CHAPTER ONE

INTRODUCTION

Ornamental fish is becoming very popular throughout the world as it requires simple operating system and less operating costs. At present, ornamental fisheries are having a global trade recognition. The demand of aquarium fishes or ornamental fishes are increasing in Bangladesh day by day. Traditionally, the people of Bangladesh are a pleasure seeker in nature. It has a great potential for ornamental fish domestication not only through indigenous species but also to furnish with exotic varieties.

There are over 30,000 fish species reported around the world and 800 belong to ornamental fishes (Thomas, 2020). Aquarium fish are mainly categorized into two groups, namely egg layers (oviparous) and live bearers.

Photoperiod is an important environmental factor that directly or indirectly influences fish growth, feeding, locomotors activity, metabolic rates, body pigmentation, maturation and reproduction.

Photoperiod directly influences the fish behavior, especially in their feeding and reproductive habits (McConnell, 1999). The photoperiod effect on fish reproduction is an important aspect to be studied. The survival and growth of the cultured fish depend upon the nutrients supplied and also the availability of light. Light compares a complex of external and ecological factors, including color spectrum, intensity and photoperiod. Receptivity of fish to light has profoundly changed according to the species and developmental status. Moreover, intense light can be stressful or even lethal. Many species including both marine and freshwater react to photoperiod treatments and long day length that stimulates growth. Light affects fish growth through better food conversion efficiency and not just through stimulated food intake (Olivotto et al., 2003).

Platy (*Xiphophorus maculatus*), a tropical live-bearer common by cultured in aquarium, belong to the family Poeciliidae under the order Atheriniformes. It is a small fish, approximately having 5 cm maximum length and highly variable in color. Several color variations have been developed, such as red, yellow, orange, blue, rainbow (combination of colors) and white.

In view of above facts, this experiment was conducted to find out the light effect on the growth of platy and popularize the reproductive success of ornamental fish with the help of light. Pigments are responsible for the wide spectrum of colors in fishes which is an essential prerequisite for the quality as they fetch higher price in the commercial market (Gupta et al., 2006).

This experiment was undertaken to investigate the photoperiod successful for better growth, lower mortality rate, higher reproduction rate, better coloration and popularize the reproductive success of ornamental fish with the help of light.

1.1: Objectives of this experiment:

1. To find out best suited photoperiod for growth, maturation, survival, coloration and carotenoid concentration in skin of fishes
2. To aware people with this basic knowledge in using different photoperiods to have a successful and fast growth of this ornamental fish

1.2: Scope of the study:

1. This research work intended to add a new dimension to improve the ornamental fish industry and better production of ornamental fish in Bangladesh. Besides, it envisages to propagandize the successful culture of aquarium fish

CHAPTER TWO

REVIEW OF LITERATURE

The seasonal changing pattern of day length provides the most precise index of time year-on-year for most species, and many fish use the growing and decreasing elements of this light cycle to coordinate development. Light intensity can be a limiting factor in aquaculture depending on turbidity and depth. Different responses are exhibited in different species and different developmental stages (Boeuf and Le Bail, 1999). Recently, several studies have been undertaken to evaluate the effect of light intensity on survival, growth, swimming activity and cannibalism of larvae or juveniles in various fish species under culture conditions (Petrell and Ang, 2001). It is important to take a look at the previous research activities on the subject topics before undertaking a report. The following is a summary of the literature applicable to the current research paper:

2.1: Ornamental fish culture in Bangladesh:

In Asian nation the culture of tank fish was started in 1980. Initially tank was set in eating house for aesthetic enjoyment to draw in individuals. Then the rearing of the tank was practiced in looking centers. Typically elite individuals keep the tank in their house or workplace for his or her aesthetic enjoyment. The decorative fish culture observes was increasing day by day. Due to the increasing demand, aquarium fish culture was oriented in mid-1980, at Kataban in Dhaka (Mostafizur et al., 2009).

Alam et. al., (2016) stated that the total numbers of 29 varieties were recorded from the aquarium shops of Barisal division. Among them, 20 varieties were identified as exotic and rest of them were indigenous. It was also found that the order Cypriniformes emerge as most dominant groups about 54% among this diverse colored fish community. All varieties of ornamental fishes exhibit great intraspecific variability in color and in certain morphological features. There are only a few indigenous fish species in Bangladesh that are considered ornamental species of fish, e.g. Fish from Rani (*Botia* sp.). Exotic species are the bulk of the available ornamental fishes.

In Rakamari Hatchery of Feni district, under the Chattogram division, common goldfish and comets are managed to breed artificial among them. Although Bangladesh has huge resources, but is still in a marginal position (Mostafizur et al., 2009). The majority of

the shops of aquarium fish are located in Dhaka city (Galib, 2010). But it is good news for us that its trade is developing currently in our country (Mostafizur et al., 2009).
In our country as well as in the world market, the ornamental fish company has a great chance. Unfortunately, however, the trade in ornamental fish in Bangladesh has so far been limited to its own territory. We have enormous resources in our region, a suitable environment and a challenging market. In the fishing business, a little consciousness can bring enormous benefit.
Most ornamental fish are imported from foreign countries and it costs a lot of money per year to import ornamental fish in order to fulfill the country's requirements. We have a wide range of colorful species of indigenous fish that can be used for ornamental purposes which can save these money and can apparently be regarded as a very possible export earnings means. If we breed and export them properly, then we will earn a great deal of foreign exchange for our country.

2.2: Culture potentiality of platy in Bangladesh:

Farmers and investors are now very committed to moving their business to more diverse markets, such as crocodile culture, pearl culture, ornametal fish culture etc.

2.3: Platy culture technique:

Kallman and Kazianis, (2006) stated that platy originated from the east coast of Central America and southern Mexico. They have a relative elongated body, but also somewhat more "stocky" individuals may occur. The dorsal fin is relatively small but there are some strains with a more prolonged "veil" like dorsal fin. They can reach up to 4 cm for mature males and 6 cm for mature females.

They have been interbred for many years in captivity. Platy's hybrids are at least 40 distinct, including the common red, sunset, and tuxedo varieties. Their lifespan is 3 years, which is shorter than other fish. Because of their short lifespan, the fish grow up and reproduce very quickly. Only after 4 months from the previous birth, the female are ready to reproduce. And also because of this fact, their population increases very quickly that makes them listed in the invasive species in the wild like to their cousins. (Schlosberg et. al., 1949)

Feed twice a day, give them the amount of food that they can consume within two-three minutes. Any un-eaten food must be removed to not compromise the water quality that in turn causes harm to the fish.

