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A Large Volume Striped Bass Incubation Chamber: Design and Comparison with a Traditional Method

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A LARGE VOLUME STRIPED BASS EGG INCUBATION CHAMBER: DESIGN
AND COMPARISON WITH A TRADITIONAL METHOD

A Thesis
Presented to
the Graduate School of
Clemson University

In Partial Fulfillment
of the Requirements for the Degree
Master of Science
Wildlife and Fisheries Biology

by
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Accepted by:
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Dr. William Bowerman
Dr. Arnold Eversole

ABSTRACT

I conducted a comparative study of a new jar design (experimental chamber) with a standard egg incubation vessel (McDonald jar). Experimental chambers measured 0.4 m in diameter by 1.3 m in height and had a volume of 200 L. McDonald hatching jars measured 16 cm in diameter by 45 cm in height and had a volume of 6 L. Post-hatch survival was estimated at 48, 96 and 144 h. Stocking rates resulted in an average egg density of 21.9 eggs ml⁻¹ (range = 21.6 – 22.1) for McDonald jars and 10.9 eggs ml⁻¹ (range = 7.0 – 16.8) for experimental chambers. I was unable to detect an effect of container type on survival to 48, 96 or 144 h. At 144 h striped bass fry survival averaged 37.3% for McDonald jars and 34.2% for experimental chambers. Survival among replicates was significantly different. Survival of striped bass significantly decreased between 96 and 144 h. Mean survival among replicates ranged from 12.4 to 57.3%. I was unable to detect an effect of initial stocking density on survival. Experimental jars allow for incubation of a larger number of eggs in a much smaller space. As hatchery production is often limited by space or water supply, experimental chambers offer an alternative to extending spawning activities, thereby reducing manpower and cost. However, the increase in the number of eggs per rearing container does increase the risk associated with catastrophic loss of a production unit. I conclude the experimental chamber is suitable for striped bass egg incubation.

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INTRODUCTION

Striped bass *Morone saxatilis* is an anadromous species of recreational and commercial importance. Although native to the Atlantic coast from New Brunswick, Canada, to Florida and along the Gulf coast from Florida to Texas (Pearson 1938), striped bass have been widely introduced (Raney et al. 1952; Merriman 1941). Artificial propagation of striped bass is commonly practiced to maintain exploited or non-self-sustaining populations (Bardach et al. 1972; Whitehurst and Stevens 1990). Increases in the demand for striped bass have created the need for state and federal culture facilities to maximize production.

McDonald jars have been the standard incubation vessel in striped bass production (Bardach et al. 1972, Piper et al. 1982). The gentle agitation of eggs produced by water flow in the jar simulates riverine environments where striped bass eggs naturally incubate (Bergey et al. 2003). A variety of commercially-produced jars based on the original design are available but the primary concepts remain the same. Water transported via a delivery tube to the concave bottom of the jar creates an upwelling effect. The constant movement of water keeps the eggs suspended and well oxygenated until hatch. Because of the simplicity of the design, a variety of inexpensive alternative chambers have been proposed (Rottman and Shireman 1988; Sloan 1996; Glenn and Tiersch 1997). However, few of these designs have been evaluated relative to the original McDonald jar. The primary focus has been to reduce the cost of the hatching jar (Rottman and Shireman 1988; Sloan 1996; Glenn and Tiersch 1997).

The standard McDonald jar holds a volume of 6 L and has a carrying capacity of 100,000–150,000 striped bass eggs (Rees and Harrell 1990). To keep the semi-buoyant eggs from overflowing the jar, water flow is often reduced to levels that do not meet minimum oxygen requirements (Spade and Bristow 1999). A higher ratio of water volume to yolk-sac larvae is also advantageous for survival (Harboe et al. 1994).

A comparative study of a new jar design (experimental chamber) with a standard egg incubation vessel (McDonald jar) was conducted. In this paper, I describe the design of the experimental chamber and compare fry survival between methods. Survival within methods and over time was also examined. The objective of this study was to compare the efficacy of the new experimental chamber to the McDonald jar.

