lepomis gibbosus*, were introduced as sport fish. Golden shiners, *Notemigonus crysoleucas*, came in as a bait fish.

Age and growth

A length frequency analysis of 394 *Catostomus rimiculus* collected from July 31 to September 7, 1979 (Figure 2) reveals four distinct age classes corresponding to ages 0+, I, II, III, and IV. The numbers of 0+ fish are badly misrepresented due to the selectivity of the shocker and dip net mesh size. Sixty-seven *C. rimiculus* were aged by the scale method and from these mean lengths for each age class were calculated. The mean length of age class from scales is shown on figure 2 by the presence of arrows along the top of the figure. These mean lengths were at or near the modes of length frequency data.

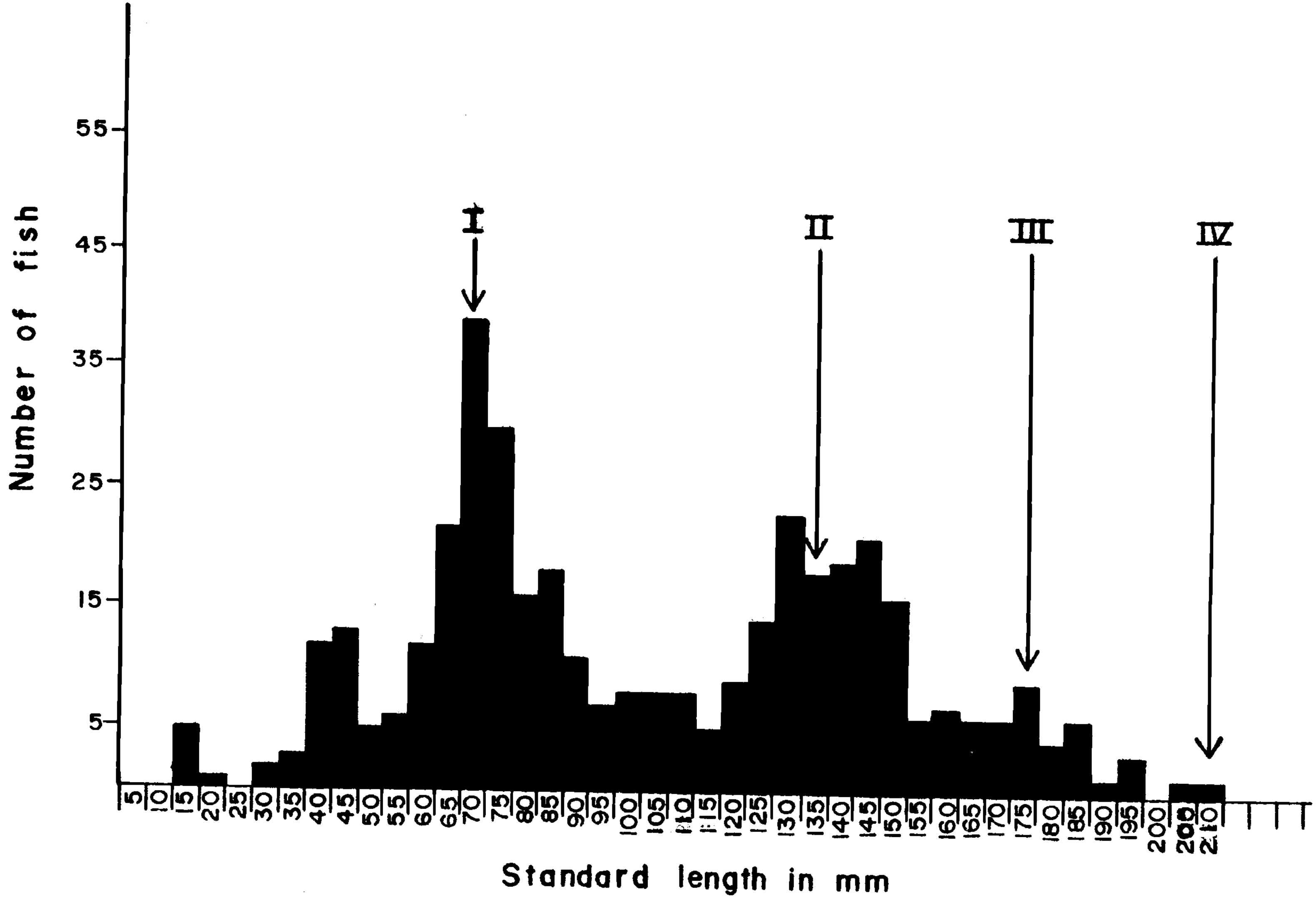
Table 5. Results of scale method aging.

Year class	Number of fish	$\overline{X}$ length (mm)	Range (mm)	SD (mm)
I	11	70.18	54- 88	8.47
II	40	135.17	105-158	13.04
III	15	173.6	153-204	19.01
IV	1	210.0		

The mean increment per year (age I is more than a year), mean length, and range of lengths (from scale method) is shown in Table 5.

Growth of Jenny Creek suckers appears to be good (Appendix 1). Comparison of my results with those of Moyle (1976) for *C. rimiculus*

Figure 2. Length frequency histogram of 394 C. rimiculus from Jenny Creek basin taken July 31 - September 4, 1979.



Number of fish
55
45
35
25
15
5
I
II
III
IV
5 10 15 20 25 30 35 40 45 50 55 60 65 70 75 80 85 90 95 100 105 110 115 120 125 130 135 140 145 150 155 160 165 170 175 180 185 190 195 200 205 210
Standard length in mm

in the Klamath River shows that Jenny Creek fish are larger at age I and II. However, his specimens were collected in April and May, but mine were taken in August. The 23-25 mm difference in mean lengths for each age probably would not have existed if collections were taken at the same time of year.

Longevity and maximum size is clearly different in the two areas. As previously stated, I did not find fish over age IV or 210 mm SL. Moyle reports suckers of age IX and 340 mm. C. rimiculus collected by California Department of Fish and Game from Copco Lake on 24 July 1978 ranged from 182 mm to 387 mm SL ($\overline{X}$ = 272 mm SL). Suckers collected from Spencer Creek were up to age VI and 270 mm, from the Rogue up to 380 mm and age VII. Finding suckers smaller than 250 mm was a problem in both the Klamath and Rogue.

Mature male suckers as small as 115 mm SL and females as small as 112 mm SL were collected in Jenny Creek. Spawning suckers in the Applegate River on March 20, 1981 ranged from 250 mm to 400 mm SL. It is difficult to determine at what size Rogue River fish mature due to my inability to collect suckers between 100 and 250 mm SL. The lack of fish below this size (250 mm) in the spawning run may indicate any one of three possibilities: (1) Smaller fisher are not mature. (2) Smaller fish are mature but run later than the large adults. (3) The proportion of the population below 250 mm is very small and so numbers of these fish in the run is very small. The last hypothesis is based on findings by Brauer (1973) for C. occidentalis in lower Hat Creek, California. He found that 81% of the population was age

VI and older. Moyle (1976) speculated that the larger fish forced the smaller fish into more exposed areas and therefore the survival of young fish was decreased. Louis Courtois (pers. comm.) speculated that this situation may exist in many populations of suckers in California. Sampling of fish from the Klamath River indicate that suckers matured at approximately 145 mm SL.

Food habits

The contents of 22 intestines of Catostomus rimiculus and 20 intestines of Rhinichthys osculus were examined and the results are shown in Tables 6 and 7.

Insects were found in 86% and 91% of the sucker and dace intestines respectively. Insects were a higher percentage of the volume of dace intestines ($\overline{X}$ = 67%, range 20-90%) than sucker intestines ($\overline{X}$ = 42%, range 2-95%). Psephenid, heptageniid and simuliid larvae are known swift water inhabitants (Pennak 1979). Presence of riffle beetles (Psephenidae) and the flattened, fast water heptageniids in sucker intestines indicate that suckers were feeding in riffle habitat. Simuliid larvae were absent from sucker intestines. Clams were absent from dace intestines. Clams were found in all the intestines of suckers from station 0-11 but were not found in suckers from other areas. Small numbers of snails (1-5/intestine) were found in a few sucker and dace intestines.

Algae was a persistent component of intestinal contents but is underrepresented in Tables 6 and 7 because only discrete, recognizable algae was categorized as such. Amorphous flocculent organic material consisted largely of mucous, algae, and detritus.

Analysis of intestine contents showed that both suckers and dace were eating a variety of benthic foods. All of the foods appearing in sucker intestines coincide with the bottom grazing behavior observed in the field. But, some items may have been picked from the

Table 6. Foods found in intestines of 22 *Catostomus rimiculus*, 58-208 mm SL from Jenny Creek, Oregon.

Food	% frequency	Estimated volume	Range	SD
Insects (includes unident.)	86	42	2 - 95	36
Psephenidae (larvae)	23	30	1 - 80	
Psephenidae (adults)	5			
Plecoptera (larvae)	14			
Ephemeroptera (larvae)	23			
Baetidae				
Heptageniidae				
Trichoptera (larvae)	27			
Diptera (larvae)				
Sialidae				
Chironomidae	59	23	1 - 90	32
Amorphous flocculent organic material	73	48	5 - 85	26
Clams (Unionidae)	27	25	10 - 40	12
Snails	27		1 - 10	
Algae	14	38	30 - 50	10

Table 7. Foods found in intestines of 20 *Rhinichthys osculus*, 45-91 mm SL from Jenny Creek, Oregon.

