Comparison of McDonald jars and plastic strainers for the artificial incubation of red tilapia eggs

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Graduation Project presented as a partial requisite to obtain a Bachelor's Degree in Agricultural Science and Production at the Academic Level of Licentiature

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ABSTRACT

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Often the development and expansion of fish farming is limited by the lack of good quality seed. An alternative to enhance fry production is to implement artificial incubation systems for fertile tilapia eggs removed from the buccal cavity of the adult females. The objective of this study was to compare McDonald jars and plastic strainers in the artificial incubation of red tilapia eggs in Zamorano, Honduras. Eggs were collected weekly from adult female red tilapia managed in concrete tanks as part of the fish reproduction program at the Aquaculture Station. Eggs were held in four McDonald jars placed within a water recirculation system, or in four plastic strainers in all-glass aquaria with static water, during seven-day long incubation periods repeated four times during a five-week period. The experimental design consisted of two treatments (McDonald jars and plastic strainers) and four replicates of each. Tilapia eggs from multiple clutches were distributed randomly in all containers. The number of eggs surviving in each incubation system was compared by an ANOVA ($P<0.05$). The results recorded for water quality was within the acceptable range for tilapia fry rearing. The results demonstrate that the artificial incubation of red tilapia eggs under conditions in Zamorano is feasible and high levels of survival can be attained after only a few weeks of practice. Most mortality occurred during the first half of each seven-day incubation period and the trends were similar between the two types of systems. Average survival during the 5th week was significantly greater for the eggs incubated in the plastic strainers (95.3%) compared to eggs from the McDonald jars (82.3%).

Keywords: Fish culture, fish seed, Honduras.

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INTRODUCTION

Globally aquaculture production has been increasing at an average of ± 9% since 1970. In 2002 world aquaculture production was estimated to be approximately 30 million metric tons (FAO 2004). The tilapia (*Oreochromis* sp.) is one of the most important fish cultured in Central America and in many other tropical parts of the world. The increase in tilapia production is due to its easy adaptation to varied environmental conditions, fast growth rate, resistance to diseases, easy reproduction, and excellent tasting flesh.

Many countries in the world have a high capacity and potential for increasing aquaculture production. Often the development and expansion of fish farming is limited by the lack of good quality seed (Meyer 1989; Triminio Meyer *et al*. 2007). Fish seed consists of fry and fingerlings to be stocked into production units for fattening. These limitations are due to a lack of knowledge and skills among local fish producers and the inefficiency of tilapia fry production systems. An alternative to increase the production of fry is to implement artificial incubation systems for fertile tilapia eggs removed from the buccal cavity of the adult females.

A total of 22 tilapia seed producers were identified in Honduras (Meyer 2007; Triminio Meyer *et al*. 2007). Out of these only one used the technique of artificial incubation of tilapia eggs. There are different designs for artificial incubation systems that are known to be efficient and can be used for tilapia eggs (Altena and Horstgen-Schwark 2002). Rana (1986) evaluated jars with round bottoms and cone-shaped containers for the artificial incubation of tilapia eggs and obtained survival rates of 60% and 85%, respectively. Watanabe *et al*. (1992) used McDonald jars for the artificial incubation of red tilapia eggs in 12,000 ppm salinity water and obtained 65% survival.

Zamorano supplies tilapia seed and technical assistance to local farmers as part of its contribution to the development of fish culture in Honduras. Zamorano is planning to increase the production of red tilapia fry for distribution to local farmers during the next five years.

The objective of the experiment was to compare McDonald jars and plastic strainers for the artificial incubation of red tilapia eggs in Zamorano, Honduras. The specific objectives were to compare the water quality, daily mortality, weekly survival and overall average survival of offspring in McDonald jars and plastic strainers used to artificially incubate tilapia eggs and managed by an inexperienced student of fish culture.

MATERIALS AND METHODS

The experiment was conducted at the Aquaculture Station of the Pan-American School of Agriculture, also known as Zamorano. Zamorano is located 30 km east of Tegucigalpa (14° north and 87° west) and receives an average annual precipitation of 1100 mm and has an annual average temperature of ±24°C.

