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### **Operation of Small-Scale Red Tilapia Hatchery as a Farming Dissemination Aid**

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#### ABSTRACT

Fifty red tilapia broodstock were introduced (35 females and 15 males) with an initial mean female weight 84±0.8 g, and 164±13.4 g for males. Three reproduction cycles were conducted successively. The hatchery design involved two rectangular concrete tanks (2m x3m) as water storage tanks, five circular fiberglass tanks (0.785m<sup>3</sup>) as mating tanks, two circular fiberglass tanks (0.785m<sup>3</sup>) for broodstock resting, and four circular fiberglass tanks (3. 05m<sup>3</sup>) for fry rearing. Each reproduction cycle was evaluated regarding the fry production and the fry performance for 30 days after hatching, total hatchery performance was also evaluated. Broodstock showed a significant growth while the female's condition index decreased through the study period. Fry production per female ranged from 314 in the first cycle to 362 in the third one. Fry number per gram female weight was 3.71, 3.71, and 3.66, respectively. The average final fry weight in the third cycle (0.55 g) was significantly greater than the average of those of other both cycles (0.53 and 0.52, respectively). Fry weight gain (WG) in the third cycle (0.44) was greater than of other both cycles (0.42 and 0.41, respectively). The specific growth rate (SGR%) was estimated at (5.25±0.19, 5.16±0.19, and 5.34±0.19, respectively). Red tilapia fry survival rate ranged from 71 to 72%. Feed conversion ratio (FCR) ranged from 1.03 in the last cycle to 1.12 in the first cycle. The total evaluation showed that the total produced fry was 18500 units with an estimated operation and depreciation costs of 5098 LE and with an estimated total profit of 4152 LE (81.44%)

#### 1. Introduction

Fish farming involves fish being reared in some enclosures under ideal conditions to maximize their growth (Huntington et al., 2006). More than half of the total world fish production comes from aquaculture (Subasinghe et al., 2009). Mariculture and coastal aquaculture collectively produced 30.8 million tonnes (USD 106.5 billion) of aquatic animals in 2018 (FAO, 2020). Despite technological developments in marine finfish aquaculture, marine and coastal aquaculture produce currently many more molluscs than finfish and crustaceans (FAO, 2020). Fish culture today is hardly possible without the artificial propagation of fish seeds of preferred cultivable fish species. The need to produce high-guality fish seeds for fish tank storage and natural water bodies has already increased exponentially (Akankali et al., 2011).

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The ultimate goal of the hatchery should be to produce morphologically, behaviorally, genetically, and physiologically fry like those found in the wild (Brown and Day, 2002). Many fishes reared in the hatchery are protected from natural hazards that may be occurred and eliminated fish of a lower level physically as in the wild (Akankali et al., 2011). From a practical point of view, a small-scale system for red tilapia hatchery production with less water consumption, preserving/improving water quality, and highly intensive red tilapia fry production have been proposed.

The present study aimed to

- 1. Introduce a model for a small-scale red tilapia hatchery with less water consumption and more profitability, which may be disseminated.
- 2. Study the production of a small-scale red tilapia hatchery model.

3. Determine the economics of red tilapia production in a small-scale hatchery model.

#### MATERIALS AND METHODS Experimental Fish

Experimental fish were hosted from the research unit which affiliates with Fish Farming and Technology Institute, Suez Canal University. Practically, a total of 50 red tilapia broodstock (35 females and 15 males) were introduced. The mean initial female weight was 80±0.8 g, while the mean initial male weight was 164±13.4 g. Water temperature in the receiving tanks was 28 °C with a salinity of 6 ppt.

#### **Experimental Design**

The proposed hatchery contains two rectangular concrete tanks  $(6 \text{ m}^3)$  for water storage, seven circular fiberglass tanks  $(0.785 \text{ m}^3)$  for rest and mating tilapia broodstock, four circular fiberglass tanks  $(3.05 \text{ m}^3)$  for rearing red tilapia fry, and an aeration system for the fish tank.

