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EFFECT OF SOME ENGINEERING PARAMETERS AFFECTING ON EGGS INCUBATION OF GRASS CARP (*Ctenopharyngodon idella*)

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ABSTRACT

Present study was conducted to induced on breeding of commercially important grass carp (*Ctenopharyngodon idella*) due to the non-availability of its quality seeds from the natural resources for environmental degradation. The aim of the study was to achieve success in fertilization and hatching using various incubator with the grass carp (Zugar and Poultry drinker), to investigate the effect of three water flow rate about (77, 155, 233) ml/min for 1 liter volume of water and three number of eggs density (75,150, 225 eggs per liter) on hatching percentage and fry production of water with mentor water quality (pH, Oxygen and Temperature) during incubation period every 2 hours until inducing hatch. The obtained results revealed that the hatching ratio in Zugar in water flow rate (77, 155, 233 ml/min) were 65% at 75 eggs/liter, 68 % at 150 eggs/liter, and 70 % at 225 eggs/L respectively. On the other hand, hatching ratio in the Poultry drinker in water flow rate (77, 155, 233 ml/min) were 61 % at 75 eggs/liter, 60 % at 150 eggs/L, and 58 % at 225 eggs/L, respectively.

Fry production in Zugar in three different water flow rate (77, 155, 233 ml/min) were 0.44 fry/L at 75 eggs/L, 0.91 fry/L at 150 eggs/L, and 1.41 fry/L at 225 eggs/L, respectively. While, fry production in water flow rate (77, 155, 233 ml/min) in Poultry Drinker were 0.41 fry/L at 75 eggs/L, 0.8 fry/L at 150 eggs/L, and 1.17 fry/L at 225 eggs/L, respectively. The main value of pH was 7.1, the value of dissolved oxygen concentration was 5.4 mg/l, and the Degree of temperature is 22.4^{o}C.

INTRODUCTION

Fish hatchery is one of the most important non-natural habitat of fish for their artificial breeding, hatching as well as rearing in the very early stage of their life. In Bangladesh most of the fish biologist and fish farmers are trying to excel the overall quality of the hatchery based fish farming due to the maximum production and sustainable benefit (Bhatnagar and Devi, 2013).

Several studies showed the huge microbial contamination in fish hatcheries water especially *Salmonella* spp., *Shigella* spp., *Vibrio* spp., and coliform bacteria as well as the imbalance physical condition of water such as DO, salinity, temperature, pH, TDS, turbidity, arsenic. (Majumder *et al.*, 2018). Aquatic life becomes stressful when the physicochemical and biological parameters have been altered and then adversely affect fish growth and reproduction by causing infections (Kiran *et al.*,2010). Poor management of water quality may be the vital reason of fish dead and illness, slow growth of fishes

Grass carp (*Ctenopharyngodon idella*) matures at the age of 2 years and above; generally, males mature little earlier than female in cultivable carps (Rath, 1993).The purpose of its introduction, in addition to culture, was for biological aquatic weed control in natural water ways, rivers and man-made lakes (Khan *et al*., 2004).

Tsuchiya (1979) showed that grass carp eggs would require 25 hours incubation at 25 ºC. Giurcia (1980) reported the breeding of grass carp in the Danube River and noted that it was successful only in years when suitable conditions occurred. These conditions were when water temperatures were over 22ºC and over 0.5 m s^{-1}water velocities (Staras and Otel, 1999). Hence, observations on the natural spawning of grass carp in the Danube River indicate that whereas some successful transport and hatching of larvae can be expected at low water velocities and temperatures, large numbers of larvae only occur when temperatures are over 22ºC and water velocities are over 0.5 m s^{-1}.

Grass carp (*Ctenopharyngodon idella*), also known as White Amur, is a vegetarian fish living in the Amur River in Asia. Because of its herbivorous feeding habits, it has received considerable attention as biological control of aquatic vegetation. Grass carp can reproduces only its own original habitat.

Therefore, grass carp culture is an important issue to overcome excess aquatic vegetation. So, gamete quality and artificial insemination is very important to obtain viable larvae for grass carp culture (Bozkurt and Öğretmen, 2012).

Muhammad *et al.* (2011) studied that the induce of spawning, fecundity, fertilization rate and hatching rate of grass carp (*Ctenopharyngodon idella*) after injection of ova prim at a fish hatchery and mentioned that of grass carp preferably spawn during mid-April to June. The fertilization rate was 80.36% and hatchling percentage were 63.88% at the favorable temperature of 26 to 30°C. Generally, the number of eggs spawned by Grass carp (*Ctenopharyngodon idella*) in the present study was lower than previous report (Ling 1980; Chaudhary *et al*. 1984 and Armando *et al*., 1989).

Rowe and Schipper (1985) presented data on egg incubation times versus temperature from a range of studies on grass carp and noted that hatching times varied more at high than at low water temperatures (e.g. 36-48 hrs at 20ºC, compared with 18-36 hrs at 25ºC). Although there is clearly variation in the time of hatching for a given water temperature, a conservative approach is required to produce a precautionary risk estimate. Eggs are carried downriver in the surface waters of rivers and there is a minimum velocity needed to keep them in suspension. If water velocity drops below this threshold the eggs settle on the river bed where abrasion and damage to the delicate membrane surrounding the egg results in death. The reviewer of the literature on water velocities required for the continued suspension of grass carp eggs and adopted a threshold of 0.6 m s^{-1} as this characterized the surface waters of rivers where successful hatching had occurred. However, the suspension of semi-buoyant eggs in water is a complex process and depends on changes in egg density during development and the spatial distribution of water velocities in rivers. Water velocity was generally highest near the surface and in midchannel, and decrease towards the river edge and river bed.

