POST-HATCH HAND-PICKING REDUCES SALMONID FRY SURVIVAL IN VERTICAL-FLOW INCUBATORS

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ABSTRACT

Embryos of three salmonid species cultured in vertical-flow incubators were subjected to physical anti-fungal treatments (hand-picking) from complete hatch until fry swim-up. Removal of dead and crippled fry from incubation trays containing feral brown trout (*Salmo trutta*) or feral Chinook salmon (*Oncorhynchus tshawytscha*) resulted in significantly increased fry mortality. Survival of domesticated shasta strain rainbow trout (*Oncorhynchus mykiss*) fry from hatch to swim-up was also negatively affected by hand-picking, but no significant difference was observed in total mortality from egg eye-up to swim-up. Hand-picking after hatch is not recommended unless there are serious fish health concerns.

Keywords

Salmonid eggs, rainbow trout, Chinook salmon, brown trout, egg incubation

INTRODUCTION

Unlike other salmonid egg incubation methods, embryos cultured as eggs in vertical tray incubators are typically allowed to hatch and remain as fry in the incubators until just prior to initial feeding (Stevenson 1980; Piper et al. 1982). After hatch, anti-fungal chemical treatments on the fry remaining in the incubators usually cease, although such treatments may be continue at less frequent intervals (Stevenson 1980). Egg shells are removed from the trays after hatch (Roberts and Shpherd 1979; Hinshaw 1990), and dead fry are also often hand-picked from the tray for fungal control until the fry are placed in other rearing units for feeding (Alaska Department of Fish and Game 1983).

Manual removal of dead fry is a laborious procedure (Leitritz and Lewis 1976), unlike chemical anti-fungal treatments which are relatively easy to administer (Bailey and Jeffery 1989). We undertook this study to determine the impacts of hand-picking of dead fry on salmonid fry survival in vertical tray incubators, and provide a basis for additional future investigations into post-hatch physical and chemical anti-fungal control.

METHODS

Methods common to all experiments. All of the experiments were conducted at McNenny State Fish Hatchery, Spearfish, South Dakota. Upon arrival at the hatchery as either newly fertilized or eyed eggs, the eggs were disinfected in a 100-mg/L buffered free-iodine solution for 10 min, inventoried by water displacement (Piper et al. 1982) and placed in Heath incubator trays (Flex-a-lite Consolidated, Tacoma, Washington). Mixing of the egg pool occurred during disinfection and egg inventory. Well water (11° C; total hardness as $CaCO_3$, 360 mg/L; alkalinity as $CaCO_3$, 210 mg/L; pH, 7.6; total dissolved solids, 390 mg/L) at a flow of 12 L/min was used for egg incubation.

Physical control of fungal infections consisted of removing dead eggs and fry by hand-picking. Hand-picking was performed by removing the trays from the incubation stack, floating them in a 274 x 66-cm fiberglass picking trough, and sucking out the dead embryos using a pipette fitted with a hand-held rubber squeeze bulb (Leitritz and Lewis 1976). Water levels in the picking trough were maintained at 18 cm (total operating volume = 322 L) with flows set at 10 L/min.

The number of dead eggs and fry removed from each experimental tray was recorded until swim-up (removal from the incubators). Percent survival was calculated by using the following formulas: Total survival (%) = 100 X [1 - (dead embryos from eye-up to swim-up / initial number of eyed eggs)], Survival through hatch (%) = 100 X [1 - (dead eggs and fry through hatch / initial number of eyed eggs)], Post-hatch survival (%) = 100 X [1 -(dead fry from hatch to swim-up / number of hatched fry)].

