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A FIELD EVALUATION OF FOUR STRAINS OF *SALMO* INTRODUCED INTO SEVEN MONTANA WATERS

by

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VITA

Michael Elmer Hensler, son of Robert G. and Patricia K. Hensler, was born in Malta, Montana, on March 4, 1961. After graduating from Flathead High School in Kalispell, Montana, he studied Biology at Whitman College, Walla Walla, Washington, where he received a Bachelor of Arts degree in Biology in 1983. He then enrolled in Montana State University and received a Bachelor of Science degree in Biological Science in 1985. He began graduate school and research toward a Master of Science degree in Fish and Wildlife Management at Montana State University in June, 1985.

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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 elswhere. 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 conditions 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 (m^3)	Abundance of rooted macrophytes[1]	maximum depth (m)	Target strains present[2]	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:

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

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 (um). 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 labled container and preserved in a mixture of 4% formalin with 40 g/1 sucrose (Haney and Hall 1973).

Collected zooplankters were identified and their presence in the waters was documented. Densities of carapaced Clacocera 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/m^3) for each sample by applying the formula (Wetzel and Likens 1979):

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

where n = density of organisms (no./m^3)

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, occassionally 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 Merrit 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 harpactacoid.

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 Growth

Calculated 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
Daphnia pulex	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
Daphnia pulex	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
Daphnia pulex	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
Daphnia pulex	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
Daphnia pulex	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
Daphnia	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
Daphnia pulex	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
Daphnia sp.	84.6	21.6	82.9	31.3
Diptera pupae	100.0	35.5	3.8	22.8
Leptodora kindti	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
Leptodora kindti	87.5	38.9	30.2	25.6
Daphnia 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

(Table 14). Together with Diptera larvae and pupae, they accounted for about 55% of the IRI. Fish remains were of C. bairdi, and terrestrial insects were from Hymenoptera (Formicidae).

Table 14. 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 Axolotl Lake #2, 1986.

Food item	Frequency of occurrence (%)	Volume (%)	Number (%)	IRI
Daphnia sp.	84.6	9.1	81.9	25.9
Diptera larvae	84.6	9.6	12.3	15.7
Diptera pupae	84.6	4.3	1.6	13.3
Diptera adults	61.5	2.5	0.2	9.4
Coleoptera	30.8	24.9	2.9	8.6
Trichoptera larvae	46.2	3.4	0.4	7.4
Fish remains	23.1	14.5	<0.1	5.5
Gastropoda	30.8	5.7	0.1	5.4
Terrestrial insects	15.4	7.8	0.4	4.0
Hemiptera	23.1	1.0	0.1	3.6
Amphipoda	7.7	0.2	<0.1	1.2

Fish were twice as important as the next food item for the larger category of McBride cutthroat (Table 15). The forage fish utilized was C. bairdi. The zooplankter Daphnia was not found in any stomachs of cutthroat trout 350 mm TL or greater.

Gill Raker Characteristics

Gill Raker Numbers

The mean number of gill rakers taken from samples of fish in the study strains are given in Table 16. There were no significant differences in gill raker numbers among strains.

Table 15. 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 Axolotl Lake #2, 1986.

Food item	Frequency of occurrence (%)	Volume (%)	Number (%)	IRI
Fish remains	85.7	97.2	8.8	40.6
Diptera pupae	28.6	0.4	66.3	20.2
Gastropoda	42.9	2.2	10.0	11.7
Ephemeroptera naiads	28.6	0.4	3.1	6.7
Hemiptera	28.6	<0.1	1.3	6.4
Terrestrial insects	28.6	<0.1	1.3	6.4
Diptera larvae	14.3	<0.1	8.8	4.9
Odonata	14.3	<0.1	0.6	3.1

Table 16. Numbers of gill rakers in the four study strains of trout.

Strain	Number of fish	Mean number of gill rakers	Range
DeSmet rainbow trout	22	19.0	18-21
Arlee rainbow trout	20	19.2	17-22
Eagle Lake rainbow trout	22	19.2	18-22
McBride cutthroat trout	65	18.5	16-20

Gill Raker Mean Lengths

All strains of trout studied showed a positive relationship between mean gill raker length and fish total length with correlation coefficients of 0.86 - 0.94 (Figure 1). An F-test comparison of the regression lines showed that both DeSmet and Arlee rainbow trout had a significantly longer mean gill raker lengths than McBride cutthroat trout. There were no other significant differences among the strains.

Gill Raker Mean Widths

All study strains showed an increase in mean gill raker widths with increasing total length. Correlation coefficients ranged from 0.78 - 0.94 (Figure 2). The only significant difference in mean gill raker widths among strains was that Eagle Lake rainbow trout had greater widths than Arlee rainbow trout.

Total Straining Area

All trout strains showed a positive correlation between total straining area and total length of trout because all gill rakers grew longer and farther apart as trout length increased (Figure 3). Correlation coefficients were 0.88 - 0.94 and there were no significant differences among strains.