Eggs were collected weekly from adult female red tilapia managed in concrete tanks with hapas as part of the fish reproduction program at the Aquaculture Station. A total of 21 adult females were stocked into each of two hapas with dimensions of 7*1.2*1.2 m. The adult females were accompanied by seven adult males in each hapa, to obtain a sex ratio of 3♀:1♂.

The egg clutches collected every Saturday were maintained separately in plastic dishes, each 30 cm in diameter and 15 cm in depth. Each plastic dish was filled with approximately 2 L of water obtained from a barrel previously filled with de-chlorinated potable water (seven days of vigorous aeration).

Using a magnifying lens, each egg clutch was examined to determine its quality in terms of color, size and form. A fertile newly laid developing tilapia egg has a yellowish or cream color, oval form and is approximately 2 mm long (Meyer and Triminio Meyer 2007).

Any small or non-ovoid eggs were discarded. Eggs with a white, brown or gray color were considered to be infertile and also discarded. Recently hatched sac-fry were not used in this experiment.

The total number of fertile eggs in each clutch collected was recorded and they were distributed equally and randomly among four plastic strainers and four McDonald jars for their artificial incubation during a seven-day period. This procedure was repeated with additional clutches of eggs until a total of 300 to 585 were deposited into each incubation container.

Both incubation systems were installed in the wet lab at the Zamorano Aquaculture Station during a 35-day period. The artificial incubation of tilapia eggs attempts to imitate the natural process performed by the adult female. The proper and rapid development of tilapia eggs requires a water temperature in the range of 28-30°C. The water should be clean, de-chlorinated and well oxygenated. The eggs should be protected from physical damage, and from potential pathogens in the water.

Tilapia eggs are negatively buoyant. They tend to sink in the water and when in permanent contact with a substrate, the embryo suffers and will eventually die (Green 2006).

All water in each incubation system was exchanged at the conclusion of each seven-day period. The water temperature in each incubation system was controlled by 1000 W submersible water heaters. At the conclusion of each seven-day period, the incubation systems were disassembled and cleaned with chlorinated water. Then they were re-assembled and filled with de-chlorinated water in preparation for the following cycle. All dead eggs, embryos and fish larvae were removed daily from each incubation container and this mortality was recorded. Details of each system are described below.

Incubation using the McDonald jars. Half of the eggs from each clutch collected were distributed into four McDonald jars for a seven-day period of incubation. The incubation system with McDonald jars had several components (Figure 1). A circular tank situated on the floor of the wet lab and containing 300 L of water was used as a reservoir. Water from the reservoir was pumped (⅛ HP submersible) to a header tank (75 cm in length, 41 cm in height and 30 cm in width with a volume capacity of 72 L) and then distributed by gravity flow to each of the McDonald jars.

The McDonald jars are made of transparent plastic with a cylindrical form and round bottom, 42 cm in height and 15 cm in diameter. Water from each McDonald jar overflowed into a sand filter (20 L plastic bucket filled with sand particles) on its return to the reservoir for recycling.

Water entered each McDonald jar through a vertical tube that caused an up-welling effect to maintain the eggs suspended. This effect imitates the natural process in the buccal cavity of a female during the incubation process.

The sand filter was cleaned daily using chlorinated water to back-flush and remove any solids. No aeration was supplied to the water used in this system.

Incubation using the plastic strainers. Half of the eggs from each clutch collected were distributed into four plastic strainers for a seven-day period of incubation. Each plastic strainer was 15 cm in diameter and 6 cm in depth. Two strainers were held in place at the water's surface and against the walls of each of two all-glass aquaria (75 cm*30 cm*41 cm) by pieces of Styrofoam (3 cm^2) (Figure 2).

The static water in each all-glass aquaria was managed with continuous aeration from a 2.5 HP blower. An air diffuser was placed directly below each plastic strainer to create an up-welling effect. Air flow was regulated to maintain the eggs in each strainer suspended in the water and in constant movement.

