



A field evaluation of four strains of *Salmo* introduced into seven Montana waters
by Michael Elmer Hensler

A thesis submitted 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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Abstract:

The food habits, growth rates, and condition factors of three strains of rainbow trout (*Salmo gairdneri*) and one strain of cutthroat trout (*Salmo clarki bouvieri*) were evaluated in seven limnetic waters in Montana during the summers of 1985 and 1986. Analysis of stomach contents revealed that *Daphnia* was the most important food item in all populations with trout <350 mm TL.

Daphnia remained important for DeSmet rainbow trout with total lengths ≥ 350 mm, while the other strains switched to insects, fish, and *Leptodora kindti*. The study indicated that at least 500 daphnids of lengths ≥ 2 mm per m^3 were needed to produce condition factors of 1.0 or greater in trout up to approximately 350 mm TL. Arlee rainbow trout appeared to more efficiently utilize low *Daphnia* densities than other strains. Eagle Lake rainbow trout did not feed on forage fish as they were reported to do elsewhere. In contrast, McBride cutthroat trout ≥ 350 mm TL fed heavily on cottids in one area, but they did not feed on them or Utah chubs (*Gila atraria*) in two other situations. The McBride strain's potential for piscivory indicates it may be more useful where forage fish are available than is presently recognized. Condition factors of fish ≥ 350 mm TL that relied on *Daphnia* were lower than in smaller fish. The effective gill raker straining area in fish ≥ 350 mm decreased for food items of ≤ 2 mm for all trout strains suggesting this was the cause of the lower condition factors in these larger fish. Condition factors for Eagle Lake rainbow trout were excellent in the high pH environment of a study reservoir with a daphnid/hemipteran food base. McBride cutthroat trout survived in waters with a wide pH range. The results indicated that these latter two strains might be successfully used in waters that might be unsuitable for other strains of trout. The suitability of the other two strains in this type situation was unknown.

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INTRODUCED INTO SEVEN MONTANA WATERS

by

Michael Elmer Hensler

A thesis submitted in partial fulfillment
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This thesis has been read by each member of the thesis committee and has been found to be satisfactory regarding content, English usage, citations, bibliographic style, and consistency and is ready for submission to the College of Graduate Studies.

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ABSTRACT

The food habits, growth rates, and condition factors of three strains of rainbow trout (Salmo gairdneri) and one strain of cutthroat trout (Salmo clarki bouvieri) were evaluated in seven limnetic waters in Montana during the summers of 1985 and 1986. Analysis of stomach contents revealed that Daphnia was the most important food item in all populations with trout <350 mm TL. Daphnia remained important for DeSmet rainbow trout with total lengths >350 mm, while the other strains switched to insects, fish, and Leptodora kindti. The study³ indicated that at least 500 daphnids of lengths >2 mm per m³ were needed to produce condition factors of 1.0 or greater in trout up to approximately 350 mm TL. Arlee rainbow trout appeared to more efficiently utilize low Daphnia densities than other strains. Eagle Lake rainbow trout did not feed on forage fish as they were reported to do elsewhere. In contrast, McBride cutthroat trout >350 mm TL fed heavily on cottids in one area, but they did not feed on them or Utah chubs (Gila atraria) in two other situations. The McBride strain's potential for piscivory indicates it may be more useful where forage fish are available than is presently recognized. Condition factors of fish >350 mm TL that relied on Daphnia were lower than in smaller fish. The effective gill raker straining area in fish >350 mm decreased for food items of <2 mm for all trout strains suggesting this was the cause of the lower condition factors in these larger fish. Condition factors for Eagle Lake rainbow trout were excellent in the high pH environment of a study reservoir with a daphnid/hemipteran food base. McBride cutthroat trout survived in waters with a wide pH range. The results indicated that these latter two strains might be successfully used in waters that might be unsuitable for other strains of trout. The suitability of the other two strains in this type situation was unknown.

INTRODUCTION

Stocks of rainbow trout (Salmo gairdneri) and cutthroat trout (S. clarki) have diverged into different strains with different characteristics both in hatcheries and in the wild. Calhoun (1966) suggested that intraspecific variability might be an important management tool. The variances could be exploited to potentially improve fisheries in areas by planting strains into environments for which they were well adapted. As a result, many evaluations of traits such as feeding habits (Trojnar and Behnke 1974), growth rates (Rawstron 1973 and 1977; Hudy 1980; Dwyer and Piper 1984), migratory behaviors (Moring 1982), and catchability and survival (Cordone and Nicola 1970; Mueller 1985) of different strains have been undertaken in the last two decades.

In 1985, the Montana Department of Fish, Wildlife and Parks (MDFWP) began evaluating performances of rainbow and cutthroat trout strains in different habitats throughout the state. In this study, wild, domestic, and introduced strains of trout were to be evaluated for longevity, catchability, food habits, growth rate, maximum size, habitat preference, adaptability, and other characteristics in the reservoirs and lakes in which they had been planted.

The objectives of this portion of that larger study were to evaluate the food habits, growth rates and conditions of Eagle Lake, DeSmet, and Arlee rainbow trout, and McBride cutthroat trout

in several Montana lakes and reservoirs with different morphological and physical/chemical parameters.