Food	% Frequency	Estimated volume	Range	SD
Insects (includes unident.)	91	67	20 - 90	24.5
Hymenoptera adults	9			
Psephenidae (larvae)	9			
Psephenidae (adults)	0			
Plecoptera (larvae)	27			
Ephemeroptera (larvae)	18			
Baetidae				
Heptageniidae				
Trichoptera (larvae)	27			
Diptera (larvae)				
Simulidae	18			
Chironomidae	27			
Trichoptera (adults)	18			
Amorphous flocculent organic material	64	33	10 - 80	27.5
Snails	18			
Algae	18	55	40 - 70	21.0

drift. Stewart (1926) reported that many chironomids were picked out of elodea. Chironomids are herbivorous and many species live in aquatic plants (Pennak 1979). The foods were usually segregated indicating discriminative feeding.

Stewart (1926) concluded that C. commersonii in the northeast were primarily insectivorous based on the fact that 66.4% of all foods ingested was insects. Only 6% was plant material.

Greenfield et al. (1970) reported that 97.53% of intestine contents of C. santaanae consisted of detritus, filamentous algae and diatoms, the remaining portion being insect larvae. However, the specimens examined were 27 to 57 mm SL. The authors reported a trend toward increased numbers of insect larvae in the larger specimens.

Hauser (1969) working on C. platyrhynchus in Montana found diatoms and filamentous algae in all intestines examined. Dipteran larvae were in 68% of intestines of adult suckers.

Brauer (1971) reported that 40% of volume of intestines of C. occidentalis from Hat Creek were diatoms and filamentous algae. The remainder was mostly chironomid and trichopteran larvae.

Moyle (1976) reported results of work by Norton and White (unpublished data) on C. occidentalis that indicated that the bulk of their diet is filamentous algae, diatoms, and detritus. Less than 20% of the intestine contents were invertebrates.

Minckley (1973) states that the mountain suckers (subgenus Pantosteus) feed upon algae and detritus by scraping rocks with their cartilage-sheathed jaws. He reports some variation in feeding habits in mountain suckers, citing heavy dependence of Colorado River forms on aquatic invertebrates.

Carl (1936) concluded that 80-100% of C. macrocheilus were ingesting aquatic insect larvae similar to those eaten by coho salmon, Oncorhynchus kisutch, and were "serious competitors" with young coho.

Jingran (1948) in his study of speckled dace in the Klamath River found that dace were feeding heavily on insects during winter, spring, and summer. A shift to a diet consisting primarily of algae was noted in the fall.

Suckers in Jenny Creek were observed feeding during all hours of the day and over most types of substrate. La Rivers (1962) reported that suckers fed only at night and moved into riffle areas to do so. Alley (1977) reported that C. occidentalis fed during all hours. Minckley (1973) stated that species of the subgenus Pantosteus are abundant in deeper areas just below riffles during the day and move into riffles at dusk to forage. Stewart (1926) in his paper on C. commersoni reported similar habits, relating them to the wariness of adult suckers.

Distribution

Catostomus rimiculus was found during summer 1979 in mainstem Jenny Creek to stream kilometer 33, in Keene Creek to kilometer 4.8, in Johnson Creek to kilometer 4.8, the lower reaches of Beaver Creek, and Corral Creek to kilometer 2.4.

The explanation for the fact that suckers were not found in the upper portions of Jenny and Keene Creeks, even though there appears to be suitable habitat, could involve one or several factors in combination. First, there is a tendency for much of the upper reaches of all the streams in the basin to become intermittent as the summer progresses, especially in low water years. Flowing stretches are fed by springs but may not be continuous. Flow records for the lower reaches were kept only for a few years in the early 1920's but they show that on August 13-15, 1926 there was no flow in Jenny Creek at the mouth. This indicates the aridity of the region and fluctuation of flow (to a maximum of 1960 cfs in February 1927) when the only diversion was Hyatt Lake and a ditch to take water over the ridge to Talent. By 1963 two more dams and an elaborate system of canals had been completed to carry a continuous 55 cfs to Talent Irrigation District. The completion of the dams could have barred access to these areas if they had been closed when suckers were in the lower reaches for the winter.

C. rimiculus is known to inhabit reservoirs on the Klamath in California but even if they had originally established populations as the dams were closed, Oregon Department of Fisheries and Wildlife poisoned all of the reservoirs as part of a "rough" fish control project to control introduced bullheads, centrarchids and golden shiners. Keene Creek below Hyatt Lake received enough rotenone spill over to kill off the rainbow trout, brook trout and brown bullheads in the stretch just above Keene Creek Reservoir. No dead suckers were observed (OSGC Fishery Division reports).

Another possible influence is competitive exclusion. The three primary species in the basin have overlapping diets to a considerable degree and as the living space is reduced in upstream sections, competition for food may exclude one or more species. As can be seen by the food habits section, suckers and dace are feeding heavily on insect larvae at least part of the time. Rainbow trout are known to be insectivorous and examination of a few stomachs confirmed this. Rainbow trout may be utilizing insects from a somewhat different source. Suckers and trout were observed in the same habitat but trout were typically off the bottom and suckers and dace right on the bottom. Suckers may rely heavily on grazing the substrate and trout on picking the drift.

Trout were collected at all sites where suckers were collected except one. Table 9 shows the correlation coefficients of the habitat characters and other species densities with the density of the native fish species in Jenny Creek. Table 8 presents density of each fish species and estimates of habitat characters for each of the stations surveyed intensively on Jenny and Keene Creeks. The fact that there

Table 8. Estimates of fish density and habitat characters of 30 sampling stations on Jenny and Keene Creeks.

Station	Dens. est. (fish/33 m) JCS	RBT	SD	Width (m) X (s) range	Depth (mm) X (s)	Depth (mm) range	Bottom (mm) X (s)	Bottom (mm) range	Shade (%) X (s)	Shade (%) range	Cover (%) X (s)	Cover (%) range	Area (m²) X	Mean length (mm) JCS	Mean weight (gm) JCS
0-C	10	89	11	7.4 (0.8) 6.4- 8.3	620 (176)	355-1016	200 (193)	6- 406	6 (7)	0- 15	59 (31)	10- 100	4.588	109 (40-190)	
0-1M	12	4	108	10.8 (0.9) 9.7-11.9	550 (146)	370-910	150 (84)	18- 280	2 (3)	0- 10	47 (36)	0- 100	5.94	119 (54-155)	34
0-1A	2	25	101	10.9 (3.2) 7.3-17	370 (160)	110-710	110 (44)	52- 212	10 (17)	0- 75	23 (22)	5- 65	4.00	69 (49- 87)	6.2
0-2	22	12	33	12.6 (14) 7.6-17.4	320 (127)	130-710	70 (53)	10- 180	3 (7)	0- 25	8 (13)	0- 50	4.032	114 (26-195)	39
0-3	30	22	233	11 (2.3) 5.5-12.8	250 (100)	76-457	130 (75)	38- 280	0	0	30 (13)	10- 50	2.75	64 (37-103)	
0-4M	9	8	174	5.4 (1.3) 3.7- 7.6	320 (107)	152-635	90 (79)	1- 250	50 (46)	0-100	10 (16)	0- 70	1.728	82 (55-145)	13 (3-48)
0-4A	9	0	91	6.2 (0.6) 5.5- 7	350 (93)	254-483	105 (65)	25- 250	1 (3)	0- 10	10 (8)	0- 25	2.17	68 (61- 74)	5.8
0-5	6	12	129	12 (3.7) 5.8-16.2	350 (205)	127-1016	130 (56)	2- 229	10 (23)	0-100	16 (21)	0-100	4.2	67 (58- 75)	5
0-6	40	9	186	11 (0.5) 10.2-11.7	390 (85)	289-572	230 (175)	2- 406	0	0	33 (33)	0-100	4.29	70 (42-140)	10
0-7	6	35	78	6.2 (1.9) 4.6-10	330 (171)	152-610	300 (106)	114- 406	0	0	30 (24)	10- 85	2.046	73 (12-134)	
0-8	12	51	18	11 (2.5) 7.3-14.6	360 (204)	140-775	180 (119)	2- 406	23 (30)	0-100	36 (27)	10- 80	3.96	132 (115-150)	38
0-9	1	34	35	6.5 (0.9) 5.2- 7.9	160 (68)	61-244	170 (48)	76- 229	27 (34)	0- 90	34 (20)	0- 70	1.04	110	26
0-10	5	3	17	5.7 (1.9) 3.6- 8.2	280 (171)	76-660	100 (80)	2- 280	2 (5)	0- 20	11 (16)	0- 70	1.596	120 (71-156)	29
0-11	24	20	14	7.9 (0.8) 6.4- 9.1	650 (285)	178-1220	120 (92)	2- 330	4 (10)	0- 35	72 (36)	10-100	5.135	136 (62-204)	47
0-12M	0	45	34	9.2 (2.5) 6.1-11.9	220 (95)	89-381	230 (120)	2- 406	40 (33)	10- 90	19 (9)	10- 30	2.024		
0-12A	4	57	29	7.3 (1.9) 4.9-10.4	220 (107)	89-508	240 (152)	2- 406	5 (13)	0- 40	24 (15)	0- 50	1.6	139 (135-147)	52
0-13L	16	18	40	7.4 (1.7) 5.8-10	490 (201)	114-838	130 (115)	2- 406	30 (36)	0-100	46 (40)	0-100	3.626	135 (105-170)	
0-13U	5	38	13	3.8 (1.0) 2.7- 5.2	160 (78)	63.5-330	130 (78)	6- 280	41 (43)	0-100	16 (18)	0- 80	.608	60 (48- 70)	

Table 8. Estimates of fish density and habitat characters of 30 sampling stations on Jenny and Keene Creeks.

