Comparative morphometry of the Rocky Mountain whitefish (Prosopium williamsoni)
by Ramona Denton Holt

A THESIS Submitted to the Graduate Faculty in partial fulfillment of the requirements for the degree of Master of Science in Fish and Wildlife Management
Montana State University

Abstract:
Twenty-three meristic counts and 34 measurements were made on 407 specimens of Prosopium williamsoni collected from 5 states in northwestern United States. The means of meristic counts and some body proportions were tested by analysis of variance for significance. The test results were compared with the range of variation for each body character within and among drainages and collections. The body proportion and meristic count ranges overlapped "among collections and within Missouri River drainage, Columbia River drainage (except head width in head of collection ll), and Bear River drainage (except branchiostegals, dorsal rays and anal rays of collection 12). Data from the present study and ten other studies oh body proportions and meristic counts of P. williamsoni, P. dregonium, P. spilohotus, P. coulteri, P. cylindraceum, and Coregonus clupeaformis were compared. All species could be separated from one another except P. oregonium and P1 spilonotus, which were indistinguishable from P1 williamsoni. The ranges of all body characters of these two species fell within the range of P. williamsoni.

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ABSTRACT

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INTRODUCTION

The Coregonines are known to be a plastic group, even within genera. Considerable variation in the meristic characters of Prosopium williamsoni was noted by McHugh (1936). Weisel and Dillon (1954) compared P. williamsoni with P. coulteri and reported variations in both species. Dymond (1943) found similar degrees of variation in P. cylindraceum, P. oregonium and P. coulteri. Kennedy's (1953) measurements and counts on P. cylindraceum agree with Dymond's (1943) results.

Thirteen collections of P. williamsoni were examined to compare body proportions and meristic characters and to study local race variations of the species. Twenty-three meristic counts and 34 measurements were made on 407 specimens. These fish were collected from three major drainages in five states (Fig. 1).

Five collections were obtained from the Missouri River drainage as follows: (1) Tongue River, above Dayton, Wyoming; (2) South Fork of Shoshone River, in and above Buffalo Bill Reservoir, Wyoming; (3) Yellowstone River, 17 miles below Livingston, Montana; (4) Hebgen Lake, an impoundment on the Madison River, at West Yellowstone, Montana; and (5) Red Rock Creek, above Upper Red Rock Lake in the headwaters of the Jefferson River, Montana. The Tongue River and the South Fork of Shoshone River are in the drainage of the lower Yellowstone River. These two collections and the one from Yellowstone River are more or less isolated from one another by the high temperature of the lower Yellowstone River. Whitefish are rarely taken below Billings, however a few have been reported downstream