Leslie *et al*. (1987) studied the issue of egg buoyancy and water velocity for grass carp, and carried out trials to determine egg survival downriver. They found that 99% of eggs were lost after travelling 3.2 km in downriver at a water velocity of 0.23 m/s. However, these losses were due to predation as well as settling.

Murphy and Jackson (2013) investigated that issue in greater depth for the Asian carps in general (i.e. silver carp, bighead carp and grass carp). When eggs are released into the water by the females, they are small (2.0-2.5 mm in diameter) and relatively dense with a settling velocity close to 0.85 cm/s. and calculated that grass carp eggs could hatch 15 km below the likely spawning site in the Sandusky River because water velocities were mostly over 10 cm s^{-1} in the lower reaches and travel time would range from 19-25 hours, which was within the time for hatching as determined by water temperature. Although water temperature in this river was not measured, air temperatures in July ranged from 25-35 ºC.

Rashid *et al.* (2014) found that hatching and egg incubation were mainly depends on temperature, because of low temperature in Kashmir valley comparing to other regions of India, the hatching period was recorded at 20-30 hours after fertilization and temperature 24-26°C.

River water temperatures in the lower Waikato River during summer months are typically over 20ºC and do not exceed 25ºC (Rowe and Boubee, 1994). At 20ºC, the hatching time for grass carp eggs was 36 hrs. Given that some eggs could be travelling downstream at average velocities over 0.1 m s^{-1}, the travel distance required for these eggs to hatch would be 13 km. Travel distances will be longer at higher average water velocities (e.g. 65 km is required if mean water velocities are 0.5 m s^{-1}), these distances are less than the length of the Waikato River below the Karapiro Dam (146 km) and therefore incubation and hatching of grass carp eggs was possible before they are washed out to sea.

Climate change is predicted to increase the incidence and size of flood flows in the Waikato and can also be expected to increase average water temperatures in the river (Mullan *et al.*, 2001). But there are insufficient data at present to indicate the magnitude or frequency of such changes. An increase in water temperature will reduce the time required for hatching and hence the length of river required, but increased flows can be expected to increase average water velocities and hence the length of river travelled during the incubation period. The risk of grass carp spawning would therefore be enhanced by higher river flows, but the effects of increased water temperature on the length of river required for egg incubation could be offset by faster mean water velocities in the river.

The present study aims to induced the breeding of commercially important grass carp due to the non-availability seeds from the naturel resources from environmental degradation using simple and cheap incubator represented in the poultry drinker comporting to the conversion incubator sugar.

MATERIALS AND METHODS

This study was carried out in Central Laboratory for Aquaculture Research (CLAR) in Abbassa Village at Abou Hammad District, Sharkia Governorate during of 2019-2020 seasons to test and evaluate the performance of a modified hatchery egg fish suitable for hatching fish under local conditions.

Eggs incubation of grass carp (*Ctenopharyngodon idella*) at different conditions were used to evaluate some study parameters on hatching ratio and production of fry from water which using in hatchery and mentor water quality during incubation period. The study included two incubator container (Zugar, and Poultry drinker);by used design incubation fish (Soliman *et al*., 2019) each container divided into six treatments each treatment was three replicates. Three treatments (first, second and third treatment) exposed the eggs to three water flow rate (77, 155 and 233 ml/min) for every litre, respectively. The fourth (T4), the fifth (T5) and sixth treatment (T6) was contain three density of eggs (75, 125 and 255 number of egg/liter) respectively. Also, the container poultry drinker are contain six treatments from seven treatment to twelve treatment same as of Zugar for of three water flow rate and three density of eggs, respectively.

Table 1. Shows the treatments.

Treatments	Type of Container	
		Zugar
T1	77	Water flow rate ml/min
T2	155	Water flow rate ml/min
T3	233	Water flow rate ml/min Egg
T4	75	density egg/l
T5	125	Egg density egg/l
T6	225	Egg density egg/l
		Poultry Drinker
T7	77	Water flow rate ml/min
T8	155	Water flow rate ml/min
T9	233	Water flow rate ml/min Egg
T10	75	density egg/l
T11	125	Egg density egg/l
T12	225	Egg density egg/l

At three water flow rate (77, 155 , 233 ml/min) for every 1 liter volume of water; at three density of eggs (75, 150, 225) number per liter using water from filter pond. A total of 12 treatments were suggested and implemented in 3 replicates each.

Grass carp eggs 5.3 mm diameter 16000 egg/kg swollen eggs were used at different densities to investigate the previous parameters. Eggs were collected from aquarium after 12h from fish laying eggs in water and one gram of eggs was take and counted separately. During the incubation the number of eggs has to be assessed several times to observing their developing embryonic. Manual counting and weighing are used then the average mass of each fry was calculated.

Types of Incubator:

1- **Zugar (Z.J.)** which made from fiberglass using to incubate eggs with 9 liter volume of water. Its shape divided into two shapes the top is cylindrical with dimension (15 cm diameter, 50 cm high) and the bottom is conical with dimension (15 cm diameter, 25 cm high). Water pump with 1 hp power using for flow of water through the eggs incubation.

2- **Poultry drinker (P.D.)** which using in chicken farms. It made of plastic with 1 liter volume of water its shape divided to two shapes one is cylindrical from top 13 cm diameter and 11 cm height and the bottom is conical 13 cm diameter and 4 cm height.