Effective Straining Area

An effective straining area for prey was calculated by using the area capable of straining a 2 mm long prey item. The 2 mm size was chosen after determining the mean length of *Daphnia* found in a

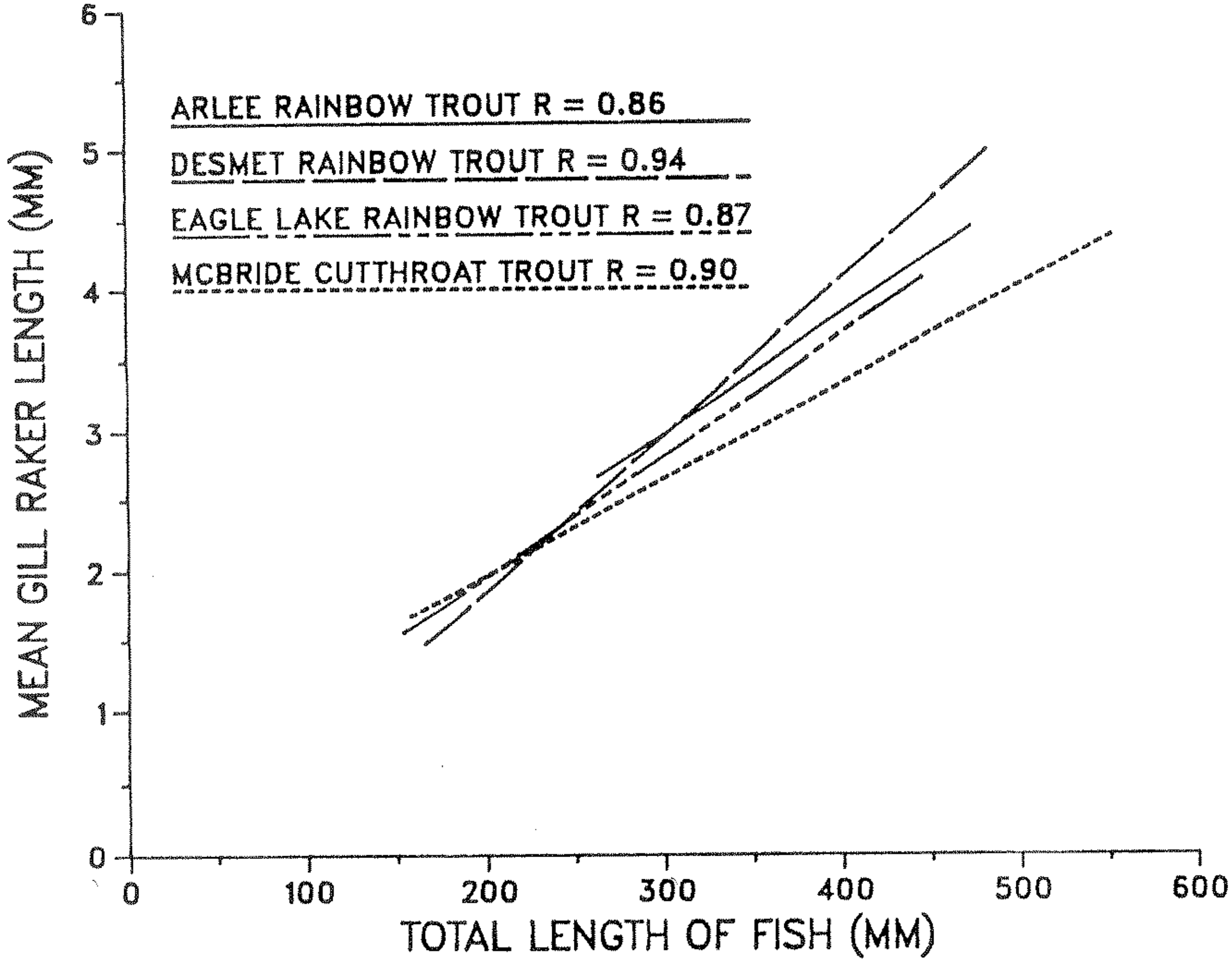

Figure 1. Regression of mean gill raker lengths (mm) with total lengths of study trout (mm).