In addition, the gill raker morphologies of the study strains were examined. This feature was investigated because gill raker morphology is correlated with food habits and habitat preferences of many fish (Galbraith 1967; Martin and Sandercock 1967; Kliewer 1970; Bodaly 1979; Lindsey 1981).

STRAIN HISTORIES

The DeSmet strain of rainbow trout originated in Lake Desmet, Wyoming. Prior to 1957, rainbow trout from many sources were planted in Lake DeSmet (both spring and fall spawning varieties). The DeSmet stock is the result of selecting for the spring spawning variety beginning in 1958. After that time the stock was maintained by trapping wild DeSmet-type Rainbow trout, spawning them, and rearing them to juvenile stage in the hatchery and then returning the young to the lake (Mueller and Rockett 1980). The strain has since been discontinued in Lake DeSmet in favor of Eagle Lake rainbow trout. DeSmets were established in Willow Creek Reservoir, Montana, by a series of four plants from Lake DeSmet in 1977, 1978, 1980, and 1981 (Richard Vincent, MDFWP, pers. comm.).

The DeSmet strain is a March-early May spawner in the wild. It is considered to be a planktivore and characteristically prefers the upper portion of the water column in the pelagic zone. The longevity of the strain in the wild averages 5 years (yr) with individuals living up to 8 yr in Willow Creek Reservoir (Richard Vincent, MDFWP, pers. comm.).

The Eagle Lake strain of rainbow trout (Salmo gairdneri aquilarium) is indigenous to Eagle Lake, California. The stock now is maintained entirely by an artificial spawning program whereby progeny are returned to the lake annually (Vernon King, California

Department of Fish and Game [CDFG], mimeo). The strain was brought to Montana in 1980 and propagated in the Creston National Fish Hatchery (Jack Boyce, MDFWP, mimeo).

Eagle Lake rainbows are March-mid April spawners in the wild. They are known for their large size, adaptability to highly alkaline waters, and piscivorous tendencies. They prefer the littoral zone in spring and fall and deep water in summer (Vernon King, CDFG, pers. comm.). Longevity averages 3 yr but individuals have been known to live 11 yr (McAfee 1966).

The Arlee strain of rainbow trout originated in 1955 at the State Fish Hatchery in Arlee, Montana, from a cross between the Donaldson rainbow strain and McCloud River rainbow/steelhead cross from Missouri (Jack Boyce, MDFWP, mimeo). The brood stock of this strain has been confined to the hatchery system. The Arlee strain has been widely planted in the state by MDFWP. The strain is currently being phased out due to its low survival and poor spawning ability in the wild (Richard Vincent, MDFWP, pers. comm.).

The Arlee strain is a mid August-early January spawner in the hatchery but probably does not spawn successfully in the wild (Jack Boyce, MDFWP, mimeo). The strain is known for its exceptional hatchery performance, disease resistance, fast growth rate, and high catchability. It is characterized as an invertebrate feeder with short longevity: most die within 2 yr but some live up to 4 yr (Richard Vincent, MDFWP, pers. comm; Jack Boyce, MDFWP, mimeo).

McBride cutthroat trout are native to McBride Lake, Wyoming in the Slough Creek Drainage of Yellowstone National Park. They are considered to be a distinct strain of the Yellowstone cutthroat (Salmo clarki bouvieri) (Robert Gresswell, United States Fish and Wildlife Service [USFWS], pers. comm.). The brood stock was developed in Big Timber Hatchery, Montana from eggs collected from fish in McBride Lake in 1971 (Dean 1972). McBride cutthroat were chosen for Montana lakes due to their rearing success, high post-planting survival, and success in high mountain lakes (Richard Vincent, MDFWP, pers. comm.).

McBride cutthroat trout spawn in late May-June. The strain is considered to feed mainly on invertebrates. They live to an average age of about 4 yr but can live to 8 yr (Richard Vincent, MDFWP, pers. comm.).

DESCRIPTION OF STUDY WATERS

Seven bodies of water, six reservoirs and one lake, containing target strains were sampled (Table 1). Water bodies were chosen to include sites with different levels of productivity, climatic influences and fish communities.

Willow Creek Reservoir (Harrison Reservoir) is located in southwestern Montana near the town of Harrison. Its main purpose is to supply water for irrigation which leads to extensive waterlevel drawdowns during the summer months. Dense algal blooms of primarily Aphanizomenon and Gleotrichia species are common in late summer and early fall. This reservoir contains a self-reproducing population of DeSmet rainbow trout that were first planted in 1977 (Appendix Table 22). Other fish found in the lake are white suckers (Catostomus commersoni), longnose suckers (C. catostomus), and brown trout (S. trutta).

Hyalite Reservoir is located in southwestern Montana in the Gallatin Mountain Range near the city of Bozeman. It is used for irrigation and as a municipal water source (Zubik 1983). Dense algal blooms of Aphanizomenon species are common in late summer and early fall. The reservoir first received McBride cutthroat trout in 1976 (Appendix Table 23). It now contains naturally reproduced fish and hatchery-reared fish. Arctic grayling (Thymallus

Table 1. The location and principal characteristics of the study waters and trout strains present. References: Anonymous (1968); Robert Domrose, MDFWP, mimeo; Richard Vincent, MDFWP, pers. comm.

