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Effects of Elevated Temperatures and Fry Density on Initiation of Feeding by Walleye Fry

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on Initiation of Feeding by Walleye Fry

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ABSTRACT

Walleye fry were held in tanks and jars at various densities and at elevated water temperatures. Fry density did not appear to influence acceptance of zooplankton food-organisms. Fry held at water temperatures 10 to 20°F above hatching temperature showed increased survival during the pre-feeding stage. Elevated water temperature may also have helped stimulate initial feeding, but high losses continued after the fry commenced feeding. Among dense groups of walleye fry held in tanks loss due to cannibalism was so severe that unless cannibalism can be curtailed, tank-rearing of fry does not appear to be a practical fish cultural technique for this species.

Observations on the reaction of walleye fry to water depth during the "swim-up" stage are presented together with some physical measurements of fry during early development.

INTRODUCTION

It has been suggested (Johnson 1969) that survival of walleye fry stocked in lakes and ponds might be increased by coordinating fry stocking with spring peaks in zooplankton-food abundance. This may require holding and feeding fry in tanks for varying periods so that stocking can be coincident with peak zooplankton periods.

Attempts to rear walleye from the fry stage in artificial enclosures have been markedly unsuccessful. Experience in Minnesota and elsewhere has indicated that the poor survival of fry in tanks and raceways is often associated with failure of fry to feed, even when either natural or artificial foods are abundant.

Failure of walleye fry to accept natural food organisms was observed during May, 1969, when an estimated 200,000 fry were held in a 750 gallon fry-tank at the Detroit Lakes hatchery. A dense zooplankton food supply was maintained via the water intake from nearby Lake Sallie and water temperatures ranged between 56 and 62°F during the 12-day period of investigation. Several hundred fry were examined throughout the study but none were found to contain food organisms. Although the fry refused zooplankton, they readily attached other walleye fry even though they were incapable of completely ingesting their prey. Most prey were disgorged in less than two hours. All prey observed were killed while most of the cannibals appeared to survive. Cannibalism, which was first observed on the 5th day, caused substantial losses and less than 100 fry survived after 12 days when the investigation was terminated.

Recent work at the University of Minnesota (unpublished) has indicated that water temperature may be a factor in initiating fry feeding. It was noted during a study of optimum and lethal temperatures for fry growth and survival that more newly-hatched fry held in heated aquaria commenced feeding than those held at normal water temperatures at this season.

The investigation reported here was undertaken during the springs of 1973 and 1974 to determine whether fry density and/or water temperature were factors in influencing initial feeding by walleye fry when confined in tanks or aquaria.

1973 TRIALS

Tank Rearing Methods

Fry for this study were obtained from eggs taken from the walleye spawning run at Ottertail Lake. Eggs were taken from a number of females and fertilized at the netting site on April 26, 1973. One and one-half quarts of eggs (142,600 eggs per quart) were incubated at the Lake Sallie fish hatchery at a mean temperature of 50°F (range 47-55°F). Hatching began on May 8 and was 90 percent completed on May 15.

On May 16, fry were stocked into 4 fry tanks, each tank containing approximately 400 gallons of lake water and a 70 gallon stock tank equipped with a water heater. A continuous supply of lake water was provided to each fry tank. It was not possible to maintain a constant flow in those tanks and the flow rates varied from 1 to 3 gallons per minute. Daily water temperatures in the tanks varied between 53 and 57°F. The numbers of fry stocked into each tank were as follows:

TANK NO.	NUMBER OF FRY	No./Gal.
1	125,000	312.5
2	25,000	62.5
3	7,000	17.5
4	1,000	2.5

The number of fry stocked into tanks Nos. 1, 2, and 3 were measured volumetrically by water displacement and the number stocked into tank No. 4 were individually counted.

Tank No. 5, the 70 gallon stock tank, with a constant-flow of lake water of one-half gallon per minute was equipped with an electric water heater. A volumetrically-measured 23,000 fry (328.5/gal.) were stocked into this tank.

It was the intent in this experiment to raise the water temperature in tank No. 5 approximately 4°F each day to reach a maximum of 72°F at the time the fry were capable of feeding. However, because of malfunctions in the thermal controls this plan could not be strictly met. The daily temperatures which were achieved in the heated tank are shown in the following table.

