



Behavioral responses to water current of age-0 Arctic grayling from the Madison River, and their use of stream habitat  
by Eric Donald Jeanes

A thesis submitted in partial fulfillment of the requirements for the degree of Master of Science in  
Biological Sciences  
Montana State University  
© Copyright by Eric Donald Jeanes (1996)

**Abstract:**

Behavioral trials and field observations were conducted on age-0 Arctic grayling (*Thymallus arcticus*) from the Madison River/Ennis Reservoir in 1993 and 1994 (ME) population to determine their riverine associated characteristics and residence. When tested in a natural stream, age-0 ME Arctic grayling displayed significantly greater downstream movement ( $P < 0.005$ ) than those from the fluvial population of the Big Hole River. In contrast, behavioral responses of age-0 F1 fluvial grayling originating from parents reared in non-fluvial environments strongly support the hypothesis that positive rheotaxis is a genetic trait in grayling from the Big Hole River. In both years, 805 of 824 (97.7%) age-0 grayling collected at the weir were recovered after the first 8-h period of daylight after release, consistent with the downstream grayling movement reported in other similar studies. In-stream acclimation more consistently reduced downstream movement of fluvial grayling than of either the ME grayling or a lacustrine grayling population from upper Red Rock Lake (RR). Field observations indicated that downstream movement of age-0 grayling to Ennis Reservoir occurred about 3.5-38-d after swimup. Age-0 ME grayling inhabited backwater habitats in the Madison River and resided in shallow water among macrophyte beds after moving downstream to Ennis Reservoir. Both behavioral trials and field observations indicate that, at least during the first four months after swimup, ME grayling behavior and distribution of ME grayling are more characteristic of adfluvial lacustrine grayling, than of fluvial grayling.

BEHAVIORAL RESPONSES TO WATER CURRENT OF AGE-0  
ARCTIC GRAYLING FROM THE MADISON RIVER,  
AND THEIR USE OF STREAM HABITAT

by

Eric Donald Jeanes

A thesis submitted in partial fulfillment  
of the requirements for the degree

of

Master of Science

in

Biological Sciences

MONTANA STATE UNIVERSITY-BOZEMAN  
Bozeman, Montana

December 1996

N378  
J346


APPROVAL

of a thesis submitted by

Eric Donald Jeanes


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

12/2/96  
Date

  
Chairperson, Graduate Committee


Approved for Major Department

12/2/96  
Date

  
Head, Major Department

Approved for the College of Graduate Studies

12/15/96  
Date

  
Graduate Dean

## STATEMENT OF PERMISSION TO USE

In presenting this thesis (paper) in partial fulfillment of the requirements for a master's degree at Montana State University-Bozeman, I agree that the Library shall make it available to Borrowers under the rules of the Library. If I have indicated my intention to copyright this thesis (paper) by including a copyright notice page, copying is allowable only by scholarly purposes, consistent with "fair use" as prescribed in the U.S. Copyright Law.

Requests for permission for extended quotation from or reproduction of this thesis (paper) in whole or in parts may be granted only by the copyright holder.

Signature 

Date 12/3/96

## ACKNOWLEDGMENTS

This study was made possible with funding by the Montana Power Company to Dr. Calvin M. Kaya. Dr. Kaya provided supervision and overall direction of the study and assisted in the preparation of the manuscript. Drs. Robert G. White, Thomas E. McMahon, and Jay J. Rotella critically reviewed the manuscript. Ron Spoon, Pat Clancey, Brad Flickinger, Pat Dwyer, Heather Jeanes, and numerous graduate students provided invaluable help in the field. Lastly, I want to sincerely thank my parents, Larry and Teresa Jeanes, and grandparents, Donald and Nellie Bartels and Caryl Jeanes, for providing moral and financial support throughout my scholastic career.