Station	Dens. est. (fish/33 m)			Width (m)	Depth (mm)		Bottom (mm)		Shade (%)		Cover (%)		Area (m^2)	Mean length (mm)	Mean weight (gm)
	JCS	RBT	SD	X (s) range	X (s)	range	X (s)	range	X (s)	range	X (s)	range	X	JCS	JCS
0-14B	2	10	35	3.4 (1.3) 1.5- 4.5	240 (124)	114-483	130 (70)	25- 264	26 (34)	0- 95	25 (28)	5- 90	.816	133 (130-136)	35
0-14M	4	16	44	4.1 (0.4) 3.6- 4.6	140 (49)	76-254	110 (48)	76- 203	81 (5)	75- 90	13 (6)	5- 20	.574	66 (65- 67)	6
0-14A	0	16	26	2.7 (1.4) 1.2- 4.6	270 (170)	102-622	240 (82)	102- 356	5 (6)	0- 15	29 (24)	5- 90	.729		
0-15B	2	35	16	3.4 (1.0) 1.8- 4.6	210 (77)	102-330	200 (163)	2- 406	22 (27)	0- 75	37 (23)	0- 70	.714	126	38
0-15M	2	16	0	3 (1.8) 1.2- 6.1	260 (87)	152-387	60 (61)	2- 127	60 (22)	30- 90	73 (31)	30-100	.78	127	35
0-16B	1	27	0	2.9 (0.8) 1.4- 3.7	250 (85)	127-381	120 (144)	13- 406	28 (24)	10- 70	43 (33)	10-100	1.750	138	43
0-16A	0	5	0	2.7 (1.2) 1.4- 4.6	190 (116)	102-470	130 (86)	51- 254	27 (18)	10- 60	33 (30)	10- 75	.513		
0-17	0	8	0	1.8 (0.6) 1.0- 2.7	210 (104)	102-457	140 (76)	2- 187	53 (22)	30- 80	33 (13)	20- 50	.378		
0-18	0	13	14	1.4 (0.7) 0.9- 2.4	130 (42)	51-229	220 (78)	153- 330	52 (24)	20- 80	40 (25)	10- 80	.182		
0-19	0	0	5	1.7 (0.8) 0.9- 3 0	110 (89)	25-280	260 (42)	203- 305	42 (41)	0-100	64 (36)	0-100	.187		
K-1	33	25	104	4.9 (1.6) 1.7- 7.6	280 (134)	114-635	220 (178)	2- 406	8 (18)	0- 80	18 (16)	0- 70	1.37	80 (32-130)	
K-2	45	60	25	4.6 (0.9) 3.3- 5.5	300 (156)	114-546	90 (52)	2- 178	27 (26)	0- 50	26 (29)	0-100	1.38	143 (60-185)	

Table 9. Product moment correlation coefficients calculated from estimates of densities of 3 fish species and estimates of 7 habitat characters of 30 sampling stations on Jenny and Keene Creeks.

Habitat character	Sucker density	Dace density	Trout density	Stream mile
Stream width ($\overline{X}$)	+0.30	+0.55*	+0.14	-0.83**
Stream depth ($\overline{X}$)	+0.27	+0.20	+0.25	-0.60*
Particle size ($\overline{X}$)	+0.34	-0.02	+0.25	+0.14
Effective cover ($\overline{X}$)	+0.03	-0.32	+0.12	+0.26
Shade ($\overline{X}$)	-0.31	-0.30	-0.12	+0.52*
Stream mile	-0.53*	-0.54*	-0.23	----
Cross sectional area ($\overline{X}$)	+0.52*	+0.40*	-0.21	-0.89**
Sucker density	----	+0.31	+0.03	-0.53*
Dace density	+0.31	----	-0.23	-0.54*
Trout density	+0.03	-0.23	----	-0.23

*Denotes significance at p = 0.05

**Denotes significance at p = 0.01

was not a correlation between trout and suckers is that although they were almost always found together in the lower reaches, trout were found high in the tributaries where suckers were not. Alley (1977) found that suckers (C. occidentalis) were not spatially restricted by trout, that trout and suckers appeared to prefer the same water quality and flow, and that both species stayed at about the same depth and fed in swift water areas. The only differences he reported were that suckers at each depth were near substrate, that these positions had less turbulence and that, therefore, suckers expended less energy to maintain position. Seventy-five percent of the suckers he observed were in water flowing 10-70 cm/second during August and September.

Dace were even more closely associated with suckers than trout were because not only were dace found at all sites that suckers were but they were not found in many places that suckers were not. The correlation of dace density with sucker density showed a positive, if non-significant relationship. The fact that dace mature and reach maximum size at much smaller sizes (50 mm dace vs. 125 mm suckers and 90 mm dace vs. 210 mm suckers) probably accounts for their presence higher upstream than suckers in all streams sampled. Suckers up to 110 mm SL and dace up to 80 mm SL have similar mouth sizes, but after reaching that length (110 mm) suckers have larger mouths than the smaller dace. Even though there is overlap in food habits and mouth sizes in the younger classes of dace and suckers, the fry were observed and collected from the same sites at the same time.

After sampling intensively throughout the summer and less intensively during the fall and spring, I concluded that the distribution of C. rimiculus is not static. I found large populations in upstream sections during the summer but much smaller populations in the fall. Although the sampling efforts during seasons other than summer were sporadic and less intensive than those of summer, I recognized a pattern of seasonal migration. Adult suckers moved up into tributaries or higher reaches in the spring to spawn then dropped down over the summer as the water level lowered, to areas that were spring fed. These areas had consistent water flows and temperatures. Alley (1977) reported a similar pattern in C. occidentalis in Deer Creek, California. There suckers and cyprinids moved downstream in late September. Alley speculated that they might move to deeper, slower pools where energetic costs could be reduced as water temperatures dropped.

Habitat preference

The only habitat characters showing significant ($p = 0.05$) correlations with estimated densities of suckers were a negative correlation with increasing stream kilometer for month and a positive correlation with increasing cross-sectional area (Table 9). Results for dace were significant for these two habitat characters plus a positive correlation with increasing stream width. No correlations between the measured habitat characters and density of trout were significant.

The correlations of the remaining habitat characters with density of suckers and dace were not significant at this sample size ($n = 30$) but showed some trends that seem intuitively reasonable. First, though, suckers were found in most habitat types at one point or another over the two year study period and were found in different densities with habitat types at different times of the year. They are versatile, mobile animals and utilize various habitats throughout the day and year. Nonetheless, and rigorous statistical interpretation aside, I believe that a few things can be said about where *C. rimiculus* is found throughout the day and year and why.

There was a significant positive correlation between cross sectional area of stream and density of suckers ($r = +0.52$) and a significant negative correlation between increasing stream kilometer and density of suckers ($r = -0.53$). These two trends are interrelated because cross sectional area decreased with increasing stream kilometer (r = -0.89). Associated with this is the observation that not only were there more suckers in the lower portions of Jenny and Keene Creeks, but they were significantly (t = 11.44) smaller. Of the suckers collected during the intensive sampling of these creeks 74.5% were taken below km 18.5 on Jenny Creek and km 2 on Keene Creek and they had a mean standard length of 88.6 mm. The remaining 24.5% that were taken above these points had a mean standard length of 132.6 mm. Jenny Creek between km 7.25 and km 18.5 and Keene Creek below km 2 consist primarily of low gradient, unshaded stream flowing through cattle pasture. Above these points, gradients are generally higher, the stream banks are more forested, and stream width decreases. The open areas have few trees and receive large amounts of sunlight and the canyon areas have trees and high walls that limit the amount of sunlight reaching the water. The amount of sunlight affects the amount of primary production and the overall productivity of the stream. Related to all of this are the negative correlation of shade and the positive correlation of particle size with density of suckers. Insect and algae populations should be greater in areas of high sunlight and silt free growing surfaces. Velocity of flow relates to this because water flow is required to bring food and oxygen to biotic components and to keep rock surfaces clean. Velocity was not included in Table 3 because of problems with the flow meter in the early portion of the study and incompleteness of the results. But, enough sampling and velocity data was gathered to say that suckers were found in water ranging from slow (< 3 cm/sec) to moderately swift

(> 60 cm/sec). This was fastest water measured. The majority of suckers were found in water between 15 and 30 cm/sec. Alley (1977) reported finding suckers in water ranging from 10 to 70 cm/sec and reported that 75% of C. occidentalis were found between these two extremes.

Elodea was found to be an important characteristic of sucker habitat. Elodea provides not only cover but also is a source of insects, especially chironomids (Pennak 1979). During the summer suckers and dace were repeatedly observed lying on the bottom in the current next to beds of elodea and at first alarm, would dash into the elodea. Careful use of electrofishing equipment would draw them out of the elodea beds. In the winter as water temperatures dropped, suckers and dace were not observed outside the elodea but could be drawn out of it.

Effective cover had an extremely low correlation coefficient, indicating no relation between that factor and sucker density. This did not seem to be true during sampling and may be a result of almost uniform effective cover throughout the length of the streams. This would make it appear was though there was not a relation when actually effective cover simply was not a limiting factor a majority of the time.

Taxonomy

Scale counts

The number of scales above the lateral line is significantly different for the Jenny Creek and Rogue River collections with the Klamath collection intermediate. The Jenny Creek sample is modal at 16 and has a mean of 15.8 scales above the lateral line (ALL). The Rogue River sample is modal at 18 and 19 and has a mean of 18.1 scales ALL. Figure 3 graphically shows the relationship of the three populations for ALL.

