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

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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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Master of Science in Fish and Wildlife Management

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Montana State College

Approved:

Head, Major Department

Chairman, Examining Committee

Dean, Graduate Division

Bozeman, Montana
April, 1955

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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

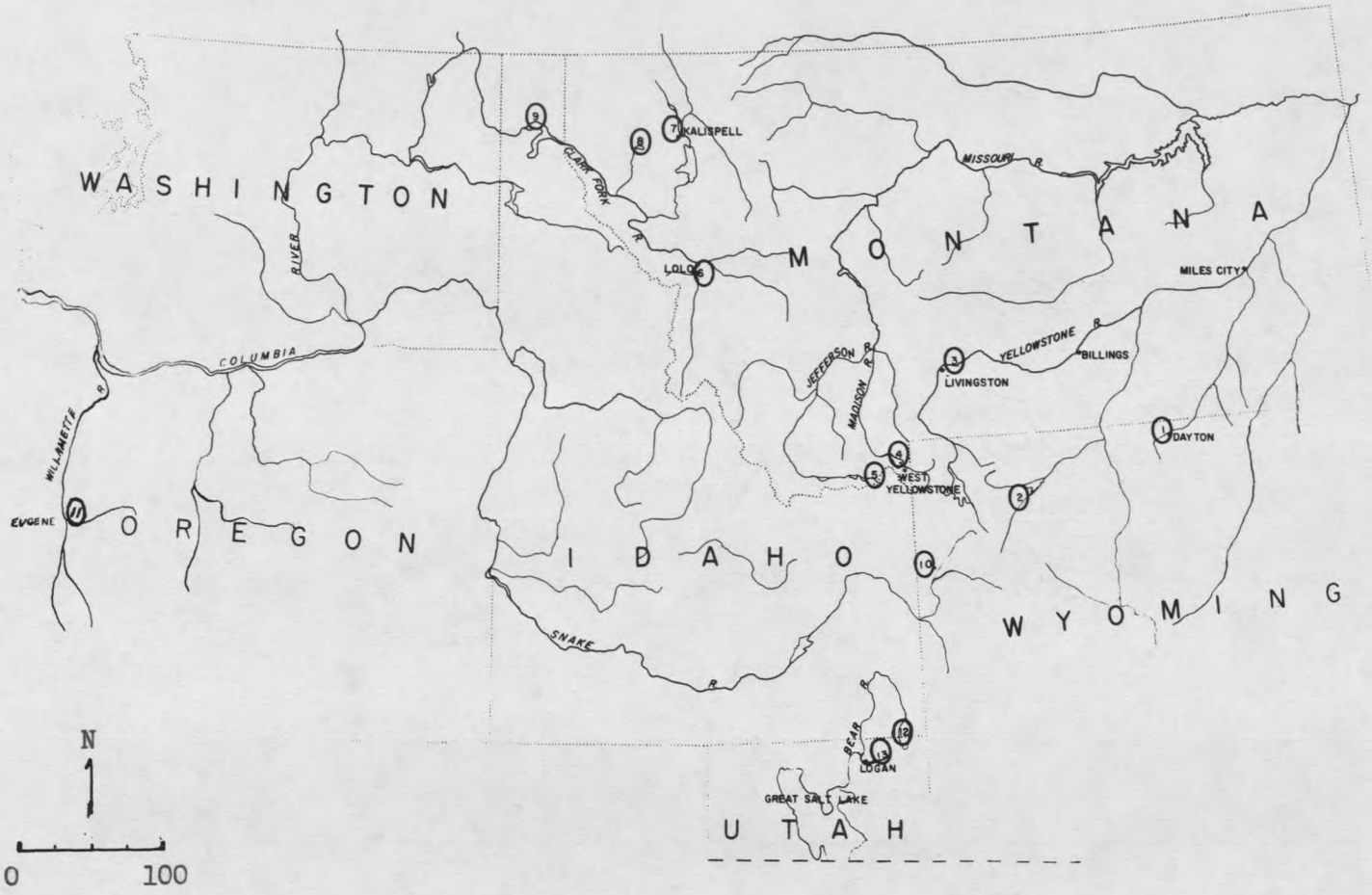

Figure 1. Map of northwestern United States showing location of collections. (1) Tongue River, (2) South Fork of Shoshone River, (3) Yellowstone River, (4) Hebgen Lake, (5) Red Rock Creek, (6) Bitterroot River, (7) Whitefish River, (8) Thompson Lakes, (9) Lake Pend Oreille, (10) Phelps Lake, (11) McKenzie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