Figure 1. Design of the McDonald jar system used in the artificial incubation of red tilapia eggs in Zamorano, Honduras.

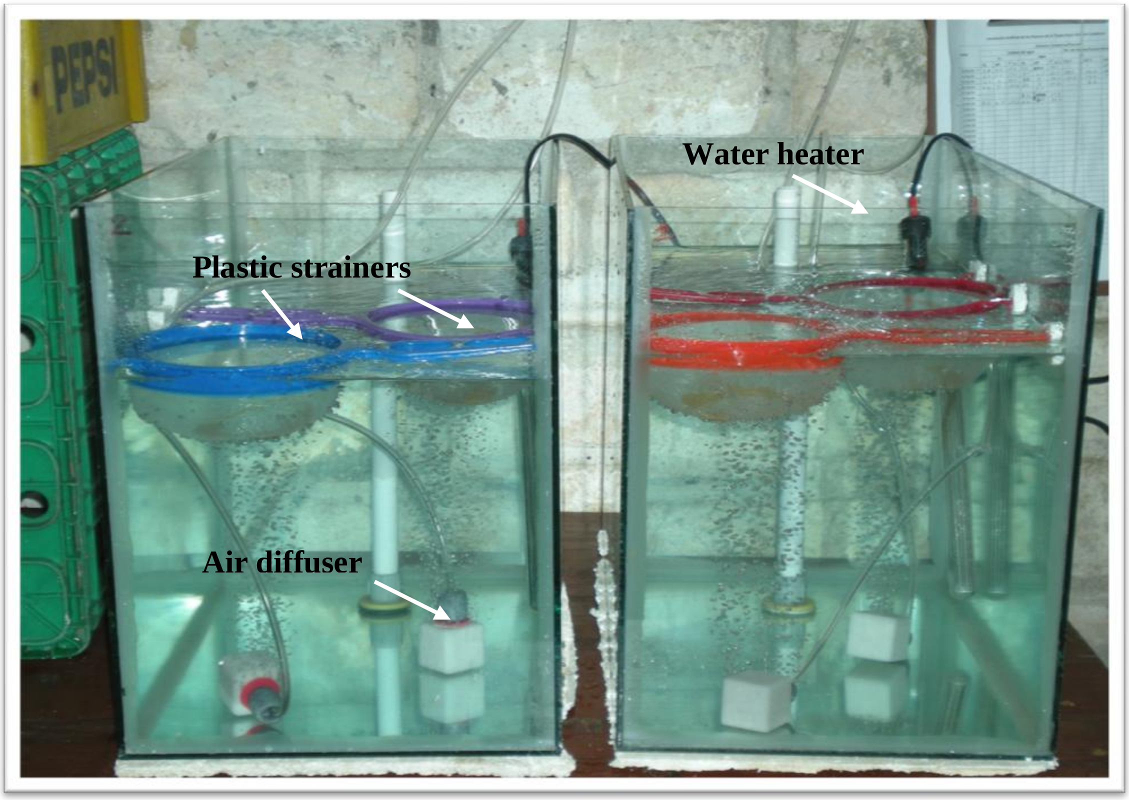

Figure 2. Design of the plastic strainers system used in the artificial incubation of red tilapia eggs in Zamorano, Honduras.

Water pH was recorded twice during each incubation cycle using the colorimetric universal indicator solution. Water temperature and dissolved oxygen readings were recorded daily using an YSI Model 52 instrument. The ECON Test Strips method was used to determine the chlorine concentration in the potable water used in the incubation systems.

The number of live offspring in each incubation container was recorded daily and at the conclusion of each incubation cycle.

The experimental design consisted of two treatments (McDonald jars and plastic strainers) and four replicates of each. Tilapia eggs from multiple clutches were distributed randomly in all containers. The number of eggs surviving in each incubation system was compared by an ANOVA ($P<0.05$) and the means separated using the method suggested by DUNCAN. The data was analyzed using the Statistical Analysis System (SAS 2003).