They eat most fish foods available, including crustaceans, worms, dried food and plant matter. They also use algae in the aquarium as a source of vegetable foods.

Male and female platies of a group with the same age are easily distinguished from each other as the males are slightly smaller than the female and also have a gonopodium.

They give birth to live fry after a gestation period of four to six weeks. A single female can give birth up to 100 babies, depending on its size. The young Platies swim freely after birth and grow rapidly, reaching maturity at the age of six to eight months.

2.4: Effects of photoperiod on platy fish:

The study of Swati et al. (2019) on effect photoperiod on ornamental fish might be suggested that mostly body color faced changes during dark phases, which created dullness and their beautiful appearance seemed to be lost which brought total economic loss. It was also concluded that during the dark phase, body color of brooder starts changing in increasing order and produced fry have to face these color changes on their body automatically from birth.

2.5: Influence of photoperiod on growth pattern:

Photoperiodic regulation is not exclusively confined to the control of the reproductive rhythms, but can also be influential in other physiological processes.

Seasonal variations in photoperiods, temperature, food sources, rainfall, etc. dominate and organize developmental and maturation events. Photoperiod and temperature are generally considered the most important factors in growth in fishes (Dutta, 1994).

It is quiet cleared that for best growth and maturation, the high light level is needed, whereas in low light level growth and maturation are almost lost. The effect of the photoperiod on the growth and development of black molly freshwater ornamental fish (*Pocellia sphenops*) indicates that the length and weight of the photoperiod in 24 h is more important than that of the photoperiod in 12 h (Jeniffer et al., 2012). It might be suggested that additional light may have positive effect on fish growth in the long term duration and photoperiod studies required more than 60 days in order to absorb effects of photoperiod (Barlow et al., 1995). Studies suggest that genotype hormones and physiological conditions are equally important endogenous regulators of growth (Dutta,

1994). The photoreceptor axis, pituitary gonadotropin, ovarian estrogen secretion, oogonial proliferation, and endogenous yolk formation are regulated by photoperiod.

It was observed by Immelman (1963), that reproductive cycles are affected by exogenous and endogenous environmental cues. Gross and Sargent (1965), observed that fish growth and development is also improved by increasing the photoperiod. The circannual rhythms of hormones to be closely related with circannual variations in ambient temperature day length and gonadal steroids (Pavlidis et al., 2000).

2.6: Effects of photoperiod on reproductive performance:

Fishes, through the course of their evolution, have adapted themselves to a wide range external stimuli that co-ordinate their seasonal breeding activities and migrations. It is well known among keepers of home aquaria, for example, that the tropical guppy and swordtail, although capable of breeding all the year round, show a heightening of reproductive activity with the increasing day lengths of the spring (Pyle, 1969).

Knowledge of how photoperiod affects reproduction in fishes can be put to practical use in at least three ways. First, manipulation of the photoperiod can accelerate, maintain or delay sexual maturation and spawning of broodstock so that spawning may occur out of season. Second, manipulation of the photoperiod can also inhibit gonadal recrudescence so that in growing fish somatic growth can be encouraged without the energy drain required for reproduction (Lam et al., 1983).

In the female, there is a large percentage of the available energy budged that goes into reproduction (Whittier and Crews, 1987). Third, photoperiod manipulation can reduce generational time by reducing time between spawning and allow for accelerated genetic improvements of fish stocks (Lam et al., 1983).

Fish like all animals, reproduce to the maintain survival of the species. They must not only reproduce, but they must reproduce when maximum reproductive success is possible (Lam et al., 1983; Whittier and Crews, 1987). Developmental and maturational events are dominated and coordinated with seasonal changes in photoperiod, temperature, rainfall etc. (Vazquez et al., 2000). Photoperiod and temperature are generally considered the most important factors. Seasonal reproduction is influenced by biotic factors such as temperatures, water quality and photoperiod and biotic factors

such as food availability, predators and pathogens being at optimum conditions (Bergman, 1987; Whittier and Crews, 1987).

Yaron et. al. (1980) stated that photoperiod would regulate the axis photoreceptors, central nervous system, hypothalamus pituitary gonadotropin, ovarian estrogen secretion, oogonial proliferation and endogenous yolk formation. In some vertebrates photoperiod acts as a chief proximate factor in the regulation of seasonal reproduction. Photoperiod changes throughout the year accurately and reliably, so that animals can use this application to predict seasonal changes and program their gonadal development accordingly.

Ovarian growth, maturation and egg laying is controlled by hormones which in turn are regulated principally by photoperiod (Stephens, 1952). Altered reproduction and spawning cycles in seasonally breeding fish species are correlated with changes in environmental signals such as photoperiods. The timing of puberty and sexual maturation was highly influenced by photoperiods. The photoperiod related information is transmitted, via the pineal hormone, Melatonin (Reiter, 1995).

The underlying physiological mechanisms are not known in detail but are thought to involve the pituitary and thyroid glands which are in turn affected by photoperiods (Baggerman, 1980).

2.7: Effects of photoperiod on coloration:

One of the essential quality attributes of fish for market acceptability is pigmentation. Carotenoids are responsible in food fish for muscle pigmentation and in ornamental fish for skin color. This is because fish are unable to synthesize carotenoids. Color changes in the fish are often linked to environmental stress, and illumination by hormone control may be a primary factor controlling the distribution of pigments. The color of fish skin is primarily based on the presence of colored pigment-containing chromatophore.

The color of fish skin is generated by the absorption, reflection, and scattering of light by the pigments and microstructures within the fish integument (Fujii, 2000). Color changes in the fish are often linked to environmental stress, and illumination by hormone control may be a primary factor controlling the distribution of pigments. The color of fish skin is primarily based on the presence of colored pigment-containing chromatophore.

Carotenoids are naturally occurring pigments that range in hues from yellow to red (Hill, 2002) which are lipid soluble pigments, are responsible for skin color of ornamental fish, and can determine their commercial value (Paripatananont *et al.*, 1999). One of the most significant factors controlling chromatophore output by pigment aggregation or dispersion is the intensity of light.

2.8: Method of carotenoid content determination:

The pigments in ornamental fish are one of the most important quality variables dictating the market value. To obtain consumer acceptance and optimal cost, the platy fish must be pigmented. Carotenoids have been involved in various roles in nature, such as pigmentation, antioxidant activity, activation and reproduction of the immune system, and play a positive role in intermediate metabolism.