Number of lateral line scales are very close (Table 10) in all three populations. Specimens from the Rogue River have more scales above the lateral line (Table 11), below the lateral line (Table 12), and before the dorsal fin (Table 13). The Klamath sample have a higher range of scales around the caudal peduncle (Table 14).

Table 10. Frequency of mean of lateral line scale counts in populations of *Catostomus rimiculus*.

	Frequency															
Basin	79	80	81	82	83	84	85	86	87	88	89	90	91	92	93	$\overline{X}$
Jenny Creek		1		2	1	3	3	1	3	4	2	5	5		1	87.6
Rogue River	1			2	1	1	4		1	1	3	1	2	1	2	87.1
Klamath River			2	3	1	3	1	4	4	4	2		2	5	2	87.2

Figure 3. Comparison of ranges, means, standard deviations and standard errors of number of scales above the lateral line for the populations of *Catostomus rimiculus*.

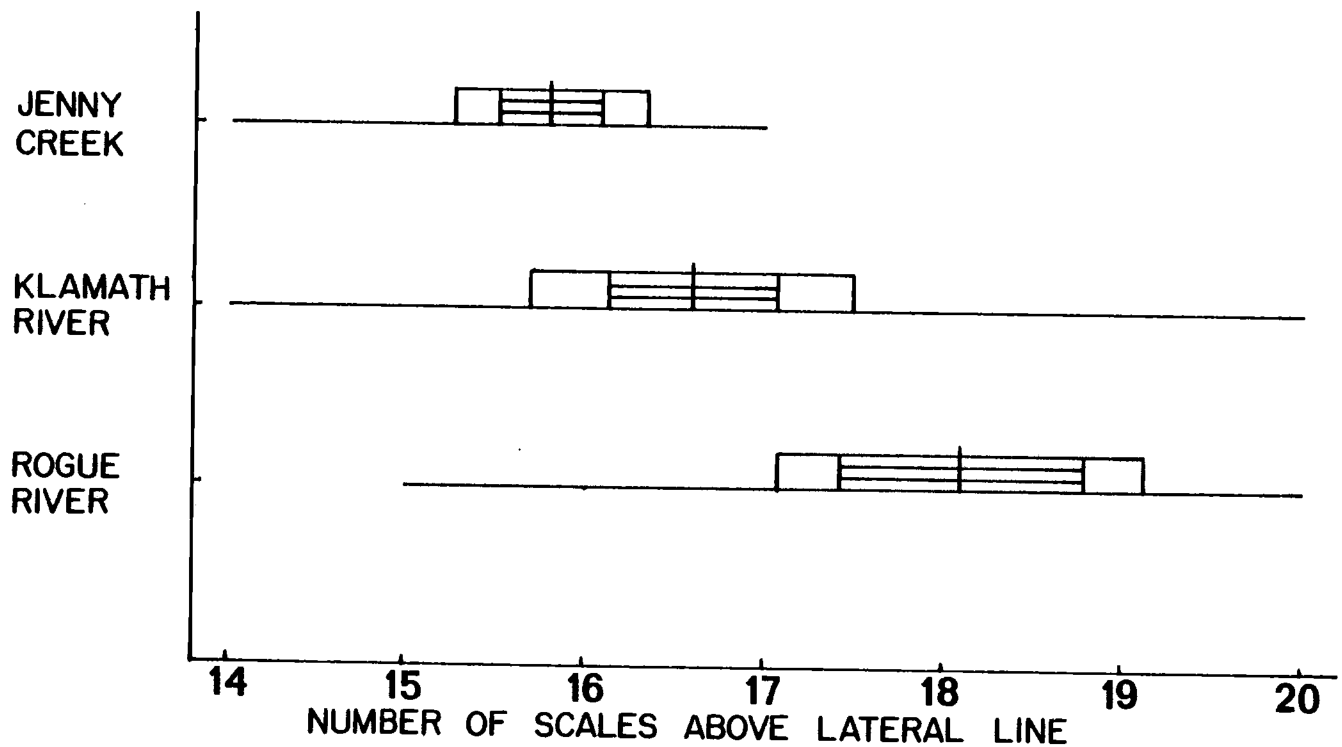

JENNY CREEK
KLAMATH RIVER
ROGUE RIVER
14
15
16
17
18
19
20
NUMBER OF SCALES ABOVE LATERAL LINE

Table 11. Frequency and mean of number of scales above the lateral line in populations of Catostomus rimiculus.

	Frequency									
Basin	14	15	16	17	18	19	20	21	$\overline{X}$	s
Jenny Creek	1	10	13	6					15.8	0.8
Rogue River		1	3	2	5	5	4		18.1	1.52
Klamath River	1	5	11	8	5	2	1		16.6	1.34

Table 12. Frequency and mean number of scales below the lateral line in populations of Catostomus rimiculus.

	Frequency							
Basin	10	11	12	13	14	15	$\overline{X}$	s
Jenny Creek	3	2	8	15	2	1	12.4	1.165
Rogue River			4	6	10		13.3	0.80
Klamath River		2	11	13	4	3	12.85	1.034

Fin rays

All three populations are modal at 9 for anal fin rays, 11 for dorsal fin rays and 10 for pelvic fin rays. The only fin character showing significant variation between populations is the number of rays in left pectoral fin. As can be seen from figure 4, both Jenny Creek fish and Klamath River fish can be separated from fish from the Rogue River. Fish from Jenny Creek are widely divergent from Rogue River but cannot be separated from those of the Klamath River at a 75% level.

Table 13. Frequency and mean of predorsal scales in populations of *Catostomus rimiculus*.

	Frequency														
Basin	38	38	40	41	42	43	44	45	46	47	48	50	52	$\bar{X}$	s
Jenny Creek	3	1	6	5	6	3	6			1				41.6	2.1
Rogue River				4	1	3	4	2	1	1	3		1	44.5	2.95
Klamath River	1	2		4	9	6	4	3	2			1		42.0	2.35

Table 14. Frequency and mean number of scales around the caudal peduncle in populations of *Catostomus rimiculus*.

	Frequency								
Basin	15	16	17	18	19	20	21	$\bar{X}$	s
Jenny Creek		10	11	10				17	0.82
Rogue River	2	6	4	5	2	1		17.1	1.37
Klamath River		8	5	15	2	2	1	17.6	1.27

Klamath specimens are harder to distinguish from Rogue specimens than are Jenny Creek specimens but are separable at a 75% level. Specimens from Jenny Creek (58%) and the Klamath (61%) are modal at 16. The Jenny Creek sample shifts downward with 25.8% at 15 and the Klamath sample shifts upward with 32.3% at 17. The Rogue sample is modal at 18 (45%) with 40% at 17.

Figure 4. Comparison of ranges, means, standard deviations and standard errors of left pectoral fin ray counts for three populations of *C. rimiculus*.

