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DEVELOPMENT OF A SYSTEM FOR THE AUTOMATION OF A HATCHERY FOR THE PROCESS OF HORMONE TREATMENT OF TILAPIA FRY USING ARDUINO

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Abstract -- This article shows the implementation of a system for the automation of the process of hormone treatment of tilapia fry, the system consists of two parts, the first part monitors environmental variables of the water such as pH and temperature as well as the water level that together determine the ideal conditions for the hormone treatment process and the second part is the feeder that provides food to the species aged 0 to 2 months. The system uses as control device the arduino mega 2560 microcontroller and a set of sensors that allow the system to provide optimal conditions for the proper development of hormone development.

Keywords: Automation, arduino mega, ph, temperature, tilapia.

Abstract -- This article shows the implementation of a system of automatization for the hormonization of the tilapia fingerlings. The system consists of two parts, the first one monitors environmental variables in the water, like the PH or the temperature as the water level, wich in group, determines the ideal conditions for the hormonization process, and the second part is conformed by the feeder that provides the food to this spice during its first two months of life. The system uses an ARDUINO MEGA 2560 as microcontroler and a group of censors that allow the system propices the correct conditions for a good develpment of the hormonization.

Key words - Automation, arduino mega, ph, temperature, tilapia.

INTRODUCTION

Aquaculture, as a multidisciplinary activity, is a productive enterprise that uses knowledge of biology, engineering and ecology to help solve nutritional problems, and according to the type of organisms that are cultivated, it has been divided into several types, one of the most developed being fish farming or fish culture, and within this, the most widely used fish worldwide is tilapia [1]. Aquaculture processes have seen the need to be at the forefront in the demand for food and in the technification of their crops. In order to make aquaculture friendly crops as a profitable and sustainable option for aquaculture farmers.

Sexual reversion in fish is aimed at achieving the largest population of male fish, and numerous investigations have been carried out over time and have been practiced in amphibians and birds. The first attempts at sexual reversal in fish took place in the 1930s [2]. Within the research, different hormones, concentrations, treatment periods, temperatures, among other variables have been evaluated, according to the tilapia species. The most commonly supplied method is the hormone 17-α-methyltestosterone, within 28 days. The economic relevance of the investment in a tilapia culture is the culture of a monosex (males) because of the yield, control population and weight gain in less time.

The process of sexual reversion has a positive correlation with the continuous supply of 17-α-methyltestosterone hormone feed, as well as abiotic factors such as pH and temperature, this is implemented in a closed recirculation system, where the process is automated, controlling the amount of feed supplied.

DEVELOPMENT

System design considerations

The species (Tilapia)

Tilapia (Oreochromis niloticus)

Tilapia are mainly freshwater tropical organisms originating from the African continent, which are currently distributed in most tropical and subtropical countries for farming purposes. [3].

Biological Traits of Tilapia

Body compressed; the depth of the caudal peduncle is equal to its length. Cycloid scales. Protuberance absent on the dorsal surface of the snout. The length of the upper jaw does not show sexual dimorphism. The first gill arch has between 27 and 33 gill filaments. The lateral line is interrupted. Continuous rigid and soft spines on dorsal fin. Dorsal fin with 16 or 17 spines and 11 to 15 rays. Anal fin has 3 spines and 10 or 11 rays. Truncated caudal fin. These genetic characteristics are considered for the selection of broodstock, a variable that is reflected in the quality of the offspring, together with good feeding in the process of sexual reversion and the maintenance of a genetic line [4]. Figure 1 shows the main bilogical traits of tilapia.

Figure 1. Biological Traits of Tilapia.

Tilapia reproduction

Reproduction takes place in ponds or tanks. The seeding ratio between females and males is 4:1. In the facilities of the TecNM campus Instituto Tecnológico de Salina Cruz, there is a tilapia reproduction area, from which hatchlings and eggs were obtained and immediately transferred to the automated system.

For the design and development of the hatchery automation system, it was necessary to analyze, identify and determine the environmental requirements to carry out the process of hormone treatment of tilapia, in addition to considering the distribution characteristics, it was determined to maintain the optimum temperature range of 28-30°C, since this does not stress the fish and its feeding is optimal.

Table 1 shows the ideal environmental parameters for the hormone production process.

Table 1. Environmental parameter requirements for tilapia hormone processing.