There are different forms of carotenoids in fish, the main one of which is unique to the species in question. Carotenoids commonly occurring in fishes with their colors are tunaxanthin (yellow), lutein (greenish-yellow), betacarotene (orange), alpha, betadoradexanthins (yellow), zeaxanthin (yellow-orange), canthaxanthin (orangered), astaxanthin (red), eichinenone (red) and taraxanthin (yellow) (Das and Biswas, 2016). Amongst these, the main carotenoid is astaxanthin, abundant in red fish.

The color enhancement was monitored by visual examination and estimated of carotenoid content in the skin of eperimental fish according to the method described by Martinez *et al.* (2005). The fish skin was extracted according to the method of Torrison and Naevdal (1984).

CHAPTER THREE

MATERIALS AND METHODS

During the period from March to September 2019, the present study was conducted in the wet laboratory in Chattogram Veterinary and Animal Sciences University, Chattogram, Bangladesh.

3.1: Aquarium setup:

Aquarium materials such as glass, measuring tape, gum, etc. were brought for making of aquarium for platy culture. A total of 12 measuring glass aquariums (9.3 inch × 7 inch × 11 inch) with 8 L of water holding capacity were made. All aquariums were numbered individually for identification.

3.2: Maintenance of photoperiod:

The natural Sunlight viz. long day (12 h) and 4 LED bulbs with 5 watts, 100 lm / W luminous efficacy used as sources of light. Dark condition was maintained naturally at night. Paper curtain was used for creating artificial dark condition.

3.3: Collection of experimental species:

The fry of platy fish was collected from the ornamental fish shop, Reyazuddin Bazar, Chattogram. Fry were visually examined to ensure good quality seed. Fish number per aquarium was 8.

3.4: Feed management:

Five percent of the total biomass in each tank was given to commercial food (aquarium fish powder) with a diet (moisture 12%, crude protein 26%, crude fat 5%, carbohydrate 35% and fiber 7%). In each treatment, the fish were fed to apparent satiation twice daily for a duration of 5 months. All unconsumed items were removed before the supplying meal by siphoning in the next morning. The rations were adjusted with the number of fish in each tank according to the daily mortality rate and quarterly growth rate.

3.5: Water quality management:

The stored tap water was used as source of water. Salt and lime were used for treatment of water. The water quality parameter were measured monthly using water analysis kits and were recorded duly. Water quality parameter was (DO: 6.5-7.5 ppm, pH: 7-8, water temperature: 24-26 ºC) maintained properly. Throughout the experiment, mechanical

aeration and filtration were continued to sustain water filtration and dissolve oxygen concentration. Water was checked once a week at a rate of 40 percent volume.

3.6: Experimental setup:

Four setups- T_1 to T_4 were constructed each with three replicates. The different photoperiods such as in T_1- 12 hrs L: 12 hrs D, T_2- 0 hrs D: 24 hrs L, T_3- 7 days 24 hrs D: 7 days 12 hrs D and 12 hrs L, T_4- 7 days 24 hrs D: 7 days 24 hrs L were maintained and aeration were provided to each aquarium. Switching of photoperiods and aeration in each setup were maintained manually throughout the study period. Table-1 presented the detail layout of the experiment.

Table-1: Layout of the experiment showing the distribution of 'Platy' fishes in aquariums and the applied treatments:

Treatment / **Replication**	**T_1 (12 hrs L: 12 hrs D) (Controlled)**	**T_2 0 hrs D: 24 hrs L (LED bulb)**	**T_3 7 days 24 hrs D: 7 days 12 hrs D and 12 hrs L**	**T_4 7 days 24 hrs D: 7 days 24 hrs L (LED bulb)**
	No. of fish			
R1	8	8	8	8
R2	8	8	8	8
R3	8	8	8	8
Total	**24**	**24**	**24**	**24**

3.7: Sampling:

Sampling was done in every 15 days to observe fish growth performance data of length, weight, body color development, carotenoid content, breeding performance were taken. Weight of fish was taken by using an electrical weight machine and standard length of fish was taken by using measuring scale. Measurements of the total biomass of each tank were carried out to avoid the stress caused by handling of fish and to measure the weight of fish. Fish were not fed for 24 hrs before each measurement.

3.8: Growth and breeding performance:

Finally, average mean length, average mean weight, survival rate, mortality rate, specific growth rate and percent weight gain were calculated using following formulas:

- Weight gain (g) = Final body weight – Initial body weight
- Length gain (cm) = Final length of the fish body – Initial length of the fish body
- % Survival = $\frac{\text{Final no. of live fishes}}{\text{Initial no. of fishes}}$ x 100
- % Mortality = $\frac{\text{Final no. of death fishes}}{\text{Initial no. of fishes}}$ x 100
- Specific growth rate = $\frac{\text{Mean final weight} - \text{Mean Initial weight}}{\text{experimental period (T2} - \text{T1)}}$ x 100
- Percent weight gain = $\frac{\text{Mean fish final weight} - \text{Mean fish Initial weight}}{\text{Rearing periods (total period)}}$ x 100

3.9: Color enhancement and carotenoid content estimation:

The color enhancement was monitored regularly by visual examination and percentage of coloration was estimated by following equation:

Percentage of coloration = $\frac{\text{Number of total colored fish}}{\text{Number of total fish}}$ x 100

Visual analysis and estimate of carotenoid content in the skin of experimental fishes controlled the color enhancement. Immediately after the completion of the experiment, total carotenoid concentration (TCC) in the fish muscle tissue was analyzed.

A sample of 1 g skin was obtained from the fish and combined with mortar pestles. They were moved to 10 mL centrifuge tubes and up to 10 ml of acetone was added. The specimens were centrifuged for 5 min at 5000 rpm. The solutions were kept in a refrigerator for 3 days at 4° C and then extracted 3 or 4 times until no more color could be produced. A spectrophotometer (wave length 470 for animals) measured the absorption of the extracted solutions. The concentration of carotenoid was estimated and expressed as µg/g carotenoid using the following equation:

Carotenoid Value = $\frac{\text{Abs x 10000 x V}}{1900 * \text{W}}$

Where,

Abs= Pigment Absorption rate which measured by spectrophotometer

V= Total volume of the extract

W= Weight of sample

3.10: Data analysis:

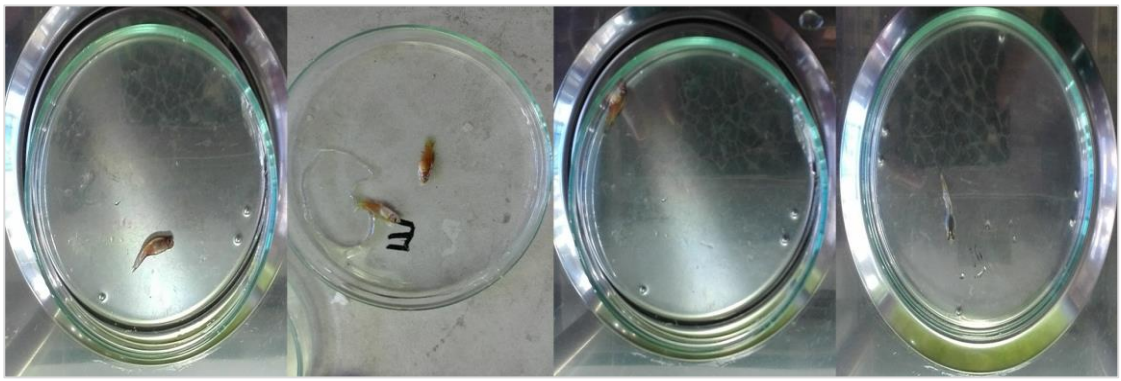
Data were analyzed statistically. The one way analysis of variance (One way ANOVA) was performed using SPSS (Statistic package for social science) version IBM SPSS Statistics 23 software to determine the significant differences among means. For all tests, a criterion of $P<0.05$ was used to determine statistical significance. Differences ($P<0.05$) between means were compared by Tukey test.

Some Pictures

Plate-1: Experimental Setup

Plate-2: Feeding of fish

Plate-3: Regular Monitoring



T_1 T_2 T_3 T_4

Plate-4: Sampled fish during 1st sampling

T_1 T_2 T_3 T_4

Plate-5: Sampled fish during 5th sampling

T_1 T^2 T_3 T_4

Plate-6: Sampled fish during 10th sampling

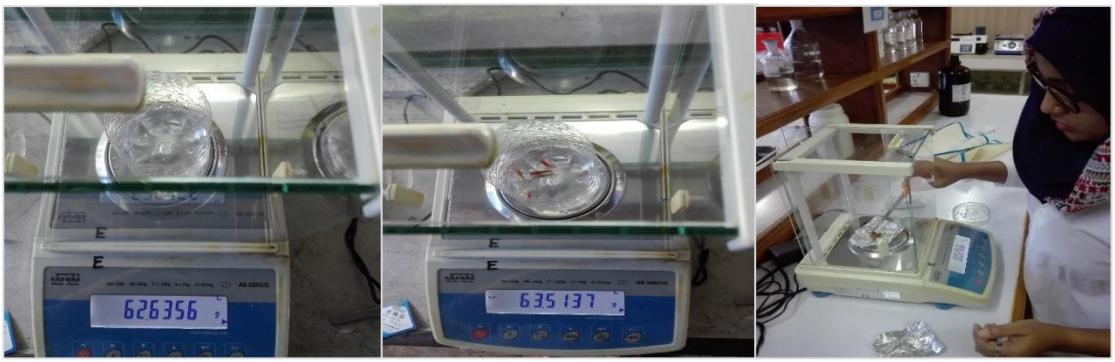


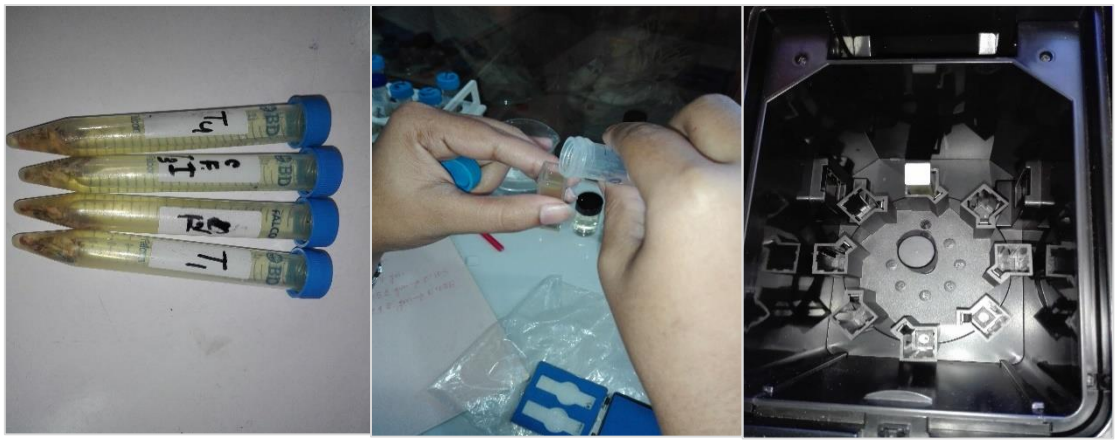
Plate-7: Weighing of live platy fish by electric balance

Plate-8: Dissection of platy fish and smashing fish flesh by motor

Plate-9: Sample weighing and adding acetone

(a) (b) (c)

Plate-10: (a) Sample putting into centrifuge machine at 5000 rpm for 5 min (b) taking out from centrifuge machine (c) putting these sample in freeze for 72 hrs



(a) (b) (c)

Plate-11: (a) Extracted sample after freezing (b) taking sample for carotenoid content analysis (c) putting sample in spectrophotometer at 470 nm wave length

CHAPTER FOUR

RESULTS

The effect of different light levels on platy fish growth has been investigated and the findings have been presented below.

4.1: Effects of photoperiod on fish weight:

Fish have been sampled for 10 times (Appendix-1, 3). At the stocking of fish, the mean weight of fish was 0.0226 g. In final sampling, it showed that the mean weight of each treatment such as T_1, T_2 T_3 and T_4 were 0.3161, 0.3587, 0.2453, 0.2634 g respectively. The data showed that the fishes provided with 'Treatment-2 (T_2 – 0 hrs D: 24 hrs L)' have the highest growth in terms of weight when comparing with other treatments (Figure-1).