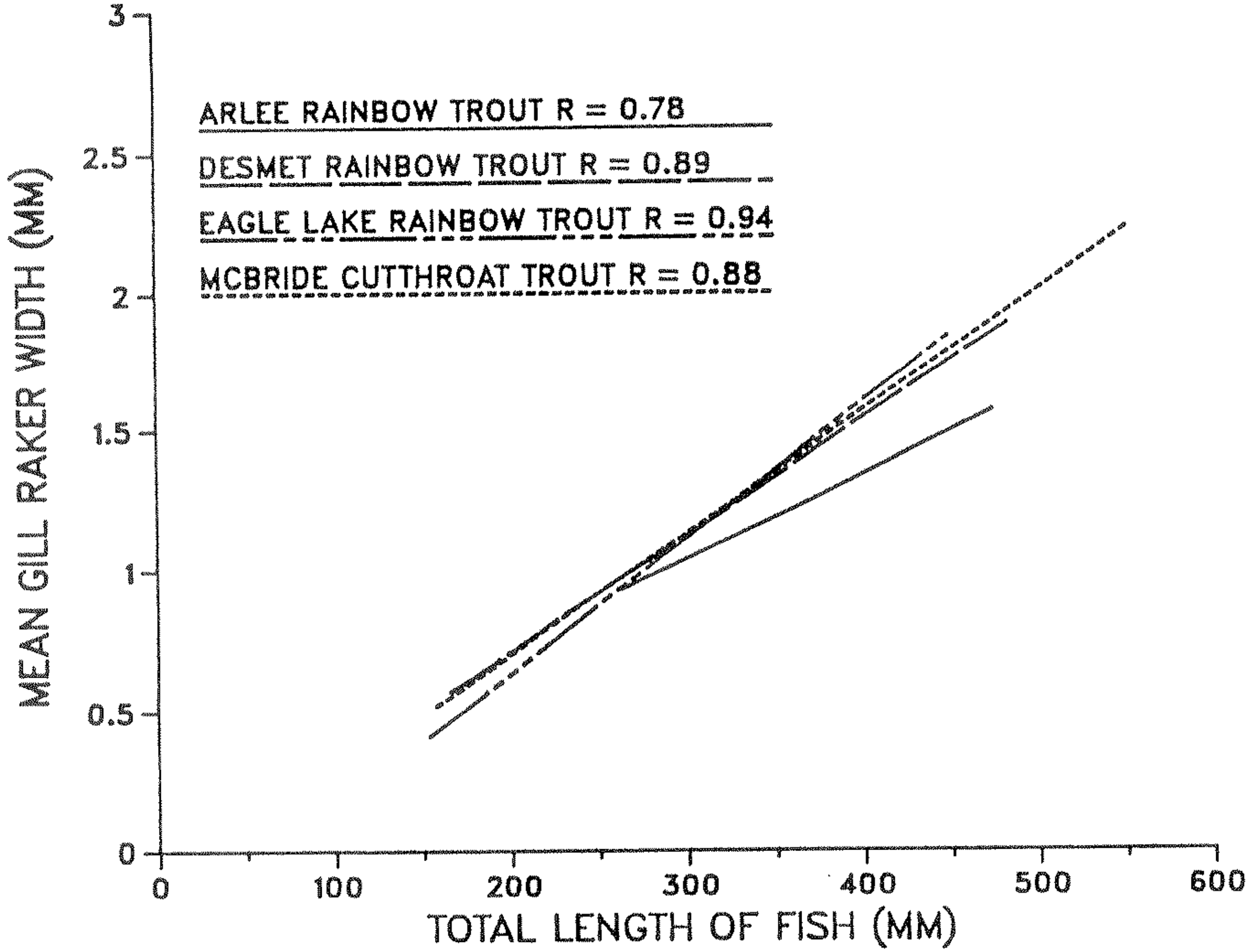

Figure 2. Regression of mean gill raker widths (mm) with total lengths of study trout (mm).

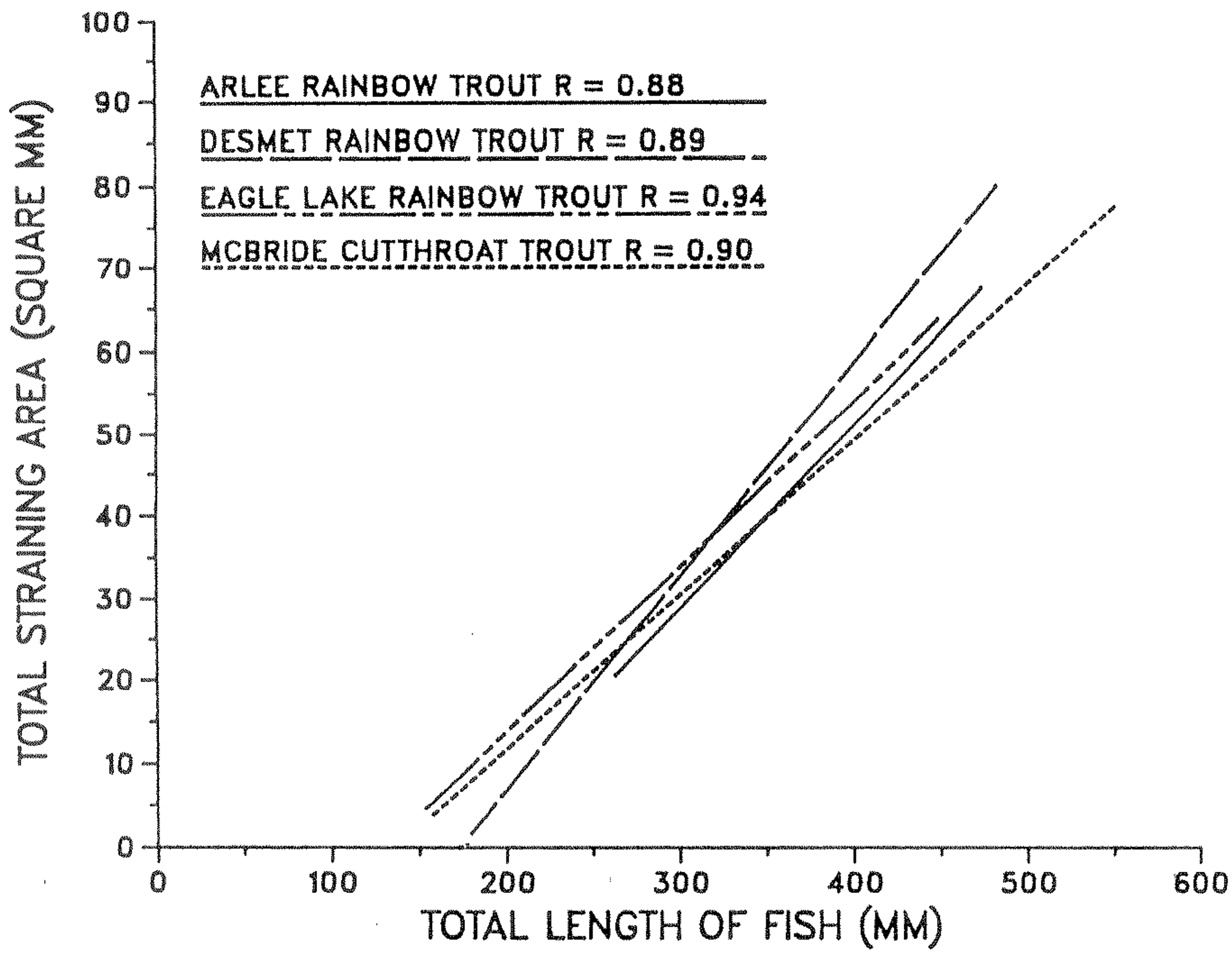

Figure 3. Regression of total straining area (square mm) with total lengths of study trout (mm).

random sample of trout stomachs taken from all study populations containing that item (Table 17).

Table 17. Mean lengths (standard deviations) of *Daphnia* found in the stomachs of the study specimens.