Factor	Requirement
Temperature	25-30° C
Dissolved Oxygen	5 mg/l
Hydrometric Potential (PH)	6-9 hydrogen ions

Hormonal feed

The feed was formulated with the hormone 17-α-methyltestosterone, obtained from the Tilanet Veracruz farm, a producer of reverted tilapia hatchlings, and was supplied immediately after yolk sac absorption by the fry, considering that their digestive tract has matured and they can feed exogenously. It is important to initiate feeding at a rate of 15-30% of body weight daily or feeding to satiety (ad libitum) is another option when hormonal feed is being provided. It is recommended to feed fry a minimum of 8 times per day when they are subject to a hormone process.

The efficiency of the process depends on a continuous and constant supply in time and weight.

Hardware to be used

The hardware used for the development of the system mainly consists of the Arduino Mega 2560 board and the set of sensors and actuators used to monitor the physical variables of the water such as the pH sensor, the temperature sensor and the level sensor, in addition to the servo motors used to power the system.

Arduino Mega 2560

Arduino Mega 2560 is a board based on the ATmega 2560 microcontroller working at a frequency of 16 MHz. Its most notable features are: 54 digital input/output pins (of which 15 can be used as PWM analog outputs), 16 analog inputs and 4 TTL-UART serial receivers/transmitters. It consists of a 256 KB flash memory of which 8 KB are used by the bootloader, 8 KB of SRAM and 4 KB of EEPROM memory which can be read and written through the use of a library. Figure 2 shows the board and its approximate dimensions [5].

DS18B20 submersible temperature sensor

The DS18B20 sensor communicates over a 1-wire bus which, by definition, requires only one data line (and ground). It does not require an external power supply.

Figure 2. Arduino mega 2560.
SOURCE: https://store.arduino.cc/usa/mega-2560-r3

Table 2 shows the technical characteristics of the temperature sensor [6].

Table 2. Characteristics of the DS18B20 sensor.

Feature	Value
Voltage feeding	3V to 5.5 V
VDD	Supply voltage
GND	Earth
DG	Data
Temperature range	-55°C to 125°C
Error(-10°C to 125°C)	± 0.5°C
Error(-55°C to 125°C)	± 0.2°C
Resolution programmable	9-bit, 10-bit, 11-bit or 12-bit (default)

pH sensor with submersible probe

Analog pH meter, for Arduino controllers has a simple connection. It consists of an LED that functions as a power indicator, a BNC connector and a PH2.0 sensor interface. Table 3 shows the technical characteristics of the sensor [7].

Table 3. Technical specifications of the submersible ph sensor.

Feature	Value
Module power	5.00V
Module size	43 mm× 32 mm
Measuring range	: 0-14PH
Measuring temperature	0-60 °C
Accuracy	± 0.1pH (25 °C)
Response time	≤ 1 min
pH sensor	with BNC connector
Interface	PH2.0 (3-foot patch)
power indicator	LED
Sensor cable length to BNC connector	660 mm

Water level sensor

It is an electronic device that allows detecting the water level. Table 4 shows the technical characteristics of the level sensor to be used. This sensor acts as a switch or switch that changes state when the water level reaches the moving part of the sensor and when it is lowered density will run according to the height of the water [8].

Table 4. Level sensor characteristics.

Feature	Value
Dimensions	68 mm x 24 mm
Operating current	0.5 A
Maximum power	10w
Contact resistance	100Ω
Operating temperature	-10~ 60℃

MG995 Servomotor

Synchronous electric motor which can be controlled both in speed and position. It has the ability to rotate its axis a certain angle based on a signal generated by an external control circuit. It has an integrated detector that allows to know its positioning and/or speed. For zero speed: It can be placed in any position and remains stable in this position. They operate on the principle of proportional control. The amount of voltage applied to the servomotor is proportional to the distance it needs to move. Table 5 shows the technical characteristics of the servomotor [9].

Table 5. Technical characteristics of the MG995 servomotor.

Feature	Value
Voltage from operation	4.8 to 7.2 V
Speed operating speed	0.2 s/60º (4.8 V), .16 s/60º (6 V)
Angle of rotation	120º approx. (60º in each direction)
Torque stopped	8.5 kgf·cm (4.8 V), 10 kgf·cm. (6 V)
Dead band:	5 µs
Weight	55g
Dimensions	Length 40.7 mm, width 19.7 mm, height 42.9 mm approx.

System design

As already mentioned, the system is divided into two parts or subsystems, the first is the monitor that starts with the pH, temperature and clock, controlled by the microcontroller of the arduino mega, which sends information to the LCD, in addition to evaluating the pH and temperature levels allowing the activation of the thermostat and pumps for recirculation of water from tank 1 to tank 2. The second part is the feeder responsible for providing hormone food to the fry, every hour for 10 hours a day. Figure 3 below shows the general scheme of the system with its two subsystems.