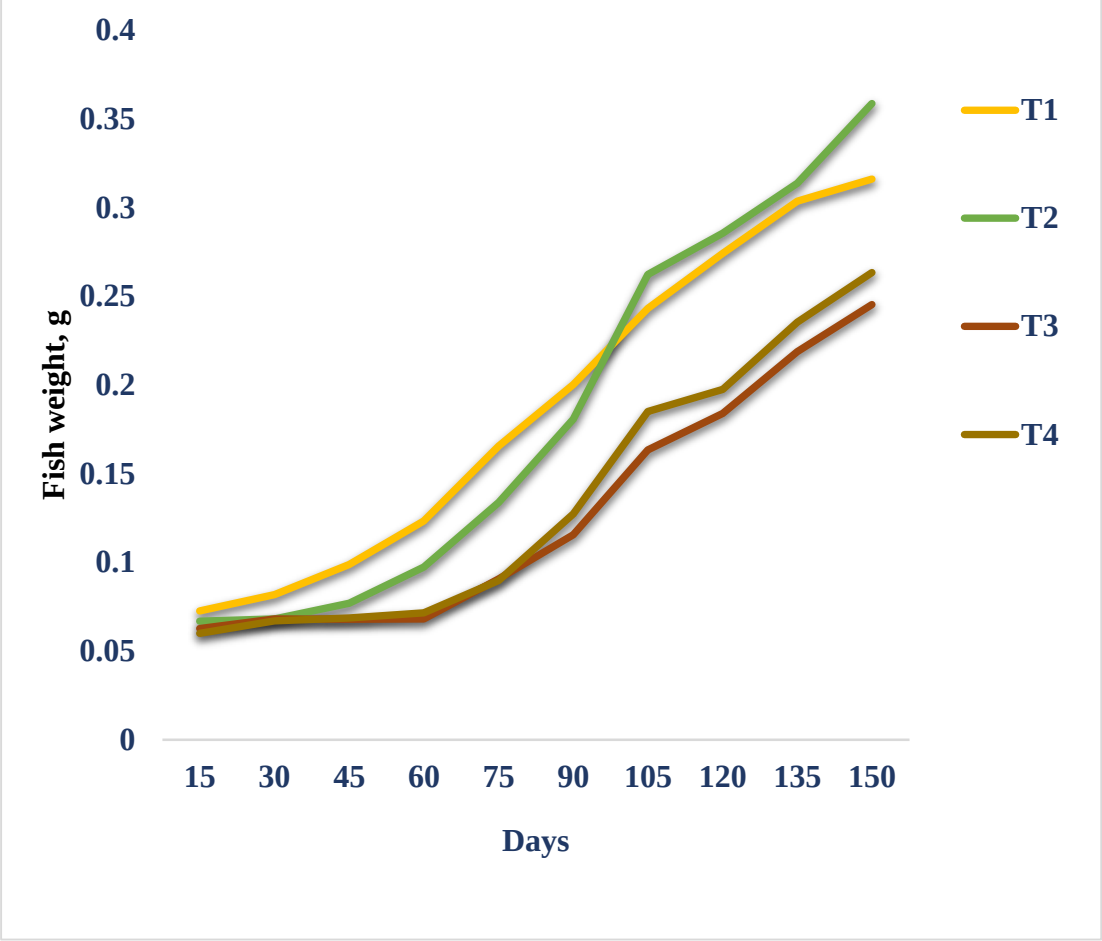


Figure-1: Average growth by weight (g)

4.2: Effects of photoperiod on fish length:

The initial length of fish was 1.3 cm. In final sampling, it showed that the average length of each treatment such as T_1, T_2, T_3 and T_4 were 2.2667, 2.4, 2.1, cm respectively. The data (Figure-2 and Appendix- 2, 4) showed that the fishes provided with 'Treatment-2 (T_2 – 0 hrs D: 24 hrs L)' photoperiod have higher growth in terms of length when comparing with other treatments.

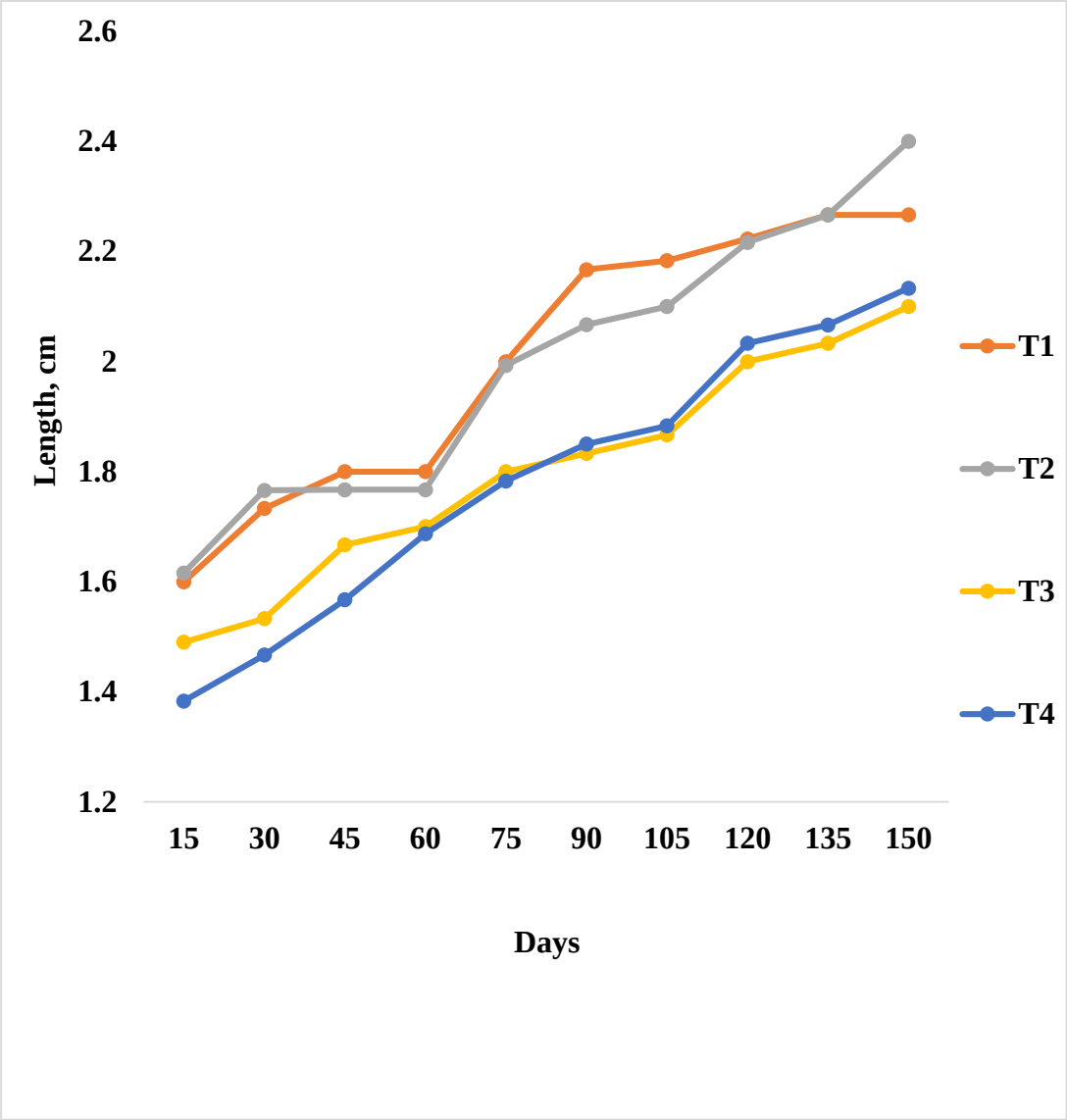


Figure-2: Average growth by length (cm)

4.3: Effects of photoperiod on weight gain:

Weight gain of fishes was calculated fortnightly by subtracting current sampling weight from immediate previous sampling fish weight and is showed in Figure-3 and Appendix-5. Highest weight gain was in T_2 treatment during 7^{th} sampling.