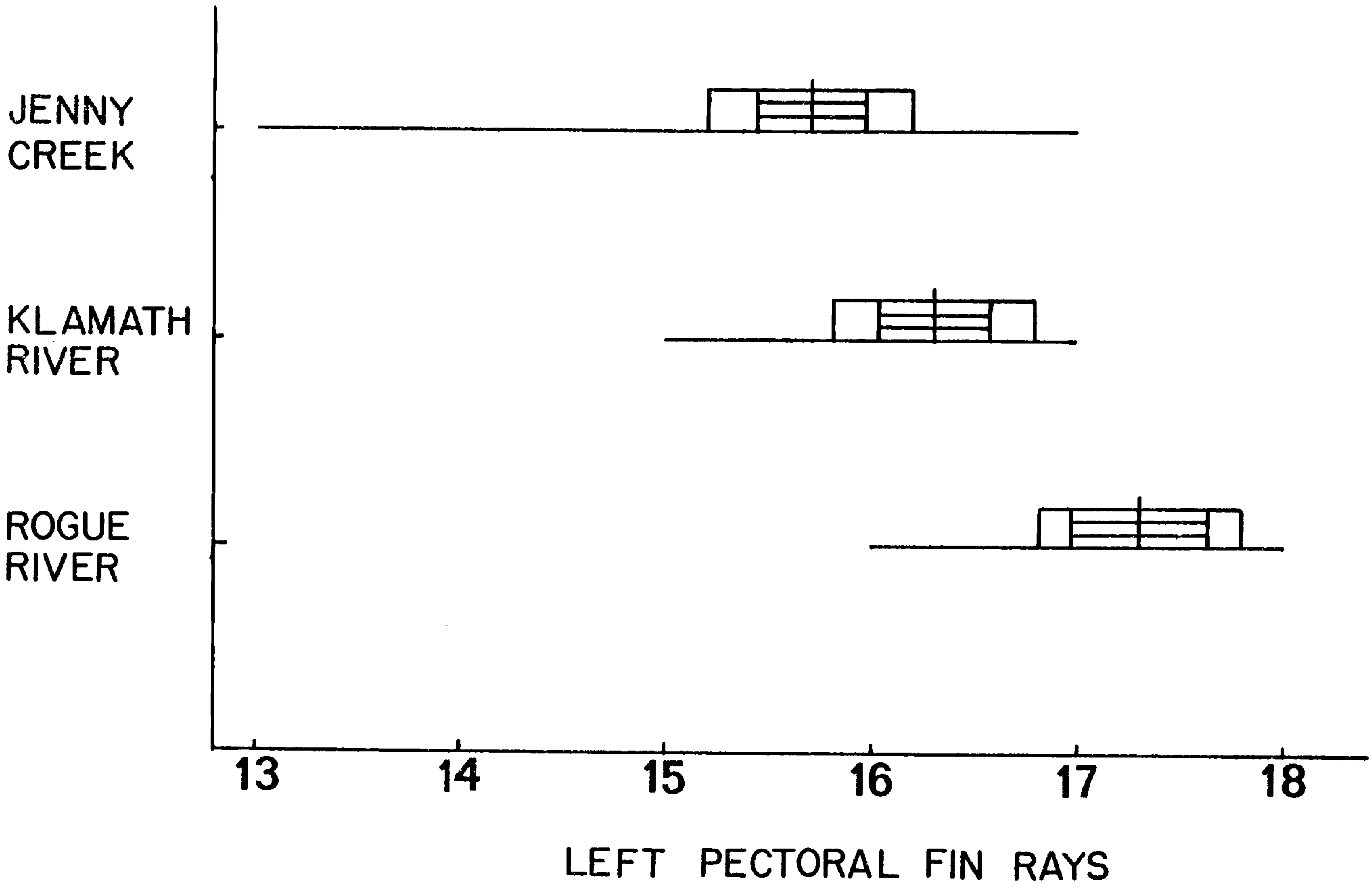

JENNY CREEK
KLAMATH RIVER
ROGUE RIVER
13
14
15
16
17
18
LEFT PECTORAL FIN RAYS

Table 15. Frequency and mean number of left pectoral fin rays in populations of Catostomus rimiculus.

Basin	Frequency 14	15	16	17	18	$\bar{X}$	s
Jenny Creek	2	8	18	3		15.7	0.74
Rogue River			3	8	9	17.3	0.73
Klamath River		3	19	10		16.3	0.73

Gill rakers

Table 16 presents frequency and means of counts of gill rakers. Specimens from Jenny Creek and the Klamath are very close in number of gill rakers. Jenny Creek and the Rogue River samples are more divergent but this may be accounted for by the extremely large suckers from the Rogue River. Gill raker numbers are reported to develop allometrically in suckers, number of gill rakers increasing as the fish get larger (Smith 1966). I found this to be true for this study also (see Allometry section). Any distinction would probably disappear if comparable size fish from the Rogue were examined.

Table 16. Frequency and mean number of left gill rakers in populations of Catostomus rimiculus.

Basin	Frequency 19	20	21	22	23	24	25	26	27	28	$\bar{X}$	s
Jenny Creek	1	1	7	10	8	3	1				22.2	1.27
Rogue River		1		2	4	2	5	3	2	1	24.45	1.99
Klamath River		2	8	2	8	8	4	1			22.85	1.6

Vertebrae

The number of caudal vertebrae (Table 17) was the most discriminating character measured for the three populations. This is the only character that will separate the Klamath River and Jenny Creek populations (Figure 5). The Jenny Creek sample is modal (41.93%) at 17 and 18 caudal vertebrae and has a mean of 17.46. The Klamath River sample has a mode (48.38%) and mean of 19. Seven counts (22.6%) each were 18 and 20. The Rogue River sample is modal (58.33%) at 19 and has a mean of 18.67.

Table 17. Frequency and mean of caudal vertebrae in populations of *Catostomus rimiculus*.

	Frequency								
Basin	15	16	17	18	19	20	21	$\bar{X}$	s
Jenny Creek	1	1	13	13	2			17.46	0.787
Rogue River				9	14	1		18.67	0.5646
Klamath River			1	7	15	7	1	19.0	0.856

Total post-Weberian vertebrae counts give a somewhat different picture (Table 18). Specimens from Jenny Creek (50%) and the Klamath River (41.9%) are both modal at 43. The Jenny Creek sample has 40% at 42 and the Klamath sample has 25.8% at 44. The Rogue sample is modal at 44 (58.33%) and shifts downward to 43 (33.3%). Figure 6 presents the number of post-Weberian vertebrae in the three populations graphically. Jenny Creek suckers are sufficiently different from the Rogue River suckers to separate subspecifically.

Figure 5. Comparison of ranges, means, standard deviations and standard errors of number of caudal vertebrae for three populations of *Catostomus rimiculus*.

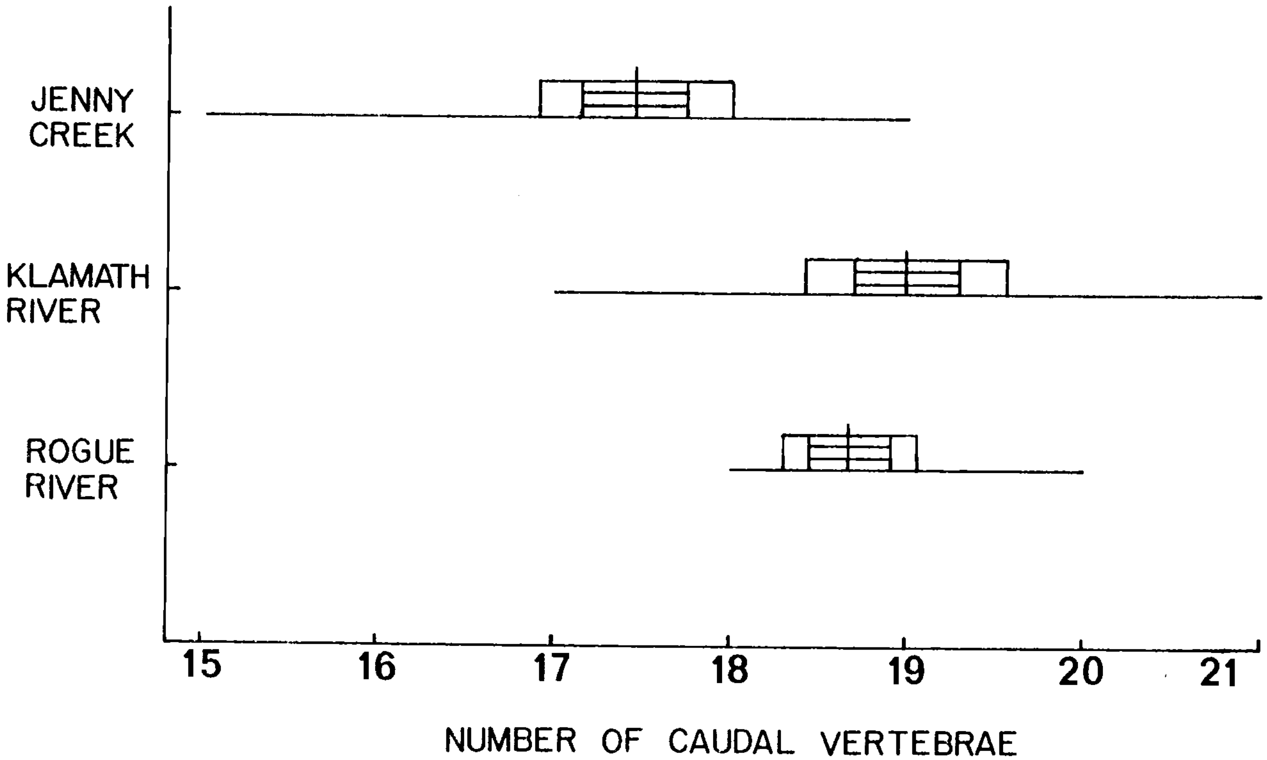
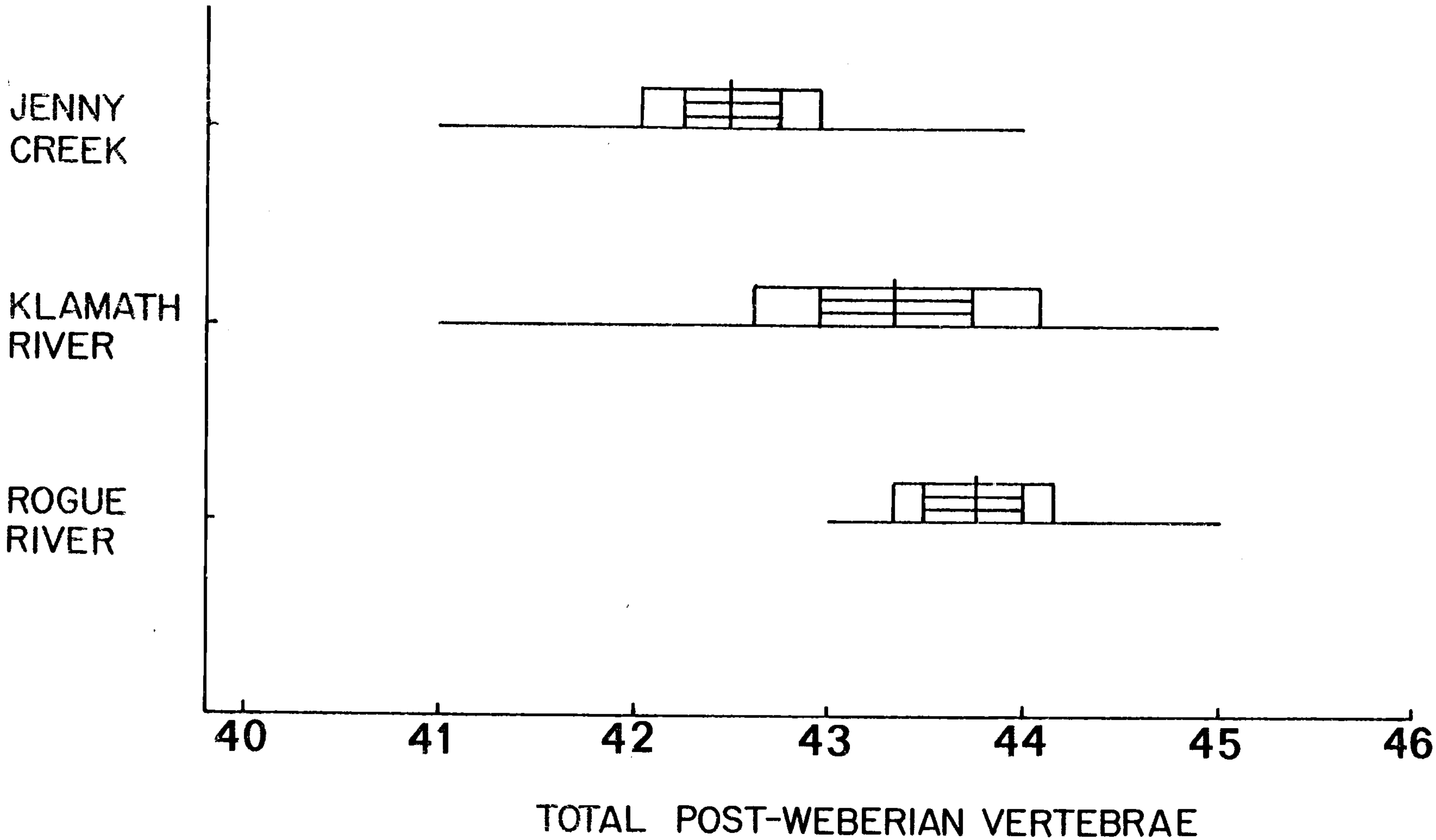