RESULTS AND DISCUSSION

Water quality parameters: The results for water quality (Table 1) fall within the acceptable range (28-30°C) for tilapia fry rearing (Meyer and Triminio Meyer 2007). Extreme temperatures were never observed during the five weeks of the experiment (Altena and Horstgen-Schwark 2002). In the plastic strainer system, the water temperature exceeded 34°C on one occasion.

Tilapia fry and juveniles withstand maximum water temperatures of ± 40°C (Subasinghe and Sommerville 1992; Ross 2000). Tilapia embryos held at 36°C for ten days survived the treatment and resulted in mostly male populations of fish in Africa (Althena and Horstgen-Schwark 2002).

The water used for the incubation systems in Zamorano was heated artificially. The water in the McDonald jars was generally lower in temperature than the water in the all-glass aquaria with the strainers. The difference in the average water temperature between both incubation systems was not statistically significant.

The approximately 300 L of water in the McDonald jar system was constantly circulated through the reservoir, header tank, jars and sand-filter. Each all-glass aquaria with the plastic strainers contained only about 50 L of water. There was difficulty in calibrating the water heaters at the initiation of the first cycle of the experiment. This difficulty resulted in the high water temperatures recorded in Table 1.

In general fry survival increased weekly (Figure 3; Table 2). During the 3rd week of the experiment there was an electrical black-out of approximately four hours duration and most of the embryos died in all replicates of both incubation systems.

Overall survival of fry was less than 50% in this experiment (Table 2). There are different designs for artificial incubation units used for tilapia eggs and known to be efficient (Altena and Horstgen-Schwark 2002). Rana (1986) evaluated jars with round bottoms and cone-shaped containers for the artificial incubation of tilapia eggs and obtained survival rates of 60% and 85%, respectively. Watanabe *et al.* (1992) used McDonald jars for the artificial incubation of red tilapia eggs in 12,000 ppm salinity water and obtained 65% survival.

Table 1. Water quality values recorded during four seven-day artificial incubation periods of red tilapia eggs in Zamorano, Honduras.

	Levels					
	McDonald jars			**Plastic strainers**		
Parameters	Maximum	Minimum	Average (no. obs.)	Maximum	Minimum	Average (no. obs.)
pH	6.5	6.0	6.3 (8)	7.0	6.0	6.4 (8)
O_2 (ppm)	7.8	2.3	6.1 (24)	7.4	2.6	6.0 (24)
Temp. (°C)	31.9	27.1	29.2 (24)	34.2	27.9	29.6 (24)

Table 2. Average fry survival from two incubation systems for tilapia eggs in Zamorano, Honduras. Each incubation period was of seven days duration.

	Average fry survival (%)	
Week	McDonald jars	Plastic strainers
1	7.7	0.4
2	36.7	9.6
3[d]	-	-
4	59.1	60.9
5	82.3b	95.3a
Average	46.4	41.6

Each value is an average for four repetitions.
Values in the same row with different letters are significantly different ($P<0.05$).
[d] Data were eliminated due to electrical blackout and resulting mass mortalities of offspring.