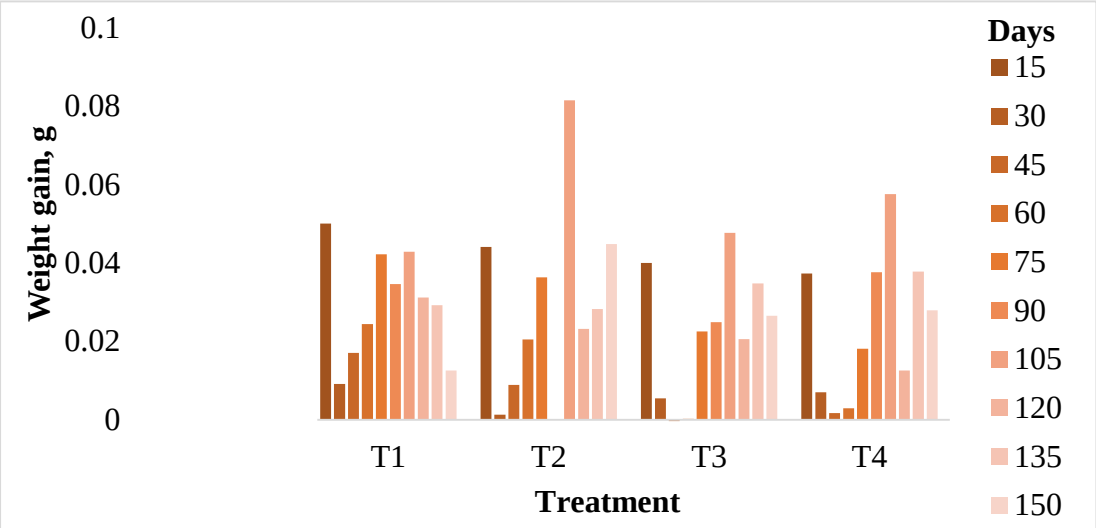


Figure-3: Average fish weight gain (g)

4.4: Effects of photoperiod on length gain:

Length gain of fishes was calculated fortnightly by subtracting of current sampling fish length from immediate previous sampling fish length and showed in Figure-4 and Appedix-6. Highest length gain was in T_2 treatment during 1^{st} sampling and lowest was during 3^{rd} sampling.

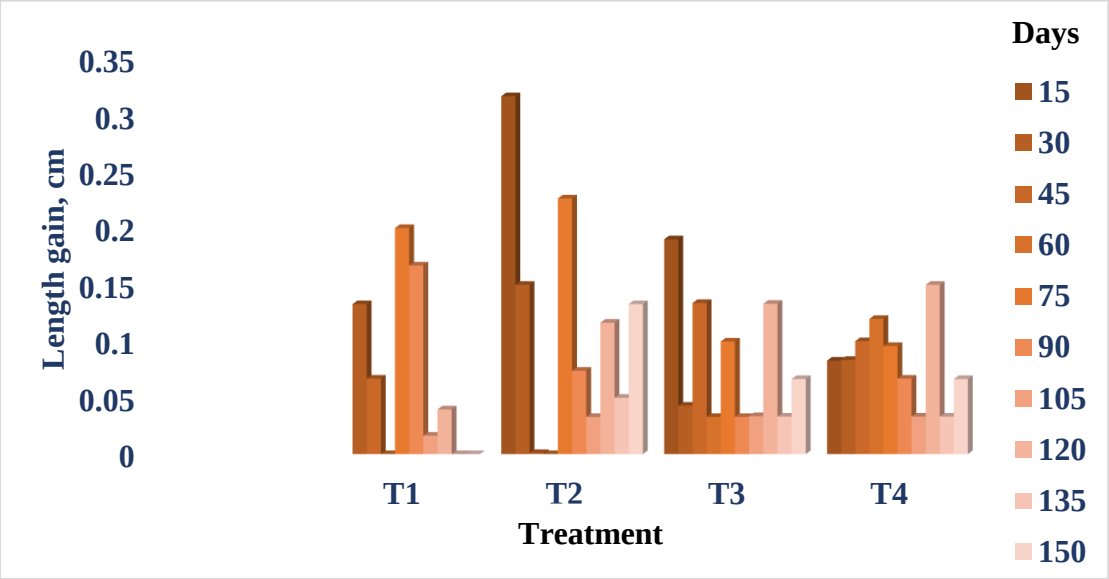


Figure-4: Average fish length gain (cm)

4.5: Specific growth rate (%):

SGR of fish was calculated fortnightly and which was showed in Figure-5 and Appendix-7, 8. The best SGR value found 0.299 ± 0.049^{a} in T_2 (0 hrs D: 24 hrs L) and lowest was 0.1768 ± 0.0452^{b} in T_4 (7days 24 hrs D: 7 days 24 hrs L).