Strain	Study area	Number of trout sampled	Mean length of *Daphnia* (standard deviations)
DeSmet rainbow trout	Harrison Reservoir	10	2.1(0.26)
Eagle Lake rainbow trout	Grasshopper Reservoir	10	1.9(0.16)
Arlee rainbow trout	Notellum Reservoir	10	1.9(0.16)
McBride cutthroat trout	Hyalite Reservoir	10	2.0(0.19)
McBride cutthroat trout	Hebgen Reservoir	10	1.9(0.20)
McBride cutthroat trout	Axolotl Lake #2	5	1.6(0.24)
All trout combined		55	1.9(0.21)

Plots of effective straining areas with total length for the strains indicated that in fish 350 mm TL or longer, effective areas had peaked and began to decrease. This is due to the increased spacing distance between adjacent gill rakers. Therefore, strains were separated into length groups of fish less than 350 mm TL and those 350 mm TL and longer for further analyses. Correlation coefficients were 0.80 to 0.97 for trout strains for fish less than 350 mm TL and effective straining area (Figure 4). There were no significant differences among strains.

The correlation coefficients of trout strains with specimens 350 mm TL or longer were -0.26 to -0.59 (Figure 5). This suggests that at lengths of 350 mm TL or longer, food items 2 mm or smaller will progressively be less efficiently strained by the gill rakers.

Study Water Zooplankton

Eight forms of zooplankters were identified from the study waters (Table 18). *Daphnia pulex* and Calanoida were found in all study waters. *Leptodora* was only found in one study water.

Densities of carapaced Cladocera of all sizes, and those 2 mm or longer were determined for the study waters (Table 19). Cladocera population densities varied by 600%, but the density of Cladocera 2 mm or greater in length only differed by 200% in waters with this size organism. These larger size Cladocera comprised about 10-18% of their respective total populations.

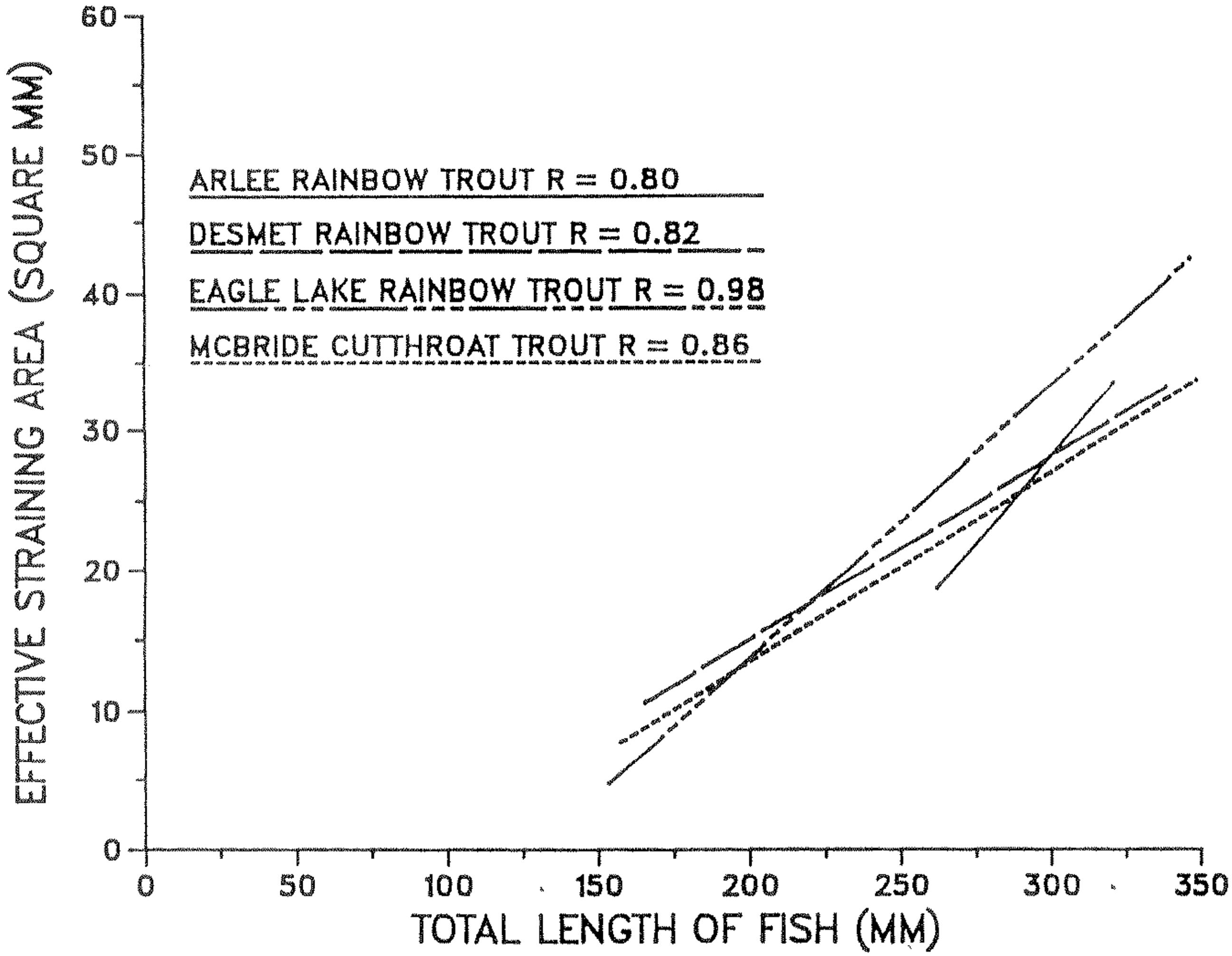

Figure 4. Regression of the effective gill raker straining area (square mm) for a 2 mm object with total lengths of study trout less than 350 mm.