JENNY CREEK
KLAMATH RIVER
ROGUE RIVER
15
16
17
18
19
20
21
NUMBER OF CAUDAL VERTEBRAE

Figure 6. Comparison of ranges, means, standard deviations and standard errors of total post-Weberian vertebrae for three populations of *Catostomus rimiculus*.


JENNY
CREEK
KLAMATH
RIVER
ROGUE
RIVER
40
41
42
43
44
45
46
TOTAL POST-WEBERIAN VERTEBRAE

Precaudal vertebrae counts (Table 18) for specimens from Jenny Creek and the Rogue River are modal at 25 with means of 25.03 and 25.08 respectively. The Klamath River sample is modal at 24 with a mean of 24.35.

Table 18. Frequency and mean of total post-Weberian vertebrae in populations of _Catostomus rimiculus_.

	Frequency						
Basin	41	42	43	44	45	$\bar{X}$	s
Jenny Creek	2	12	15	1		42.5	0.68
Rogue River			8	14	2	43.75	0.61
Klamath River	2	3	13	8	5	43.35	1.08

Table 19. Frequency and mean of precaudal vertebrae counts in populations of _Catostomus rimiculus_.

	Frequency						
Basin	23	24	25	26	27	$\bar{X}$	s
Jenny Creek		5	20	4	1	25.03	0.668
Rogue River		3	16	5		25.08	0.584
Klamath River	5	14	8	4		24.35	0.946

To summarize, _C. rimiculus_ in Jenny Creek can be separated at a subspecific level from those of the Klamath River on the basis of number of caudal vertebrae and from _C. rimiculus_ of the Rogue River on number of total post-Weberian vertebrae. The Rogue River and Klamath River C. rimiculus differ most with respect to number of precaudal vertebrae but cannot be separated at a subspecific level on that basis.

Morphometrics

Tables 20-22 present results of morphometric analysis. Eight morphometric characters show variation among populations of C. rimiculus. Allometry and the lack of suckers between 100 and 200 mm from the Rogue River cloud the picture appreciably. Only one character exhibits enough variation to separate populations on a subspecific level. Lip width, the maximum lateral extent of the lips, distinguishes the suckers in the Rogue River from those of Jenny Creek (Figure 7). The Klamath River collection is intermediate between the two. As can be seen from Table 24, lip width is allometric. Because the relationship between LW/SL and SL is positive, the inclusion of the larger fish from the Rogue would tend to obscure the difference between the Rogue and Jenny Creek. So one would expect that if fish of the "missing" length interval were available the results would accentuate the differences between those populations.

Sexual dimorphism is an influence that must be considered in morphometric analyses. Table 23 presents the results of that consideration for the lengths of four fin measured during this study.

Table 20. MORPHOLOGICAL MEASUREMENTS IN THOUSANDTHS OF STANDARD LENGTH (SL) for 30 C. rimiculus from Jenny Creek drainage, Oregon.

Character	range	mean	Standard deviation	Standard error
Standard length (mm)	67- 208	128.9	33.3	
Predorsal length	455- 540	493.5	16.5	3.018
Head length	213- 261	233.0	12.26	2.24
Head depth	140- 167	155.1	6.9	1.26
Head width	147- 171	161.3	7.73	1.4
Body depth	171- 246	214.5	18.35	3.35
Body width	152- 200	181.0	12.4	2.26
Orbit length	31- 46	36.9	3.77	0.688
Snout length	101- 132	115.3	5.75	1.23
Snout to nostril length	74- 97	83.3	4.7	0.86
Least fleshy interorbital dist.	92- 115	100.4	5.56	1.015
Least bony interorbital dist.	73- 89	79.8	4.33	0.789
Anal to caudal length	159- 243	186.8	14.5	2.65
Depressed dorsal fin length	201- 252	222.9	13.57	2.48

Table 20. MORPHOLOGICAL MEASUREMENTS IN THOUSANDTHS OF STANDARD LENGTH (SL) for 30 C. rimiculus from Jenny Creek drainage, Oregon.

Character	range	mean	Standard deviation	Standard error
Depressed anal fin length	136- 255	189.33	26.09	4.76
Left pectoral fin length	168- 214	191.9	10.5	1.92
Left pelvic fin length	119- 165	146.67	10.2	1.86
Depth of caudal peduncle	87- 100	92.3	3.83	0.699
Mouth width	45- 58	50.53	3.48	0.636
Lip width	85- 124	105.8	7.8	1.43

Table 21. MORPHOLOGICAL MEASUREMENTS IN THOUSANDTHS OF STANDARD LENGTH (SL) for 30 C. rimiculus from Klamath River basin excluding Jenny Creek.

Character	range	mean	Standard deviation	Standard error
Standard length (mm)	67- 207	128.5	47.6	
Predorsal length	468- 502	483.6	9.57	1.74
Head length	216- 252	236.6	8.7	1.59
Head depth	140- 169	154.5	7.77	1.42
Head width	143- 171	160.2	7.4	1.35
Body depth	195- 247	216.8	12.24	2.24
Body width	147- 191	172.6	11.68	2.13
Orbit length	32- 52	39.7	5.85	1.068
Snout length	106- 122	115.9	4.62	0.84
Snout to nostril length	74- 94	85.16	5.065	0.92
Least fleshy interorbital dist.	94- 107	100.9	3.51	0.64
Least bony interorbital dist.	74- 85	80.3	2.92	0.53
Anal to caudal length	176- 210	190.0	7.2	1.32
Depressed dorsal fin length	195- 252	223.4	12.48	2.28

Table 21. MORPHOLOGICAL MEASUREMENTS IN THOUSANDTHS OF STANDARD LENGTH (SL) for 30 *C. rimiculus* from Klamath River basin excluding Jenny Creek.

Character	range	mean	Standard deviation	Standard error
Depressed anal fin length	152- 235	184.16	16.08	2.93
Left pectoral fin length	167- 226	204.66	11.96	2.18
Left pelvic fin length	136- 171	152.43	10.33	1.89
Depth of caudal peduncle	88- 100	94.03	3.55	0.65
Mouth width	46- 56	51.2	2.975	0.5433
Lip width	77- 117	98.36	10.5	1.92

Table 22. MORPHOLOGICAL MEASUREMENTS IN THOUSANDTHS OF STANDARD LENGTH (SL) for 20 *C. rimiculus* from the Rogue River basin, Oregon.

Character	range	mean	Standard deviation	Standard error
Standard length (mm)	63- 387	216.47	133.19	
Predorsal length	463- 524	491.9	14.56	3.26
Head length	212- 257	231.45	12.5	2.8
Head depth	132- 159	145.8	7.5	1.69
Head width	131- 202	149.55	14.7	3.29
Body depth	187- 228	208.0	11.8	2.64
Body width	140- 184	167.1	12.9	2.89
Orbit length	26- 59	36.4	9.93	2.22
Snout length	98- 124	111.25	6.15	1.37
Snout to nostril length	72- 97	83.25	6.79	1.53
Least fleshy interorbital dist.	85- 102	93.75	4.59	1.025
Least bony interorbital dist.	69- 89	79.0	5.72	1.28
Anal to caudal length	169- 201	186.0	8.63	1.93
Depressed dorsal fin length	186- 229	206.45	13.04	2.92

Table 22. MORPHOLOGICAL MEASUREMENTS IN THOUSANDTHS OF STANDARD LENGTH (SL) for 20. C. rimiculus from the Rogue River basin, Oregon.

Character	range	mean	Standard deviation	Standard error
Left pectoral fin length	161- 204	183.15	11.62	2.59
Left pelvic fin length	108- 156	138.15	11.19	2.50
Depth of caudal peduncle	77- 96	90.05	5.01	1.12
Mouth width	42- 59	49.15	4.7	1.05
Lip width	71- 102	87.45	8.53	1.9

Figure 7. Comparison of ranges, means, standard deviations and standard errors of lip width for three populations of *Catostomus rimiculus*.