3- **Plastic tube** for water flow in Poultry drinker incubator. Irrigation water offers drips 1/2” and 3/4" Mainline Poly Tubing Hose. Our tubing is made with commercial grade, high quality low density Union Carbide 7510 polyethylene resin. This drip irrigation tubing hose has a 2% carbon black additive for maximum UV Resistance; this drip irrigation tubing hose will last 7 years in direct sunlight and more if the drip irrigation tubing hose is mulched over. the drip irrigation tubing hose is used in Agriculture, Commercial Growing, Professional Landscaping and other gardening applications. We offer either Compression Fittings or Direct-Loc Series Fittings for connecting our Poly Tubing. Other common names for Drip Tubing include Poly Pipe, Poly Tubing, and Supply Line.

4- **Micro Tubing**: Feeder Tubing: 1/4" micro tubing hose can be used as the main line for small deck/flower-pot installations, and hydroponic installations, but this drip irrigation hose is more often used as a lateral or feeder supply line off of 1/2" main line tubing. Also referred to as "Distribution Tubing" this flow water hose is available in Polyethylene (PE). Valve taps use to control water flow in Tube Connector to hose in eggs container.

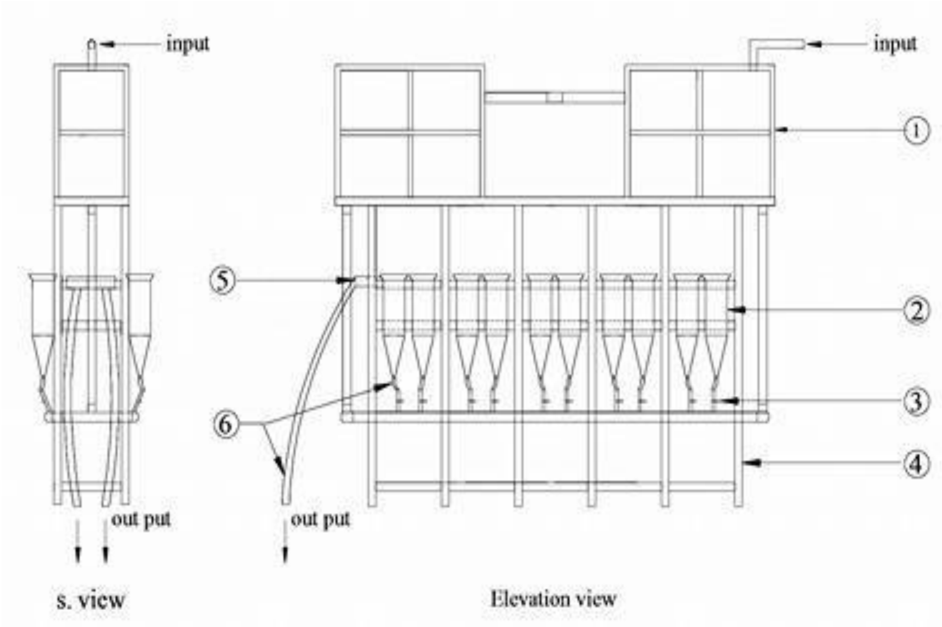

Fig. 1. Incubation Units for Z.J. (Soliman, *et. al*. 2019).

Table 2. Symbols in Incubation Units for Z.J.

Num.	Name
1	Water Tank
2	Zugar
3	Valve
4	Stand
5	Vessel
6	Hose

Fig. 2. Incubation Units for Zugar (Z.J.)(Soliman *et al*., 2019) 1. water tank; 2. Zugar; 3. Valve and 4. Stand.

Fig. 3. Incubation Units for poultry drinker (Soliman *et al*., 2019).

Hatching ratio:

Hatching ratio has to be monitored carefully and dead eggs were counted and noted during incubation. The hatching ratio (HR) was calculated using the following equation according to (Gapasin and marto, 1990).

$$\textbf{Hatching ratio} = \frac{\text{Amount of hatched fry}}{\text{Amount of fertilized eggs}}$$

Production Of Fry From Water Volume

= amount of fry / (water effluents rate x time of incubator /min)

Water Quality:

Water samples from each treatment were tested to determine the concentration of pH, dissolved oxygen, and temperature. pH was assessed using pH meter. Dissolved oxygen and temperature were measured in (mg/l and ^{o}C) using Dissolved Oxygen Meter (YSI Model 58 made of U.S.A).

Cost Of Hatching Eggs:

The cost incurred by the incubation unite was estimated using the following equation, (Awady, 1978):

$$C = \frac{p}{h}\left(\frac{1}{a} + \frac{i}{2} + t + r\right) + (0.9\, w.s.f) + l \qquad \text{L.E/h}$$

Where:

C = hourly cost, L.E.
P = Capital investment (unit price = 20,000 LE)
h = yearly working hours (assumed 1080 h/year)
a = life expectancy of the unit (assumed 20 years).
i = interest rate/year (assumed 10%).
t = taxes, and overheads ratio (assumed 10%).
r = repairs and maintenance ratio (assumed 10%).
w = horsepower of motor, 1 hp.
s = specific electricity consumption, 0.74 kw/h.hp.
f = electricity price, 0.50 LE/kw
l= operator wage, 10.00 LE/h.
0.9 = factor to take lubrication and greasing into account.

Statistical analyses:

The observed data were tabulated, analyzed, and plotted to investigate the effect of different study parameters.

RESULTS AND DISCUSSION

Water Quality pH Value: pH was measured by pH meter every 2 hours. Figure (4) show the measurements during the incubation period. It can said that the pH varied from 5.3 at time 8 am to 6.91 at time 6 pm. This results are agreement with those of Nabil (2002) indicated that the embryonic development of grass carp was possible within the range of pH 5.5 - 9.5. During spawning periods in the Tone River of Japan, pH ranged from 6.9 to 7.2 (Tsuchiya 1979).