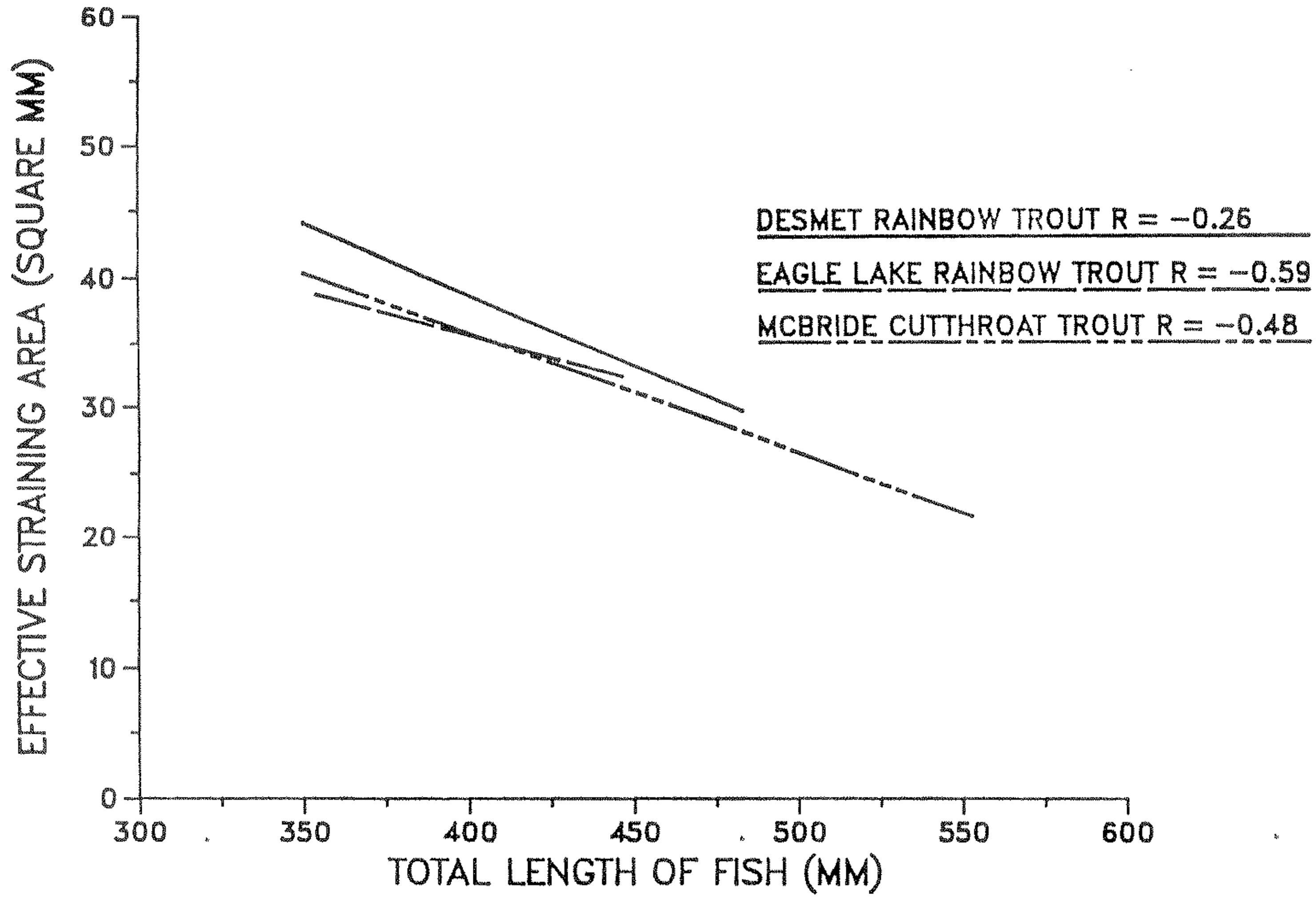

Figure 5. Regression of the effective gill raker straining area (square mm) for a 2 mm object with total lengths of study trout 350 mm or greater.

Table 18. Distribution of zooplankton identified in the study waters during 1985-1986.

Plankton type	Study waters*						
	Har. Res.	Wds. Lake	Grs. Res.	Ntl. Res.	Hya. Res.	Heb. Res.	Axl. Lake #2
Cladocera							
Daphnia pulex	X	X	X	X	X	X	X
Daphnia galeata mendotae	X		X			X	
Diaphnasoma leuchtenbergianum		X	X	X			X
Ceriodaphnia reticulata	X	X		X			X
Bosmina longirostris	X				X	X	
Leptodora kindti						X	
Copepoda							
Calanoida	X	X	X	X	X	X	X
Cyclypoida	X		X		X		X

* Har. = Harrison Reservoir; Wds. = Woods Lake; Grs. = Grasshopper Reservoir; Hya. = Hyalite Reservoir; Heb. = Hebgen Reservoir; Axl. = Axolotl Lake #2.

Table 19. Densities (number/m^3) of carapaced Cladocera in the study waters, 1985-1986.

Study water	Density Total	Organisms ≥ 2 mm
Harrison Reservoir	21501	2103
Woods Lake	37588	0
Grasshopper Reservoir	14343	1861
Notellum Reservoir	6139	902
Hyalite Reservoir	6831	1120
Hebgen Grayling Arm	6703	1215
Axolotl Reservoir	12852	0

Two bodies of water did not contain Cladocera with lengths of 2 mm or greater. The reason for their absence from Axolotl Lake #2 is not understood, but their absence from Woods Lake may be due to the *R. balteatus* (Robert Domrose, MDFWP, pers. comm.) present. Johannes and Larkin (1961) reported that high redside shiner populations may reduce populations of *Daphnia* to a point that rainbow trout may not be able to feed on them as rapidly as they would during years when shiners are not present. In addition, Brooks and Dodson (1965) suggested that fish predation may influence the size structure of herbivorous zooplankton by removing the larger organisms.

In Hebgen Reservoir, *L. kindti* were present at a density of 8/m^3 but were not considered with the above Cladocera because sample specimens became fragmented and non-measurable. They also represent a potential food source not restricted by gill raker widths because of their large size (Pennak 1978).