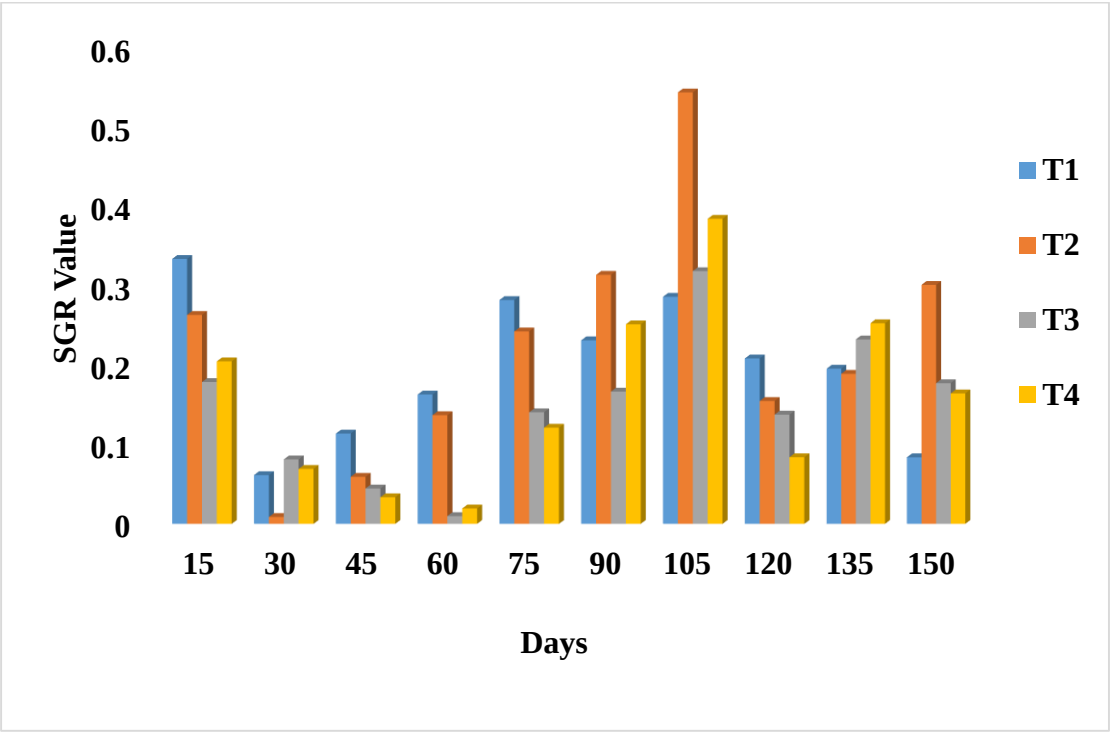


Figure-5: Specific Growth Rate (%)

4.6: Effects of photoperiod on survival rate:

Effects of photoperiod on survival and mortality rate of platy fish are recorded in Table-3 and Appendix-11. The highest survival rate was 87.5% in T_1 (12 hrs D: 12 hrs L) and T_2 (0 hrs D: 24hrs L) in the experiment.

Table-2: Survival and mortality rate of platy:

Treatment	Survival rate (%)	Mortality rate (%)
T_1	**87.5**	12.5
T_2	**87.5**	12.5
T_3	70.833	29.167
T_4	79.167	20.833

4.7: Growth performance of platy:

Among photoperiod treatments, significant differences ($p<0.05$) were observed for final weight and final length. Growth parameters were significantly higher in T_2 photoperiod treatment that were shown in Table-3. Mean weight of each treatment such as T_1, T_2 T_3 and T_4 were 0.3161 ± 0.0063^b, 0.3587 ± 0.009^a, 0.2453 ± 0.0187^c and 0.2634 ± 0.0117^c g respectively. It showed that the average length of each treatment such as T_1, T_2, T_3 and T_4 were $2.267\pm.058^b$, 2.4 ± 0.000^a, 2.1 ± 0.000^c, 2.133 ± 0.0577^c cm respectively. The mean weight, mean length and mean SGR of fish of T_2, T_3 and T_4 fish were compared to the controlled group (T_1). T_1 and T_2 were statistically significantly different from other treatments and there was no difference between T_3 and T_4. Percent weight gain of platy fish in this experiment are mentioned below (Table-3). The highest weight gain was 0.198% in T_2 and lowest was 0.158% in T_4.

Table-3: Growth performance of platy fish:

Treatment	Weight (g)	Length (cm)	SGR	Percent weight gain
T_1	0.3161 ± 0.0063^b (0.3003-0.3318)	$2.267\pm.058^b$ (2.123-2.41)	0.0837 ± 0.0175^c (0.0402-0.1274)	0.196
T_2	**0.3587 ± 0.009^a (0.3345-0.3829)**	**2.4 ± 0.000^a (2.4-2.4)**	**0.299 ± 0.049^a (0.1773-0.4213)**	**0.198**
T_3	0.2453 ± 0.0187^c (0.1989-0.2917)	2.1 ± 0.000^c (2.1-2.1)	0.1768 ± 0.0452^b (0.0644-0.2892)	0.159
T_4	0.2634 ± 0.0117^c (0.2342-0.2925)	2.133 ± 0.0577^c (1.98-2.27)	0.1862 ± 0.0071^b (0.1687-0.2037)	0.158
Level of significance	0.000	0.000	0.000	-

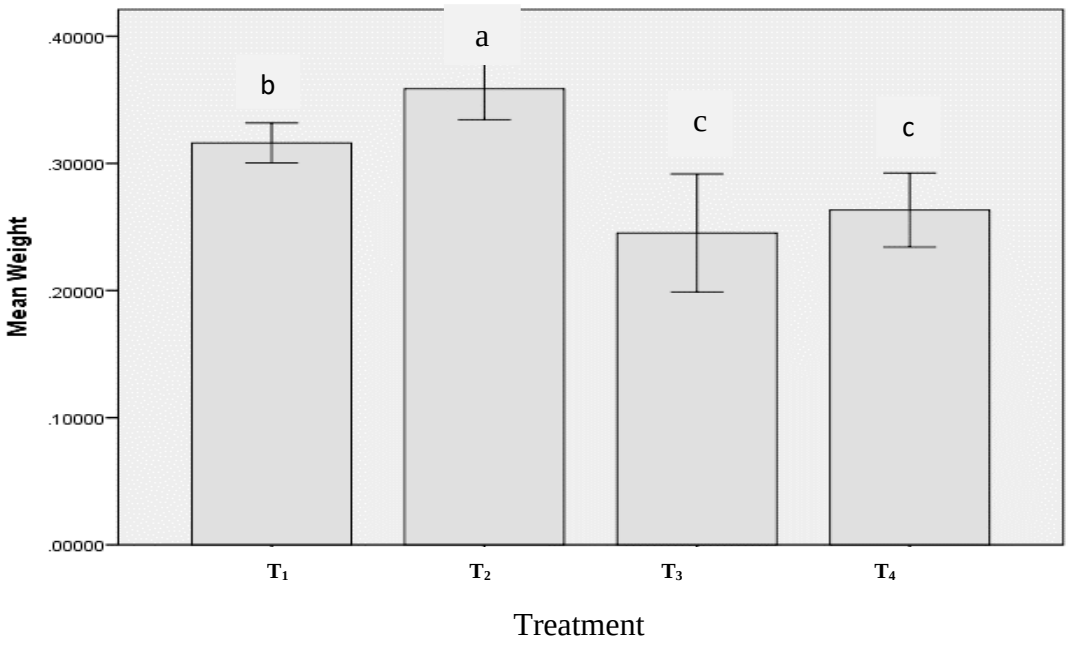


Figure-6: Effects of photoperiod on fish mean weight (Mean ± SD) were shown after 5 months. The weight of fish of T_2, T_3 and T_4 fish were compared to the controlled group. T_1 and T_2 were statistically significantly different from other treatments and there was no difference between T_3 and T_4.