The writer wishes to thank Dr. C. J. D. Brown who directed the study

and helped prepare the manuscript. Dr. Robert R. Miller offered valuable suggestions throughout the study. Statistical guidance was given by Dr. Bernard Ostle. Collections of whitefish were supplied by C. J. D. Brown, Richard B. Miller, Leroy Ellig, Marvin F. Boussu, Perry H. Nelson, Frank A. Stefanich, John Echo, Richard Graham, Chris Jensen, William J. McConnell, Charles F. Sowards, Pete McCreery, Nels A. Thoreson, James R. Simon, Harold K. Hagen, Martin Laakso, William D. Clothier, and Paul W. Jeppson.

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

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

Table I (continued).

Drainage	Missouri River					Columbia River						Bear River	
Collection	1	2	3	4	5	6	7	8	9	10	11	12	13
Predorsal scales	31-35	31-36	31-36	29-37	30-37	29-35	29-35	29-33	28-36	30-36	31-37	30-36	31-39
	32.6	32.8	33.4	34.0	33.8	31.3	31.6	30.9	31.6	32.4	34.1	32.3	34.6
Body circum. rows (above LL)	19-21	19-22	20-21	20-23	18-22	18-21	17-20	18-20	18-20	20-22	19-23	16-20	19-21
	19.8	19.8	20.3	21.0	20.1	19.0	18.7	18.9	19.2	20.7	20.0	18.9	19.6
Body circum. rows (below LL)	24-27	24-27	25-28	25-29	25-28	23-26	22-25	23-25	22-26	24-27	22-27	20-26	23-26
	25.7	24.9	26.5	26.9	26.2	24.5	23.4	23.7	23.8	25.1	24.7	23.2	24.5
Body circum. rows (total)	46-50	45-50	47-51	47-53	45-50	43-48	41-47	43-47	43-48	47-50	43-50	39-49	44-48
	47.5	46.8	48.8	50.0	48.3	45.7	44.1	44.6	45.1	47.8	46.8	44.1	46.2
CP circum. rows (above LL)	10	9-10	10-11	9-11	9-10	9-10	8-10	9-9	9-10	9-10	8-10	9-10	9-10
	10	9.8	10.1	10.1	9.9	9.5	9.3	9.0	9.2	9.7	9.3	9.6	9.4
CP circum. rows (below LL)	9-10	9-10	9-10	9-11	9-10	9-10	8-10	9-9	9-10	9-10	9-10	9-10	9-10
	9.9	9.8	9.9	10.0	9.8	9.2	9.2	9.0	9.3	9.5	9.3	9.7	9.1
CP circum. rows (total)	21-22	20-22	21-23	21-24	20-22	20-22	19-22	20-20	20-22	20-22	19-22	20-22	20-22
	21.9	21.6	22.0	22.1	21.7	20.7	20.4	20.0	20.5	21.2	20.6	21.3	20.5
Gillrakers	17-20	19-22	18-20	18-23	18-23	21-25	19-25	19-24	18-23	18-23	18-22	17-21	18-21
	18.0	20.4	19.1	19.9	20.7	22.6	22.1	21.4	20.4	19.4	19.8	19.4	20.1
Vertebrae	58-61	58-61	53-59	55-60	53-58	56-59	55-59	53-58	58-61	54-59	53-58	...	58-61
	59.5	59.7	56.6	56.9	55.5	57.2	57.1	55.5	59.4	57.9	55.7	...	59.5
Pyloric caeca	75-116	76-116	68-130	79-143	65-146	73-125	82-117	61-95	67-105	50-132	90-128	...	99-126
	91.5	89.9	102.3	109.7	113.1	97.2	98.2	77.6	86.9	100.7	104.6	...	110.4

River drainage are greater than the averages of Missouri River and Bear River drainages. The Missouri River drainage averages a larger orbit in length ratio than the other drainages.

Within Bear River drainage (c): The averages of anal origin to caudal base in length, caudal base to adipose origin in length, depressed anal in length, and isthmus width in isthmus length are larger in collection 12 than in 13. The orbit in length ratio and lateral line count are smaller in collection 12 than in 13. The ranges and averages of the right branchiostegals, dorsal rays and anal rays of collection 12 (Bear Lake) agree with Snyder's (1917) original description of P. spilonotus (Table II), and separate it from collection 13. However, the ranges of all ratios and counts of P. spilonotus and collection 12 fall within the ranges of all other P. williamsoni of the present study.

