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# DESIGN AN INCUBATION SYSTEM USING ARDUINO UNO CONTROLLER FOR HATCHING COMMON CARP (*CYPRINUS CARPIO LINNAEUS*) EGGS

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## ABSTRACT

In this paper, the design had been aimed to control water temperature and circulating water system to achieve the better enhancement of hatching fish eggs; Arduino C as software and arduino board and temperature sensor as hard ware. By using arduino uno board provides multiple inputs analogs and input/output digitals to made reading data of sensor, control water temperature degree and water pump operating as desiring. Present study was conducted to induced on breeding of commercially important common carp (*Cyprinus carpio linnaeus*) due to the non-availability of its quality seeds from the natural resources for environmental degradation. This study to investigate the effect of three water flow rate about (110, 230, 350) ml/min for 1 litre volume of water and three number of eggs density (1000, 2000 , 3000 eggs per litre ) on hatching percentage and fry production of water quality mentor (pH , oxygen and temperature) was measured during incubation period every 2 hours until the eggs hatch. The obtained results revealed that the hatching ratio in incubator unite in water flow rate (110, 230, 350 ml/min) were 64%, 65%, 70 % at 1000, 2000, 3000 eggs/liter respectively. On the other hand, hatching ratio in the incubator unite in water flow rate (110, 230, 350 ml/min) were 68 %, 73%, and 77 % at density of eggs 1000, 2000, 3000 eggs/L respectively. Fry production at the third different water flow rate (110, 230, 350 ml/min) were 20.4, 21.9, and 23.1 fry/L at 1000, 2000, 3000 eggs/L respectively. The mean value of pH was 6.0, the mean value of dissolved oxygen was 5.7mg/l, and the mean Degree of temperature was 24$^{o}$C±0.1.

## INTRODUCTION

The multi-functional aquarium equipped with automated thermal control/fodder-feeding/water treatment using a network remote control system. In the product, PC (personal computer) is used as main controller to manage all the sensors. The sensors were connected to the PC controlling system via

different module. The module is the ADC (Analogue to Digital) which convert the analogue signal from the sensors to digital signal so that the PC can read and classify the values. Then, via the VB interface, the client PC can communicate with server-PC to monitor and control the aquarium based on the data from sensors. In the following system, product consists of a PC as center of the system which control and managed the whole system. It is really expensive to allocate a whole PC just to manage the aquarium system. The used of PC as center part of system make it difficult to move the product from one place to another. The solution for the cost and portability issue can be solved by using a single board computer called Arduino Uno board, to replace the PC to function as main controller of the system to operate the system, (Chie C.، 2010). the Design and Development of Automatic Fish Feeder System using PIC microcontroller This device, basically consists of pellet storage, former, stand, DC motor and microcontroller, (Noor *et al.*، 2012 ). The Automatic Arowana Raiser Controller Using Mobile Application Based on Android. This system is called AURORA systems consist of Raspberry pi as microcontroller which is always online and it is connected to sensors like, ultrasonic sensor, temperature sensor and actuator like servo motor to feed, light for aquarium and water pump, (Nurliani *et al.*، 2016). The biggest obstacles in aquaculture are the modernizing fish ponds and the workers to operating methods to monitoring levels of water and temperature degrees and nutrition, so he used Arduino for operating aeration and water pumps using integrating system to reducing the cost and easy to operating and improve efficiency, (Zambri *et al.*، 2018) . We living in the automation area, and we faced difficulties in maintaining their indoor aquariums, and unable to constantly monitor their aquarium, so he directed to using Arduino board monitor which using devices smartphones and laptops, (Shree *et al.*، 2019). Grass carp hatching times varied more 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, (Rowe and Schipper 1985) . In greater depth for the Asian carps (i.e. silver carp, bighead carp and grass carp, (Murphy and Jackson 2013). 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.), (Rashid *et al*., 2014). The poultry drinker and Zugar which were used in incubation, they were consumed large amount of water during incubation period resulting in low fry production, hence there is an problem need to fabricate a simple incubator, with modulated control for the operation parameters to reduce the water consumption during incubation period and consequently increasing the fry production, (Soliman *et al*.، 2019). The present study aims to design an incubator using Arduino board for controlling in induced the hatching of commercially important common carp eggs due to the non-availability seeds from the naturel resources from environmental degradation using simple and cheap incubator represented in the poultry drinker.

## MATERIALS AND METHODS

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

## Hard ware description:

To control the environment condition incubator was used proper condition design of hardware for incubator controlling. There are some parts used in hard ware

### Arduino uno Board.

Arduino uno board is programmable for control relay module and water temperature degree.