Three reproduction cycles were conducted successively from June to November 2018. Each production cycle was evaluated regarding the fry production and the fry performance for 30 days after hatching. After the end of the third production cycle, the total hatchery performance was also evaluated.

#### **Experimental scheme**

Thirty-five broodstock (10 males and 25 females) were selected according to their readiness for hatching and stocked into five mating tanks, with sex ratio (2 males to 5 females in each tank). The remaining number of the broodstock (5 males and 10 females) were stocked in the circular fiberglass rest tank (1m diameter × 1m height).

After two weeks hatched eggs/fry were collected from the females in each tank and counted. Collected fry was distributed into four circular fiberglass fry rearing tanks (3.05 m<sup>3</sup>). The three cycles were conducted in symmetric procedures regarding the sex ratio, mating time, egg/ fry collection, fry density, feeding routine, measuring time, and water quality.

#### **Experimental management**

#### - Fish feeding

Broodstock fish was fed with 35% protein floating feed (4 mm). As for fry, fine powder diets containing 40% protein content. The fish fry was fed at 8-10% of initial body weights, the daily feeding amount was divided into five times.

#### - Water quality

Water samples were taken every cycle from the different tanks once a week to monitor water quality. Water quality parameters were maintained within the listed ranges in table (1).

## Table 1. Water quality parameters during operation of small-scale red tilapia hatchery

	-					
	Broodstock				⊢ry	
Water quality specifications	Cycle 1	Cycle 2	Cycle 3	Cycle 1	Cycle 2	Cycle 3
Temperature maximum	28 °C	29 °C	28 °C	27 °C	28 °C	29 °C
Salinity	6 ppt	6 ppt	6 ppt	4 ppt	4 ppt	4 ppt
DO Minimum	6 mg/L	6 mg/L	6 mg/L	6 mg/L	6mg/L	6 mg/L
Ammonia Maximum	0.5 mg/L	0.5 mg/L	0.5 mg/L	0.5 mg/L	0.5 mg/L	0.5 mg/L
Ph	6.7:6.9	6.6:6.9	6.5:6.8	6.6:6.8	6.5:6.7	6.5:6.8

#### **Target Traits**

#### **Broodstock characterization**

Broodstock growth performance parameters were evaluated throw male and female weight, length and condition factor (as in table 2)

#### Fry performance

Fry performance was evaluated through fry growth performance and feed utilization. Fry growth performance was estimated with weight gain (WG) according to **(Carlos, 1988)** formula:

Where: Wi: the initial mean weight of fish in grams, Wf: the final mean weight of fish in grams.

Specific growth was estimated as follows (Knaus and Palm, 2017):

SGR% =  $100 \times (\ln Wf - \ln Wi) \div days$ 

Where:In: natural logarithm, and survival rate was according to **(Carlos, 1988)** formula:

- The Survival rate, (%) = 100 × (Final fish number ÷ initial fish number).

Feed utilization was evaluated with feed efficiency (FE) according to **(Uten, 1978)** 

FE = wet weight gain ÷ feed intake (fish feed quantity), Feed conversion ratio (FCR) according (Jobling et al., 2001)

- (FCR) = feed intake (fish feed quantity) ÷ total gain in weight.

#### **Statistical analysis**

Data were collected and statistically analyzed. Numerical data were explored for normality by checking the distribution of data and using tests of normality (Kolmogorov-Smirnov and Shapiro-Wilk tests) using the computer program SPSS software for windows version 22.0 (Statistical Package for Social Science, Armonk, NY: IBM Corp) at significant levels 0.05 (P-Value ≤0.05).

All statistical observations were presented as means ± standard deviations of the five replications. First, Levene's tests for homogeneity of variance were performed, which is a standard assumption of analysis of variance (ANOVA).

Analysis of variance (one-way ANOVA) was subjected to statistical analyses using a Computer program Costas software (version 6.311). Means were separated using LSD > 0.05 according to (Steel *et al.*, 1997) to compare between cycles.