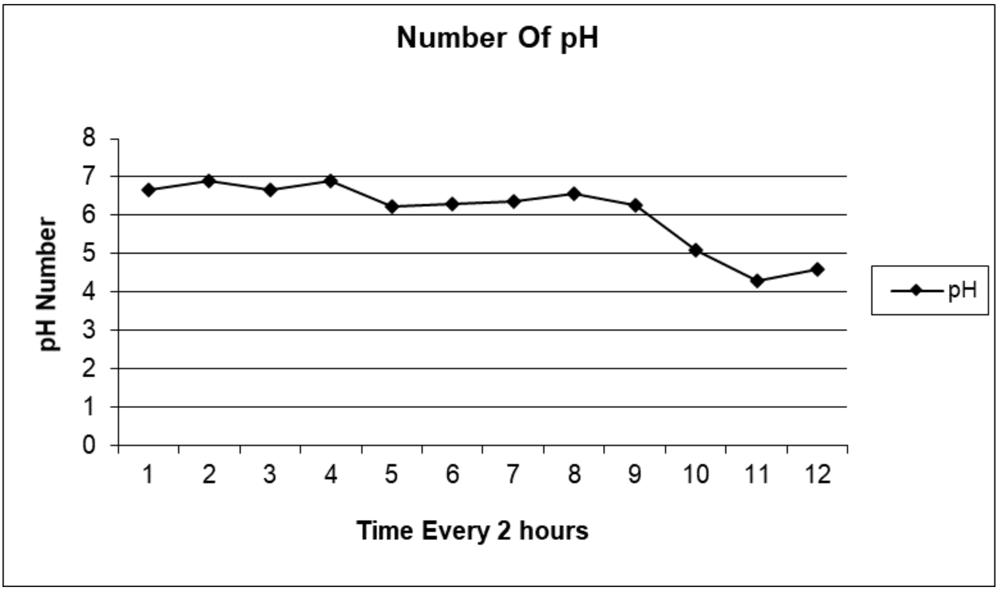

Figure 4. Show pH Number During Incubation Period**.**

Oxygen Concentration:

Oxygen concentration was measured by Oxygen meter every 2 hours. Figure (5) show the measurements during the incubation period. The oxygen concentration was 4.3 and 6.5 mg/l at time 2 am and 2 pm respectively. The hatching process in fish embryos is a critical period during development and is strongly influenced by both temperature and oxygen (Korwin-Kossakowski, 2012). In the present study, warm temperature alone minimally reduced hatching compared to controls, which is not surprising given that California Central Valley Chinook salmon embryos were found to tolerate temperatures up to 16°C in laboratory studies. Fish embryos are particularly susceptible to low DO in their environment during the critical period of hatching (Keckeis *et al.*, 1996). These results are agreement with those by (Dimichele and Malcolm, 1980) dissolved oxygen, pH and temperature were examined as possible environmental cues that might initiate hatching in Fundulus heterolitus. Incubation in or transfer to water adjusted to ranges of salinity, pH, and temperature within the physiological range of the species had no direct effect on hatching. Eggs incubated in water with dissolved oxygen concentrations greater than 6 ml O2/L or solutions of Carbowax PEG 4000 producing an osomotic flux of water out of the eggs delayed hatching indefinitely. Eggs hatch by incubation in highly oxygenated water hatched normally when placed in water of 4 ml O2/L or less.

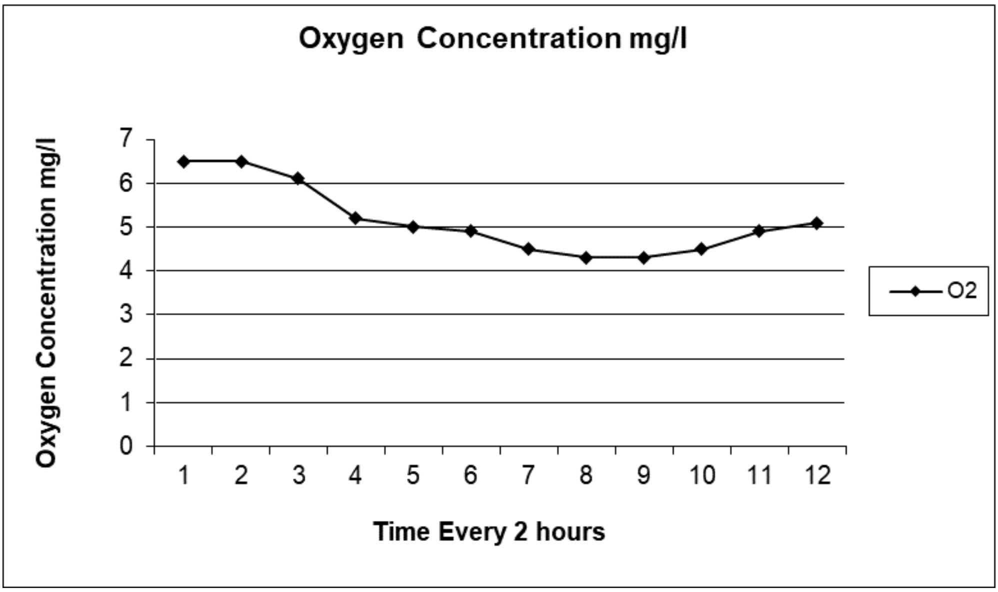

Figure 5. Show Oxygen Concentration During The Incubation Period.

Temperature:

Temperature degree was measured by Oxygen meter every 2 hours. Figure (6) show the measurements during the incubation period. It can said that the degree of temperature varied from 21.2 ^{o}C at time 8 am to 23.5^{o}C at time 2 pm.