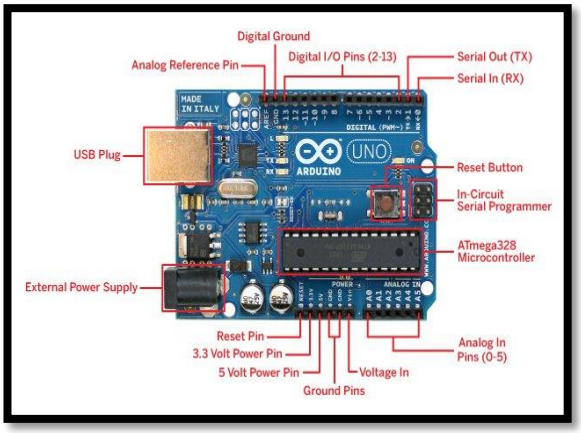


**Figure 1.** Arduino Uno board.

### Temperature Sensor.

This is a prewired and water proofed version of the LM35 sensor all submersible temperature probe, specifically designed to be used in the field. It is used the equation.

Temp = (5.0 * analogRead(tempPin) * 1000.0) / 1024;

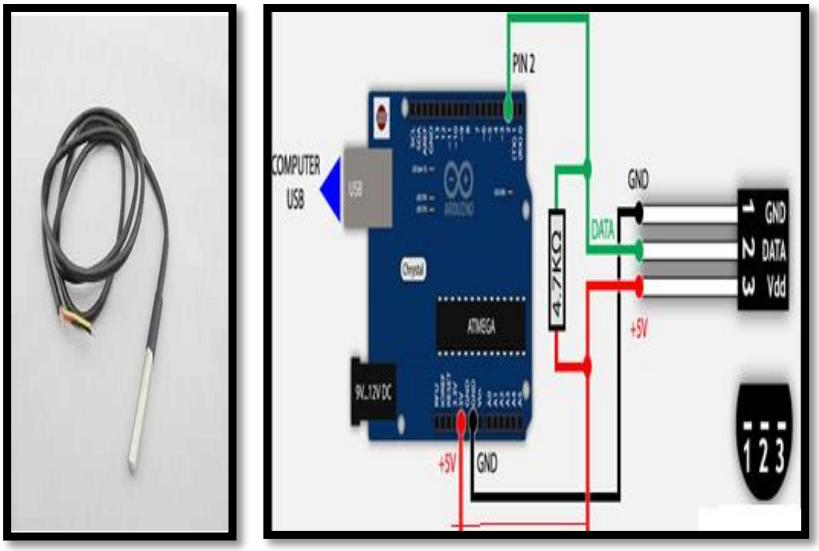


**Figure 2.** Temperature sensor and connection with arduino board.

## Relay module for Arduino.

This relay module consistes of 4 relays. Each relay is connected to a current buffer so that we can connect them directly to Arduino. Using these relays we can easily control high power devices or appliances usin garduino, the relay is rated for 230v 10 amps.

The connections to Arduino (or microcontroller) side: VCC is the supply voltage 5V from Arduino board, IN1 - set to HIGH to set the relay to its "default" state, set to LOW to switch the relay to its alternate state, IN2 - same as IN1, but controls the second relay on the board, IN3 - same as IN1, but controls the second relay on the board, IN4 - same as IN1, but controls the second relay on the board and GND is the ground wire.

The connections to power Device side: NC main that normally close, COM is common and NO is normally open.

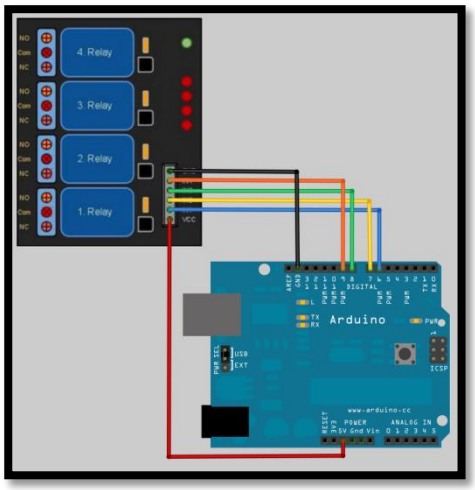


**Figure 3.** Relay module connecting with Arduino board.

## Adapter Power Supply.

This adapter is used to supply Arduino board Dc power with 5V, 1A output. And using power supply 12 V for solenoid valve operation.

**Figure 4.** Adapter power supply.

## Devices:

### Water Pump.

Using water pump submersible 220-240V, 32 watt, 2000 l/h, 2.0m lift to Circulating water through the system.

**Figure 5.** Water pump.

### Air Pump.

Using Air pump to inject air in the water for increasing dissolved oxygen 5watt, 220-240V, Max. flow 3.5l/min.

**Figure 6.** Air pump.

## Water heater coil.

For raising temperature using submersible aquarium heating tank 200 watt, 20-34 ºC.