Water body name	Lake (L) or reservoir (R)	Location				Maximum capacity or volume ³ (m ³)	Abundance of rooted ¹ macrophytes	maximum depth (m)	Target strains ² present	Elevation above sea level (m)
		County	Sec.	T.	R.					
Willow Creek Reservoir	R	Madison	26,27 34,35	1 & 2S	1W	22,204,800	very low	33.4	DR	1440
Hyalite Reservoir	R	Gallatin	15,16	4S	6E	9,902,107	very low	27.0	MC	2012
Hebgen Lake (Grayling Arm)	R	Gallatin	22	11S	3E	9,220,870	low	7.3	MC	2003
Notellum Reservoir	R	Flathead	16	26N	25W	294,830	high	6.7	AR	1225
Woods Lake	L	Flathead	18	31N	22W	288,662	high	5.5	ER	1031
Axolotl Lake #2	R	Madison	8DC	7S	2W	92,000	very high	5.0	MC	2430
Grasshopper Reservoir	R	Blaine	29	31N	19E	100,000	very low	6.1	ER	820

1. Macrophyte abundances: very low = < 20% of water body; low = 20 - 40% of water body; moderate = 40 - 60% of water body; high = 60 - 80% of water body; very high = > 80% of water body.
2. DR = Desmet rainbow trout; ER = Eagle Lake rainbow trout; AR = Arlee rainbow trout; MC = McBride cutthroat trout.

arcticus), brook trout (Salvelinus fontinalis) and mottled sculpin (Cottus bairdi) are also found in the lake.

Hebgen Reservoir is located in a high valley in southwestern Montana near West Yellowstone. The reservoir supplies water for power generation. It is also subject to dense algal blooms of Aphanizomenon in late summer. The lake contains a naturally reproducing population of McBride cutthroat trout. This strain was initially planted in the reservoir in 1979 (Appendix Table 24) and has been continually planted since then. The lake also contains several strains of rainbow trout, mountain whitefish (Prosopium williamsoni), Utah chub (Gila atraria), and brown trout. The study area consisted of the Grayling Arm in the eastern part of the reservoir.

Notellum Reservoir is located in northwestern Montana near the City of Kalispell. The reservoir supplies water for irrigation. It contains Arlee rainbow that are planted each year (Robert Domrose, pers. comm.) and westslope cutthroat trout. Blooms of Aphanizomenon are common during the summer and fall.

Woods Lake is located in northwestern Montana near the town of Whitefish. It is a closed-basin lake. The lake was planted with 1000 Eagle Lake rainbow trout and 1000 Arlee rainbow trout in 1983 (Robert Domrose, MDFWP, pers. comm.). Redside shiners (Richardsonius balteatus) are also present.

Axolotl Lake #2 is part of a series of small irrigation reservoirs located in the Gravelly Mountain Range of southwestern

Montana near the town of Ennis. It contains a self-reproducing population of McBride cutthroat trout that were first planted in 1980 (Richard Vincent, MDFWP, pers. comm.). There is also a population of mottled sculpin present in the reservoir.

Grasshopper Reservoir is located in eastern Montana near the town of Chinook. It is used for irrigation and is subject to dense algal blooms of Aphanizomenon in the summer and fall. The reservoir contains Eagle Lake rainbow trout that were planted in 1985 and 1986 and Arlee rainbow trout that also were planted in 1985 (Kent Gilge, MDFWP, mimeo). Other fish are found in the reservoir and include Iowa darters (Etheostoma exile), fathead minnows (Pimephales promelas), and brook stickleback (Culaea inconstans).

METHODS

Collection of Fish

Trout were collected with floating and sinking experimental gill nets between the months of June and October of 1985 and 1986. All experimental nets were 38.1 meters (m) long, 1.8 m deep and consisted of five panels of equal length. Panel mesh sizes were 19, 25, 32, 38, and 51 millimeters (mm). Nets were placed perpendicular to the shoreline with the small mesh inshore. Nets were set on one afternoon and retrieved the following morning.

Age and Growth

Lengths at Age and Growth Increments

The length of trout collected was measured as total length (TL) to the nearest millimeter. Whole weight was measured to the nearest gram with a Homs Temperature Compensated Model 1000 Gram Scale. All trout weighing more than 1000 g were cut in pieces and weighed.

All scales were taken from the left sides of fish in an area above the lateral line and between the dorsal and anal fins. Cellulose acetate impressions of the scales were examined at 42X magnification using a microfiche reader. Distances were measured in a straight line from the focus to the annuli and mid-anterior margin of the scales using a millimeter ruler.

Age and growth information was analyzed using the Fire 1 computer program as modified by the Montana Department of Fish Wildlife and Parks. Body length-scale radius relationships were most accurately described using log-log plots generated from the CURVE67 program. The slope of the regression created by CURVE67 was used in the MONASK program to calculate lengths at age for fish based on the Monastyrsky method.