Among non-mixing populations of Columbia River drainage (d): Collection 11 has larger orbit in length and caudal base to longest ray in length averages than collection 10 and the four mixing populations (6, 7, 8, and 9). Collection 10 averages larger depressed anal in length and pelvic in length ratios than the other collections. The mixing populations average fewer predorsal scales and pyloric caeca and more gillrakers than collections 10 and 11. The average isthmus width in isthmus length for collection 10 is much higher than for other collections. Collection 11 (McKenzie River) compares quite favorably with P. oregonium described by Jordan and Snyder (1909), but also falls within the range of ratios and counts of all other P. williamsoni of the present study.

Within mixing populations of Columbia River drainage (e): These collections compare closely in most ratios and counts. Collections 6 and 7 average a greater head width in head and a smaller adipose height in adipose base than collections 8 and 9. The average dorsal rays was smallest for collection 8.

Among non-mixing populations of Missouri River drainage (f): The two mixing populations have the highest depressed anal in length, pectoral in length, pelvic in length and caudal base to longest ray in length averages. They have more pectoral rays and pyloric caeca and lower averages of body width in length, head width in head, interorbital in head and suborbital in upper jaw ratios than collections 1, 2, and 3.

Within mixing populations of Missouri River drainage (g): Collection 4 averages a smaller caudal base to longest ray in length ratio and a larger orbit in head ratio than collection 5. They compare favorably in other ratios and counts.

The ranges overlap for most of the above proportions and counts, but the averages are distinct. The variations between collections are numerous. Dymond (1943) noted considerable variation in body form and fin lengths of P. cylindraceum from one locality to another even in the same region. It is probable that Prosopium is even more subject to environmental modification than Coregonus or Leucichthys (Dymond, 1943). Only four isolated collections vary extremely from other collections in body proportion averages: collection 4 (Hebgen Lake), orbit in head and isthmus width in isthmus length; collection 7 (Whitefish River), head

width in head; collection 10 (Phelps Lake), head in length, depressed anal in length, pelvic in length and isthmus width in isthmus length; and collection 12 (Bear Lake), depressed anal in length. The meristic count averages of each collection vary little from the grand means.

The body proportion averages differ somewhat between drainages. The body width in length ratios are high in the collections of the Columbia River and Bear River drainages, but low in those of the Missouri River drainage. The depressed anal in length, orbit in head, adipose height in adipose base and isthmus width in isthmus length ratios also vary among drainages. However, this variance is due to extreme values of one or two collections and not all collections of the drainage.

COMPARISON OF SIX COREGONINE FISHES

Five body proportions and five meristic counts of six Coregonine fishes (P. williamsoni, P. oregonium, P. spilonotus, P. coulteri, P. cylindraceum, and Coregonus clupeaformis) are compared (Table II). Dymond's (1943) body proportions of P. oregonium differ considerably from the original description of this species (Jordan and Snyder, 1909). The type specimen has a longer snout and upper jaw, more compressed and slender body and more slender caudal peduncle. A large adipose is one character which distinguishes the type P. oregonium. The whitefish from the McKenzie River (collection 11) agree with the type P. oregonium in measurements and counts, but they have no unusually large adipose. P. spilonotus differs from P. oregonium in numbers of dorsal rays, anal rays and gillrakers. Neither species varies greatly in any character from the

Table II. Ranges and averages of body proportions and meristic counts of six Coregonine fishes.