Rashid *et al.* (2014) cited that Hatching and incubation mainly depends on temperature, because of low temperature in Kashmir valley comparing to other regions of India, hatching period was recorded as 20-30 hours after fertilization at temperature 24-26°C. Murphy and Jackson (2013) reviewed the literature on the relationship between incubation time and temperature and found a curvilinear relationship. The data presented to the for grass carp of hatching rate similarly (Tsuchiya 1979) were indicated that hatching times were slightly greater than for silver carp (i.e. 25 hr at 28ºC, 28 hr at 25ºC, and 47 hr at 20ºC).

On the other hand, the grass carp is a pelagophilic spawner in relatively-large rivers. Breeding migrations commence when water temperature reaches 15-17°C (Aliev 1976).

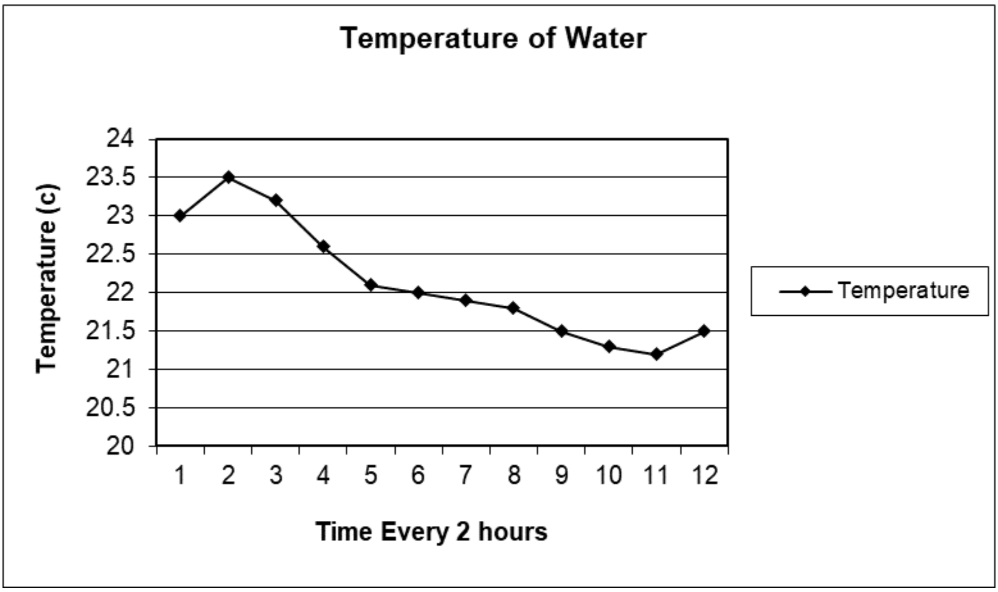

Figure 6. Show Degrees Of Temperature During Incubation Period.

Hatching Ratio:

The effect of water flow rate and density of eggs in Zugar on hatching ratio is shown in Fig. 7. It can be said that hatching ratio was increasing with low level of water flow rate and decreased significantly to 10 % with high level of water flow rate233 ml/min. Hatching ratio was increased significantly to 12 % with increasing number of eggs per liter 150 eggs/liter in low level of water flow rate. Hatching ratio in Zugar in water flow rate 77, 155, and 233 ml/min were 65, 44, and 10 % at 75 eggs/liter, 68,50, and 12 %at 150 eggs/liter, and 70, 53, and 15% at 225 eggs/liter respectively.

The effect of water flow rate and density of eggs in Poultry Drinker on hatching ratio is shown in Fig.8. It can be said that hatching ratio was increased significantly to 35% with low level of water flow rate 155 ml/min and decreasing with high level of water flow rate. Hatching ratio increasing with increasing number of eggs per liter in low level of water flow rate. Hatching ratio in poultry Drinker in water flow rate 77, 155, and 233 ml/min were 61, 35, and 2 % at 75 eggs/liter, 60, 41, and 5% at 150 eggs/liter, end 58, 42, and 6% at 225 eggs/L respectively. On the other hand, (Soliman *et al.*, 2019) showed that the highest values for each hatching ratio and fry production in eggs incubator of common carp (*Cyprinus carpio*) were increased significantly after exposed the eggs to high flow rate of water and high density of eggs.

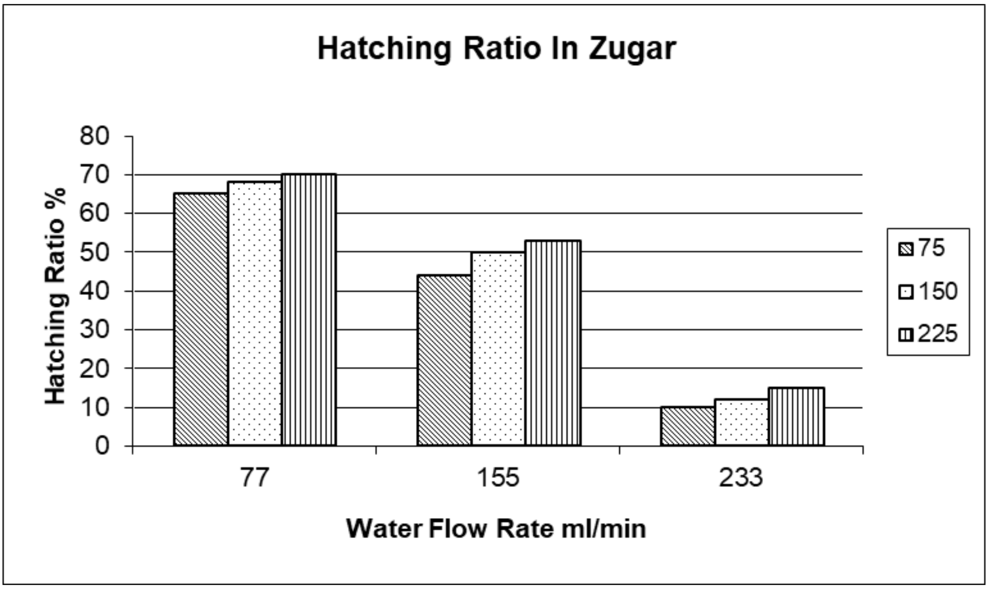

Figure 7. Effect Water Flow Rate And Density of Eggs on Hatching Ratio In Z.J.