Condition Factors

The FREQCON program was used to calculate condition factors at specified lengths for trout with the formula:

$$K = \frac{(10^4)(w)}{L^3}$$

where K = condition factor

w = total weight (g)

L = total length (mm)

Food Habits

The stomach of each study specimen was removed and its contents emptied into a labeled glass vial containing a solution of 4 percent (%) formalin with 40 grams (g) per liter (l) sucrose (Haney and Hall 1973). Trout with empty stomachs were not considered in this study. The numbers, volumes, and frequency of occurrence of identified food items were then evaluated.

The numbers of each food item were determined by direct enumeration, except for the numbers of Cladocera which were determined by subsampling. Each Cladocera sample was diluted to a 50 milliliter (ml) suspension volume and 1 or 2 ml subsamples were taken from it using a Hensen-Stempel pipette. The numbers of Cladocera in three to five subsamples of each sample were counted so that 50 to 100 organisms were counted (Bowen 1983). Subsamples were enumerated using a Ward plankton counting wheel and a binocular dissecting microscope at 25X magnification. The mean number of Cladocera counted from the subsamples was multiplied by the suspension volume and divided by the subsample volume to estimate the total number of Cladocera in the stomach sample. The number of food items in each category in the stomach was then converted to a percentage of the total number of food items in the stomach.

Volume of the stomach contents was determined by fluid displacement. Individuals of each type were pooled, blotted to remove excess preservative and placed in a measured amount of the solution in which they were preserved to guard against differences in buoyancy. Organisms with volumes less than 10 ml were measured in a 12 ml graduated centrifuge tube to the nearest 0.05 ml. Fish remains and invertebrate items with volumes greater than 10 ml were measured to the nearest 0.5 ml in a 50 ml graduated cylinder. Any organisms displacing less than 0.05 ml were arbitrarily assigned a volume of 0.01 ml. The volume of each food item then was calculated

as a percentage of the volume of the combined food items in each stomach.

After the numbers and volumes of the food items were determined, the contents were pooled and frequency of occurrence was determined. The frequency of occurrence of a given food item was determined by dividing the number of stomachs that contained at least one of that food item by the total number of stomachs examined (Bowen 1983).

The representation of food habits by each of these three techniques contain inherent biases (George and Hadley 1979; Hyslop 1980; Bowen 1983). Because a combination of indices can be more valuable than single indices (Windell 1971), a modification of the Relative Importance Index (RI_a) (George and Hadley 1979) was used to compare diets. The RI_a for a particular food item was determined by the formula:

$$RI_a = \frac{100 AI_a}{\sum_{a=1}^n AI_a}$$

where AI_a = % frequency of occurrence + % total numbers
+ % total weight for food item a.

a = a particular food item

n = total number of different types of food items

For this study, volume was substituted for weight in the equation. The values from this index range from 0 to 100, where the value 100 indicates exclusive use of a particular food item.

In addition, a measure of the length of the Cladocera eaten was obtained by measuring specimens from a random sample of stomachs from fish of different lengths. The length was measured as the distance from the anterior margin of the head to the base of the spine. Length was measured to the nearest 0.05 mm with an ocular micrometer mounted in a binocular dissecting scope at 25X magnification. Only intact specimens were measured. Copepods were not measured because they were not found in the stomachs.

Gill Raker Characteristics

The straining efficiencies of the study strains were estimated from the morphology of the gill rakers. The first branchial arch on the right side of each processed fish was removed entirely and preserved in a solution of 4 % formalin and 40 g/l sucrose.

Because number of gill rakers has been shown to be significantly correlated to feeding habits (Kliewer 1970), total number of rakers was counted for each strain. Numbers then were compared between strains to find if significant differences existed.

The length of selected gill rakers and the distance between the bases of successive gill rakers were measured to the nearest 0.05 mm with an ocular micrometer mounted in a binocular dissecting scope at 25X magnification. Measurements included those for the apex gill raker, and also for the upper four gill rakers, and lower six gill rakers. These rakers were commonly longer than 10.0 mm and considered to be effective at straining.

The total straining area for each arch was estimated by multiplying the width between two adjacent gill rakers times the length of the shortest of the two. Areas were then summed for measurements on all 11 gill rakers.

An "effective straining area" was calculated from the total straining area by estimating that proportion of the total that would effectively strain a Daphnia of an assigned length. The assigned length of Daphnia was based on measurements from intact stomach samples and plankton tows.

The same strains that were captured in different lakes were found to have equivalent gill raker morphologies. Therefore, measurements from their gill rakers were pooled to get measurements for the strain as a whole.

Zooplankton

Crustacean zooplankton populations were sampled in each study water during the same hours that the physico-chemical parameters were measured. Zooplankton samples were collected with a Wisconsin-type plankton net having a mouth diameter of 12 cm and a mesh size of 80 microns (μm). Three vertical tows from bottom to surface were taken within each water body, two in shallower water locations and one in the middle of the water body. All tows were made along the long axis of the basin. Samples were placed in a labeled container and preserved in a mixture of 4% formalin with 40 g/l sucrose (Haney and Hall 1973).