#### Results and Discussion Broodstock Characterization

Table (2) shows that the broodstock characterization varied significantly between the three reproduction cycles. The average weight of females in the third cycle was greater than the females in the second cycle which in turn was higher significantly more than the average weight of females in the first cycle. Similarly, the body weight of males was the highest in the third cycle with a significant difference at 5%, while the second cycle and first cycle did not differ significantly. The average length of females was greater in the third cycle than the second cycle than the first cycle with a significant difference at 5 %. No significant difference in the average length of males in the three cycles. The broodstock weight and length increase within the experiment represent a normal growth pattern with time. Condition factor of females showed lower results in the third cycle, while there are no significant differences between the second and first cycle. Male's condition factor results showed that there are no significant differences among the three cycles. The lower female condition factor of females in the last cycle may be explained as a result of the repeated reproduction activity. This effect of the reproduction activities on the

female condition factor agreed with (Nehemia et al., 2012).

#### Table 2. Body weight (g), total length (cm) and condition factor (K %) of red tilapia brood-stock of males and females utilized in small scale hatchery

	Growth performance parameters					
Production cycle	Female weight	Male weight	Female length	Male length	Female conditio n Factor	Male Condition Factor
Cycle 1	84.00 ± 0.81°	164.73 ± 13.45⁵	16.93 ± 0.27°	21.19 ± 1.65ª	1.73 ± 0.10ª	1.78 ± 0.45ª
Cycle 2	93.98 ± 2.60 <sup>b</sup>	166.13 ± 29.04 <sup>b</sup>	17.85 ± 0.62⁵	22.14 ± 1.12ª	1.66 ± 0.16ª	1.52 ± 0.06ª
Cycle 3	99.10 ± 1.42ª	188.42 ± 17.09ª	19.12 ± 0.06ª	23.20 ± 1.29ª	1.42 ± 0.02 <sup>b</sup>	1.51 ± 0.13ª
L.S.D 0.05	2.38	15.27	0.64	2.036	0.176	0.418
P value 0.05	0.000**	0.048*	0.000**	0.135	0.008**	0.300

\*Mean values in the same column with different letters are significantly different (p<0.05).

#### **Fry Production Performance**

The Results shown in table (3) reveal that the total seeds production per tank (2 males and 5 females each) ranged from 1570 in the first cycle to 1812 in the last one which is not significantly different from those of the first and second cycles. The current results revealed that the fry production per female of red tilapia ranged from 314 in the first cycle to 362 in the third one.

#### Table 3. Fry/ egg production on small scale red tilapia hatchery represented as per tank (2males and 5 females each), per female, and per gram of female during three consecutive reproduction cycles

	Fry number					
Production cycle	Number / Tank	Fry number /F	Fry number/ gram female			
Cycle 1	1570.20±257.84 <sup>a</sup>	314.04±51.57 <sup>a</sup>	3.71±0.65 <sup>a</sup>			
Cycle 2	1739.20±330.69 <sup>a</sup>	345.32±61.68 <sup>a</sup>	3.71±0.66 <sup>a</sup>			
Cycle 3	1812.80±331.47 <sup>a</sup>	362.56±62.01 <sup>a</sup>	3.66±0.66 <sup>a</sup>			
L.S.D 0.05	284.60	56.32	0.705			
P value0.05	0.193	0.1939	0.980			

Relative fecundity was defined as the number of mature oocytes in a female divided by the total weight of a female (Kraus *et al.*, 2000). The current results showed that there were no significant differences between the three reproduction cycles regarding the fry number per gram female weight (relative fecundity) 3.71, 3.71, and 3.66 egg/ gram, respectively.

#### **Fry Performance**

Table (4) showed that the initial fry weight did not differ significantly between the different cycles while the initial length differs significantly between the first two cycles and the third one.