Total density of Cladocera regressed against mean condition factors for fish less than 350 mm TL in all populations had a correlation coefficient of only 0.19. The correlation coefficient of densities of carapaced Cladocera 2 mm or greater in length regressed against condition factors of trout less than 350 mm total length was 0.82, indicating the importance of this food item to growth (Figure 6). A similar analysis with trout 350 mm TL or greater resulted in a correlation coefficient of 0.45.

Study Water Limnology

The physico-chemical characteristics of the study waters contained a wide range of values in some characteristics (Table 20). Conductivity and alkalinity values varied 18- and 13-fold, respectively. Hydrogen ion concentrations ranged from slightly acid to highly alkaline.

Mean depths and euphotic depths were more similar, differing by factors of 3 and 12, respectively. The percent of the total water volume that was euphotic, temperature regimes and dissolved oxygen levels were more similar among the waters than the other measured parameters.

None of the maximum temperatures exceeded the the maximum temperature of 25.6^{o}C tolerated by trout (Piper et al. 1986). The only measured dissolved oxygen levels that were below the desirable

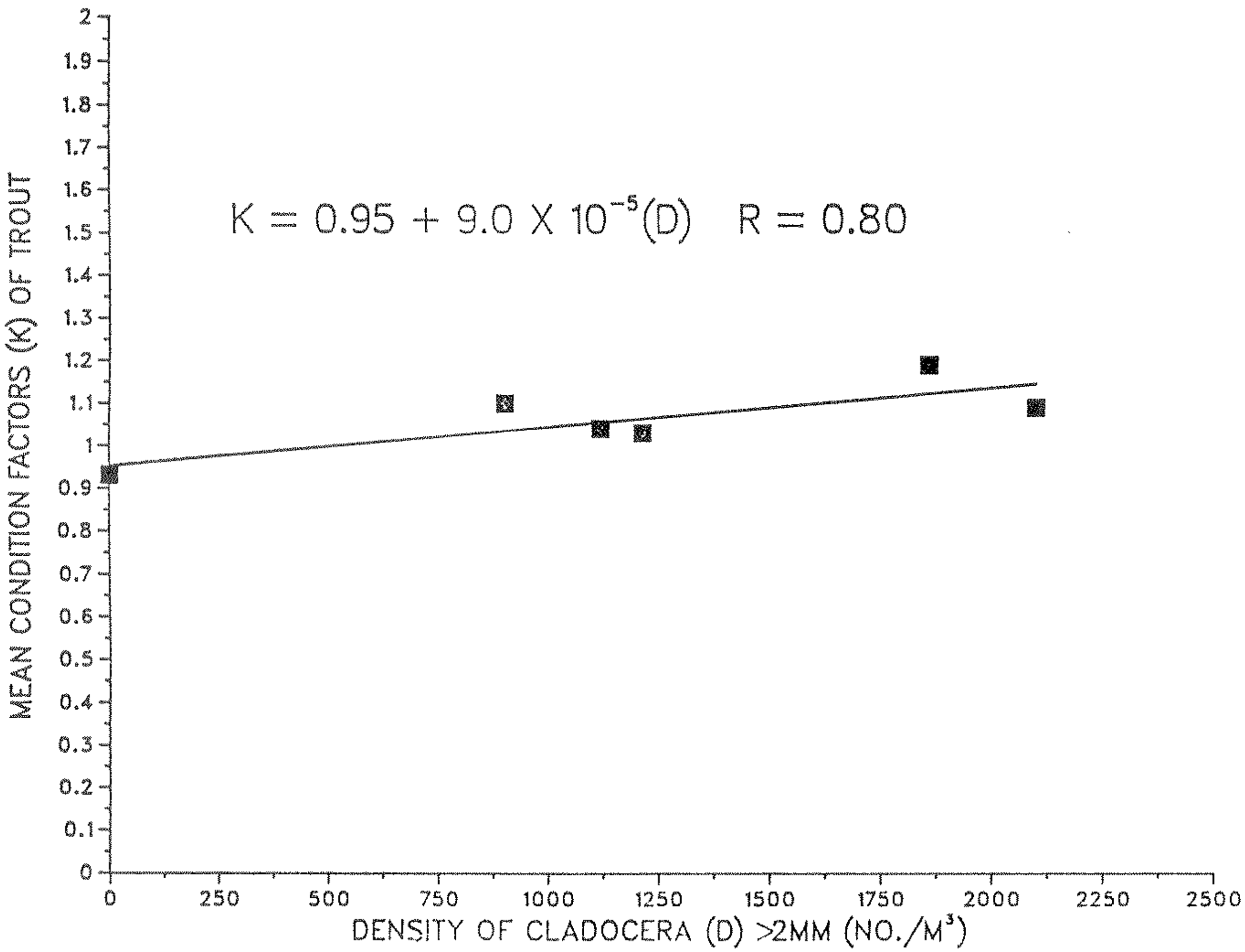

Figure 6. Regression of the mean condition factors of trout less than 350 mm TL with densities of Cladocera 2 mm or longer in the study waters during 1985 - 1986.

Table 20. Physico-chemical measurements made on study waters during 1985-1986.

Study water	Conductivity (umho)	Alkalinity (meq/l)	pH	Mean depth (m)	Euphotic depth (m)	Euphotic volume (%)	Maximum/minimum summer temperatures (°C)	Mean (range) DO levels (mg/l)
Harrison Reservoir	346	3.42	7.8	7.0	7.4	95	23.0/13.1	5.0(2.3-7.7)
Woods Lake	171	2.00	8.7	3.8	6.0	100	21.5/19.0	9.1(8.3-10.0)
Grasshopper Reservoir	1009	7.16	8.6	4.3	3.5	93	18.1/10.5	7.4(6.0-8.2)
Notellum Reservoir	55	0.70	6.9	4.6	5.0	91	21.0/9.0	6.0(0.6-8.9)*
Hyalite Reservoir	65	0.54	7.3	11.8	27.0	100	17.0/7.1	7.5(6.7-8.1)
Hebgen Grayling Arm	237	1.38	8.6	3.9	7.0	99	18.0/15.7	7.9(7.6-8.1)
Axolotl Lake #2	192	1.92	9.1	3.7	5.0	100	14.0/11.5	10.5(9.9-11.5)*

* Dissolved oxygen levels were based on measurements from single trips.