**Figure 7.** Water heater coil.

## Solenoid valve.

This ¾ inch electric solenoid valve powered by 12V DC with filters on inlet and outlet ports are often used for automatic fluid circulation.

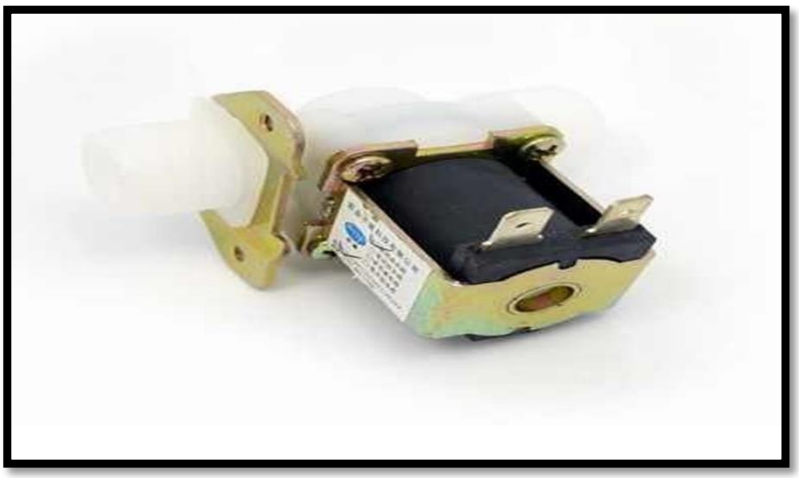

**Figure 8.** Solenoid valve.

## Container of Eggs:

Poultry Drinker is available for any one. It is modified to contain eggs. It is used 1 liter poultry drinker.

**Figure 9.** Poultry drinker.

## Main frame:

Fig. (10) Show view of the main frame. This made of galvanized iron sheet fixed by bolts and washers with dimensions 50 *50 *95 cm. it divided to three roofs 40, 20 and 35 cm.

The main frame contain 3 drawers. One for poultry drinker which contain eggs, one for container fry and the last one for water container which contain water pump, heater, water temperature sensor and air stone.

**Figure 10.** Main frame of incubator.

Fig. (11) Show view of the hatchery egg. This machine was consisted of the following: Fig. (12) Shows view of the new design prototype incubator common carp eggs. The new automated controlled prototype incubator is consisted of the following parts:

**Table. 1.** Show the describation of the new automated controlled prototype incubator

| Symbol | Description |
|---|---|
| 1 | Body of Incubator |
| 2 | Control Unit |
| 3 | Fish Eggs container (Third Shelf) |
| 4 | Valve |
| 5 | Fry Container (Second Shelf) |
| 6 | Container of Storage Water (First Shelf) |
| 7 | Water Pump |
| 8 | Air Stone |
| 9 | Heater |
| 10 | Discharge Valve |
| 11 | Poultry Drinker |