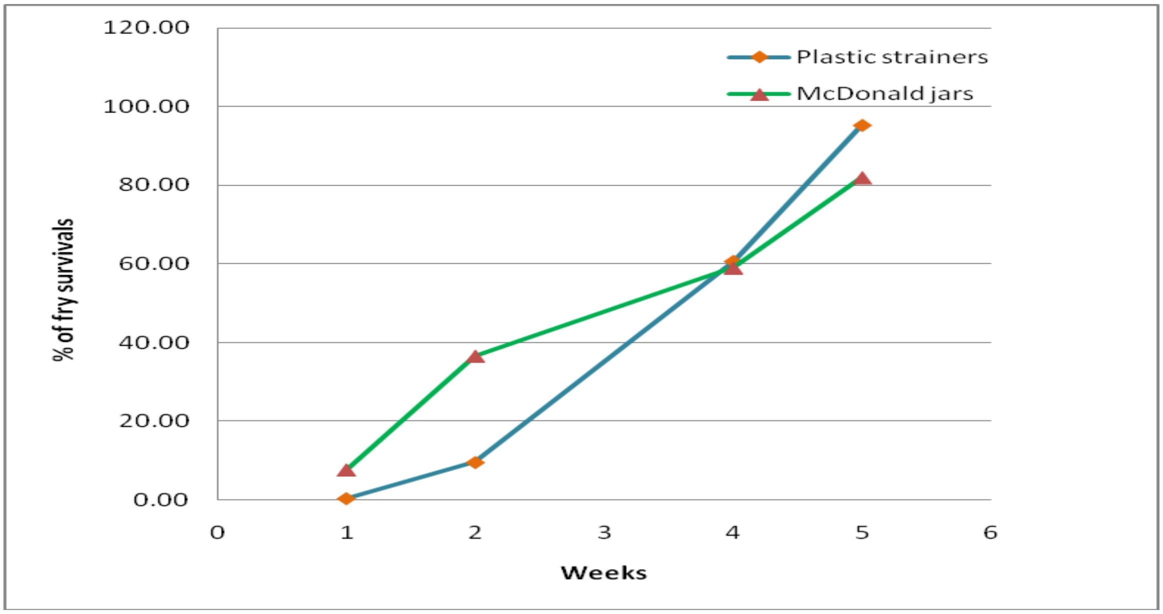

Figure 3. Average fry survival using two artificial incubation systems during a seven-day period repeated four times during a five week period in Zamorano, Honduras.

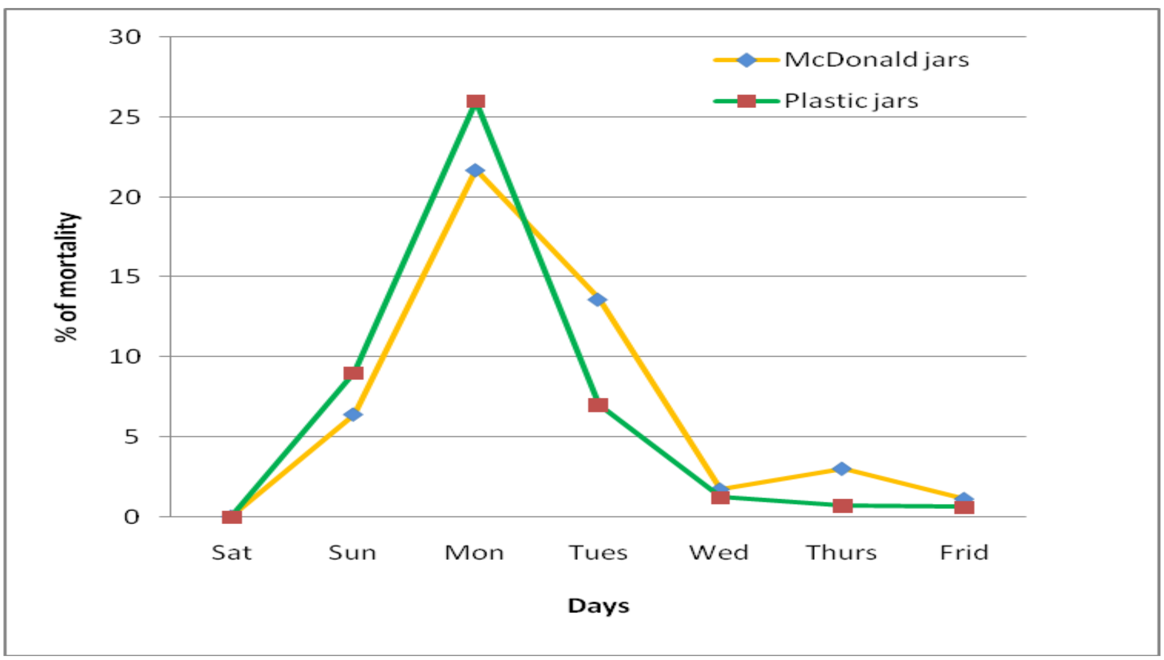

Figure 4. Average observed daily mortality, of total offspring, during the seven-day artificial incubation period beginning with tilapia eggs in Zamorano, Honduras.