Daily Minimum and Maximum Temperatures; Heated Tank - 1973

Date	Minimum	Maximum °F
5-16	54	63
5-17	58	60
5-18	60	64
5-19	64	73
5-20	73	76
5-21	70	76
5-22	70	78
5-23	72	78
5-24	70	72
5-25	68	70

Dense zooplankton in the intake water from Lake Sallie provided a superabundant food supply in all tanks throughout the investigation.

Tank Rearing Findings - 1973

High fry mortality was observed in all five tanks. Greatest mortality was in tanks 1 and 3 where less than 25 fry survived in each tank on May 20, 5 days after the beginning of the investigation. Tanks 2 and 4 contained about 100 and 200 survivors respectively on May 20, when this phase of the investigation was terminated. An explanation of the somewhat higher survival of fry tanks 2 and 4 is not readily apparent. Tanks 1 and 3 were used to collect the fry as they hatched and were therefore filled with lake water on May 9. Tanks 2 and 4 were filled with lake water 7 days later on May 16, the date when they were stocked. This suggests that the lower survival in tanks 1 and 3 may have resulted from a greater build-up of metabolites or products of decomposition in tanks 1 and 3. However, a comparison on May 19, of pH, ammonia and nitrate nitrogen in tank 1 with that of the inflow water from Lake Sallie showed similar concentrations:

	pH	NH_3-N mg/l	NO_2-N mg/l
Tank 1	8.45	0.165	0.005
Inflow water	8.35	0.150	0.004

Walleye fry survival in tank 5, the heated tank, was estimated by visual inspection on May 20, to be about 10 to 20 percent of the original 23,000 fry stocked.

The great fry mortality which occurred in all tanks during the first five days (May 16-20) was not attributable to starvation or cannabalism, nor did it appear to be related to fry density. Inspection of fry mouth parts indicated that most fry were incapable of feeding before May 19, and no cannabalism was observed during this period.

Samples of fry were inspected each day to determine if they had food organisms in their stomachs. First food organisms were noted in fry from the heated tank on May 20, the fifth day after stocking. Seven of 11 fry inspected contained copepods and/or cladocerans. The fry in tank 5 continued to feed on zooplankton throughout the remainder of the experiment. Fifty-one of 72 fry examined during the investigation contained food organisms.

With the beginning of cannibalism on May 21 in tank 5, fry numbers continued to decrease daily. Approximately 100 fry remained alive on May 25 and their numbers decreased to 3 on May 30, when the experiment was terminated.

A total of 47 cannibals with prey-fish partially ingested were held in a hatchery jar for observation. None of the cannibals were capable of completely ingesting their prey and most were disgorged in one to four hours.

Jar Rearing Trials

Twelve standard hatchery jars were filled with 54°F lake water on May 16, and stocked in replica as follows:

Jar No.	Number of Fry/Jar
1, 1A	10
2, 2A	20
3, 3A	40
4, 4A	80
5, 5A	160
6, 6A	320

Water was not circulated through the jars and temperature increased to 66°F on May 18. Mean water temperature was 68°F during remainder of the investigation.

Most of the fry were swimming laterally when stocked. The number of surviving fry was assessed each day by removing and counting dead fry from the bottom of each jar. On May 18, jars Nos. 1 to 6 were provided with additional zooplankton. The amount of zooplankton introduced into each jar was not measured but was of a sufficient amount to provide a high opportunity for the fry in jars 1 to 6 to obtain food. Food organisms were not introduced into the A series jars and although present in small number, were not abundant. Samples of fry were examined daily to determine if they were feeding.

Jar Rearing Findings - 1973

Zooplankton (mostly copepods and cladocerans) were first found in the stomachs of fry examined on May 20. Fourteen of 67 fry from jars in which plankton had been introduced contained one or more food organisms. Only one of 62 fry from unfed jars contained food, and that consisted of a single copepod.

Fry in jars stocked with plankton continued to feed throughout the remainder of the investigation. Twenty-seven of 86 examined after May 20, contained food in their stomachs. Only one of 24 fry from the unfed series (A series) jars contained food.