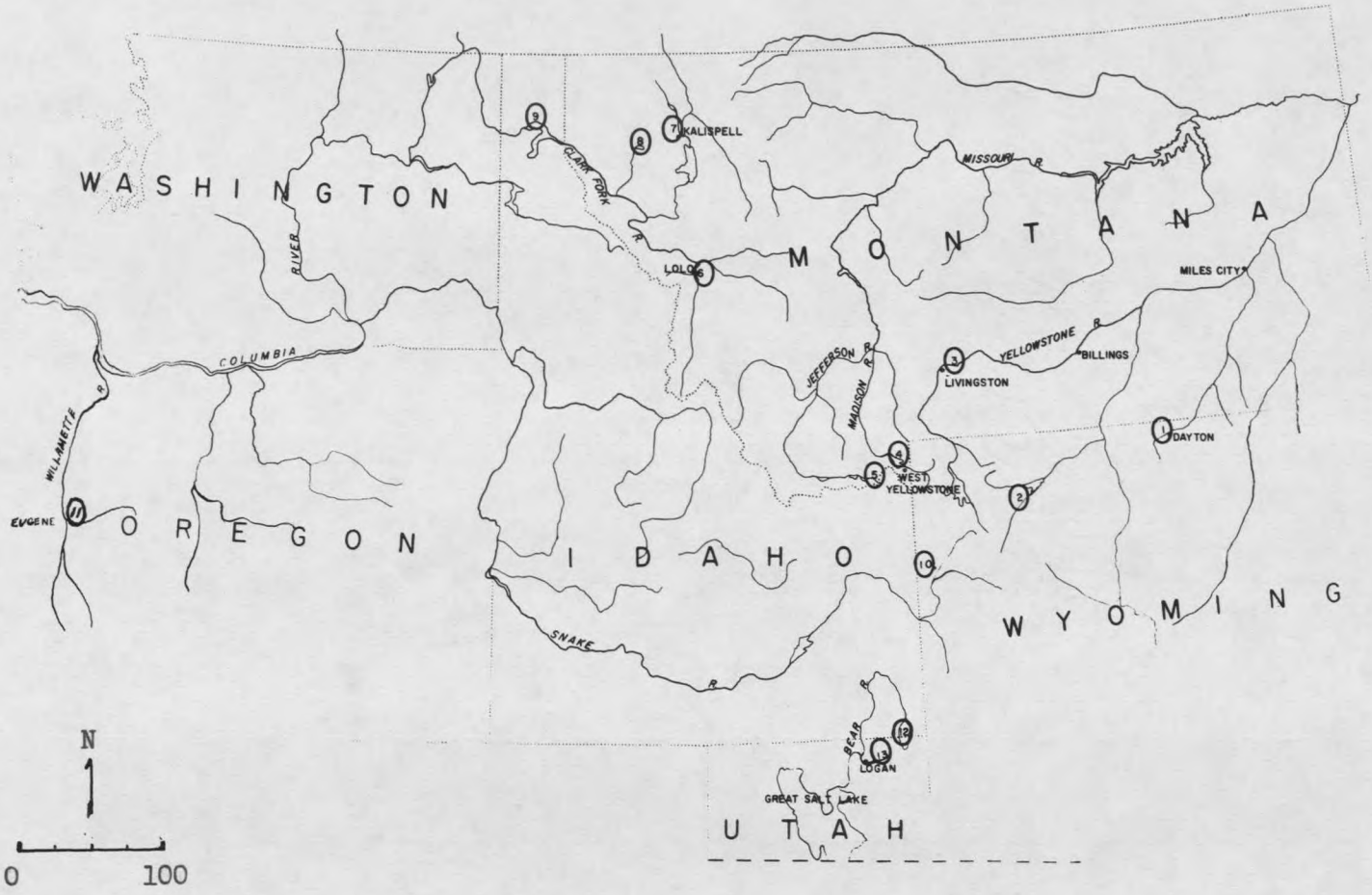

Figure 1. Map of northwestern United States showing location of collections. (1) Tongue River, (2) South Fork of Shoshone River, (3) Yellowstone River, (4) Hebgen Lake, (5) Red Rock Creek, (6) Bitterroot River, (7) Whitefish River, (8) Thompson Lakes, (9) Lake Pend Oreille, (10) Phelps Lake, (11) McKenzie River, (12) Bear Lake, and (13) Logan River.

as far as Miles City, Montana. The whitefish from Hebgen Lake and Red Rock Creek are not isolated from each other by natural barriers, although artificial barriers to upstream movement exist in the headwaters of the Jefferson River and Madison River at the present time.

Six samples were collected from the Columbia River drainage as follows: (6) Bitterroot River, Lolo, Montana; (7) Whitefish River, above Kalispell, Montana; (8) Thompson Lakes, in the headwaters of Thompson River, Montana; (9) Lake Pend Oreille, on the Clark Fork River; (10) Phelps Lake, in Grand Teton National Park, Wyoming; and (11) McKenzie River, below Leaburg Dam, Eugene, Oregon. The Bitterroot River, Whitefish River and Thompson River are in the drainage of the Clark Fork River in Montana. The Clark Fork River flows through Lake Pend Oreille in Idaho and enters the Columbia River in Canada. Phelps Lake is in the extreme headwaters of the Snake River and the McKenzie River is tributary to the Willamette River and the lower Columbia River. No natural barriers separated the whitefish taken from the Columbia River drainage with the possible exception of those from Phelps Lake. Numerous dams now prevent upstream movement of whitefish in this drainage.

The two collections from the Bear River drainage are: (12) Bear Lake, in the headwaters of Bear River, Idaho and Utah; and (13) Logan River, above Logan, Utah. These collections are from tributaries of Bear River which enters Great Salt Lake. No natural barriers exist in this drainage.