## TABLE OF CONTENTS

	Page
TABLE OF CONTENTS .....	vi
LIST OF TABLES .....	vii
LIST OF FIGURES .....	ix
ABSTRACT .....	x
INTRODUCTION .....	1
STUDY SITE .....	5
Deep Creek .....	5
Madison River/Ennis Reservoir .....	7
METHODS .....	12
Deep Creek .....	12
Madison River/Ennis Reservoir .....	20
RESULTS .....	22
Deep Creek .....	22
Observations in Madison River and Ennis Reservoir .....	30
DISCUSSION .....	42
CONCLUSIONS .....	53
LITERATURE CITED .....	55

## LIST OF TABLES

Table	Page
Table 1. Date of release, source, number released, mean total lengths (mm) (standard deviation in parenthesis) of age-0 Arctic grayling tested during the 1993 behavioral trials in Deep Creek. Statistical comparisons (ANOVA) were made between values within columns. . . . .	16
Table 2. Date of release, source, number released, mean total lengths (mm) (standard deviation in parenthesis) of age-0 Arctic grayling tested during the 1994 behavioral trials in Deep Creek. Two other trials, on 20 July and 27 July, were abandoned when stream temperatures approached or exceeded lethal levels (28 C) during the acclimation period. Statistical comparisons (ANOVA) were made between values within columns. . . .	17
Table 3. Temperature, discharge, and turbidity of Deep Creek on dates of release of age-0 Arctic grayling tested during the 1993 and 1994 behavioral trials in Deep Creek. . . . .	18
Table 4. Total cumulative numbers, and percentages of released fish (in parenthesis), of age-0 Arctic grayling captured in nets at the weir in Deep Creek by the first sunset, the first sunrise (about 18-h), and by 48-h after release during 1993. Statistical comparisons (chi-square) were made between values within columns. . . . .	26
Table 5. Total cumulative numbers, and percentages of fish released (in parenthesis), of age-0 Arctic grayling captured in nets at the weir in Deep Creek by the first sunset, the first sunrise (about 18-h), and by 48-h after release during 1994. Statistical comparisons (chi-square) were made between values within columns . . . . .	27
Table 6. Numbers of age-0 Arctic grayling captured (Cap) and recaptured (Recap) in electrofishing surveys conducted 9-and 11-d in 1993 and 18-and 25-d in 1994 after the final trial for each year. Statistical comparisons (chi-square) were made between values within columns . . . . .	29
Table 7. Mean and range of total lengths (mm) and source of Arctic grayling captured in Deep Creek prior to the 1994 behavioral trials, after having been released a year previously for the 1993 trials. . . . .	30

## LIST OF TABLES-Continued

Table	Page
Table 8. Mean and range of total lengths (mm) and habitat of age-0 Arctic grayling and mountain whitefish sampled in the Madison River, 25 May to 21 June 1994. . . . .	32
Table 9. Mean and range of total lengths (mm) of fish collected during the electrofishing survey conducted on 12 July 1994, in the Madison River above Ennis Reservoir. . . . .	33
Table 10. Mean and range of total lengths (mm) and habitats of age-0 Arctic grayling and mountain whitefish sampled in Ennis Reservoir, 16 June to 1 September 1994. . . . .	37
Table 11. Summary of fish captured by beach seining conducted in Ennis Reservoir, 16 June to 1 September 1994. . . . .	39
Table 12. Summary of purse seining activities conducting in Ennis Reservoir, 11 August to 1 September 1994. . . . .	41
Table 13. Stream residence period (ending with the date of appearance at a lake or reservoir) and mean total lengths (mm) at this time of some age-0 Arctic grayling populations. . . . .	48
Table 14. Slope and intercept comparisons between observation day-total length relationships from populations of age-0 Arctic grayling in Montana. . . .	52