It is evident that the introduction of additional zooplankton into jars 1 to 6 increased food intake, however, feeding did not increase survival. (Table 1). On the contrary, in jars of lower fry density (10, 20, 40, 80 fry per jar) the survival rates were greater in jars in which no additional plankton food was introduced. Fry survival in jars 5 and 5A was similar through May 20, after which there was an abrupt and unexplained mortality in jar 5A. Jars 6 and 6A which were stocked at the greatest fry density (320 per jar) showed generally higher survival rates than in jars stocked at lower fry densities.

Cannibalism was not observed in the jars although it is likely that some cannibalism occurred. The high fry mortality during this nine-day period did not appear to be associated with high fry density nor to death from starvation.

Following the abrupt mortality in jars 5 and 5A on May 22, dissolved oxygen was measured and it was found that each jar contained 3.0 p.p.m. of dissolved oxygen. Althouth dissolved oxygen was not measured in other jars, it was likely at low levels throughout the entire series and could have been the principal cause of the poor survival.

Fry Behavior in Hatchery Jars and in Shallow Plastic Containers

It was originally intended that fry rearing be undertaken in shallow 11" x 18" plastic containers containing 3.5 inches of water. Preliminary trials showed these containers to be unsuitable for rearing newly hatched fry. It appeared that the containers were unsuitable because the shallow water depth interfered with the normal vertical swimming motion of newly-hatched fry.

On May 10, 50 fry were stocked into each of two pans and two hatching jars containing lake water. The hatching jars were 5.5 inches in diameter and held approximately 16 inches of water. Fry in the jars were continuously in vertical motion, swimming up and sinking, but seldom resting motionless on the bottom of the jars. Fry in the pans also showed vertical motion but spent more time resting on the bottom than in motion.

Table 1: Daily Percentage Survival of Fed and Unfed Fry Held in Hatchery Jars

Jar Number	1	1A	2	2A	3	3A	4	4A	5	5A	6	6A
Number of Fry Per Jar	10	10	20	20	40	40	80	80	160	160	320	320
Date												
5-17	100	100	100	100	98	95	99	99	99	98	96	94
5-18*	90	70	80	85	83	80	89	85	83	82	80	65
5-19	70	40	65	60	53	58	65	79	80	78	76	59
5-20	0	40	5	45	28	40	50	71	75	73	74	54
5-21		30	0	45	10	38	23	66	72	56	70	51
5-22		20		45	3	28	13	54	60	1	59	47
5-23		20		30	3	18	9	36	26	0	33	34
5-24		20		25	3	8	1	24	21	0	27	24
5-25		10		15	0	3	1	10	6	0	8	13

*Plankton food stocked into Jars 1 - 6 but not into A series Jars.

After 2 days the fry in jars remained in vertical motion while those in pans seldom left the bottom.

After 3 days 27 dead fry were removed from pan No. 1 and 34 dead fry from pan No. 2. Two dead fry were removed from jar No. 1. Most fry in the jars had discontinued their vertical motion and were swimming laterally.

After 4 days all fry in pan No. 1 were dead and five fry survived in pan No. 2. No additional mortality was observed in the jars on this date.

It appears from these observations that newly-hatched walleye fry require a water-depth greater than 3.5 inches in order to survive a three day "swim-up" period.

Physical Measurements of Developing Walleye Fry

Physical measurements of samples of walleye fry were made daily with an ocular micrometer. The mean total length, length and depth of the yolk sac, and diameter of the oil globule are shown in Table 2. The mouth parts of each fry was inspected to determine when tooth development had been completed.

The mean total length of walleye fry increased from 7.1 mm on May 10, to 9.2 mm on May 19. The mean total lengths of fry in samples taken from May 20, through May 25, varied from 9.0 to 9.6 mm. Fry in tank 5 appear to have grown slightly faster than those in the jars.

The mean depth of the yolk sac and the diameter of the oil globule decreased slowly from May 10, through May 19. However, after tooth development was completed on May 20, the yolk sac food-supply was more rapidly depleted. Only a trace of yolk sac material was evident after May 21.

It appears that the presence of developed teeth is the single best index of fry capability to feed. Although hatching occurred over an extended 8-day period, tooth development occurred primarily during a 4-day period. This indicated that the rate of physical development was similar for fry hatching early or late in the incubation period.