Collected zooplankters were identified and their presence in the waters was documented. Densities of carapaced Cladocera were counted by the same method described for counting Cladocera in stomach samples.

The mean number of carapaced Cladocera obtained from the subsamples was used to estimate the total density (number/m³) for each sample by applying the formula (Wetzel and Likens 1979):

$$n = \frac{NV_s (1000)}{V_f}$$

where n = density of organisms (no./m³)

N = average number of organisms per subsample

V_s = volume of sample (ml)

V_f = volume of lake water sampled (l)

The densities from each of the three samples was then averaged to obtain an estimate of the carapaced Cladoceran density within the water body. In addition, the mean length of carapaced Cladocerans was estimated from measurements of a random sample of 100 or more individuals taken from the pooled subsamples from a given water body so that densities of carapaced Cladocera 2 mm or greater and those less than 2 mm could be found. Cladocera were measured in the same manner as was described earlier for those found in stomach samples.

All Leptodora kindti in samples were counted because they were rare in plankton tows. L. kindti were counted at low power using a

binocular dissecting microscope and their density in a study water estimated by the method of Wetzel and Likens (1979). In analysis, L. kindti were considered separately from other Cladocerans.

Limnology

The physico-chemical parameters of the study lakes or reservoirs were measured near noon on the day of gill net placement. Measurements were made in the deepest portion of the basin in which the gill nets were placed.

Depth, temperature, dissolved oxygen, hydrogen ion concentration (pH), and conductivity were measured at 1 m intervals from surface to bottom. These parameters were usually measured with a Hydrolab 8100 series water quality data transmitter system, however, occasionally when the apparatus was unusable, depth, temperature, and dissolved oxygen were measured with a Yellow Springs Instrument Company (YSI) 54ABP Dissolved Oxygen Meter, the pH was determined with an Orion model 407 Specific Ion Meter, and conductivity was found using a Beckman RB3-Solu Bridge Conductivity Meter.

Surface alkalinity was measured by end point titration (APHA 1975). Ending pH equivalence points of 5.1, 4.8, and 4.5 were used for water bodies based on trial alkalinity measurements of <30, 30 - 150, and >150 mg/l calcium carbonate CaCO_3 , respectively (APHA 1975). All alkalinity measurements were reported as total alkalinity in milliequivalents/l (meq/l).

Light transmittance was measured with a submarine photometer fitted with a Weston B56 photocell. Measurements were made from the unshaded side of the boat at 1 m intervals until the euphotic zone (level of 1% light transmittance) was found.

Invertebrate Identification

The food items in each stomach were identified to the lowest taxon practical using references by Pennak (1978), and Merritt and Cummins (1984). Zooplankton taxa were identified with the use of Brooks (1959) and Pennak (1978). Cladocerans were identified to species. Copepods were identified to the suborders cyclopoid, calanoid, or harpacticoid.

Statistical Analyses

Statistical tests were made following the methods of Snedecor and Cochran (1980). Analyses were performed with the computer program MSUSTAT (Lund 1986). Statistical differences were considered to be significant at the $p < 0.05$ level.

RESULTS

Age and GrowthCalculated Lengths at Age
and Growth Increments

The back calculated lengths at annuli determined for the study populations are given in Appendix Tables 25-31. Because some sampled stocks were planted, and planted at different sizes, and others were from naturally reproducing populations, the lengths at annuli among strains are not directly comparable.

Length at annuli were converted to mean growth increments to facilitate growth comparisons among the populations, at least after the first year of life (Table 2). Zubik (1983) found that growth increments in wild and hatchery trout were similar after the first year.

Growth increments for the second year of life showed that trout from Axolotl Lake #2, Grayling Arm of Hebgen Reservoir, and Harrison Reservoir had non-significant differences from each other but had significantly greater increments than the strains in the other locations. The growth increments of fish from Hyalite Reservoir, Woods Lake, and Notellum Reservoir, were all significantly different from each other. The Grasshopper Reservoir population did not have any 2 yr old fish.

Table 2. Calculated mean growth increments (standard deviations) of the study trout strains from 1985-1986.

Strain	Study area	N	Mean growth increments at annuli				
			1	2	3	4	5
DeSmet rainbow trout	Harrison Reservoir	89	104 (15.3)	123 (43.3)	129 (41.4)	82 (41.4)	25 (3.5)
Eagle Lake rainbow trout	Woods Lake	10	222 (17.8)	84 (12.7)	67 (19.9)		
Eagle Lake rainbow trout	Grasshopper Reservoir	57	203 (19.0)				
Arlee rainbow trout	Notellum Reservoir	42	208 (15.0)	69 (11.1)			
McBride cutthroat trout	Hyalite Reservoir	78	110 (16.2)	103 (27.9)	83 (24.5)	84 (7.0)	
McBride cutthroat trout	Hebgen Reservoir	27	151 (30.4)	130 (50.5)	98 (25.0)		
McBride cutthroat trout	Axolotl Lake #2	21	77 (11.8)	136 (37.3)	130 (47.7)	87 (22.9)	

In the third year, growth increments of strains in Axolotl Lake #2 and Harrison Reservoir were not significantly different from each other but were significantly greater than those in Grayling Arm of Hebgen and Hyalite Reservoirs which had similar growth

increments. Increments from trout in Woods Lake were the lowest and were significantly different from all other populations.