In the present experiment best survival of fry (average 88.8%) was observed in week five for both incubation systems. Average survival during the 5th week was significantly greater for the eggs incubated in the plastic strainers ($P<0.05$) compared to eggs from the McDonald jars. The average egg survival rates for week five in this experiment are higher than those reported by Watanabe *et al.* (1992) and Rana (1986) for artificial incubation of tilapia eggs.

Trends in daily mortality of offspring were similar between the two types of systems used for artificial incubation of tilapia eggs. Most mortality occurred during the first half of each seven-day incubation period (Figure 4). During the first days of the incubation period the yolk content can coagulate if not maintained in constant movement (Green 2006). This can result in death to the embryo or sac-fry.

By Tuesday (day 4) of each incubation period most sac-fry had hatched but were still negatively buoyant and unable to swim due to the large amount of remaining yolk. Recently hatched sac-fry (2-3 days old) are fragile because they are no longer protected by the chorion or egg membrane. Without this membrane they may be more susceptible to damage from physical contact and abrasion (Coll Morales 1983; Bardach *et al*. 1972).

During this five-week experiment offspring survival was steadily increased to levels above of those reported by Rana (1986) and Watanabe *et al*. (1992). The results demonstrate that the artificial incubation of red tilapia eggs under conditions in Zamorano is feasible and high levels of survival can be attained after only a few weeks of practice.

CONCLUSIONS

- The observed water quality for the two incubation systems falls within the acceptable range for tilapia fry rearing.
- In general fry survival during each of the seven-day artificial incubation periods increased weekly.
- Most offspring mortality occurred during the first half of each seven-day incubation period.
- Overall survival of offspring was 46.4% and 41.6% for the McDonald jars and strainers, respectively.
- Average survival during the 5th week was significantly greater for the eggs incubated in the plastic strainers compared to eggs from the McDonald jars.
- The artificial incubation of red tilapia eggs under conditions in Zamorano is feasible and high levels of survival can be attained.

RECOMMENDATIONS

- Implement an incubation system based on plastic strainers for red tilapia eggs at Zamorano.

- Develop a contingency for managing electrical blackouts during artificial incubation of tilapia eggs in Zamorano.

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APPENDIX

Appendix 1. Advantages and disadvantages of using McDonald jars and plastic strainers for the artificial incubation of red tilapia eggs.

McDonald jar incubation system

Advantages:
- The sand filter removed solids and apparently contributed to cleaner water in the recirculation system with the McDonald jars.
- There was no need to use artificial aeration because the recirculation water received oxygen via agitation in the McDonald jars.
- Each McDonald jar can accommodate approximately 10,000 tilapia eggs during each incubation period (Subasinghe and Sommerville 1992).

Disadvantages:
- The McDonald jar system functions with electricity and an electrical blackout will quickly result in serious problems.
- The McDonald jar system requires a greater volume of water to operate (approximately 250 L) than the plastic strainer system.
- It was difficult to access and physically remove dead eggs and larvae from the McDonald jars.
- It was difficult to regulate the water flow and maintain the eggs continuously suspended in the McDonald jars without causing them physical damage.
- The McDonald jar has a price of USD 90.00 each.

Plastic strainer incubation system

Advantages:
- The strainer incubation system requires less water volume (approximately 50 L/aquarium) than the McDonald jar system.
- The strainers provide access to physically remove dead eggs and larvae from the incubation system.
- Air flow was regulated by making knots in the supply tubing.
- The strainers can be purchased for USD 1.10 each in a variety of department stores found throughout Honduras.

Disadvantages:
- Each plastic strainer was estimated to accommodate approximately 2,000 tilapia eggs during the incubation cycle.

- Plastic strainers may come with defects that can increase mortality of eggs or larvae.
- Newly hatched larvae can have their tails entangled in the strainers’ mess.