METHODS

I purchased eight semi-clear phytoplankton culture tanks (experimental chambers; Figure 1) from a commercial supplier (model TC185; Aquatic Eco-Systems Inc., Apopka, Florida). Experimental chambers measured 0.4 m in diameter by 1.3 m in height. The bottom of each experimental chamber was conical and fitted with a 5-cm female threaded hole through which water was supplied. Experimental chambers were filled with 200 L of well water that had been mechanically degassed, aerated and chilled to 18.5°C. Flow was controlled by a valve adjusted to approximately 9 L min⁻¹. Flow was adjusted so that eggs would be gently suspended without being expelled. A 5-cm hole was cut 30 cm from the top of the experimental chamber and a 25-cm length of 3.2-cm diameter PVC pipe was attached with a bulkhead (Uniseal model U125; Aquatic Eco-Systems Inc., Apopka, Florida) and encased within a 0.8-m length of flexible 5-cm diameter PVC pipe used to discharge water into a 200-L aquarium. The fiberglass seam was sanded and sealed with silicone adhesive to remove any rough edges.

McDonald hatching jars were purchased from a commercial supplier (model J30; Aquatic Eco-Systems Inc., Apopka, Florida) and measured 16 cm in diameter by 45 cm in height and held a volume of 6 L. Water was introduced through a central supply tube. The orientation of the supply tube in relation to the round bottom produced an upwelling that gently suspended the eggs. Flows were adjusted to approximately 0.5 L min⁻¹ and monitored to ensure that eggs were not expelled. Discharge water exited the hatching jar from a built in canal and was collected in an adjacent 200-L aquarium.

Striped bass broodfish were collected from the wild using standard electrofishing techniques (Reynolds 1983; Yeager et al. 1990). Fish were transported in 1500-L circular tanks to the Georgia Department of Natural Resources Richmond Hill State Fish Hatchery (Richmond Hill, Georgia). Female broodfish were injected with human chorionic gonadotropin (HCG) at a rate of 330 IU kg⁻¹ of body weight and males were injected with 150 IU kg⁻¹ of body weight. Egg maturation was assessed 24 h after HCG injection. At the time of ovulation, both male and female broodfish were anesthetized with electricity using methods described by Kolz (1989). Fish were exposed to an electrical field until adequately sedated (~5 s) and were then hand dried using a cotton towel to facilitate the dry spawn method of fertilization (Rees and Harrell 1990). Eggs were stripped into a stainless steel bowl and fertilized with sperm from one to two male striped bass. Approximately 150 g of eggs were removed and stocked into each of two McDonald jars for incubation. The remaining eggs were weighed to the nearest gram and placed into an experimental chamber for incubation. Egg weight was converted to egg number by counting the number of eggs in a known weight sub-sample (Table 1). Although 10 female striped bass were collected for the experiment, on four occasions eggs from two females were combined into a single experimental chamber. In these instances a total of four McDonald jars (two from each striped bass female) were combined into a single aquarium. With the exception of two fish, time to ovulation was 34-41 h after HCG injection. Two fish showed no progression following HCG injection and were re-injected. Following a second injection, these fish reached ovulation within 24 h.

Table 1 – Egg numbers and stocking density of incubation chambers. Trial, chamber (C = control, E = experimental), number of females used in replicate, number of vessels used per replicate, number of eggs per replicate X1000, stocking density of eggs per mL.

Trial	Chamber	Female (N)	Vessels (N)	Eggs	
				(N X 1000)	Eggs mL ⁻¹
1	C	2	4	525	21.9
	E	2	1	1,401	7.0
2	C	1	2	265	22.1
	E	1	1	1,731	8.7
3	C	1	2	265	22.1
	E	1	1	2,110	10.6
4	C	2	4	523	21.8
	E	2	1	1,961	9.8
5	C	2	4	519	21.6
	E	2	1	2,488	12.4
6	C	2	4	526	21.9
	E	2	1	3,350	16.8

Upon hatch, fry from experimental and control chambers were passively transferred to 200-L rectangular aquaria by the discharge flow. Post-hatch survival was estimated at 48, 96 and 144 h. To accomplish this, three 1-L samples were obtained using a flexible siphon tube attached to a 4-mm diameter glass rod. Sample density was quantified using an electronic fry counter (Model FC-2; Jensorter Inc., Bend, Oregon) and expanded to represent the number of fry per aquarium.