The fourth year growth increments could be compared among only three strains. The fish from Axolotl Lake #2 had the greatest growth followed by trout from Hyalite and Harrison Reservoirs, although they were not significantly different from each other.

Mean growth increments at annuli were not used in further comparisons because there were not consistent age classes among all populations of trout. This is because the various strains were not planted in the same years at the water bodies studied. Condition factors were considered to be a more immediate measure of the well-being of the studied strains as related to factors occurring in the summer.

Condition Factors

Initial examination of the spacing between gill rakers and food habits in the study populations indicated that changes occurred in fish at about 350 mm TL. Mean condition factors, therefore, were calculated for fish with total lengths of less than 350 mm and for those 350 mm or greater from each study population (Table 3).

A multiple comparison test showed that mean condition factors for DeSmet rainbow trout in Harrison Reservoir and McBride cutthroat trout in Hyalite Reservoir were significantly greater at total lengths of fish less than 350 mm than they were in larger fish. In contrast, McBride cutthroat trout in Axolotl Lake #2 had a

significantly greater condition factor in trout 350 mm or greater than in the smaller size group.

Table 3. Mean condition factors in study strains with total lengths of less than 350 mm and 350 mm or greater (standard deviations) during 1985 - 1986.

Strain	Study area	N	Total length <350 mm	N	Total length ≥ 350 mm
DeSmet rainbow trout	Harrison Reservoir	31	1.09(0.13)	58	1.01(0.09)
Eagle Lake rainbow trout	Woods Lake	---		10	0.86(0.06)
Eagle Lake rainbow trout	Grasshopper Reservoir	42	1.19(0.13)	15	1.20(0.09)
Arlee rainbow trout	Notellum Reservoir	41	1.10(0.12)	0	
McBride cutthroat trout	Hyalite Reservoir	70	1.04(0.14)	8	0.97(0.07)
McBride cutthroat trout	Hebgen Reservoir	13	1.03(0.09)	8	0.99(0.07)
McBride cutthroat trout	Axolotl Lake #2	13	0.93(0.05)	8	1.08(0.14)

Condition factors for the two size groups of McBride cutthroat trout in Hebgen Grayling Arm were not significantly different. Both size classes of Eagle Lake rainbow trout in Grasshopper Reservoir

were represented by age 1+ fish. Growth in length was exceptional for that summer, although differences in condition factors between size classes were not significantly different.

Mean condition factors for all populations of trout less than 350 mm TL were compared in a multiple comparison test. Analysis showed that condition factors for Eagle Lake rainbow trout taken from Grasshopper Reservoir were greater than in all other populations. There were no Eagle Lake rainbow trout less than 350 mm TL taken in Woods Lake. The two other rainbow trout populations had significantly higher condition factors than all McBride cutthroat trout populations. Condition factors for McBride cutthroat trout in Hebgen Grayling Arm and Hyalite Reservoir were similar and significantly greater than that of McBrides from Axolotl Lake #2. McBride cutthroat trout from Axolotl had the lowest condition factors of all populations.

Analysis of mean condition factors for trout 350 mm TL or longer again showed Eagle Lake rainbow trout from Grasshopper Reservoir were significantly greater than those in all other populations. The condition factors of the remaining populations were similar with the exception of the Eagle Lake rainbow trout population from Woods Lake which was significantly lower than those in all other populations. No Arlee rainbow trout equal to or greater than 350 mm TL were taken from Notellum Reservoir.

Food Habits

After initial analysis of food habits, it appeared that the utilization of Daphnia decreased with increasing length. When fish length was plotted against percent volume of Daphnia in their stomachs, a decline occurred at about 350 mm TL. For this reason, trout food habits for fish less than 350 mm TL and those 350 mm TL or longer were separated from each other.

DeSmet Rainbow Trout From
Harrison Reservoir

Daphnia pulex was the most important food item in the diet of DeSmet rainbows less than 350 mm TL (Table 4). Insects and water mites, the only other food items found, had about one half the relative importance value of the Daphnia.

Table 4. The Index of Relative Importance (IRI) and its components for food items in the stomachs of DeSmet rainbow trout less than 350 mm total length in Harrison Reservoir, 1985-1986.

Food item	Frequency of occurrence (%)	Volume (%)	Number (%)	IRI
<u>Daphnia pulex</u>	100.0	83.5	98.3	65.9
Diptera larvae	50.0	11.3	1.5	14.6
Diptera pupae	55.6	3.6	0.2	13.9
Diptera adults	11.1	1.5	0.1	3.0
Hemiptera	5.6	0.1	<0.1	1.3
Hydracarina	5.6	<0.1	<0.1	1.3

Daphnia was also the most important single food item in the diets of DeSmet rainbow trout 350 mm TL or greater (Table 5). However, there was more utilization of insects in these larger fish. Collectively, insects were slightly more important than daphnids in these larger fish. Terrestrial insects included Hymenoptera, Orthoptera, and Lepidoptera. The semi-aquatic Hemiptera included Corixidae.