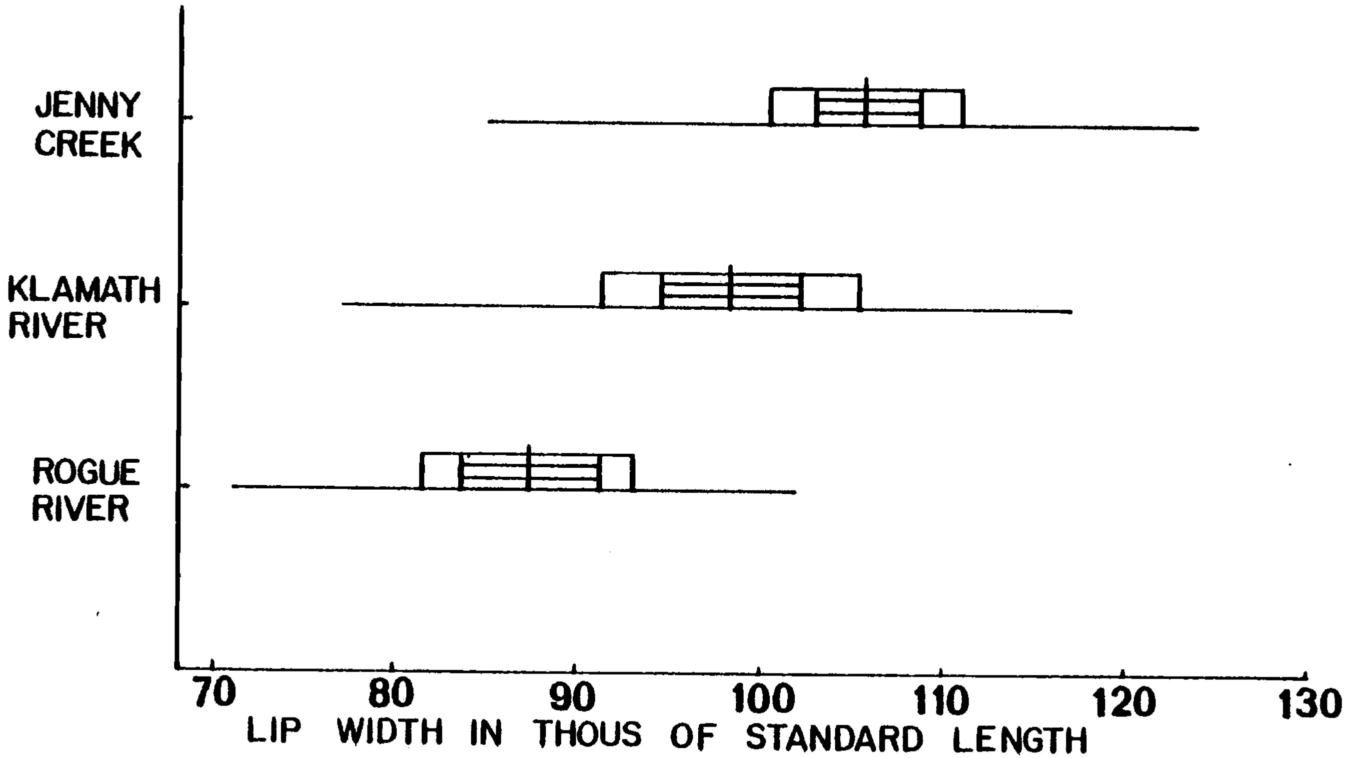

JENNY CREEK
KLAMATH RIVER
ROGUE RIVER
70
80
90
100
110
120
130
LIP WIDTH IN THOUS OF STANDARD LENGTH

Table 23. Mean anal fin length, pectoral fin length, pelvic fin length and dorsal fin length for females and males of the three populations of C. rimiculus. Numbers are expressed as thousandths of standard length (SL).

Basin	Anal fin length		Pectoral fin length		Pelvic fin length		Dorsal fin length	
Jenny Creek	187	219	192	198	147	157	216	237
	(15)	(6)						
Klamath River	173	208	176	179	137	142	193	218
	(9)	(4)						
Rogue River	184	221	202	202	150	159	218	238
	(6)	(4)						

The anal and dorsal fin lengths show a high degree of sexual dimorphism. Pelvic fin length has a moderate amount and pectoral fin length is virtually free of sexual dimorphism. The trends within each fin length are consistent, with all populations showing comparable increases in the lengths of fins for males, except pectoral fin length. The differences among the populations for each sex would be diagnostic if the sample sizes were larger. For both the Rogue and Klamath River collections, only four sexually mature males were available for analysis. In addition to this is the problem of allometry which obscures the results because the fish from the Rogue River were so much larger than those examined from the Klamath River and Jenny Creek.

Table 24. Product moment correlation coefficients calculated for morphological measurements in thousandths of standard length and standard length for populations of *Catostomus rimiculus*.

Character	Jenny Creek	Klamath River	Rogue River
Predorsal length	-0.03	-0.63**	-0.29
Head length	-0.54**	-0.93**	-0.57**
Head depth	-0.41*	-0.68**	-0.59**
Head width	-0.43*	-0.47**	+0.22
Body depth	+0.05	+0.25	+0.36
Body width	-0.27	+0.11	+0.76**
Orbit length	-0.80**	-0.93**	-0.94**
Snout length	-0.17	-0.20	+0.15
Snout to nostril length	-0.01	+0.25	+0.25
Least fleshy interorbital dist.	-0.51**	-0.51**	-0.36
Least bony interorbital dist.	-0.04	+0.25	+0.69**
Anal to caudal length	+0.36*	+0.09	+0.47*
Depressed dorsal fin length	-0.27	-0.25	-0.28
Depressed anal fin length	+0.41*	+0.48*	+0.71**
Left pectoral fin length	-0.02	-0.28	-0.54*
Left pelvic fin length	+0.32	-0.10	+0.02
Mouth width	-0.30	-0.15	+0.49*
Lip width	-0.06	-0.11	+0.54*
Caudal peduncle depth	+0.13	-0.09	+0.67**

* = significance at p = .05 ** = significance at p = .01

Allometry was a concern in this study precisely because the fish available from the Rogue River were much larger than those in Jenny Creek. Klamath River fish are generally much larger than those of Jenny Creek but smaller fish were collected along with the large fish.

Table 24 presents the product moment correlation coefficients for the calculations of each morphometric character measured and the standard length of the fish in the three samples. Allometry is present in many of the measurements and this fact stresses the need for comparable size ranges in each sample.

The allometry that exists could explain many of the differences in the morphometrics in Tables 20-22. Head width, head depth, least fleshy interorbital distance and dorsal fin length of the Rogue River sample all have smaller means than the comparable measurements for the Klamath River and Jenny Creek samples. However, product moment correlation coefficients calculated for those measurements against SL reveal that there is a negative correlation with increasing standard length. Therefore, the differences are largely explained by the larger fish in the sample from the Rogue.

Two differences hold. Lip width and pelvic fin length increase disproportionately with increasing standard length. The larger lips of the suckers in Jenny Creek compared with the suckers in the Rogue goes against the allometric trend and is probably greater than this study showed. Pelvic fin lengths are not significant but show an increase in Jenny Creek compared to the Klamath.

CONCLUSIONS

1. The results of meristic and morphometric analyses suggest that *C. rimiculus* in Jenny Creek is more closely related to *C. rimiculus* in the Klamath River than it is to the population in the Rogue. Five characters separate the fish in Jenny Creek at a subspecific level from those in the Rogue and only one will separate the populations in the Klamath from those in Jenny Creek.

2. *C. rimiculus* in the Klamath and Rogue Rivers are very close in all characters. One character, number of left pelvic fin rays, will separate the fish in the two systems at the 75% level. My results agree with the statement of Snyder (1908) that only minor differences were noted in these two stocks.

3. Adult suckers in Jenny Creek are much smaller in size than those of the Klamath or Rogue Rivers. They are, by definition, dwarfed. Sexually mature females as small as 112 mm SL and mature males as small as 115 mm SL were collected from Jenny Creek basin. The majority of suckers in the Jenny Creek basin typically mature at age II and approximately 130 mm SL. The proportion maturing at this size from the Klamath and Rogue River systems is probably very small because they mature at IV or V. The smallest mature sucker examined from the Klamath River was 145 mm SL. No mature fish below 200 mm were examined or collected from the Rogue River system.

4. Jenny Creek suckers grow at a rate equal to or greater than those in the Klamath and Rogue Rivers. The small size of Jenny Creek

fish can be attributed to the scarcity of fish over age III. That lack could be due to 1) death at age III from spawning, stress, disease, natural mortality, etc. or 2) movement of larger fish downstream and out of the system during winter.

5. A movement from headwater to downstream areas was noted in sampling during summer and fall. A movement downstream over summer could be explained by the fact that much of the upstream areas become very low or intermittent. A continuation of that movement to slow pool areas might be explained by lower water temperatures and increased winter flows. Dampening of temperature fluctuations and slow currents make these areas preferable to upstream areas. Larger fish might move farther downstream and over the falls.

6. C. rimiculus in Jenny Creek were feeding on a variety of benthic foods, some of which indicate that they feed in riffle habitat at times.