Experiment 1. Soda Lake strain brown trout (*Salmo trutta*) eggs were used in this experiment. After initial incubation of 283 temperature units (TU - each centigrade degree of daily water temperature above freezing represents one TU) (283 TU) at Dubois State Fish Hatchery, Dubois, Wyoming, the eyed eggs were received on November, 17, 1999 at McNenny. Trays were initially loaded at 350 mL (5,738 eggs at 16.39 eggs per mL of water displaced). Six trays were randomly selected for inclusion in the experiment. Dead eggs and fry were removed from all six trays on November 19, 24, 26, 29 and 30 (complete hatch). After hatch, three trays continued to receive physical fungal control by hand-picking on December 2, 7, 13, 20. The other three trays were not picked until swim-up on December 20.

To ensure that substantial fry mortalities were not missed during tray picking, fry mortality was monitored during initial feeding. After the final hand-picking, fry were removed from the incubator trays and moved to 1.83-m-diameter circular tanks (76 cm operating depth) to start on feed. Due to space limitations, all replicates for each treatment were placed in one tank (i.e. all three replicates of the unpicked trays were placed in one tank and all three replicates of the picked trays were placed in another tank). Mortalities were recorded daily from these two tanks until December 31, 1999.

Experiment 2. This experiment was designed similarly to experiment 2, except fall Chinook salmon (*Oncorhynchus tshawytscha*) eggs were used with only two trays per treatment. These eggs were spawned from Lake Oahe, South

Dakota, salmon on October 20, 1999 and incubated prior to eye-up at McNenny. Eyed eggs were auto-picked on November 22, pooled, re-inventoried, and re-trayed at 900 mL (4,654 eggs at 5.171 eggs/mL). Daily formalin treatments of 1,667 mg/L were begun the day after initial traying and continued on all trays after eye-up (Barnes et al. 1997) until the start of hatching (November 29), eliminating the need for any hand-picking during that time. No formalin treatments were administered after the start of hatching. Hatching was complete on December 6. Dead and crippled fry from two randomly selected trays were removed post-hatch on December 8, 10, 12, 17, 20, 23, 26, 31. Two other trays were not picked until swim-up on December 31. After the final hand-picking, fry were removed from the incubator trays and moved to two 1.83-m-diameter circular tanks (76 cm operating depth) to start on feed. Due to space limitations, both replicates for each treatment were placed in one tank. Mortalities were recorded daily from these two tanks until January 14, 2000.

Experiment 3. This experiment used Shasta strain rainbow trout (*Oncorhynchus mykiss*) which were initially incubated for 222 TU at White Sulfur Springs National Fish Hatchery (White Sulfur Springs, West Virginia) and received at McNenny as eyed eggs on January 25, 2000. Trays were loaded at 250 mL (5,555 eggs at 22.22 eggs/mL). Eight trays were randomly selected to be included in the experiment. Three trays were subjected to hand-picking only up through complete hatch on February 7 (picking dates were January 26, 30, February 2, 7, 20). Three other trays were hand-picked throughout incubation until swim-up on February 20 (picking dates were January 26, 30, February 2, 7, 9, 13, 17, 20). Two trays received were not subjected to hand-picking at all.

Statistical Analysis. Data were analyzed by t-tests using the SPSS (9.0) statistical analysis program (SPSS 1999). Significance was predetermined at $\underline{P} \leq 0.05$. All embryo survival percentage data were arcsine transformed prior to analysis to stabilize the variances (Ott 1984).

RESULTS

Both the brown trout and Chinook salmon embryos exhibited increased mortality as a result of post-hatch fry picking. In treatments with no hand-picking after hatch, total embryo survival was significantly increased by approximately 2% (Table 1). Additional mortality was not observed during initial feeding after removal of the fry from the incubators. Total brown trout mortality was only 129 in the tank containing fry that had been picked versus 114 in the tank containing the trays of fry which had not been picked. The two Chinook salmon tanks were similar, with 106 mortalities in the tank with fry from the picked trays and 85 mortalities from the tank with fry from the unpicked trays.

Rainbow trout embryo mortality from hatch until swim-up was significantly greater in hand-picked trays. However, total mortality from eye-up to hatch was not significantly different ($\underline{p} = 0.07$) between trays which were hand-picked and those which were not. Abundant fungal growth in the rainbow trout trays which were not hand-picked after egg eye-up prevented any enumeration of egg or fry mortality.