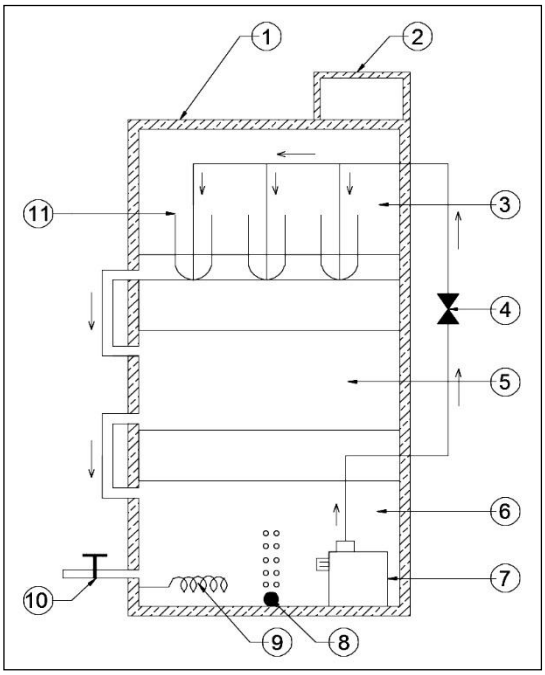


**Fig. 11.** Schematic diagram of the new automated controlled prototype incubator.

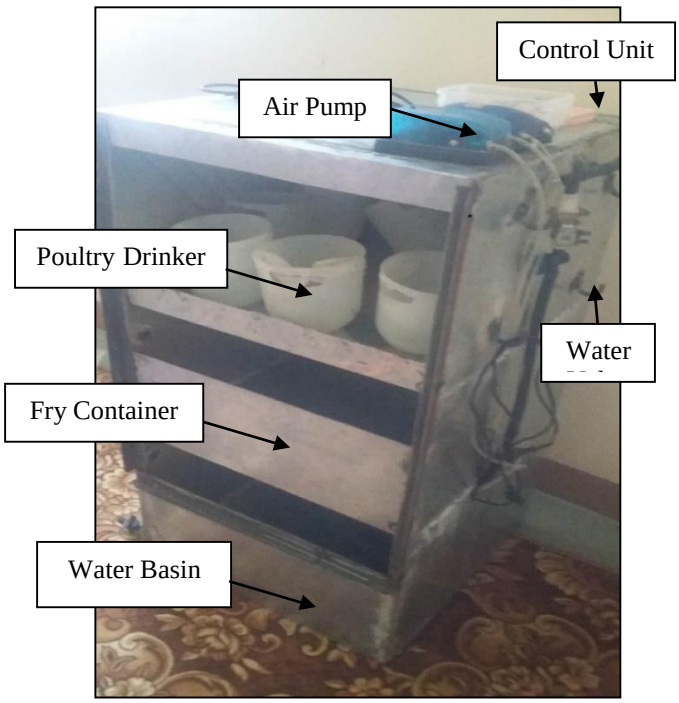


**Figure 12.** View of the new automated controlled prototype incubator.

## Software program:

Arduino C is open source is used to programming Arduino Board to control devices.

### Code controlling water temperature.

```
float temp C;
int reading;
int tempPin = 0;
void setup()
{analogReference(INTERNAL);
Serial.begin(9600);}
void loop()
{reading = analogRead(tempPin);
tempC = reading / 9.31;
Serial.println(tempC);
delay(1000);
}
```

### Code controlling Circulating system.

```
void setup()
{
// Initialise the Arduino data pins for OUTPUT
pinMode(RELAY1, OUTPUT);
pinMode(RELAY2, OUTPUT);
pinMode(RELAY3, OUTPUT);
pinMode(RELAY4, OUTPUT);
}
void loop()
{
digitalWrite(RELAY1,LOW);        // Turns ON Relays 1
digitalWrite(RELAY3,LOW);        // Turns ON Relays 3
delay(2000*60*60);                    // Wait 2 hr
digitalWrite(RELAY1,HIGH);       // Turns Relay1 Off
```

```
digitalWrite(RELAY3,HIGH);        // Turns Relay Off
digitalWrite(RELAY2,LOW);         // Turns ON Relays 2
digitalWrite(RELAY4,LOW);         // Turns ON Relays 4
delay(2000*60*60);                      // Wait 2hr
digitalWrite(RELAY2,HIGH);        // Turns Relay Off
digitalWrite(RELAY4,HIGH);        // Turns Relay Off
 }
```

## Control unit:

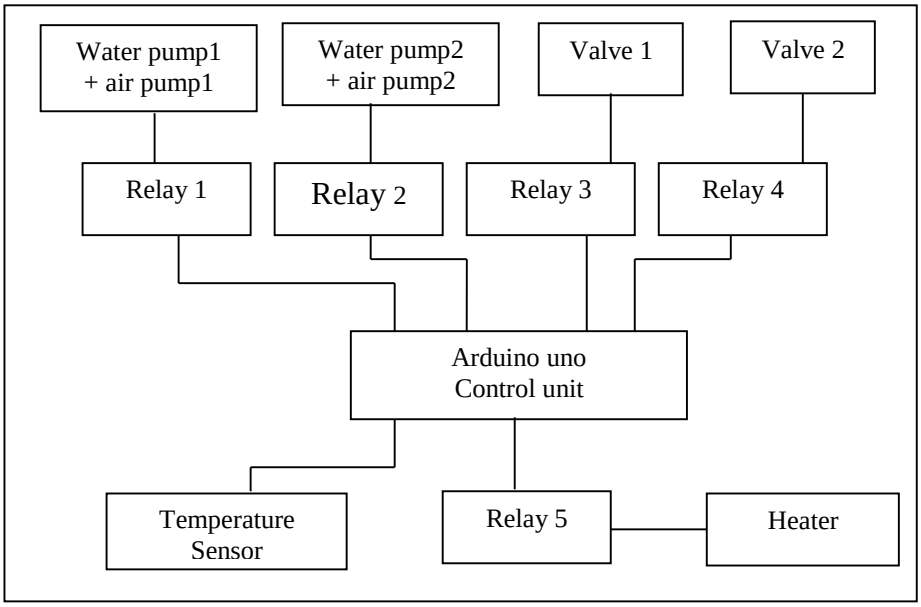


**Figure 13.** Diagram of control unit.

## Common Carp:

Carp are a fast growing fish, which mature at two to four years of age (35 to 45 cm, ~1 kg). Common carp is used to artificial spawning and obtaining eggs for incubator unit.