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METHODS

All whitefish were preserved in 10 per cent formalin. The coelomic cavity of the larger specimens was either injected with formalin or cut open to insure penetration of the preservative. Each collection was soaked in water for a day before examination.

Measurements and counts: Measurements and counts followed the system outlined by Hubbs and Lagler (1947). All measurements were taken to the nearest one-tenth millimeter with calipers, except standard and total lengths which were determined to the nearest millimeter on a measuring board. All weights were to the nearest one-hundredth pound. Scale counts were made as follows: lateral line scales, dorsal origin to lateral line, anal origin to lateral line, predorsal rows, predorsal scales, body circumference rows above and below lateral line, and caudal peduncle circumference rows above and below lateral line. The fin rays were determined for all fins and both left and right branchiostegal rays were counted. Gillraker determinations were made on the first gill arch of the right side. The pyloric caeca were separated from the stomach and counted

individually. The number of vertebrae was counted after making a sagittal section parallel to the vertebral column.

Statistical treatment: All meristic counts and 25 body proportions were tested by analysis of variance in 7 different combinations of drainages and collections, making a total of 336 tests. These test combinations were: (a) among all thirteen collections; (b) among drainages (Missouri River, Columbia River and Bear River drainages); (c) within Bear River drainage (Bear Lake and Logan River); (d) among non-mixing populations of Columbia River drainage (Bitterroot River, Whitefish River, Thompson Lakes and Lake Pend Oreille collectively, and Phelps Lake and McKenzie River separately); (e) within mixing populations of Columbia River drainage (Bitterroot River, Whitefish River, Thompson Lakes, and Lake Pend Oreille); (f) among non-mixing populations of Missouri River drainage (Tongue River, South Fork of Shoshone River, and Yellowstone River separately, and Hebgen Lake and Red Rock Creek collectively); and (g) within mixing populations of Missouri River drainage (Hebgen Lake and Red Rock Creek). The significance of the results was determined at the five per cent and one per cent levels.

COMPARISON OF BODY PROPORTIONS AND COUNTS

Analysis of variance of the means of most ratios and counts was significant at the one per cent level. It seemed imperative to compare the tests with the ranges and averages for all collections (Table I). Only those which were significant at the one per cent level and had differences in ranges or averages are discussed below.

Among all thirteen collections (a): The variance of the means for all body proportions and meristic counts was significant at the one per cent level. However, the ranges of variance overlapped for many proportions and counts (Table I). Collection 6 has a smaller head in length range than collections 10 and 13. The range of depressed anal in length is smaller in collection 1 than in 10 and 12. The caudal base to longest ray in length is greater in collection 5 than in 9. Collection 1 has a smaller pelvic in length range than 10 and the orbit in length range of collection 4 is greater than in 6. The range of adipose height in adipose base of collection 5 is smaller than in 9. Collections 6, 7, and 9 have 12-14 dorsal rays while collection 12 has 9-12. Collections 1, 2, 8, 9, and 13 have fewer scales below the lateral line than 3 and 5. Collections 3 and 4 have a greater body circumference rows total than collections 7 and 8. Collections 1 and 3 have 17-20 gillrakers while collection 6 has 21-25. Collections 1, 2, 9, and 13 have 58-61 vertebrae and collections 5, 8, and 11 have 53-58. Collection 8 has a smaller range of pyloric caeca than collection 13.

Among drainages (b): The averages of depressed dorsal in length, depressed anal in length, pelvic finlet in pelvic fin, and vertebrae are smaller for the collections from the Missouri River and Columbia River drainages than from the Bear River drainage. Columbia River and Bear River drainages average larger body width in length and adipose height in adipose base ratios than the Missouri River drainage. The averages of isthmus width in isthmus length ratio and gillraker count of the Columbia

Table I. Ranges and averages of body proportions and meristic counts of Prosopium williamsoni.