## LIST OF FIGURES

Figure	Page
1. Location of the Deep Creek study site. . . . .	6
2. Location of Ennis Reservoir and Madison River study site. . . . .	9
3. Discharge volume in Deep Creek during the 1993 and 1994 study periods. . . .	23
4. Mean temperatures in Deep Creek during the 1993 and 1994 study periods. . .	24
5. Turbidity levels in Deep Creek during the 1993 and 1994 study periods. . . . .	25
6. Mean daily temperature ( $^{\circ}\text{C}$ ) and discharge volume (in $\text{ft}^3/\text{s}$ , cfs; and $\text{m}^3/\text{s}$ , cms) in the Madison River above Ennis Reservoir, 1994. The arrow indicates the approximate date (21 June) when age-0 grayling disappeared from the river, apparently moving downstream to the reservoir. . . . .	35
7. Distribution and sizes of age-0 Arctic grayling in the Madison River above Ennis Reservoir and in the reservoir, May through August 1994. Also depicted are the spawning, hatching, and swimup periods. . . . .	36

## ABSTRACT

Behavioral trials and field observations were conducted on age-0 Arctic grayling (*Thymallus arcticus*) from the Madison River/Ennis Reservoir in 1993 and 1994 (ME) population to determine their riverine associated characteristics and residence. When tested in a natural stream, age-0 ME Arctic grayling displayed significantly greater downstream movement ( $P < 0.005$ ) than those from the fluvial population of the Big Hole River. In contrast, behavioral responses of age-0  $F_1$  fluvial grayling originating from parents reared in non-fluvial environments strongly support the hypothesis that positive rheotaxis is a genetic trait in grayling from the Big Hole River. In both years, 805 of 824 (97.7%) age-0 grayling collected at the weir were recovered after the first 8-h period of daylight after release, consistent with the downstream grayling movement reported in other similar studies. In-stream acclimation more consistently reduced downstream movement of fluvial grayling than of either the ME grayling or a lacustrine grayling population from upper Red Rock Lake (RR). Field observations indicated that downstream movement of age-0 grayling to Ennis Reservoir occurred about 35-38-d after swimup. Age-0 ME grayling inhabited backwater habitats in the Madison River and resided in shallow water among macrophyte beds after moving downstream to Ennis Reservoir. Both behavioral trials and field observations indicate that, at least during the first four months after swimup, ME grayling behavior and distribution of ME grayling are more characteristic of adfluvial lacustrine grayling, than of fluvial grayling.

## INTRODUCTION

Two distinct life-history forms of Arctic grayling (Thymallus arcticus) are indigenous to the state of Montana. Lacustrine grayling (residing within lentic systems) are native to only the Upper and Lower Red Rock lakes and possibly nearby Elk Lake of the upper Beaverhead River drainage (Kaya 1992). Fluvial grayling (spending their entire life in lotic systems) are native to the upper Missouri River system above the Great Falls including the Madison, Gallatin, Jefferson, Sun, and Smith rivers (Tyron 1947; Vincent 1962). Both the lacustrine and fluvial populations of grayling in Montana are genetically distinct and divergent from populations in Alaska and Canada (Lynch and Vyse 1979; Everett and Allendorf 1985). In addition, fluvial grayling from the Big Hole River possess innate behavioral tendencies that enable them to reside in lotic environments (Kaya 1991).

Since the end of the 19th century, the distribution of fluvial grayling in Montana has declined substantially, and, at present, the only known self-sustaining fluvial population is confined to the upper Big Hole River, above the Divide Dam (Shepard and Oswald 1989). These Big Hole River grayling are also the last known fluvial population in the lower 48 states. This population appears concentrated within about 100 km of the Big Hole River, at estimated densities of about 18.6 yearling and older per km (30 per mile) since 1989 (Byorth 1993).

In contrast, the distribution of lacustrine grayling has been expanded through introductions to many western lakes, on both sides of the Continental Divide in Montana (Kaya 1992). Most of these populations appear to have originated from grayling captured in Meadow Creek, a tributary of Ennis Reservoir on the Madison River (Kaya 1992) or from Red Rocks lakes (Leary 1990).