**Figure 14.** Common carp fish.

## Induction of spawning.

Pituitary gland prepared solution was used for inducing artificial spawning by 3mg/1kg of body weight to female, whereas male was injected by 10% of female dose. The spawning was induced after 12 hours from last injection. The eggs were collected from female and mixed with semen fluids of male and treated with the fertilization solution (0.4% sodium chloride, 0.3 urea carbamide), then the all of eggs were treated with tannin solution to remove any final traces of stickness. After spawning the egg transfer from acclimation tank to incubation units.

## Operational parameter.

At the hatchery of Central Laboratory for Aquaculture Research, common carp was spawning and collecting fertilizing eggs and weight average mass of 1.0 g for determine fertilizing ratio and distributing eggs for each treatment and kept in incubator until hatching. They were then incubating using the unit which design. The experiments were conducted using complete random design in 9 treatments.

Each treatment was replicated three times. Initial bond water analysis, which used to fill in transportation containers were 6.0 mg/l oxygen

concentration, 6.2 pH value. The following combinations are used in forming treatments with poultry drinkers:

1- Three water flow, i.e., 110 , 230 and 350 cm3/min.

2- Three stocking densities, i.e., 1000, 2000 and 3000 g/l.

The following procedures are used during experiments execution:

### Measuring instruments.

Water samples from each treatment were tested to determine the concentration of dissolved oxygen and pH.

### 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 marte, 1990**).

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

### Fry production of water used:

The total amount of water used was 100 liters nearly so the fry production of water used was calculated as:

= (Hatching ration *Number of Eggs* number of poultry drinker) / Amount of Water Used fry/l.

### 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 fry production:

The cost incurred by the incubation unite was estimated using the following equation,

Cost of Fry = Total Cost of Incubator / (Hatching Ratio*Number of Eggs) L.E./fry

Total cost of Incubator =1700 L.E. which including cost of operation and cost of manufacturing.

**Statistical analyses**:

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

## RESULTS AND DISCUSSION

**Water quality:**

pH was measured by pH meter every 2 hours as depicted in Fig. 15. It was varied from to 6.74 in the first day at time 4 P.M and 5.33 in the third day at time 8 P.M.

Oxygen concentration was measured by oxygen meter every 2 hours (Fig. 16). It was 7 mg/l in the third day at time 2 P.M and 4.6 mg/l in the third day at time 4 P.M.

Temperature degree was controlled by Arduino Controller at 24$^{o}$C ±0.1 during all time of incubation in the incubator unite.

Water quality mentor during the incubation period for observe any change in water parameters (pH and Oxygen Concentration). pH levels can fluctuate daily due to respiration in the water. Oxygen Concentration is lower in warmer water. This may be a consequence of cooling water discharge on surface waters due to controlled of temperature which was steady of 24$^{o}$C during the incubation period. That was agree with results of Ali *et al*. (1993) during evaluation of water quality and nutritional status of aquaculture effluent in Saudi Arabia.