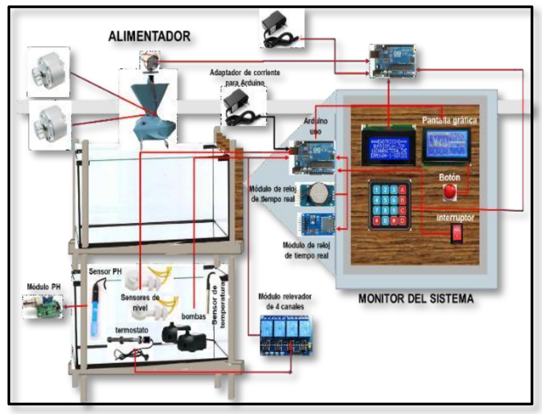

Figure 3. General scheme of the automated system for hormone treatment.

Figure 4 shows the block diagram of the monitoring stage, which allows the identification of the different modules that integrate it. Similarly, Figure 5 shows the block diagram of the feeding subsystem, which is in charge of supplying hormone feed to the tilapia fry.

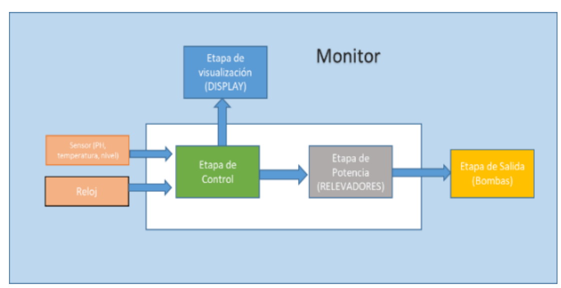

Figure 4. Block diagram of the monitoring subsystem.

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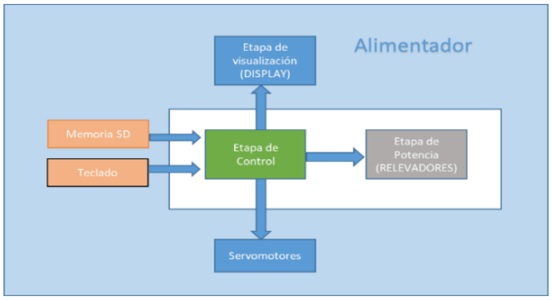

Figure 5. Block diagram of the power subsystem.

Figures 6 and 7 below show the connection diagrams of both subsystems.

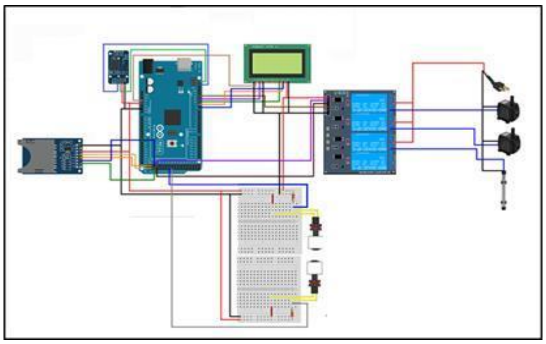

Figure 6. Wiring diagram of the monitoring subsystem.

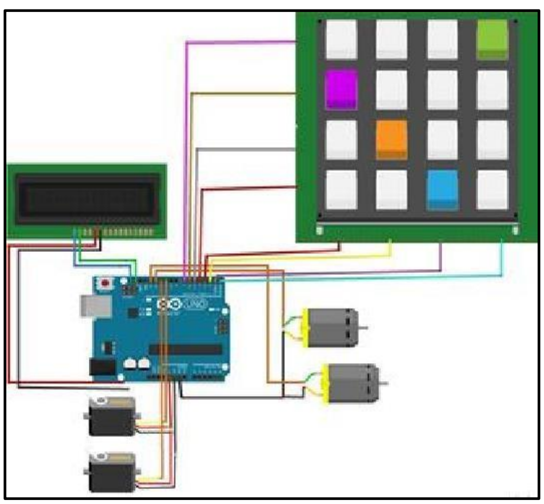

Figure 7. Power subsystem connection diagram.

Figure 8 shows the proposed dimensions for the structure, the monitor box and the feeder.