#### Table 4. Growth performance parameters (Mean ± SE) of red tilapia fry in small-scale hatchery during three consecutive reproduction cycles

D. J. C.	Growth performance parameters							
cycle	IW	IL	FW	FL	WG	LG	SGR %	CF
Cycle 1	0.11 ± 0.01ª	0.86 ± 0.05ª	0.52 ± 0.02⁵	3.14 ± 0.08ª	0.41 ± 0.02⁵	2.28 ± 0.07 <sup>b</sup>	5.25 ± 0.19 <sup>a</sup>	1.69 ± 0.10 <sup>ab</sup>
Cycle 2	0.11 ± 0.01ª	0.74 ± 0.08⊳	0.53 ± 0.02⁵	3.28 ± 0.21ª	0.42 ± 0.02⁵	2.54 ± 0.27ª	5.16 ± 0.19 <sup>a</sup>	1.53± 0.28 <sup>b</sup>
Cycle 3	0.11 ± 0.01ª	0.73 ± 0.13 <sup>b</sup>	0.55 ± 0.01ª	3.09 ± 0.21ª	0.44 ± 0.02ª	2.36 ± 0.27 <sup>b</sup>	5.34 ± 0.19 <sup>a</sup>	1.87 ± 0.29 <sup>a</sup>
L.S.D 0.05	0.011	0.09	0.017	0.227	0.017	0.176	0.329	0.281
P value0.05	0.599	0.020*	0.019*	0.187	0.028*	0.0259	0.460	0.0679

\* Means followed by different letters in each column are significantly different (P<0.05).

IW = Initial Weight, IL = Initial Length, FW= Final Weight, FL = Final Length, WG = Weight Gain, LG = Length Gain, SGR = specific growth rate, and CF= Condition Factor

Regarding the final weight (FW) and length (FL) of the fry in the different reproduction cycles, the average of the final weight in the third cycle (0.55 g) is significantly greater than the average of the final weight of the other cycles (0.53 and 0.52 respectively). No significant differences were noted in the final length between the three cycles.

Growth performance parameters as weight and length gain may be affected by many factors like

feeding rates, feed utilization, protein efficiency and stocking density (Soltan, 2013), water salinities (Refaey, 2009) ammonia concentration (El-sayed, 2006). The superiority of the final weight and the weight gain in the last cycle maybe because of adequate temperature.

#### Survival rate% and Feed Utilization

The results showed in Table (5) revealed that the red tilapia fry survival rate ranged from 71 to 72%. **Biswas et al. (2011)** defined survival rate as (Number of fish harvested per Number of fish stocked)\*100. Many factors were involved in the tilapia fry survival rate like stocking density, water quality (**Salih, 2019**), water salinity (**Watanabe et al., 1993**), pond depth and water temperature (**EI-Sayed et al.,1996**). Many studies investigated the survival rate in red tilapia fry.

#### Table 5. Survival rate% and feed utilization of red tilapia fry in small-scale hatchery during three consecutive reproduction cycles

	Survival and feed utilization parameters					
cycle	survival rate %	feed intake	FCR	FE %		
Cycle 1	71.31±0.35 <sup>a</sup>	588.83±70.63 <sup>b</sup>	1.12±0.06 <sup>a</sup>	89.68±4.64 <sup>b</sup>		
Cycle 2	72.11±0.25 <sup>a</sup>	652.20±69.85 <sup>ab</sup>	1.08±0.04 <sup>ab</sup>	92.85±3.70 <sup>ab</sup>		
Cycle 3	71.61±0.99 <sup>a</sup>	691.50±85.63 <sup>a</sup>	1.03±0.04 <sup>b</sup>	96.68±3.38ª		
L.S.D 0.05	1.77	89.64	0.05	4.34		
P value0.05	0.477	0.078	0.032*	0.0215*		

\* Means followed by different letters in each column are significantly different (P<0.05).

FCR = Feed conversion ratio, FE = Feed Efficiency

Our results revealed that the feed conversion ratio (FCR) during 30 days after hatching was ranged from 1.03 in the last cycle to 1.12 in the first reproduction cycle. Regarding the significant difference between the first and last cycles in the feed conversion ratio and the feed efficiency, many factors may affect the fry feed utilization including feeding frequency, water temperature, diet quality and water quality (Salih, 2019), water turbidity (Elsayed, 2006), stocking density (Refaey, 2009).