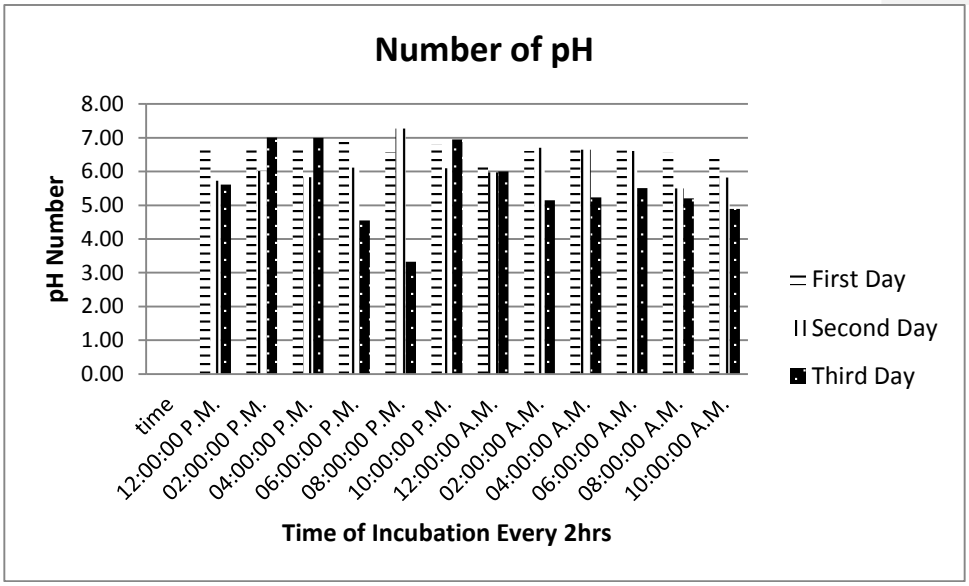


**Figure 15.** Show number of pH.

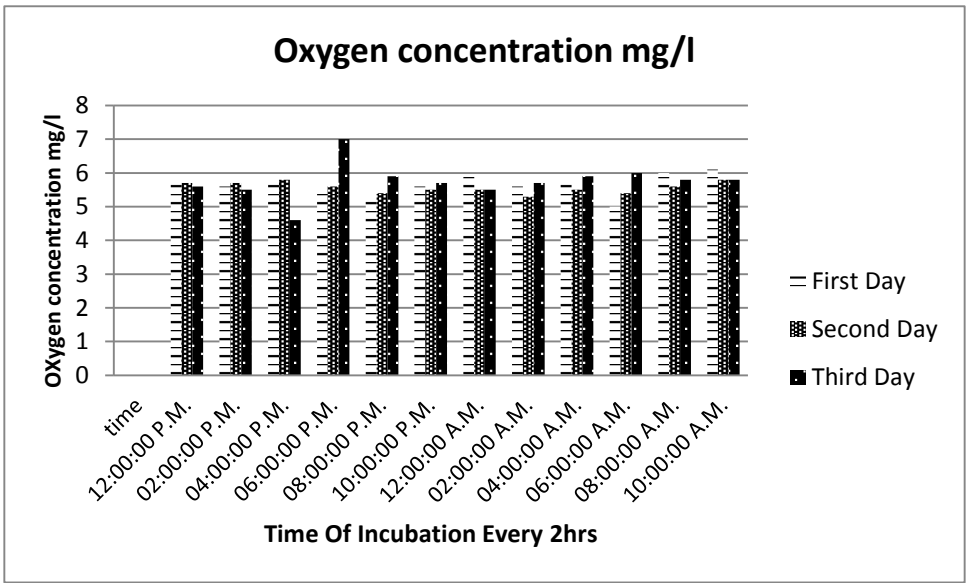


**Figure 16.** Show oxygen concentration mg/l.

## Hatching ration:

Fig. 17. Illustrates the effect of water flow rate and density of fertilized eggs in incubator unite on hatching ratio at the end of incubation period that

extended to three consecutive days. The obtained results showed that the hatching ratio were about 67, 68 and 68 % for eggs density of 1000, 2000, and 3000 egg/L respectively at water flow rate 110 ml/min, while 68, 69 and 73 % at water flow rate of 230 ml/min, and 72 , 75 and 77% at water flow rate 350 ml/min. Generally, there is no significant difference in hatching ratio at the low egg density under all water flow rates but a clear difference appeared at the high egg density of 3000 egg/L, where the increase of egg density from 1000 to 3000 egg/L led to increase the hatching ratio with about 5% and 9% at water flow rate of 110 and 350 ml/min respectively ,hence the highest hatching ratio was achieved at the highest egg density and water flow rate. It is obvious that the increase of water flow rate at the high egg density means renewing the water continuously within the incubator and preventing the sudden collapse of the oxygen concentration resulting in a good increment in the hatching ratio. Furthermore, increasing the water flow rate can give good flipping for eggs that can be led to boost the chances of eggs to obtain the optimum amounts of oxygen. These results are in agreement with those of the Jeffery *et al.*, (1995 )who found that egg cultured in hatching jars at 1200 ml/min flow were lifted into the water column and rolled moderately , this flow rate significantly increased the present hatch due to the control of fungals while the eggs in hatching jars at 300 and 600 ml/min flow rate exhibited to egg movement and reduced hatching success.