Drainage	Missouri River					Columbia River						Bear River	
Collection	1	2	3	4	5	6	7	8	9	10	11	12	13
Number of specimens	30	30	30	30	30	24	50	30	27	30	30	50	16
Head in length	4.2-4.8 4.5	4.3-5.0 4.6	4.0-4.7 4.4	4.4-5.0 4.8	4.3-5.0 4.7	4.1-4.6 4.4	4.0-4.7 4.4	4.6-5.0 4.8	4.5-5.1 4.7	4.6-5.4 5.1	4.3-5.0 4.7	3.9-5.0 4.5	4.7-5.3 4.9
Predorsal in length	2.0-2.4 2.2	2.2-2.5 2.3	2.0-2.4 2.2	2.1-2.4 2.3	2.2-2.4 2.3	2.2-2.4 2.3	2.2-2.5 2.3	2.1-2.4 2.3	2.1-2.4 2.3	2.2-2.5 2.4	2.1-2.3 2.3	1.9-2.3 2.1	2.1-2.6 2.2
Body depth in length	4.1-5.3 4.7	4.2-5.1 4.6	3.9-5.1 4.5	3.8-5.1 4.3	4.1-4.9 4.5	4.5-5.0 4.7	4.2-5.3 4.8	4.3-5.3 4.8	4.5-5.5 4.9	4.3-5.9 4.9	4.2-4.9 4.6	3.8-5.4 4.6	4.1-5.1 4.6
Body width in length	6.3-7.7 6.9	6.1-8.0 7.0	5.8-7.4 6.6	5.3-8.4 6.3	5.6-7.0 6.3	6.0-7.2 6.6	6.5-8.7 7.3	6.9-8.4 7.7	6.9-9.3 7.7	6.6-8.3 7.5	6.2-8.1 7.0	6.3-8.7 7.5	6.2-8.2 7.3
Dorsal origin to occiput in length	3.1-3.7 3.4	3.2-3.9 3.5	3.0-4.1 3.4	3.1-3.8 3.4	3.1-3.8 3.4	3.2-3.6 3.4	3.1-3.9 3.4	3.1-3.9 3.5	3.0-4.3 3.5	3.2-3.9 3.6	3.1-3.7 3.4	2.9-3.8 3.4	3.2-3.7 3.4
Anal origin to CB in length	3.5-4.1 3.8	3.5-4.1 3.9	3.8-4.3 4.1	3.7-4.3 4.0	3.6-4.2 3.9	3.8-4.2 4.0	3.8-4.6 4.2	3.8-4.4 4.1	3.7-4.3 4.0	3.8-4.4 4.1	3.6-4.3 4.0	3.7-4.9 4.4	3.7-4.0 3.8
CB to adipose origin in length	4.7-5.6 5.1	4.5-5.4 4.9	4.7-5.6 5.1	4.7-5.6 5.1	4.6-5.6 4.9	4.4-5.1 4.8	4.5-6.1 5.0	4.3-5.0 4.6	4.3-5.2 4.8	4.5-5.6 5.1	4.5-5.3 4.9	4.7-6.2 5.3	4.5-5.1 4.8
CB to longest ray in length	4.4-5.3 4.9	4.5-5.6 5.3	4.6-5.5 5.1	4.7-6.1 5.3	5.1-6.2 5.7	4.7-5.6 5.1	4.4-5.7 4.9	4.2-5.2 4.6	4.4-4.9 4.6	4.5-5.7 5.0	4.6-6.6 5.4	3.9-5.8 4.7	4.7-6.2 5.5
Depressed dorsal in length	4.4-5.6 4.9	4.5-5.4 4.9	4.6-5.6 5.1	4.5-5.6 4.8	4.7-5.7 5.1	4.6-5.2 4.9	4.5-5.7 5.1	4.6-5.6 5.2	4.5-5.2 5.0	4.8-5.9 5.3	4.6-6.2 5.3	4.9-6.3 5.6	4.7-5.6 5.2
Depressed anal in length	5.8-6.5 6.2	5.6-7.2 6.5	5.7-7.0 6.3	6.2-7.5 6.9	6.4-7.8 7.1	6.0-7.3 6.5	5.9-7.6 6.5	6.4-7.9 7.1	5.9-7.3 6.7	6.8-8.2 7.6	6.1-7.3 6.6	6.7-9.6 8.1	6.3-7.1 6.7
Pectoral in length	5.0-5.8 5.5	5.0-6.2 5.7	5.2-6.0 5.6	5.6-6.9 6.1	5.6-6.9 6.3	5.2-6.1 5.8	4.8-6.1 5.4	4.9-5.8 5.4	5.1-6.1 5.6	5.5-6.8 6.2	5.5-6.9 6.1	4.7-6.3 5.4	5.8-6.5 6.1
Pelvic in length	5.6-6.5 6.1	5.8-7.3 6.5	5.6-6.7 6.1	6.4-7.4 6.9	6.3-7.7 7.0	5.8-7.2 6.6	5.6-7.4 6.4	6.1-7.2 6.6	5.9-7.1 6.6	6.7-8.3 7.4	6.2-8.0 6.8	6.0-8.7 6.8	6.3-7.6 6.9

Table I (continued).