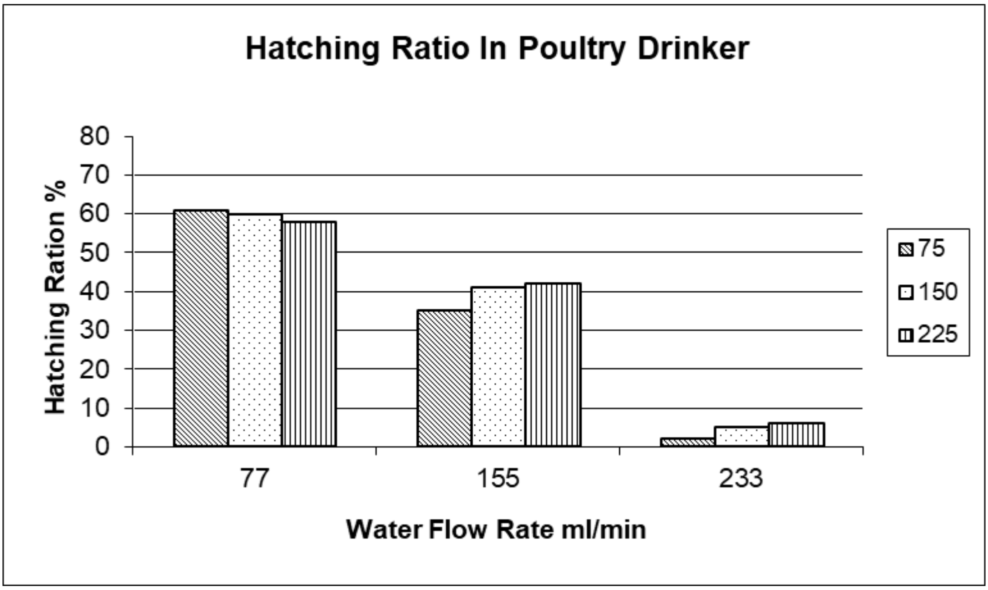

Figure 8. Effect Water Flow Rate And Density of Eggs on Hatching Ratio In P.D.

Fry Production:

The effect of water flow rate and density of eggs in Zugar on fry production was shown in Fig.9, the hatching ratio was increasing to 0.44 fry/liter with 77 ml/min low level of water flow rate and decreasing with high level of water flow rate. Hatching ratio increasing to 0.05 fry/liter at 150 eggs/liter with increasing number of eggs per liter in low level of water flow rate. Fry production in Zugar in water flow rate 77, 155, and 233 ml/min were 0.44, 0.12, and 0.02 fry/liter at 75 eggs/liter, 0.91,0.34, and 0.05 fry/liter at 150 eggs/liter, and 1.41, 0.53, and 0.1 fry/liter at 225 eggs/liter respectively.

Also in this work, the effect of water flow rate and density of eggs in Poultry Drinker on fry production is shown in Fig. 10. It can been showed said that hatching ratio was increasing to 0.8 fry/liter at 77 ml/min with low level of water flow rate and decreasing with high level of water flow rate. Hatching ratio was increasing to 1.17 fry/liter at 225 eggs/liter with increasing number of eggs per liter in low level of water flow rate. Fry production in Poultry Drinker in water flow rate 77, 155, and 233 ml/min were 0.41, 0.12, and 0.01 fry/liter at 75 eggs/liter, 0.8,0.28, and 0.02 fry/liter at 150 eggs/liter, and 1.17, 0.42, and 0.04 fry/liter at 225 eggs/liter respectively. This is can be attributed to the remarkable increment that occurred in the amount of hatchery eggs compared to the increase of water flow rate . whereas the increase of amount of fry reduce the negative effect of the increase of water flow rate on the fry production .These results are in agreement with those of these (Valeta *et al.*, 2016 and Soliman *et al.*, 2019) showed that the potential to increase fry production in *Orechromius* and common carp by manipulating water flow rate and egg population density combined during incubation.

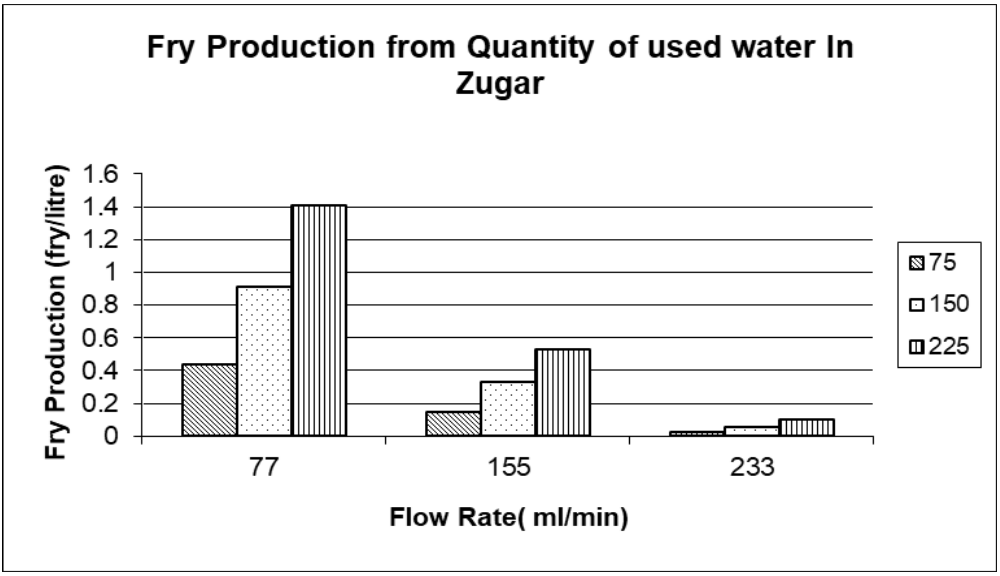

Figure 9. Effect Water Flow Rate And Density of Eggs on Number of fry/litre in Z. J.