The effects of rearing chambers on survival to 48, 96 and 144 h were independently tested using a paired t-test (SAS 9.1; SAS Institute, Cary, North Carolina). Variability within and between replicate samples were compared using an analysis of variance test.

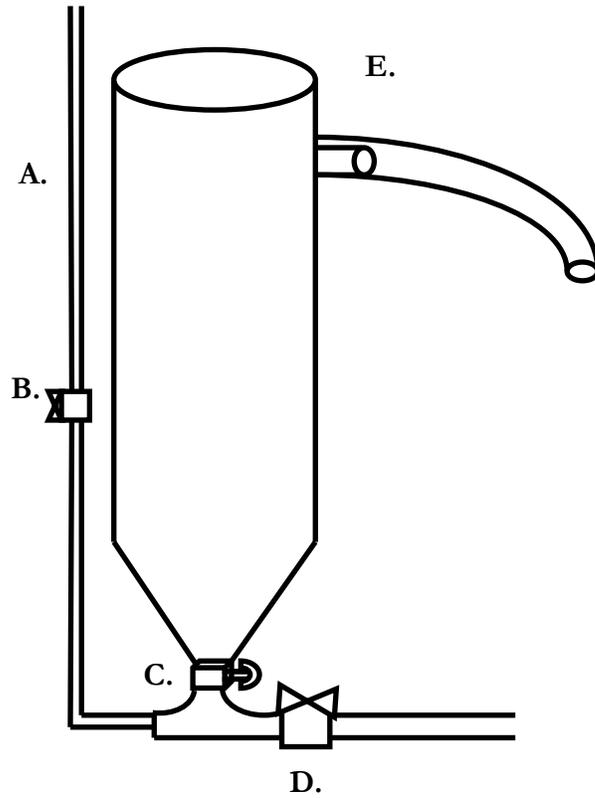


Figure 1 – Side-view schematic of experimental chamber. A = 1.25-cm PVC water inflow line, B = 1.25-cm ball valve for water control, C = 5-cm gate valve, D = 5-cm PVC ball valve to drain chamber, E = flexible 5-cm PVC discharge pipe.

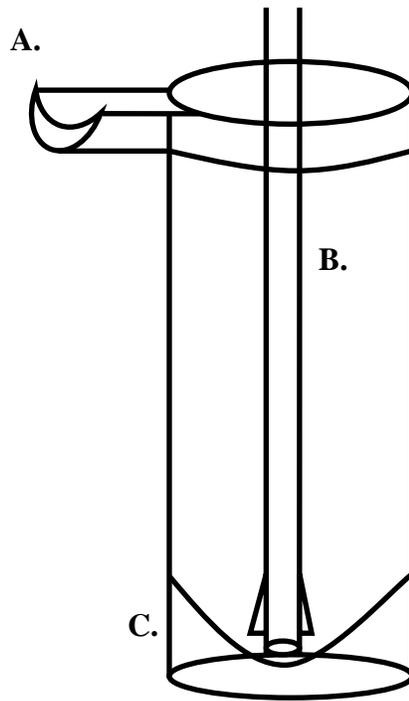


Figure 2 – Side-view schematic of McDonald jar. A = water discharge canal, B = central water supply tube, C = concave bottom.

RESULTS

The six paired trials were conducted using two chamber types (Table 1). In four trials, the eggs from two females were combined into a single experimental chamber. The single female in trial six was spawned with two males. An average of 131,000 eggs (range = 129,000–132,000) was stocked in each McDonald jar. Experimental chambers were stocked with an average of 2,174,000 eggs (range 1,401,000–3,350,000). Stocking rates resulted in an average egg density in McDonald jars of 21.9 eggs mL⁻¹ (range = 21.6–22.1) and in experimental chambers of 10.9 eggs mL⁻¹ (range = 7.0–16.8).