Drainage	Missouri River					Columbia River						Bear River	
Collection	1	2	3	4	5	6	7	8	9	10	11	12	13
Branchiostegals	7-9	8-9	7-9	7-9	7-9	...	...	7-8	7-9	7-9	7-9	6-8	8-9
(right)	8.0	8.4	8.2	8.0	8.1	...	...	7.1	8.0	8.1	8.2	7.3	8.3
Branchiostegals	7-9	7-9	8-9	7-9	7-10	...	...	7-9	7-9	5-9	7-10	6-9	8-9
(left)	7.8	8.4	8.6	8.3	8.2	...	...	7.7	7.9	7.8	8.6	7.5	8.6
Dorsal rays	11-13	12-14	12-14	11-13	11-14	12-14	12-14	11-12	12-14	11-14	11-13	9-12	12-13
	12.3	12.3	12.6	12.4	13.1	12.7	12.6	11.4	12.5	12.4	12.3	10.9	12.5
Anal rays	10-12	10-12	10-12	10-12	10-12	10-12	10-12	10-11	10-12	10-12	10-13	9-11	11-12
	11.1	11.1	11.3	10.7	11.3	11.3	11.2	10.4	10.9	11.3	11.7	9.9	11.5
Pectoral rays	15-17	15-17	15-17	15-17	15-18	10-17	15-19	15-18	15-18	15-18	14-16	14-17	15-16
(right)	15.7	15.6	15.7	15.9	16.4	15.7	15.6	16.7	16.1	16.0	15.4	15.4	15.9
Pectoral rays	15-16	15-16	14-17	15-18	15-18	14-16	14-18	15-18	15-18	15-18	14-17	14-16	14-16
(left)	15.8	15.5	15.4	16.1	16.5	15.8	15.6	16.6	16.0	16.6	15.2	15.4	15.4
Pelvic rays (right)	10-11	10-12	11-12	10-11	10-12	10-13	10-12	10-11	10-11	10-12	8-11	10-12	10-11
	10.9	10.7	11.1	10.8	11.1	11.1	10.9	10.9	10.9	10.8	10.5	10.7	10.5
Pelvic rays (left)	10-11	10-12	10-12	10-11	11-12	10-12	10-12	10-11	10-11	10-13	10-11	10-12	9-11
	10.9	10.8	10.9	10.5	11.3	11.0	10.9	10.9	10.8	10.6	10.1	10.7	10.4
Caudal rays	19	19	19	19-20	18-21	19-21	19-21	19	19	18-20	18-20	18-19	19
	19	19	19	19.1	19.1	20.0	19.9	19	19	18.9	19.0	18.7	19
Lateral line	80-89	79-89	75-92	80-90	78-87	74-85	74-85	76-83	74-88	73-87	75-91	71-86	81-89
	83.7	83.6	82.8	84.8	82.9	79.4	80.9	79.2	79.7	80.2	82.4	80.1	84.3
Scales above lateral	9-10	9-10	9-10	10-11	9-11	9-11	9-10	9-9	8-10	8-11	9-10	8-10	9-10
line	9.0	9.1	9.8	10.2	9.9	10.0	9.5	9.0	8.9	10.2	9.7	9.1	9.1
Scales below lateral	7-8	7-8	8-10	7-10	8-10	8-9	7-9	7-7	6-8	7-9	7-9	6-10	7-8
line	7.2	7.2	9.1	8.7	8.3	8.4	8.0	7.0	7.0	8.2	8.2	7.6	7.2
Predorsal rows	29-32	29-33	28-34	29-35	29-35	26-31	27-31	26-30	27-30	28-32	29-35	28-36	28-33
	30.2	29.8	30.7	30.9	32.1	28.8	28.8	28.8	29.0	29.8	31.8	30.5	30.2