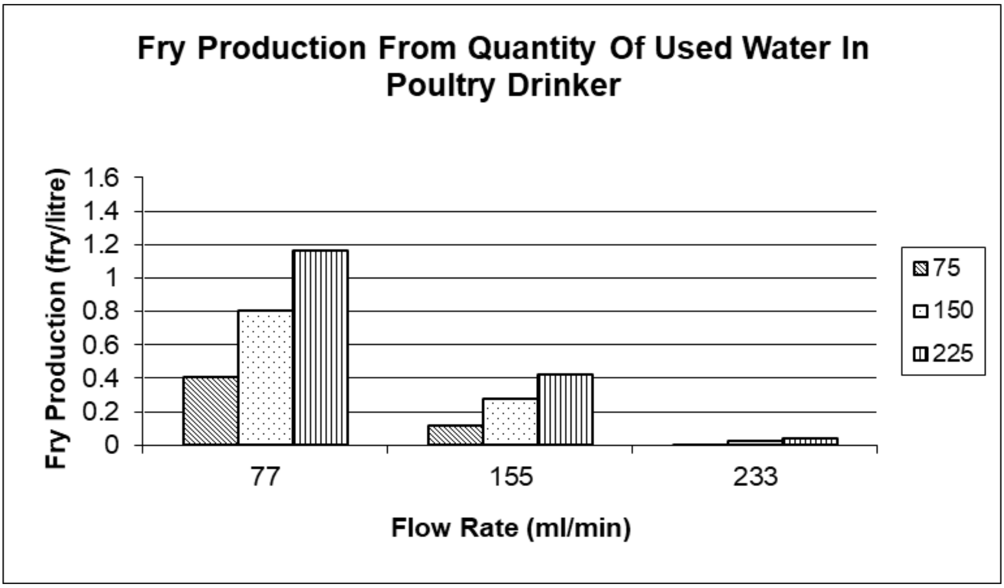

Figure 10. Effect Water Flow Rate And Density of Eggs on Number of fry/liter in P. D.

Cost of Hatching Fry:

Figures (11, 12) depict the cost incurred using Zugar and Poultry Drinker incubator under different stocking density, water flow rate. It can be concluded from these figures that the cost associated with type of incubator was increasing by increasing stocking density. It is interesting to notice that the total cost incurred using lower flow rate was lower than that using higher flow rate. The total cost using Zugar is less than the total cost using Poultry Drinker in the same water flow and the same eggs density.

The Cost of Hatching Fry in Zugar:

Figure (11) show the total cost in Zugar with stocking density 75 eggs/liter was increasing from 0.04 to 0.3 L.E. with flow rate 77 to 233 ml/min and decreasing from 0.04 to 0.01 L.E. with increasing stocking density from 75 to 225 eggs/liter.

The Cost of Hatching in Poultry Drinker Figure (12) show the total cost in Poultry Drinker with stocking density 75 eggs/liter was increasing from 0.05 to 1.4 L.E. with flow rate 77 to 233 ml/min and decreasing from 0.05 to 0.02 L.E. with increasing stocking density from 75 to 225 eggs/liter.

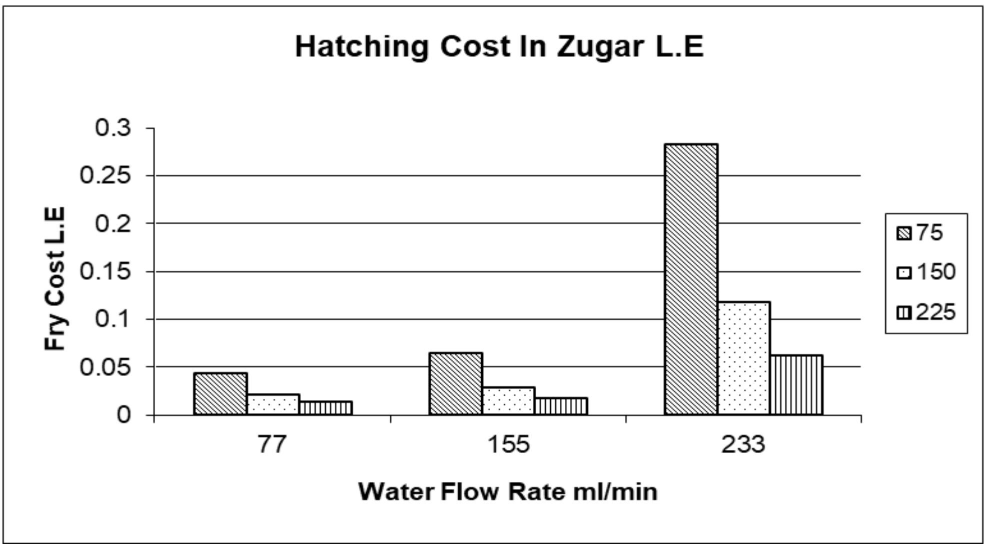

Figure 11. Show Hatching Cost In Z.J. L.E.