In response to the diminished and uncertain future status of fluvial grayling in Montana, the Fluvial Arctic Grayling Workgroup (FGW) was formed in 1987. The FGW is made up of representatives from state, federal, and private agencies and from the two state universities. The FGW (1993) has derived a conservation goal of "the presence of at least five stable, viable populations distributed among at least three of the major river drainages within the historic range by the year 2020". Grayling used in restoration efforts must be capable of residing permanently in lotic environments to accomplish this goal.

Laboratory behavioral tests on age-0 grayling originating in Montana indicate that fluvial grayling from the Big Hole River are more positively rheotactic (maintain position in water current) than lacustrine stocks (Kaya 1989). Other populations of grayling have been suspected of exhibiting fluvial characteristics: One of these, the Madison River/Ennis Reservoir grayling population (ME), may represent a remnant population originating from grayling residing in the Madison River prior to the construction of the impoundment in 1906. The ME population presently appears to be adfluvial, residing in the reservoir and spawning in the Madison River channels, upstream of Ennis Reservoir (Byorth and Shepard 1990), and has fluctuated in

abundance since 1906. In 1983, the population was reduced to very low numbers, apparently due to an early spring drawdown of the reservoir to control macrophyte growth (Byorth and Shepard 1990; Jourdonnais et al. 1992a).

Although ME grayling appear to be adfluvial, other observations suggest the possibility of fluvial characteristics in this population. Sporadic reports have been received by Montana Department of Fish, Wildlife & Parks (MDFWP) personnel of grayling being captured during non-spawning periods as far upstream as the West Fork of the Madison River, approximately 85 km upstream from Ennis Reservoir (Pat Clancey, MDFWP, pers. comm.). Also, electrophoretic analysis indicates that ME grayling resemble fluvial grayling from the Big Hole River more closely than any other population within Montana (Leary 1990).

The extent to which ME grayling in the upper Madison River system exhibit fluvial characteristics is of obvious importance to FGW conservation goals. To address the uncertainty of the fluvial nature of ME grayling, this study examined the early life history of this population, testing the hypotheses:

(1)  $H_0$ : in streams, behavior and early life history of age-0 ME grayling are characteristic of those from fluvial populations.

$H_A$ : in streams, behavior and early life history of age-0 ME grayling are not characteristic of those from fluvial populations.

(2)  $H_0$ : in streams, behavior and early life history of age-0 ME grayling are characteristic of those from adfluvial lacustrine populations.

$H_A$ : in streams, behavior and early life history of age-0 ME grayling are not

characteristic of those from adfluvial lacustrine populations.

To test these hypotheses, the objectives of this study were: (1) experimentally compare the rheotactic behavior of age-0 ME grayling with those from known fluvial (Big Hole River) and adfluvial lacustrine (Red Rock Lake) populations in a natural stream; (2) determine the distribution and residence time in the Madison River of age-0 ME grayling; and, (3) determine whether age-0 ME grayling have a lacustrine residence phase.

## STUDY SITE

### Deep Creek

Field trials on rheotactic behavior were conducted in Deep Creek, a tributary of the Missouri River. Behavioral tests in a natural stream setting provide a novel approach to testing rheotactic behavior, in that responses can be compared over an extended length of natural stream, instead of an artificial stream or channel. Deep Creek originates on Grassy Mountain of the Big Belt Range in the Helena National Forest, and flows through Broadwater County in central Montana (Figure 1). It is formed by 19 tributaries within the U.S. Forest Service boundary. Deep Creek flows westward for approximately 41 km to its confluence with the upper Missouri River, 4 km south of the town of Townsend. The elevation at the confluence of Deep Creek with the Missouri River is 1,180 m.

The Deep Creek watershed drains 22,000 ha, of which approximately two-thirds is U.S. Forest Service land, with the remainder being comprised of 37 tracts of private land. Major land uses in the watershed include woodlands, livestock grazing, small grains, and irrigated haylands (Ostreich 1992). In this area, average annual precipitation is 27 cm. Monthly mean temperatures range from lows of 4 C to a high of 14 C ("Montana" 1988).





























































































