Species	*P. williamsoni*			*P. oregonium*		*P. spilonotus*	*P. coulteri*	*P. cylindraceum*		*C. clupeaformis*	
Study	Present study	McHugh (1939)	Weisel & Dillon (1954)	Dymond (1943)	Jordan & Snyder (1909)	Snyder (1917)	Weisel & Dillon (1954)	Kennedy (1953)	Dymond (1943)	McHugh (1939)	Kennedy (1953)
Number of specimens	407	19	6	7	5	22	23	8	4	40	78
Head in length	3.9-5.4	...	4.4-4.7	1.2-1.8	4.0-4.6	3.6-4.6	3.9-4.4	1.3-1.6	...	...	...
	4.7	...	4.5	1.5	4.3	4.1	4.1	1.4	1.7	...	...
Body depth in length	3.8-5.9	...	4.3-5.0	1.1-1.4	...	3.6-4.8	4.8-5.9	1.3-1.7	...	...	...
	4.6	...	4.6	1.2	5.0	4.3	5.3	1.5	1.5	...	...
Snout in head	2.8-4.1	...	...	2.9-3.5	2.6-3.5	2.8-4.0	...	3.8-4.4	...	...	3.1-3.9
	3.5	...	...	3.2	3.0	3.3	...	4.2	3.6	...	3.4
Orbit in head	3.4-7.3	...	4.0-4.3	4.4-5.3	...	3.3-5.3	3.0-3.7	4.4-5.0	...	...	4.0-6.2
	4.8	...	4.1	4.8	5.5	4.3	3.4	4.7	5.0	...	5.0
Upper jaw in head	2.8-4.4	...	3.6-4.2	3.2-3.9	2.9-3.6	2.8-4.2	3.2-4.1	4.3-4.8	...	...	2.7-3.7
	3.6	...	3.8	3.6	3.2	3.5	3.4	4.5	4.3	...	3.3
Branchiostegals	6-9	7-9	...	8-9	...	...	...	7-8	8-8	8-10	8-10
	8.0	8.0	...	8.3	8.0	8.0	...	7.1	8.0	9.0	9.2
Dorsal rays	9-14	11-14	12-13	14-15	12-13	10-12	9-11	13-15	13-14	10-12	12-16
	12.3	12.0	12.5	14.3	12.6	10.8	9.7	14.4	13.5	11.0	13.7
Anal rays	9-13	10-12	12-13	12-14	11-12	9-11	9-11	11-13	12-13	9-13	12-16
	11.0	11.0	12.5	12.8	11.8	10.1	9.9	12.0	12.5	11.0	13.8
Lateral line	71-92	75-89	74-77	77-88	81-86	74-81	54-63	86-102	90-100	75-85	72-85
	81.8	82.0	75.0	82.5	84.6	77.7	59.7	91.2	95.0	77.0	77.8
Gillrakers	17-25	17-25	19-23	22-24	...	18-22	13-16	17-21	18-19	26-31	23-31
	20.2	22.0	...	22.4	19.0	19.0	...	19.4	18.8	29.0	27.0

studies of P. williamsoni.

P. coulteri (Weisel and Dillon, 1954) differs from the other species in four characters (lateral line, dorsal rays, orbit in head and body depth in length). Each meristic average is lower in P. coulteri than P. williamsoni and there is no overlap in the lateral line and gillraker counts.

The two studies (Kennedy, 1953; Dymond, 1943) of P. cylindraceum do not differ appreciably. P. cylindraceum varies from the other species in most body proportions and the lateral line count.

The two distinguishing meristic characters of C. clupeaformis are number of gillrakers and branchiostegal rays (McHugh, 1939; Kennedy, 1953). Body proportions vary among populations of different waters.

P. williamsoni, P. coulteri, P. cylindraceum and C. clupeaformis are readily distinguishable species but P. oregonium and P. spilonotus fall within the ranges of P. williamsoni.

DISCUSSION

No collection is distinguishable from all other collections of the present study by ranges of body proportions or meristic counts. Collections 11 and 12 are distinguishable within their respective drainages, but not among all collections. Only one character (head width in head) separates collection 11 from the other collections of the Columbia River drainage while collection 12 differs in three meristic counts from the other collection of the Bear River drainage. Since these collections can not be separated from all other collections of P. williamsoni, they all

should be considered the same species. Similarly, P. oregonium and P. spilonotus (from original descriptions) can not be separated from P. williamsoni by body ratios or counts.

SUMMARY

1. Thirteen collections of whitefish were obtained from three major drainages as follows: Missouri River drainage, (1) Tongue River, (2) South Fork of Shoshone River, (3) Yellowstone River, (4) Hebgen Lake, and (5) Red Rock Creek; Columbia River drainage, (6) Bitterroot River, (7) Whitefish River, (8) Thompson Lakes, (9) Lake Pend Oreille, (10) Phelps Lake, and (11) McKenzie River; Bear River drainage, (12) Bear Lake, and (13) Logan River.

2. Measurements and counts were taken on all 407 fish. The means of body ratios and meristic counts were tested by analysis of variance in seven different combinations.

3. The majority of the tests were significant at the one per cent level. The ranges of variation for most body proportions and counts overlapped, but some means differed greatly among collections and drainages.

4. Collections from McKenzie River and Bear Lake were distinguishable from their respective drainages, but not among all collections.

5. Body proportions and meristic counts from eleven studies of six Coregonine fishes (P. williamsoni, P. oregonium, P. spilonotus, P. coulteri, P. cylindraceum, and C. clupeaformis) were compared. All species except P. oregonium and P. spilonotus were distinguishable from one another. The body proportion and count ranges of P. oregonium and P.

spilonotus fell within the ranges of P. williamsoni.

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