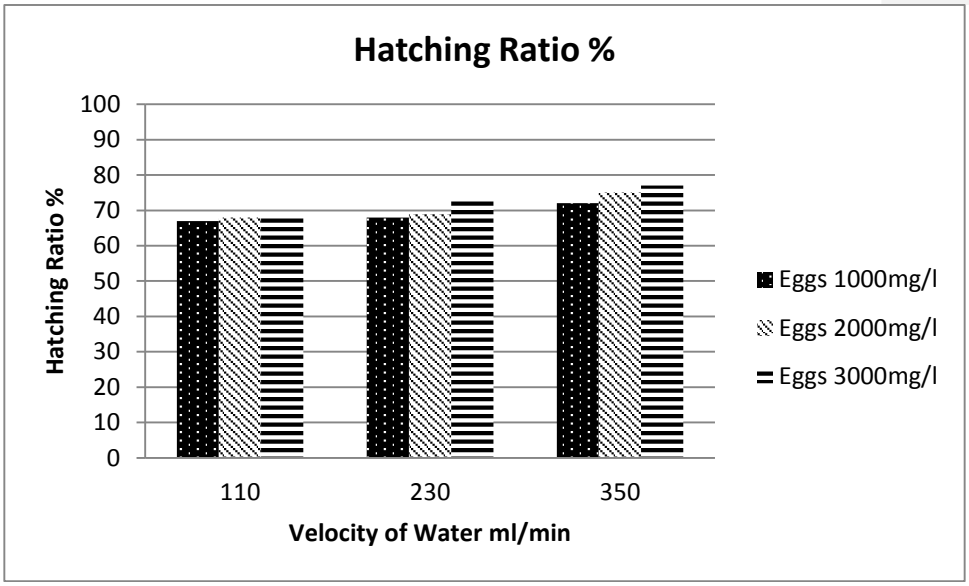


**Figure 17.** Show hatching ration %.

## Production fry of water used:

The fry production is the number of fry per the unit of water volume used, in other words it is an important indicator for efficiency of using water during the incubation period. Concerning to the incubation of common carp eggs in poultry drinker, Fig.18 depicts the effect of density of eggs and water flow rate on fry production after three days of incubation. The obtained results showed that the consumed water at the end of incubation period were about 100 L corresponding to fry production of 6.7, 13.6,and 20.4 fry/L for eggs density of 1000, 2000, and 3000 eggs/L, respectively using flow rate 110 ml/min. Moreover, the increasing water flow rate of 350 ml/min were fry production of 7.2, 15,and 23.1fry/L for eggs density of 1000, 2000, and 3000 eggs/L, respectively. At constant water flow rate, the fry production increased by increasing the density of eggs due to the increase of hatching ratio and the constant flow of water, whereas the fry production increased by increasing the water flow rate from 110 to 350 ml/min. This is can be attributed to the remarkable increment that occurred in the amount of hatched 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 rat on the fry production. The effect of water flow rate and density of eggs within the

incubation unite on fry production is shown in Fig. 18. Which depicts the effect of density of eggs and water flow rate on fry production after three days of incubation. where at constant water flow rate, the fry production increased by increasing the density of eggs due to the increase of hatching ratio and the constant amount of using water, whereas the fry production increased by increasing the water flow rate from 110 to 350 ml/min. This due to the increase of amount of fry is higher than the increase of water flow rate at constant incubation time. These results are in agreement with those of the Valeta *et al*. (2016) indicated that there is potential to increase fry production by main pulating water flow rates and egg population density combination during incubations .

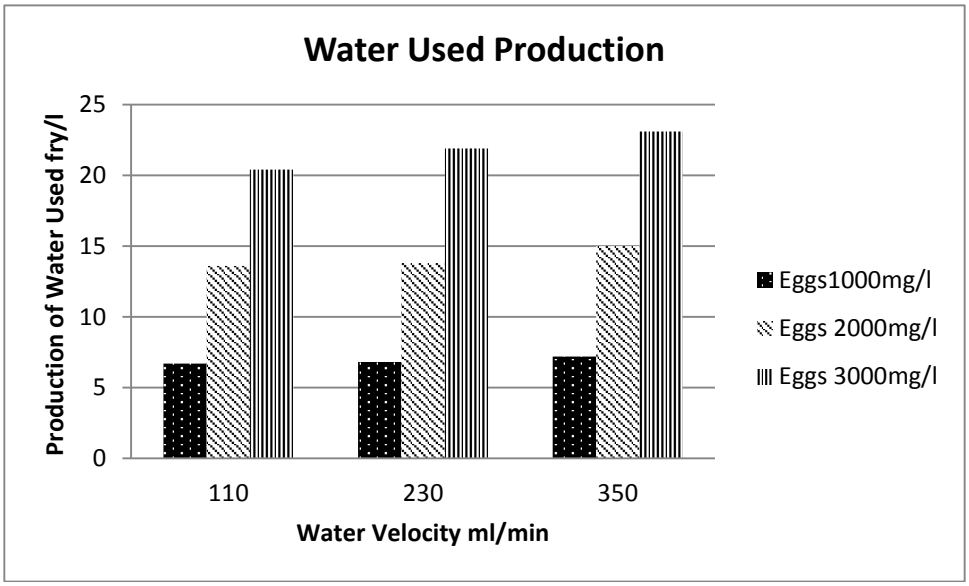


**Figure 18.** Show Water Fry Production of Water Used fry/l

## Cost of production fry:

Fig. 19. Show the cost of fry production through the hatching period in the incubator unite. It shows that the cost of fry with 110 l/min water flow rate was 0.28, 0.14 and 0.09 L.E/fry with eggs of density 1000, 2000 and 3000 mg/l respectively, the cost of fry with 230 l/min water flow rate were 0.28, 0.14 and 0.09 L.E/fry with eggs of density 1000, 2000 and 3000 mg/l respectively, and the

cost of fry with 350 l/min water flow rate were 0.26, 0.13 and 0.08 L.E/fry with eggs of density 1000, 2000 and 3000 mg/l respectively. The results of cost show that the cost with low eggs of density is higer than the cost with high eggs of density due to of decreasing of number of fry in the incubation unite which led to increasing of the cost; while the cost is decreased through the increasing water flow rate due to of increasing of hatching ratio which led to decreasing the cost of fry production.