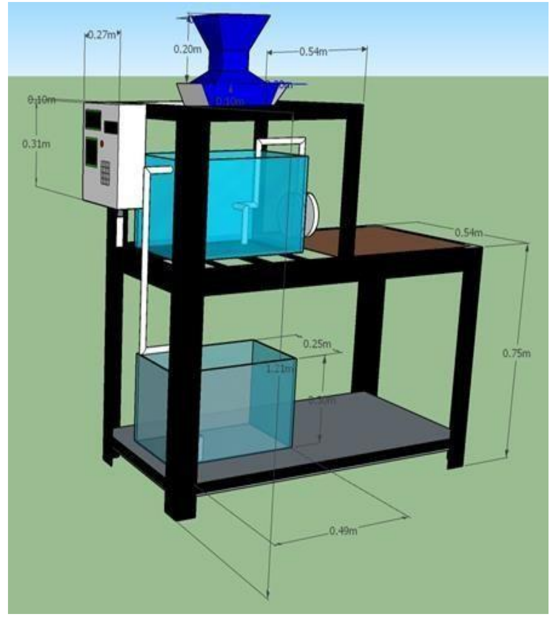

Figure 8. Dimensions of the feeding system structure for the hormone processing.

Implementation

The automated system was developed using a metallic structure, which supports the two 1.21x0.50x0.25m glass fish tanks. On the upper part there is a plastic feeder with dimensions of approximately 25cm high located exactly on a support on the upper tank and on one side the metallic box with an aluminum frame door with dimensions of 0.31m x .27x .10m, which contains all the electronics and connections of the sensors and the monitor.

It also contains an MDF table as an extension for maneuvering in the system and food preparation, as shown in Figure 9.

The monitor identifies if the value obtained by the pH census shows values above 8, the system activates the water pumps, recirculating the water from tank 1 to tank 2 until values below 7.5 pH are obtained. Likewise, as soon as the monitor identifies water temperature values below 25°C, turns on the thermostat and turns it off when it reaches 32°C. Figure 10 shows the front view of the monitor, which contains a 2x16 display used to show the menu for selecting the number of

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The system also has a graphic display that allows the user to observe the values measured by the system, as well as the system's power buttons, and Figure 11 shows the internal connection of the monitor.

Figure 9. Automated system for hormone treatment of tilapia fry.

Figure 10. Front view of the monitor.

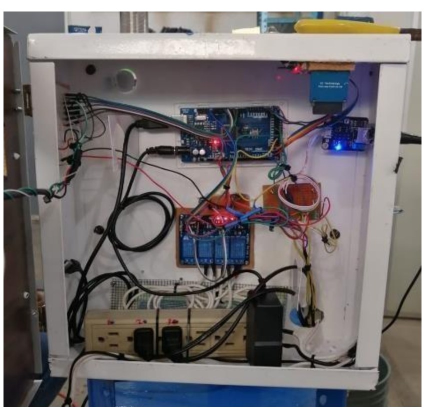

Figure 11. Internal view of the connections on the monitor.

DISCUSSION AND ANALYSIS OF RESULTS

The system was able to monitor the physical environmental variables necessary to hormone tilapia fry, in the first tests it was observed that the pH sensor after 5 days of hourly sampling gave very unstable results, so the sampling intervals were modified.

The arduino was programmed with its modules and communication with the sensors, the pumps associated with the operation of the pH sensor were activated and finally tested with different water temperatures to corroborate the activation of the thermostat when a temperature lower than 25° was identified.

The data obtained were recorded and stored in SD memory in a format to be read in Excel.

On the other hand, the feeding system with the design employed allows activating and deactivating the necessary mechanisms to provide the hormone feed, the system starts the feeding process from 7:00 am to 18:00 hrs, feeding a total of 12 times a day for 5 seconds at a time, for 28 days, which is the storage capacity of the feeder.

The results were obtained using a prototype feeder and the method of feed delivery was calculated volumetrically in addition to considering the number of fish.

The food delivery samples were taken and we proceeded to measure whether the portion was correct, so adjustments had to be made not only in the programming of the arduino but also to the delivery mechanism, since after 10 days of feeding it was identified that the humidity in the environment and the physical constitution of the food itself made the food too compacted, preventing the exact delivery of the food.

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CONCLUSIONS

The automated system for the process of hormone treatment of fry provides many advantages to the aquaculture area of ITSAL, firstly with the delivery of the exact food portions, allowing the efficiency of the hormone treatment process, since it is directly proportional to the growth of the fish and weight gain, addition to maintaining the ideal environmental conditions of the water so that the sexual reversion of the fry can develop in an ideal way.

The results obtained allow us to demonstrate that the automated system with the arduino Mega 2560 inputs used are sufficient for the number of sensors that were proposed to monitor the hormone process.

RECOMMENDATIONS

For the feeder to deliver portions more accurately, it is necessary that the hormone feed is completely dry to prevent the feed from solidifying before delivery.

It is necessary to verify that the fry are not leaking from the recirculation system in addition to accelerating the change in the pH reading of the system.

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