Table 1. Mean percent mortality (± SE) of brown trout and Chinook salmon embryos subjected to hand-picking after hatch. Means with a different letter within each experiment are significantly different ($p \leq 0.05$).

Species	Hand-pick	N	Eye-up to hatch	Hatch to swim-up	Total mortality
Brown trout	To hatch only	3	4.70 ± 0.11	1.62 ± 0.01z	6.32 ± .012z
	To swim-up	3	5.46 ± 0.21	3.35 ± 0.17y	8.81 ± 0.12y
Chinook salmon	To hatch only	2	-	-	8.18 ± 0.31z
	To swim-up	2	-	-	10.02 ± 0.14y
Rainbow trout	To hatch only	3	4.31 ± 0.10	1.28 ± 0.07z	5.59 ± 0.16
	To swim-up	3	3.84 ± 0.04	2.41 ± 0.18y	6.25 ± 0.21
	None	2	Fungal clumps made mortality determination impossible.		

DISCUSSION

The results from all the experiments consistently identify the negative effect of hand-picking on embryo survival. Physical control via hand-picking may be producing additional embryo mortality because of extra handling (physical contact) or additional exposure to light during the picking process.

We believe the gross handling of each tray during hand-picking probably contributed little to the additional mortality observed. Salmonid embryo sensitivity to physical shock essentially disappears after complete retinal pigmentation (Jensen and Alderdice 1989; Johnson et al. 1989), and shocking after egg eye-up has no effects on survival to hatch (Rosenberg 1985; Crisp 1990). We suspect that hand-picking may have caused additional mortality by smaller actions within the tray. Inserting the picking apparatus directly into the tray typically induced substantial fry movement. This excessive fry movement in the incubation trays likely results in dermal abrasions and subsequent microbial infections (Jochimsen and Bedell 1968; Alaska Department of Fish and Game 1983). Paradoxically, removing dead fry to prevent fungal growth may instead be facilitating the growth of water mold on previously healthy fry via damaged skin (Post 1987). Different strains might be more resistant to physical handling (Fitzsimons 1994), which might explain why we did not observe any increased mortality with increased picking frequency using a very domesticated rainbow trout strain versus the increased mortality observed in brown trout and Chinook salmon embryos obtained from wild stock.

Trays that were hand-picked were subjected to approximately 10 minutes of indirect fluorescent lighting each time they were removed from the incubator stack for picking. Constant exposure to intense and extended periods of light has been associated with increased mortality of salmonid embryos, although fry are much less susceptible than eggs before the eyed stage of development (Bell and Hoar 1950; Eisler 1961; Nikolsky 1963; Kwain 1975; Day and Damkaer 1990). However, Day and Damkaer (1990) also suggested that early light stimulation of fry may not always be harmful, and that survival could possibly be enhanced with proper light conditions. In addition, Fuss and Johnson (1988) found no

negative effects from light on salmonid embryos. Because of the relatively small amount of time spent picking each tray, we believe that light by itself was not a determining factor in the results which we observed.

Based on our results from those trays containing rainbow trout eggs which were not hand-picked, some anti-fungal control measure is required if an accurate count of embryo survival to hatch or swim-up is desired. Because of fungal growth, we could not accurately determine the number of dead embryos, and do not know if the lack of fungal control contributed to increased embryo mortality. Others have recommended either chemical or physical control methods during this time of salmonid embryo incubation as well (Stevenson 1980; Alaska Department of Fish and Game 1983; Hinshaw 1990).

Because of the additional mortality which may be caused by hand-picking fry from hatch until swim-up, as well as the additional labor required, we recommend that such picking be curtailed or severely limited. If fungal growth is a concern of the hatchery manager from egg eye-up to hatch, we recommend the use of chemical control (Barnes et al. 1997, 2000, 2001).

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