#### **Overall Evaluation**

Table (6) showed some reproductive performanceparameters of broodstock used in a small-scale redtilapiahatcherythroughthreeconsecutive

reproduction cycles including fry per female and fry per gram female weight.

#### Table 6. Reproductive performance parameters of red tilapia broodstock in small scale hatchery using 35 broodstock in three cycles.

FRY N	FRY N/F	FRY N/GF
25611	340.64	3.69

#### **Fry Performance**

Table (7) showed some overall growth performance parameters of fry reared in a small-scale red tilapia hatchery through three consecutive reproduction cycles including weight gain, length gain, and specific growth rate%.

# Table 7. Growth performance of red tilapia fry in<br/>small-scale hatchery during three<br/>consecutive reproduction cycles

IW	IL	FW	FL	WG	LG	SGR %	CF
0.11	0.77	0.53	3.17	0.42	2.39	5.25	1.69

Results of survival rate and feed utilization parameters (FCR & FE) of red tilapia fry reared in a small-scale red tilapia hatchery through three consecutive reproduction cycles in the current study showed that red tilapia fry produced and raised in a small-scale hatchery, within a month of breeding, had a survival rate of 71.67 % with feed conversion ratio 1.07 and feed efficiency 93.07 %.

The current results revealed that fry production per female was significantly higher in the third reproduction cycle than in both the first and the second cycles. Absolute fecundity is defined as the number of ripening oocytes and mature ova or eggs just before spawning (Qadri et al., 2015). Peña-Mendoza et al. (2005) reported that the absolute fecundity of tilapias was 243 to 847 eggs in tilapias natural lagoon in Mexico and <100 up to 3,000 eggs in cultured Nile tilapias. As for the red tilapia the absolute fecundity was estimated to be 342 to 3504 (Desprez et al., 2008). The current study results revealed the total fecundity was 314.04±51.57, 345.32±61.68 & 362.56±62.01 which is in agreement with El-Sayed et al. (2003), who reported that optimum fecundity of Oreochromis niloticus as 305:753 spawn<sup>-1</sup>. Additionally, Coward and Bromage (1999) listed the tilapia total fecundity to be varied from 461 to 11640. On the other side, the current results differ from the findings of Fryer, (1972), who obtained a fecundity of 3706 eggs for a total length of 57 cm T. nilotica females. This difference may be referred to as the female size as

the current study female's length ranged from 21 to 23 cm. The significant increase of the total production of each female in the last cycle over the first and second cycles may be explained because of the female weight of 99 g as compared to 84 g and 93 g, respectively. This result agreed with **Mohammed** *et al.* (2014) who mentioned a positive relationship between female weight and its fry/egg production.

Relative fecundity was defined as the Number of mature oocytes in a female divided by the total weight of a female (Kraus *et al.*, 2000). The current results show that there were no significant differences between the three reproduction cycles regarding the fry number per gram female weight (relative fecundity) 3.71, 3.71, and 3.66 egg/ gram, respectively. The relative fecundity in cultured tilapias has been reported as  $3.12 \pm 0.36$  (Tsadik and Bart, 2007),  $7.2 \pm 0.2$  (Campos-Mendoza *et al.*, 2004), and 3.05 to 7.53 eggs/kg, despite the different experimental circumstances. Kassam and Sangazi (2016) listed red tilapia relative fecundity as  $3.36 \pm 0.29$ ,  $2.27 \pm 0.22$ , and  $2.00 \pm 0.14$ 

The superiority of the final weight and the weight gain in the last cycle may be explained because of adequate temperature. **Pauly (1976)** reported that the optimum temperature for the red tilapia fry growth is 28:30 °C which is compatible with this in the third cycle temperature.