7. Correlations of habitat features and sucker densities in selected stream sections failed to show significant correlations with most of the measured habitat features. Mean cross sectional area and stream kilometer showed the only significant correlations with estimated sucker density. Correlation between sucker density and increasing stream kilometer was negative. Not only were there more suckers in downstream areas but they were smaller. This is believed to be true because of the combination of low gradient streams and downstream movement of fry after hatching. Moyle (1976) reported that fry of C. occidentalis drifted downstream after hatching. Fry of

C. rimiculus were found in shallow areas with rubble bottoms and little or no current. Sucker fry were always associated with dace fry.

Appendix 1. Age and growth results for various species of *Catostomus*.

Reference	Species	Mean length (SL) unless noted for each age group I	II	III	IV	V	VI	VII	Maximum size and age
Rawson & Elsey 1950	*Catostomus catostomus*	51 mm	84 mm	107 mm	132 mm	152 mm	340 mm		
Bailey 1969	*Catostomus catostomus*	102 mm	153 mm	188 mm	229 mm	340 mm			568 mm, XI
Harris 1962	*Catostomus catostomus*		152 mm	170 mm	253 mm	290 mm	314 mm		642 mm, XIX
Scott & Crossman 1973	*Catostomus columbianus*	40-80 mm		127 mm					381 mm
Beamish 1970	*Catostomus commersoni*	179 mm	274 mm	336 mm	387 mm	424 mm	452 mm		
Rawson 1951	*Catostomus commersoni*								510 mm, XII
Clemens, et al. 1939	*Catostomus macrocheilus*	46 mm	76 mm	124 mm	170 mm	190 mm	229 mm		540 mm, XV
Moyle & Marciochi 1975	*Catostomus microps*	70 mm	110 mm	140 mm	180 mm				280 mm, V
Hubbs & Wallis 1948	*Catostomus occidentalis*	47 mm							
Hauser 1969	*Catostomus platyrhynchus*	60-70 mm TL	90-100 mm TL	115 mm	133 mm	149 mm	165 mm		250 mm, IX
Moyle 1976	*Catostomus rimiculus*		110 mm	150 mm	160 mm	230 mm	260 mm	310 mm	410 mm
Hohler 1981	*Catostomus rimiculus*	70 mm	135 mm	173.6 mm					210 mm, IV
Greenfield et al. 1970	*Catostomus santaanae*		75-110 mm	140-160 mm					160 mm, III
Willsrud 1971	*Catostomus tahoensis*	58 mm FL		200 mm FL	300 mm FL				610 mm
Coombs, et al. 1979	*Catostomus warnerensis*	40 mm FL	80 mm FL	130 mm FL	160 mm FL	210 mm FL	250 mm FL	300 mm FL	430 mm, VIII

Appendix 2. Fish species collected at sampling sites.

	Lampetra tridentata	*Salmo gairdneri*	*Salvelinus fontinalis*	*Catostomus rimiculus*	*Rhinichthys osculus*	*Richardsonius balteatus*	*Pimephales promelas*	*Notemigonus crysoleucas*	*Ictalurus nebulosus*	*Lepomis cyanellus*	*Lepomis gibbosus*	*Micropterus salmoides*	*Perca flavescens*	*Cottus klamathensis*	*Cottus perplexus*
Rogue River	X	X		X		X			X	X					X
Applegate River	X	X		X		X			X	X					X
Evans Creek	X	X				X									
Sams Creek		X													
Dead Indian Creek		X			X										
Little Butte Creek	X			X		X			X						
Elk Creek	X														X
Bear Creek										XX					
Jump Off Joe Creek		X													X
Klamath drainage															
Jenny Creek (below falls)	X	X		X	X		X		X	X	X	X	XX	X	
Jenny Creek (above falls)		X		X	X			X	X		X			X	
Keene Creek (above km 8)		X			X				X						
Keene Creek (below km 8)		X		X	X										
Mill Creek		X													
Cottonwood Creek		X	X												
Beaver Creek		X		X	X										
Corral Creek		X		X	X										
Johnson Creek		X		X	X										
Grizzly Creek		X			X			X	X		X				
Willow Creek		X						X							
Soda Creek		X													
Hoxie Creek		X			X			X							
Fall Creek		X												X	
Camp Creek		X											X		

LITERATURE CITED

Alley, D. W. Jr. 1977. The energetic significance of microhabitat selection by fishes in a foothill Sierra stream. MS thesis. Univ. of Calif., Davis.

Andreasen, J. K. 1974. Progress report to U.S. Fish and Wildlife Service (Contract # 14-16-0001-5381FS). Status of rare suckers (Catostomidae) in Oregon; distribution, life history and systematics.

Bailey, M. M. 1969. Age, growth, and maturity of the longnose sucker _Catostomus catostomus_, of western Lake Superior. Fish. Res. Board Canada 26:1289-1299.

Beamish, R. J. MS 1970. Factors affecting the age and size of the white sucker, _Catostomus commersonii_, at maturity. Ph.D. thesis, Dept. Zoology, Univ. Toronto, Ontario.

Beamish, R. J. and E. J. Crossman. 1977. Validity of the subspecies designation for the dwarf white sucker, _Catostomus commersonii utawana_. J. Fish Res. Board Can. 34:371-378.

Brauer, C. O. 1971. A study of the western sucker _Catostomus occidentalis_ Ayres in lower Hat Creek, California. MS thesis, Calif. St. Univ., Humboldt.

Carl, G. C. 1936. Food of the coarse-scaled sucker (_Catostomus macrocheilus_) (Girard). J. Biol. Bd. Can. 3(1):20-25.

Clemens, W. A. 1939. The fishes of Okanagan Lake and nearby waters, pages 27-38. In A biological survey of Okanagan Lake, British Columbia. Fish Res. Board Canada Bull. 56: 70 pages.

Coombs, C. I., C. E. Bond and S. F. Drohan. 1979. Spawning and early life history of the Warner sucker (Catostomus warnerensis). Final report to U.S. Fish and Wildlife Service (Order No. 10181-0294). Dept. of Fisheries and Wildlife, OSU.

Dence, W. A. 1931. Fish of the Huntington Forest. Roosevelt Wildlife Bulletin 5(4):620-630.

Gilbert, C. H. 1898. The fishes of the Klamath basin. Bull. U.S. Fish Comm. 17:1-13.

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

Harris, R. H. D. 1962. Growth and reproduction of the longnose sucker, Catostomus catostomus (Forster), in Great Slave Lake. J. Fish. Res. Board 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):209-224.

Hubbs, C. L. and C. Hubbs. 1953. An improved graphical analysis and comparison of series of samples. Systematic Zoology 2:49-57.

Hubbs, C. L. and K. F. Lagler. 1958. Fishes of the Great Lakes Region. Bull. Cranbrook Inst. Sci. 231 pages.

Hubbs, C. L. and D. L. Wallis. 1948. The native fish fauna of Yosemite National Park and its preservation. Yosemite Nat. Notes 27(12):131-144.

Jingran, V. G. 1948. A contribution to the biology of the Klamath black dace, Rhinichthys osculus klamathensis (Evermann and Meek). Ph.D. thesis, Stanford Univ. 94 pp.

Kendall, W. C. and W. A. Dence. 1929. Fishes of the Cranberry Lake Region. Roosevelt Wildlife Bull. 5:215-309.

Minckley, W. L. 1973. Fishes of Arizona. Arizona Game and Fish Dept., Sims Printing Co., Phoenix. 293 pages.

Minckley, W. L. 1980. Catostomus plebius (Baird and Girard), Rio Grande sucker. Page 387 In Atlas of North American freshwater fishes. Edited by Lee, D. S., C. R. Gilbert, R. E. Jenkins, D. E. McAllister, J. R. Stauffer, Jr. North Carolina State Museum of Natural History. 854 pages.

Moyle, P. B. 1976. Inland fishes of California. Univ. of Calif. Press, Berkeley, Calif. 405 pages.

Moyle, P. B. and A. Marciochi. 1975. Biology of the Modoc sucker, Catostomus microps (Pisces: Catostomidae) in northwestern California. Copeia 1975 (3).

Pennak, R. W. 1979. Fresh-water invertebrates of the United States. Ronald Press, New York. 769 pages.

Rawson, D. S. 1951. Studies of the fish of Great Slave Lake. J. Fish. Res. Board Canada 8(4):207-240.

Rawson, D. S. and C. A. Elsey. 1950. Reduction in the longnose sucker population of Pyramid Lake, Alberta, in an attempt to improve angling. Trans. Amer. Fish. Soc. 78(1948):13-31.

Scott, W. B. and E. J. Crossman. 1973. Freshwater fishes of Canada. Fish Res. Bd. Can., Ottawa.

Seber, G. A. F. 1973. The estimation of animal abundance. Hafner Press, New York, N.Y. 506 pages.

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.

Snyder, J. O. 1908. The fishes of the coastal streams of Oregon and Northern California. Bull. U.S. Fish Comm. 27:155-189.

Sokal, R. R. and F. J. Rohlf. 1973. Introduction to biostatistics. W. H. Freeman and Co., San Francisco. 368 pages.

Stewart, N. H. 1926. Development, growth, and food habits of the white sucker, _Catostomus commersonii_ Le Sueur. Bull. U.S. Bur. Fish., 42:147-184.

Van Oosten, J. and H. J. Deason. 1938. The food of the lake trout (_Cristivomer namaycush namaycush_) and of the lawyer (_Lota maculosa_) of Lake Michigan. Trans. Amer. Fish. Soc. (1937), 67:155-177.

Willsrud, T. 1971. The study of the Tahoe sucker, _Catostomus tahoensis_ (Gill and Jordan). M.S. Thesis, San Jose State College. 96 pages.