Table 5. The Index of Relative Importance (IRI) and its components for food items in the stomachs of DeSmet rainbow trout 350 mm total length or greater in Harrison Reservoir, 1985-1986.

Food item	Frequency of occurrence (%)	Volume (%)	Number (%)	IRI
<u>Daphnia pulex</u>	69.6	42.7	97.8	45.0
Diptera pupae	91.3	25.8	1.0	25.4
Diptera larvae	43.5	5.4	0.4	10.6
Terrestrial insects	21.7	7.2	0.1	6.2
Hemiptera	13.0	10.9	1.0	5.4
Coleoptera	17.4	6.2	0.1	5.1
Diptera adults	4.3	1.6	<0.1	1.3
Trichoptera larvae	4.3	0.1	<0.1	1.0

Eagle Lake Rainbow Trout
From Woods Lake

Only trout equal to or greater than 350 mm TL were captured at Woods Lake. The single most important food item in the stomachs of these fish were snails (Table 6). Again, insects collectively made up over one-half of the IRI of these larger fish. The fish remains

were probably of R. balteatus which were abundant in the lake.

Table 6. The Index of Relative Importance (IRI) and its components for food items in the stomachs of Eagle Lake rainbow trout 350 mm total length or greater in Woods Lake, 1986.

Food item	Frequency of occurrence (%)	Volume (%)	Number (%)	IRI
Gastropoda	33.3	37.1	21.8	22.4
Diptera larvae	33.3	0.7	25.5	14.5
Trichoptera larvae	33.3	18.9	7.3	14.5
Diptera pupae	33.3	0.9	14.5	11.9
Odonata	22.2	11.1	12.7	11.2
Hirudinea	22.2	12.5	3.6	9.3
Amphipoda	22.2	0.3	12.7	8.6
Fish remains	11.1	18.4	1.8	7.6

Eagle Lake Rainbow Trout From
Grasshopper Reservoir

The importance of D. pulex and Hemiptera (Notonectidae and Corixidae) were about equal for Eagle Lake rainbow trout less than 350 mm TL (Table 7). The fish remains were of C. inconstans and P. promelas.

In Eagle Lake rainbow trout 350 mm TL or larger, Hemipterans (Notonectidae and Corixidae) were nearly twice as important as the next most important food item, Gastropods (Table 8). Daphnia declined to about one-fifth the importance of the most important item. Fish remains (C. inconstans, E. exile, and P. promelas) were more than twice as important for larger trout than they were for the smaller fish.

Table 7. The Index of Relative Importance (IRI) and its components for food items in the stomachs of Eagle Lake rainbow trout less than 350 mm total length in Grasshopper Reservoir, 1985-1986.

Food item	Frequency of occurrence (%)	Volume (%)	Number (%)	IRI
<u>Daphnia pulex</u>	55.2	11.5	95.2	36.5
Hemiptera	100.0	56.7	3.8	35.9
Diptera pupae	31.0	0.8	0.3	7.2
Odonata	24.1	5.9	0.4	6.8
Gastropoda	6.9	19.4	0.1	5.9
Amphipoda	13.8	0.2	0.1	3.1
Fish remains	6.9	3.8	<0.1	2.4
Trichoptera larvae	3.4	1.8	<0.1	1.2
Diptera larvae	3.4	<0.1	<0.1	1.0

Table 8. The Index of Relative Importance (IRI) and its components for food items in the stomachs of Eagle Lake rainbow trout 350 mm total length or greater in Grasshopper Reservoir, 1985-1986.

Food item	Frequency of occurrence (%)	Volume (%)	Number (%)	IRI
Hemiptera	90.9	39.1	68.9	49.7
Gastropoda	45.4	50.1	10.6	26.6
<u>Daphnia pulex</u>	18.2	0.1	19.3	9.4
Fish remains	18.2	6.3	0.4	6.2
Odonata	18.2	4.4	0.4	5.7
Coleoptera	9.2	<0.1	0.4	2.4

Arlee Rainbow Trout From
Notellum Reservoir

Only Arlee rainbow trout smaller than 350 mm TL were captured in Notellum Reservoir. Daphnia pulex were about twice as important as the next most important item in the diet of small Arlee rainbows (Table 9). However, again insects collectively made up about two thirds of the IRI.

Table 9. The Index of Relative Importance (IRI) and its components for food items in the stomachs of Arlee rainbow trout less than 350 mm total length in Notellum Reservoir, 1986.

Food item	Frequency of occurrence (%)	Volume (%)	Number (%)	IRI
<u>Daphnia pulex</u>	66.7	21.0	92.7	32.3
Diptera larvae	76.2	13.5	5.1	16.9
Terrestrial insects	42.9	39.3	1.5	14.9
Diptera pupae	61.9	2.1	0.3	11.4
Coleoptera	38.1	5.4	0.1	7.7
Hemiptera	28.6	11.3	0.1	7.1
Odonata	23.8	4.4	<0.1	5.0
Diptera adults	9.5	1.4	<0.1	1.9
Amphipoda	9.5	0.1	<0.1	1.7
Trichoptera larvae	4.8	0.3	<0.1	1.1

McBride Cutthroat Trout From
Hyalite Reservoir

In Hyalite Reservoir, Daphnia was the most important food item in the stomachs of small McBride cutthroat trout and comprised nearly 52 % of the IRI (Table 10). Dipterans, Hymenoptera (Formicidae), and Orthoptera combined provided about 40 % of the IRI. The presence of Plecoptera, Trichoptera, and Ephemeroptera

suggested that some McBride cutthroat trout might have been using stream drift or actually moving into the inlet streams to feed.