The specific growth rate (SGR) was estimated with (5.25±0.19, 5.16±0.19, and 5.34±0.19, respectively) in the three reproduction cycles. These results were agreed with **Gharib (1998)**, who estimated SGR% with 5.45 for red tilapia. On the other hand, the current result is considered low as compared to other similar rearing studies, such as that of **Siddiqui and AI-Harbi (1995)**, who found that the SGR% of red tilapia fry was 9.86%. **Persand and Bhikajee (1997)** mentioned different estimations of the red tilapia fry SGR as they listed 1.13%. The different estimates between studies regarding the SGR% maybe referred to as one of the different growth effective factors.

Many studies investigated the survival rate in red tilapia fry. **Refaey (2009)** recorded a survival rate of red tilapia fry as 72% which is in agreement with the current study. Additionally **Ting et al. (1984)** also listed a similar survival rate% when fish reared in salinity of 8 ppt.

The feed conversion ratio (FCR) during 30 days after hatching was ranged from 1.03 in the last cycle to 1.12 in the first reproduction cycle. The current results were in agreement with **EI-sayed (2004)** who indicated that FCR for red tilapia fry was 1.09 when protein level in the fish diet was 40 %., **Kamal and Mair (2005)** also informed red tilapia FCR with

1.08, when water salinity was 30 ppt. In contrast, **Suresh and Lin (1992)** recorded different estimates for the feed conversion ratio of the red tilapia fry as 2.25.

Regarding the significant difference between the first and last cycles in the feed conversion ratio and the feed efficiency, many factors may affect the fry feed utilization including feeding frequency (Kaya and Bilgüven, 2015), water temperature, diet quality (Riche and Garling, 2003), water quality (Salih, 2019), water turbidity (El-sayed, 2006), and stocking density (Refaey, 2009). In our study, the difference may be a result of different temperatures and broodstock size in the three reproduction cycles.

#### **Economic Evaluation**

The hatchery consisting of 2 water storage tanks (6  $m^3$ ), 2 broodstock rest tanks (0.785  $m^3$ ), 5 mating tanks (0.785  $m^3$ ), and 4 fry rearing tanks (3.05  $m^3$ ). Additionally, the hatchery has aeration and water distribution lines. Accordingly, the construction costs were as represented in table (8).

Table 8. Construction costs of small-scale redtilapia hatchery

Item	Price	Unit No	Cost
Water storage tanks	1300	2	2600
Mating Tanks	1200	5	6000
Broodstock rest tanks	1200	2	2400
Fry rearing tanks	1000	4	4000
Waterline	1800	1	1800
Aeration line	1400	1	1400
Others	1000	1	1000
Total	19200 LE		

The reproduction cycles were conducted using 35 red tilapia broodstock. Fish were fed using 25 kg broodstock feed and 10 kg fry feed. Table (9) showed the running costs for the proposed hatchery.

## Table 9. Construction costs of small-scale redtilapia hatchery

ltem	No	Unit	Total	
		price		
Broodstock	50	7	350	
Broodstock feed	25	12	300	
Fry feed	10	15	150	
Power	500 Kw	1.2	600	
consumption				
Water	120 m <sup>3</sup>	1.65	198	
consumption				
Others		300		
<sup>20</sup> Total	1898			

After three consecutive reproduction cycles, the hatchery-produced 25611 red tilapia fry with an average weight of 0.53 g so the total production value and the profit will be as follows in table (10).

## Table 10. Production value, total costs, and profit of small-scale red tilapia hatchery

-	
Total production	18500
Unit value	0.5
Production value	9250
Operation costs	1898
DEPRECIATION	3200
expenses	5200
Total costs	5098
Profit	4152
Profit %	81.44

The results showed that the running of a small-scale red tilapia hatchery for about five months (three reproduction cycles) revealed a good economically alternative for the dissemination of red tilapia fry as the operation results in 81.44% profit.

#### Conclusion

- Total evaluation of small-scale red tilapia hatchery operation showed that the final product was 25611 fry using only 35 broodstock (25 femal+10 Male).
- Operation and depreciation costs were 5098 LE and while the estimated total profit was 4152 LE (81.44%).

From the results mentioned above, a small hatchery system for red tilapia fish can be recommended to rationalize water use and efficiently produce highquality tilapia in Egypt.

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