1974 Trials

Methods

In 1974 tank rearing of walleye was attempted in aerated well water since it appeared that less than optimal environmental conditions were likely a factor in fry mortality in 1973 in the unheated tank rearing trials and was not due to starvation or cannabalism.

Table 2: Some Daily Physical Measurements of Walleye Fry During Early Development

Date	Source	Sample Size	Mean Total MM Lgth. MM	Mean Yolk Sac MM Lgth. MM	Depth MM	Mean Diameter Oil Globule MM	Percent with Developed Teeth
5-10	Tank 1	10	7.1	2.4	1.1	0.9	0
5-11	Tank 1	10	7.4	2.3	1.1	0.9	0
5-12	Tank 1	10	7.7	2.2	0.9	0.8	0
5-13	Tank 1	10	7.9	2.3	1.0	0.8	0
5-14	Tank 1	10	8.2	2.4	1.0	0.8	0
5-15	Tank 1	10	8.3	2.4	0.8	0.9	0
5-16	Tank 1	10	8.2	2.3	1.0	0.8	0
5-17	Tank 1	10	8.5	2.2	0.9	0.7	10
5-18	Tank 1	10	8.7	2.3	0.8	0.8	50
5-19	Tank 5	10	9.2	2.4	0.7	0.7	70
5-20	Tank 5	10	9.0	1.7	0.7	0.6	100
5-21	Tank 5	15	9.2	0.5	0.3	0.5	"
5-21	Jar 6	10	9.0	0.7	0.3	0.6	"
5-22	Tank 5	13	9.1	Trace	Trace	0.1	"
5-22	Jar 6,6A	23	9.1	"	"	0.5	"
5-23	Tank 5	13	9.5	"	"	0.2	"
5-23	Jar 6	11	9.2	"	"	0.4	"
5-24	Tank 5	10	9.6	"	"	Trace	"
5-24	Jar 5,6	17	9.2	"	"	0.3	"
5-25	Tank 5	10	9.6	"	"	Trace	"
5-25	Jar 5,6,6A	26	9.2	"	"	0.2	"

A 100 gallon stock-tank was filled with well water on May 20, and dissolved oxygen was maintained near saturation by means of an air compressor and perforated-tube bubbler. Water temperature in the tank was 60°F on May 20, when 24,000 (volumetrically measured) walleye fry were stocked into the tank. Water temperature increased to 62°F on May 24, then dropped to 57°F on May 25, at which time a heat lamp was installed. Water temperature increased to 68°F on May 28, and remained near 68°F throuth May 31. Fry stocked on May 20, were not yet capable of feeding. Zooplankton food-organisms were first introduced on June 24, when it appeared that most fry had well-developed mouth parts. A dense supply of food organisms (mostly copepods, cladocera, and ostracods) were maintained in the tank throughout the remainder of the study.

Findings - 1974

During the 11-day period from May 20-31, fry numbers declined from approximately 24,000 to less than 100 survivors. No attempt was made to precisely estimate daily mortality but visual inspection indicated that most rapid mortality occurred after May 24.

Some fry commenced feeding on May 24, when plankton were introduced and feeding continued throughout the study. Of 401 fry examined between May 27-30, 33.7 percent contained one or more food organisms. Cannibalism, first observed on May 26, was a significant cause of fry mortality.

Summary - 1973-74 Trials

Attempts at tank-rearing walleye fry were unsuccessful. While fry held at high densities accepted natural food organisms, food intake did not appear to improve overall survival.

Higher than normal water temperatures at this season appeared to increase fry survival during mouth and gut development, and may also have helped initiate feeding. However, elevated water temperature did not reduce the high daily losses after the fry began to feed.

Specific causes of fry mortality other than cannibalism could not be defined However, cannibalism alone was of such magnitude that even if all other causes of mortality could have been eleminated, survival would still have been very low. It appears that unless cannibalism can be eliminated or drastically reduced that tank rearing of walleye fry is not a practical cultural technique.

LITERATURE CITED

Johnson, Fritz H., 1969, Environmental and species associations of the walleye in Lake Winnibigoshish and connected waters, including observations on food habits and predator-prey relationships. Minn. Fish. Invest., No. 5, p. 11.