5 mg/l level (Piper et al. 1986) were found in Harrison Reservoir and Notellum Reservoir below depths of 7.5 m and 4.5 m, respectively.

Limnological variables were regressed with condition factors for fish less than 350 mm TL in all populations (Table 21). Positive correlation coefficients greater than 0.80 were found between mean condition factors and conductivity and alkalinity, while the strongest negative correlation was with condition factors and the percent euphotic volume of the total volume of the water body. These three parameters often are indicators of general productivity of waters.

Table 21. Correlation coefficients for limnological variables with mean condition factors of trout less than 350 mm total length in all study waters, 1985-1986.

Limnological variable	Correlation coefficient
Alkalinity	0.87
Conductivity	0.84
Minimum summer water temperature	0.54
Mean dissolved oxygen level	0.29
Hydrogen ion concentration	0.19
Maximum summer water temperature	-0.20
Mean depth	-0.42
Euphotic depth	-0.56
Minimum dissolved oxygen level	-0.59
Maximum dissolved oxygen level	-0.69
Percent euphotic volume of total	-0.75

SUMMARY AND DISCUSSION

Food habits of trout less than 350 mm TL were similar regardless of study strain. All strains primarily utilized *Daphnia* and had an efficient gill raker morphology to do so. The food habits found for this size group of trout were similar to those McMullin (1979) reported in wild rainbow trout and westslope cutthroat trout (*Salmo clarki lewisi*) at lengths less than 330 mm.

It appeared that the condition factors of smaller size group of fish increased as the density of daphnids larger than 2 mm increased. The regression of condition factors in fish less than 350 mm TL with the density of large daphnids in this study showed that populations of at least 500 dapnids 2 mm or more in length per m^3 would be needed to maintain this sized trout in condition factors of 1.0 or greater. Galbraith (1975) reported that summer plankton hauls containing 150 or more daphnids greater than 1.34 mm in length were characteristic of good quality rainbow trout fishing lakes. However, quality of fishing was subjectively judged by the reports of trout fisherman, the size of fish caught was not mentioned.

The Arlee strain appeared to be particularly adept at utilizing *Dahpnia* even in the absence of a morphological advantage in gill raker structure. The volumes of *Daphnia* in the stomachs of Arlee strain fish were equal to or greater than the like volumes in other strains from lakes with substantially greater daphnid densities. This suggests that Arlee strain fish may be the better type to plant in zooplankton poor waters. More investigation is needed though, to determine the effectiveness of the larger size class of Arlees under similar circumstances.

The food habits of trout 350 mm TL or longer diverged within and among strains. The study population of DeSmet rainbow trout continued to be primarily planktivorous even at lengths larger than 350 mm TL. This is consistent with the reports on this strain (Mueller and Rockett 1980; Jack Boyce, MDFWP, mimeo; Richard Vincent, MDFWP, pers. comm.), although there have been instances where the strain has been found to be piscivorous (Boyce 1985).

Eagle Lake rainbow trout fed almost exclusively on tui chubs (G. bicolor) during summer months in their native lake and fed very little on invertebrates even when they were abundant (McAfee 1966). This strain was introduced into Montana because it was reported to be a fast growing piscivore (Richard Vincent, MDFWP, pers. comm.; Jack Boyce, MDFWP, mimeo) and had the potential to be useful in reducing unwanted forage fish. However, the two populations of this strain planted in Montana waters, showed very little piscivory. They mostly fed on gastropods and hemipterans even though the study waters contained good populations of redside shiners (Robert Domrose, MDFWP, pers. comm.) and brook sticklebacks, fathead minnows, and Iowa darters (Kent Gilge, MDFWP, pers. comm.).

It is possible that these forage species may have been undesirable or unavailable to the Eagle Lake trout, but these explanations seem unlikely. There were remains of each forage species in a few trout stomachs and McMullin (1979) reported that the redside shiner was an important food item in the diets of wild rainbow trout greater than 330 mm. Also, since the trout in this study were in small, shallow waters, this probably forced the potential predators and prey into the same habitat even though there appeared to be abundant escape cover at one site.

Like DeSmet and Arlee rainbow trout, McBride cutthroat trout are reported to feed primarily on insects and zooplankton (Sharp and Arnold 1967; McMullin and Dotson 1987). However, this study's findings also showed that the McBride strain could be piscivorous. They utilized cottids in one study water, but they did not feed on cottids in another water, or lake chubs (Couesius plumbeus) in their native lake (Varley et al. 1976; Jones et al. 1983). Although they did not feed on Utah chubs during this study, remains of that forage fish have been found in stomachs of some McBride cutthroats in subsequent studies (Richard Vincent, MDFWP, pers. comm.). It may be possible that this form only switches to fish when other food resources are scarce. In the two situations in this study in which fish were not utilized, terrestrial insects and Leptodora were abundant in stomachs.