I was unable to detect an effect of container type on survival to 48 (F = 6.57; df = 1, 5; p > 0.05), 96 (F = 0.02; df = 1, 4; p > 0.89) or 144 h (F = 3.50; df = 1, 4; p > 0.13; Figure 3). Over the course of the study, striped bass fry survival averaged 37.3% for McDonald jars and 34.2% for experimental chambers. Survival between replicates differed (F = 152.34; df = 5, 23; p < 0.001; Figure 4). Mean survival between replicates ranged from 12.4 to 57.3%. Survival of striped bass decreased after 96 h (t = 2.07; df = 23; p < 0.05), but was not different between 48 and 96 h (t = 2.07; df = 23; p > 0.05). I was unable to detect an effect of initial stocking density on survival (t = 0.06; df = 10; p > 0.95).

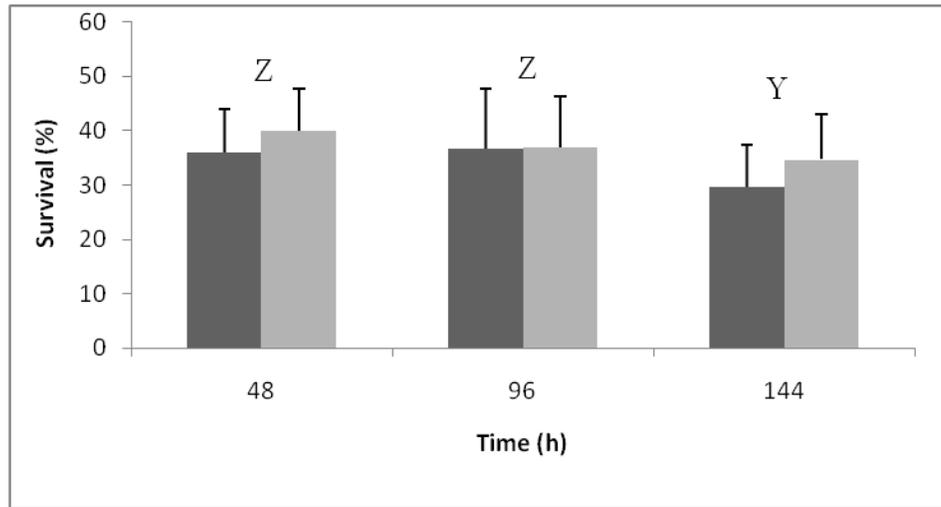


Figure 3 – Mean survival (\pm SE) for striped bass *Morone saxatilis* fry estimated at 48, 96 and 144 h. Significant difference ($p < 0.05$) between replicates are indicated by different letters.