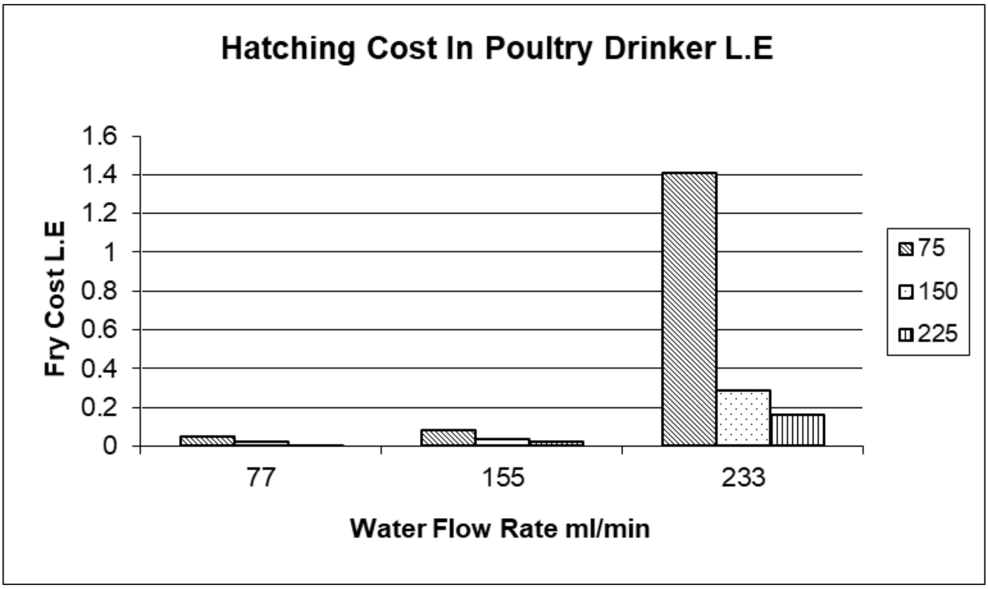

Figure 12. Show Hatching Cost In P. D. L.E.

CONCLUSION

Analysis of the results of the current research can led to using the low following flow rate of water with the eggs of grass carp 77 ml/min for l liter volume of water and it can increasing the density of eggs to 225 eggs /liter and using Zugar for incubation methods because of high hatching ration and production of fry from using water in incubation units.

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تأثير بعض العوامل الهندسية المؤثرة على تحضين بيض مبروك الحشائش

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الملخــــــص العربـــــي

التفريخ فى الأسماك من أهم مقومات تقدم قطاع الثروة السمكية فى العالم مما جعل العمل على زيادة معدلات انتاج الزريعة من المتطلبات الضرورية للتوسع فى إنشاء المزارع السمكية فى مصر. أجريت هذه الدراسة فى المعمل المركزى لبحوث الثروة السمكية بالعباسة بمحافظة الشرقية فى المفرخ السمكى بالمعمل لوضع اسس علمية صحيحة لإنجاح عملية فقس بيض مبروك الحشائش وذلك بواسطة استخدام حضانة بيض الاسماك) سليمان واخرون 2019 (وقد تم دراسة المعاملات الأتية: نوعين من أوعية التحضين) الزيجار سعة 9 لتر، سقاية الدواجن سعة 1 لتر(ثلاثة معدلات سريان المياه) 77، 155، 233 مل/ق (ثلاثة كثافات بيض) 75، 150، 225 بيضة /لتر(. وتأثيرها على معدلات الفقس ومعدل انتاجية المياه المستخدمة من الزريعة مع ملاحظة جودة المياه) الاكسجين، درجة الحرارة، درجة الحموضة (وقد أوضحت النتائج أن نسبة فقس البيض فى الزيجار عند معدلات سريان المياه)77 ، 155 ، 233 مل/ ق(كانت 65% عند كمية بيض 75 بيضة/لتر وكانت 86% عند 150 بيضة/لتر، 70% عند 225 بيضة/لتر. بينما كانت معدلات الفقس فى سقايات الدواجن عند معدلات سريان المياه) 77، 155، 233 مل/ق(61% عند75 بيضة/لتر و60% عند 150 بيضة/لتر، 58% عند 225 بيضة/لتر. كانت معدل انتاجية الزريعة فى الزيجار عند معدلات سريان المياه) 77، 155، 233 مل/لتر(44.0 زريعة/لتر عند 75 بيضة/لتر، 91.0 زريعة/لتر عند 150 بيضة/لتر، 41.1 زريعة/لتر عند 225 بيضة/لتر.

بينما كانت معدلات انتاجية الزريعة فى سقايات الدواجن عند معدلات سريان المياه 77، 155، 233 مل/ق. 41.0 زريعة /لتر عند 75 بيضة/لتر، 8.0 زريعة/لتر عند 150 بيضة/لتر، 17.1 زريع/لتر عند 225 بيضة/لتر .

وقد تراوحت رقم حموضة المياه ما بين 3.5 إلى 9.6 . وتركيز الأكسجين فى المياه ما بين 3.4 إلى 5.6 مجم/لتر.

ودرجة حرارة المياه ما بين 2.21 إلى 5.23 م. لذا يوصى البحث باستخدام الزيجار فى التفريخ حيث كانت أفضل النتائج المتحصل عليها فى الزيجارات بسبب ارتفاع معدل فقس البيض 70% ومعدل انتاجية المياه المستخدمة من الزريعة 4.1 زريعة/لتر عندما كان معدل سريان المياه 77 مل/ق مع كثافة بيض 255 بيضة/لتر.