Table 10. The Index of Relative Importance (IRI) and its components for food items in the stomachs of McBride cutthroat trout less than 350 mm total length in Hyalite Reservoir, 1985-1986.

Food item	Frequency of occurrence (%)	Volume (%)	Number (%)	IRI
<u>Daphnia</u>	96.4	46.6	97.1	51.7
Diptera pupae	75.0	16.5	1.9	20.0
Diptera larvae	41.1	4.8	0.5	9.9
Terrestrial insects	19.6	26.4	0.5	9.9
Ephemeroptera naids	8.9	1.0	<0.1	2.0
Diptera adults	5.4	0.1	<0.1	1.2
Coleoptera	3.6	<0.1	<0.1	1.0
Hemiptera	3.6	<0.1	<0.1	1.0
Gastropoda	1.8	2.5	<0.1	1.0
Hydracarina	3.6	<0.1	<0.1	0.8
Trichoptera	1.8	0.6	<0.1	0.6
Odonata	1.8	0.4	<0.1	0.5
Plecoptera	1.8	0.2	<0.1	0.4

Terrestrial insects (Hymenoptera, Formicidae) were the most important food items McBride cutthroat trout 350 mm TL or greater (Table 11). Diptera pupae and D. pulex were about of equal importance and slightly less important than terrestrials. Unidentified fish remains were about one-half as important as Daphnia and could have been young McBride cutthroat trout, brook trout, Arctic grayling, or mottled sculpin.

Table 11. The Index of Relative Importance (IRI) and its components for food items in the stomachs of McBride cutthroat trout 350 mm total length or greater in Hyalite Reservoir, 1985-1986.

Food item	Frequency of occurrence (%)	Volume (%)	Number (%)	IRI
Terrestrial insects	16.7	56.8	33.3	29.1
Diptera pupae	66.7	13.1	2.1	22.4
<u>Daphnia pulex</u>	16.7	1.1	63.0	22.0
Gastropoda	33.3	20.5	1.2	15.0
Fish remains	33.3	8.5	0.4	11.5

McBride Cutthroat Trout From Grayling
Arm of Hebgen Reservoir

For the smaller size group (less than 350 mm TL) of McBride cutthroat trout in Hebgen Reservoir, Daphnia was the most important food item (Table 12). Diptera pupae, Diptera adults, and L. kindti, each comprised over 10% of the index of relative importance. All other food items were of substantially less importance.

In 350 mm TL or larger McBride cutthroat the zooplankter L. kindti was the most important food item, providing about 25% of the IRI closely followed by Daphnia sp. (Table 13). Once again, the combined dipteran forms comprised the majority of the importance index.

McBride Cutthroat Trout From
Axolotl Lake #2

The single most important food item in the stomachs of the smaller size group of McBride cutthroat trout was Daphnia pulex

Table 12. The Index of Relative Importance (IRI) and its components for food items in the stomachs of McBride cutthroat trout less than 350 mm total length in the Grayling Arm of Hebgen Reservoir, 1985-1986.

Food item	Frequency of occurrence (%)	Volume (%)	Number (%)	IRI
<u>Daphnia</u> sp.	84.6	21.6	82.9	31.3
Diptera pupae	100.0	35.5	3.8	22.8
<u>Leptodora kindti</u>	69.2	19.3	11.6	16.4
Diptera adults	69.2	9.3	0.2	12.9
Terrestrial insects	23.1	7.5	0.9	6.4
Diptera larvae	30.7	0.8	0.1	5.2
Ephemeroptera naiads	7.7	5.7	0.6	1.4
Gastropoda	7.7	<0.1	<0.1	1.3
Hemiptera	7.7	<0.1	<0.1	1.3
Hydracarina	7.7	<0.1	<0.1	1.0

Table 13. The Index of Relative Importance (IRI) and its components for food items in the stomachs of McBride cutthroat trout 350 mm total length or greater in the Grayling Arm of Hebgen Reservoir, 1985-1986.

Food item	Frequency of occurrence (%)	Volume (%)	Number (%)	IRI
<u>Leptodora kindti</u>	87.5	38.9	30.2	25.6
<u>Daphnia</u> sp.	62.5	7.0	62.2	21.4
Diptera pupae	100.0	17.2	4.4	19.9
Diptera adults	75.0	10.2	0.5	14.0
Terrestrial insects	25.0	21.7	2.4	8.0
Diptera larvae	25.0	0.1	0.9	4.2
Hemiptera	12.5	3.5	<0.1	2.6
Ephemeroptera adults	12.5	1.1	0.1	2.2
Odonata	12.5	0.4	<0.1	2.1