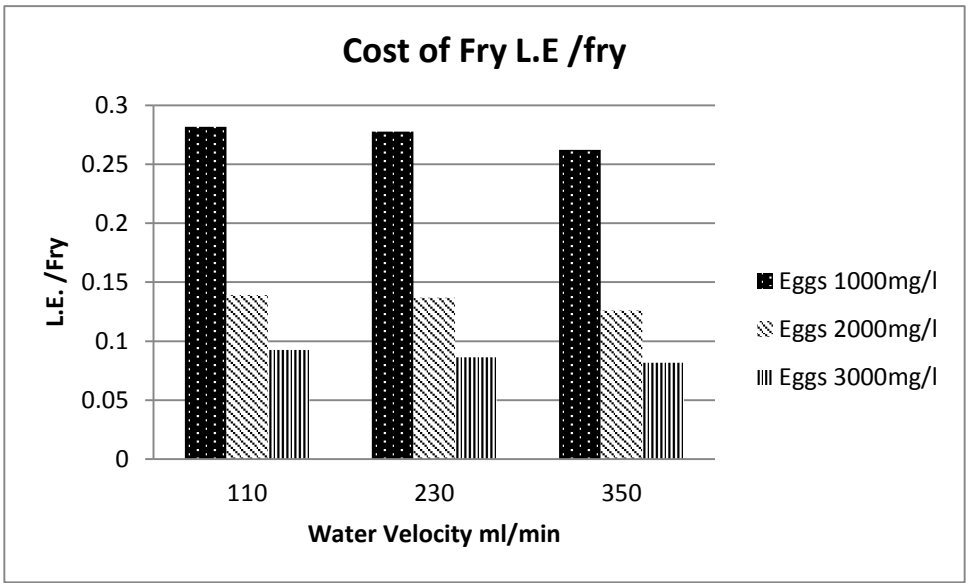


**Figure 19.** Show cost of production fry L.E/fry.

## CONCLUSION

The best results for the hatching ratio and fry production, particularly at high water flow rate and eggs density was achieved by using the Arduino Uno controller unite and still has the advantage of the low cost comparing to the other controller systems. Generally, the automatic of incubators consumed small amount of water during incubation period resulting in high fry production and reducing cost of operation unite, but it has still need more moderate and adaptation for using through the farmers.

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# تصميم نظام تحضين بواسطة المتحكمة اردوينو اونو لتفريخ بيض أسماك المبروك العادى

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[٢] قسم الهندسة الزراعية، كلية الزراعة، جامعة الزقازيق، الشرقية، مصر.

## الملخـــــص العربـــــي

تم اســـتخدام أردوينو كنترولر للتحكم فى الحضـــانة للعمل على انخفاض تكلفة الحضـــانة عن استخدام كنترول كلاسيك فى التحكم والمرونة باستخدام البرمجة وخاصة لغة البرمجة أردوينو سى فى كتابة كود التحكم كما أن هناك إمكانية للبرمجة بأكثر من لغة متاحة للجميع. وتقليل اســـتخدام المياه وزيادة معدل إنتاجية الفقس من المياه المســـتخدمة نتيجة الاتجاه إلى ترشـــيد استهلاك المياه وخاصة المياه العذبة. تم استخدام معدلات سريان مياه (١١٠، ٢٣٠، ٣٥٠ مل\ق) لكل واحد لتر من المياه مع كثافة بيض ( ١٠٠٠ ، ٢٠٠٠ ، ٣٠٠٠ بيضة\لتر) . وكانت نتائج نسبة الفقس ٦٤، ٦٥، ٧٠ % عند ١٠٠٠ بيضة \ لتر. بينما كانت ٦٨، ٧٣، ٧٧ % عند كثافة ٣٠٠٠ بيضة \ لتر عند معدلات سريان مياه (١١٠،٢٣٠، ٣٥٠ مل\ق). ولذلك توصى الدراسة باستخدام كثافات بيض ٣٠٠٠ بيضة فى اللتر بمعدل ســـريان مياه ١١٠ مللى لتر/ دقيقة عند درجات حرارة ٢٤ درجة مئوية واســـتخدام مصـــدر أكســـجين باستخدام مضخات هواء لجعل تركيز الأكسجين ٥,٥ مجم/لتر والرقم الهيدروجينى pH ٦ خلال فترة تحضـــين البيض وذلك لقلة تكاليف عملية تفريخ البيض للأســـماك بما يناسب المشروعات الصغيرة لذلك استخدام نظم التحكم الحديثة فى الحضانة ساعدت على زيادة الانتاجية لكل لتر مياه مع توفير كمية المياه المستخدمه فى التفريخ باستخدام الكثافة الاعلى مع معدل السريان الاقل.