The lower condition factors in some populations of trout with fish greater than 350 mm TL is probably the result of energetics. Werner (1979) reported that for fish to be energy efficient, they must take prey of sufficient size and number to more than compensate for the energy lost in chase and capture. In this study, the larger fish (≥ 350 mm TL) in some populations continued to feed heavily on zooplankton despite their reduced effective gill raker straining areas. This may account for the lower condition factors in these larger fish. Mueller and Rockett (1980) also found that DeSmet rainbow trout primarily utilizing Daphnia after approximately 360 mm had lower condition factors than smaller trout. Conversely, trout populations in this study that used larger prey item more heavily, were not significantly lower in conditon factors compared to the smaller fish. These data indicate that it is unrealistic to attempt to manage for large, high condition factor trout in situations without a desirable and available food resource larger than dapnids.

Two strains of trout were found to have promising prospects for use in managing waters with high pH levels. The Eagle Lake stock comes from a lake that has a pH that approaches 10.0 (McAfee 1966; Vernon King, CDFG, mimeo) and in this study, they had excellent condition factors for both size classes in waters with a pH of 8.6. The same strain had poor condition factors in a pH of 8.7 which was likely due to a poorer food supply.

Also, the McBride cutthroat strain which is used primarily in the state's planting program in high mountain lakes (McMullin and Dotson 1987; Richard Vincent, MDFWP, pers. comm.) were found to have excellent condition factors in waters with a pH of 9.1. In its native lake, the strain survives pH ranges of 8.7 to greater than 10.0 during the summer (Sharpe and Arnold 1967; Varley et al. 1976).

The abilities of the Arlee rainbow strain and the DeSmet rainbow strain to sustain themselves in high pH situations are unknown.

The results of this study suggest some strain characteristics that could have important management implications, but they are based mainly on single population measurements of a given strain alone in different water types. Additional testing is needed to document characteristics of the test strains. It is important to compare strains raised under the same conditions.

A series of lakes/reservoirs should be selected to represent the major kinds of waters receiving trout plants. Each test strain should be marked differently and planted in significant numbers in each of the representative waters during one short time period, if possible. These plants should be made for three consecutive years to produce a series of size and age class samples for analysis. These situations were not as available during this study as originally believed because introductions of some strains were made only recently and other strains did not provide adequate samples. Only after these additional tests have been performed can the most efficient use of the strains be assured.

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APPENDIX

Table 22. Trout stocking records for Harrison Reservoir, Montana (Richard Vincent, MDFWP, 1986).

Year	Strain	Number stocked
1977	DeSmet rainbow trout	80,000
1978	"	72,160
1979	no stocking	----
1980	DeSmet rainbow trout	74,820
1981	"	143,497
1982	no stocking	----
1983	DeSmet rainbow trout	40,000
1984	"	1,210
1985	no stocking	----
1986	DeSmet rainbow trout	10,000

Table 23. Trout stocking records for Hyalite Reservoir, Montana (Richard Vincent, MDFWP, 1986).

Year	Strain	Number stocked
1976	McBride cutthroat trout	20,070
1977	"	19,834
1978	"	19,534
1979	"	21,006
1980	"	21,269
1981	"	22,178
1982	no stocking	----
1983	McBride cutthroat trout	21,328
1984	"	30,047
1985	"	25,116
1986	"	30,000

Table 24. Trout stocking records for Hebgen Reservoir, Montana (Richard Vincent, MDFWP, 1986).

Year	Strain	Number stocked
1979	McBride cutthroat trout	208,000
1980	"	220,863
1981	"	281,921
1982	"	328,735
1983	"	363,970
1984	"	83,000
1985	"	12,065
1986	"	135,313

Table 25. The calculated mean total lengths (mm) at annuli for DeSmet rainbow trout in Harrison Reservoir, Montana, 1985-1986.

Age	Number	Mean length at capture (mm)	Annulus 1	2	3	4	5
1	14	215	102				
2	36	349	107	243			
3	22	414	107	232	367		
4	15	432	95	194	314	391	
5	2	453	92	149	286	400	424
Total	89						
Grand mean			104	227	342	392	424

Table 26. The calculated mean total lengths (mm) at annuli for McBride cutthroat trout in Hyalite Reservoir, Montana, 1985-1986.

Age	Number	Mean length at capture (mm)	Annulus 1	2	3	4
1	29	188	114			
2	26	275	106	223		
3	19	317	112	199	279	
4	4	412	109	201	295	378
Total	78					
Grand mean			110	212	282	378

Table 27. The calculated mean total lengths (mm) at annuli for Arlee rainbow trout in Notellum Reservoir, Montana, 1986.

Age	Number	Mean length at capture (mm)	Annulus 1	2	3
1	2	218	174		
2	39	306	209	278	
3	1	381	236	324	366
Total	42				
Grand mean			208	279	366

Table 28. The calculated mean total lengths (mm) at annuli for Eagle Lake rainbow trout in Grasshopper Reservoir, Montana, 1985-1986.

Age	Number	Mean length at capture (mm)	Annulus 0	Annulus 1
0	32	179		
1	25	359		203
Total	57			
Grand mean				203

Table 29. The calculated mean total lengths (mm) at annuli for Eagle Lake rainbow trout in Woods Lake, Montana, 1986.

Age	Number	Mean length at capture (mm)	Annulus 1	Annulus 2	Annulus 3
3	10	395	222	306	373
Total	10				
Grand mean			222	306	373

Table 30. The calculated mean total lengths (mm) at annuli for McBride cutthroat trout in Hebgen Reservoir, Montana, 1985-1986.

Age	Number	Mean length at capture (mm)	Annulus 1	Annulus 2	Annulus 3
1	11	246	144		
2	8	338	168	297	
3	6	392	141	245	344
Total	25				
Grand mean			151	275	344

Table 31. The calculated mean total lengths (mm) at annuli for McBride cutthroat trout in Axolotl Lake #2, Montana, 1986.

Age	Number	Mean length at capture (mm)	Annulus 1	Annulus 2	Annulus 3	Annulus 4
2	11	317	77	235		
3	7	378	80	204	315	
4	3	502	68	152	329	416
Total	21					
Grand mean			77	213	319	416