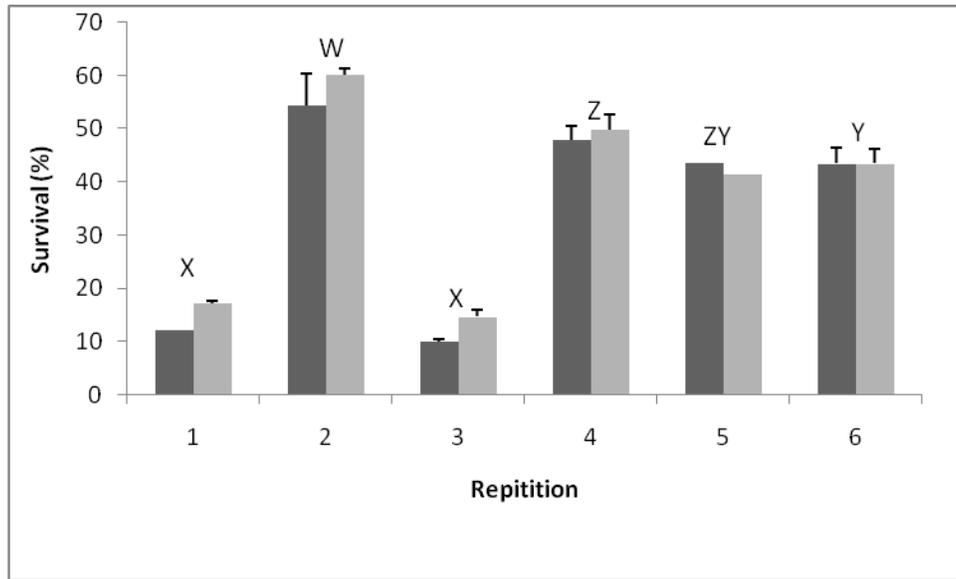


Figure 4 – Mean survival (\pm SE) of striped bass *Morone saxatilis* fry by repetition. Significant differences ($p < 0.05$) among repetitions are indicated by different letters.

DISCUSSION

Striped bass hatcheries depend on broodstock captured from the wild during natural spawning periods. Availability of ripe females is dependent upon a variety of stochastic environmental variables (Woods et al. 1992). During the peak of the spawning season, available broodfish often exceeds the fry production capacity of the hatchery. In order to meet hatchery goals, broodfish collection often extends beyond the peak in natural spawning. Broodfish collected outside of peak spawning often produce inferior-quality sperm or eggs (Yeager 1990; Yeager et al. 2006) reducing survival to fry stage. Broodfish collection during this study was protracted. Initial egg stage was also variable. A general shortage of female striped bass required the inclusion of sub-optimal females to reach production goals. Further, female striped bass are typically spawned with two or more males (Rees and Harrell 1990). Due to a lack of males on the spawning ground, all but one female was spawned with a single male. Fertilization rates tend to be lower when a single male is used. The high variability in initial within-trial survival I observed was likely due to variability in egg or sperm quality.

Recommended McDonald jar stocking densities are based on a combination of oxygen and flow limitations. Low flows may not meet the oxygen demand or remove waste products resulting in high egg mortality and fry deformity (Spade and Bristow 1999). High flows entrain eggs, resulting in loss of eggs in the effluent. McDonald jars were stocked within the range suggested by Rees and Harrell (1990). In order to control for variation among individual fish, it was necessary to limit average stocking density for

experimental chambers to only half that of McDonald jars. Maximum stocking density for experimental chambers has not been evaluated.

Fry mortality typically occurs within 120-h post hatch (Rees and Harrell 1990). I observed an increase in mortality between the 96 and 144 h post hatch samples that could not be attributed to jar type. This period corresponded with both swim bladder inflation (Stickney 1994) and first feeding (Bonn et al. 1976). Stickney (1994) suggests that this period is critical in establishing population size. Although Rees and Harrell (1990) suggest production should be estimated at 72 h, my study suggests production should be estimated at > 120 h post hatch.

Experimental jars allow for incubation of a greater number of eggs in less than half the space. As hatchery production is often limited by space or water supply, experimental chambers offer an alternative to extending spawning activities, thereby reducing manpower and cost. However, the increase in the number of eggs per rearing container does increase the risk associated with catastrophic loss of a production unit. Given the reduction in man power and duration of spawning period, I believe that these risks are acceptable in relation to the potential gains.

This experimental chamber may be useful to produce other species that require low-density culture. For example, studies of Japanese spiny lobster *Panulirus japonicus* exhibit higher mortality at higher stocking density (Matsuda and Takenouchi 2005). Harboe et al. (1994) also observed that less crowding was advantageous in the culture of Atlantic halibut *Hippoglossus hippoglossus*.

Although a variety of alternative production chamber designs have been described (Rottman and Shireman 1988; Sloan 1996; Glenn and Tiersch 1997), this study represents the first comparative study available in the literature. The experimental chamber reduces space, manpower and water requirements on a per-fry basis, in comparison to the traditional method. As survival was similar to McDonald jars, I conclude the experimental chamber is suitable for striped bass egg incubation. Further studies should be performed to test for optimum stocking densities in experimental chambers.

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