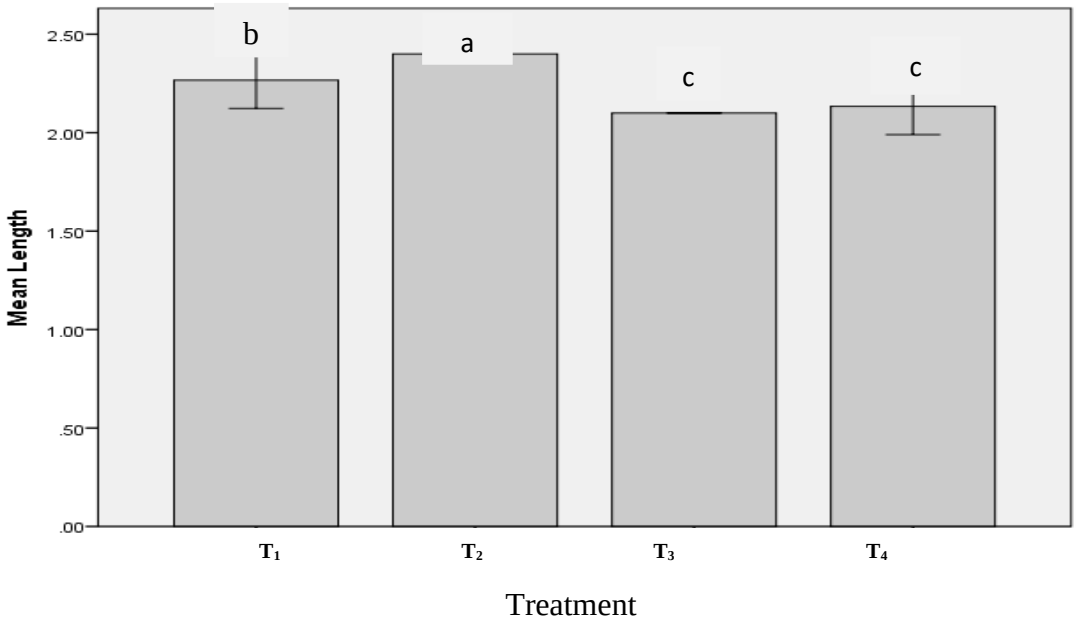


Figure-7: Effects of photoperiod on fish mean length (Mean ± SD) were shown after 5 months. The length of fish of T_2, T_3 and T_4 fish were compared to the controlled group. T_1 and T_2 were statistically significantly different from other treatments and there was no difference between T_3 and T_4.

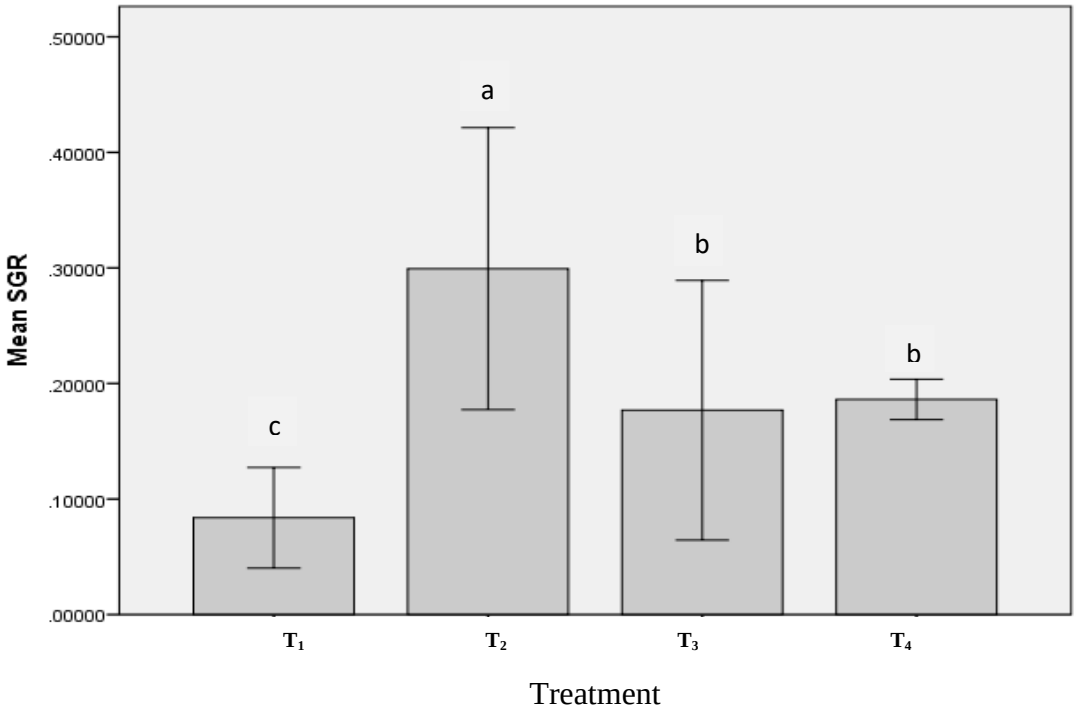


Figure-8: Effects of photoperiod on mean SGR of fish (Mean ± SD) were shown after 5 months. The SGR of fish of T_2, T_3 and T_4 fish were compared to the controlled group. T_1 and T_2 were statistically significantly different from other treatments and there was no difference between T_3 and T_4.

4.8: Effect of photoperiod on reproduction rate of platy:

Table-4 and Appendix-12 showed that, among four treatments, T2-treated (0hrs D: 24hrs L) brood fish gave birth early. It only took 113 days (average) for giving newly born platy fish. This also gave among others much of the fry.

Table-4: Reproduction rate of platy:

Treatment	Maturation period (days)	Fry Number
T_1	126	16
T_2	**113**	**25**
T_3	134	8
T_4	140	6

4.9: Effects of photoperiod on coloration and carotenoid content of platy:

Carotenoid content of fish under different photoperiodic levels were calculated after completion of this experiment and were shown in Figure-9 and Appendix-9. It is shown that the highest carotenoid content was found 0.0054031mg/g in T_2 (0hrs D: 24hrs L) treatment and lowest was 0.003573467 mg/g in T_3.

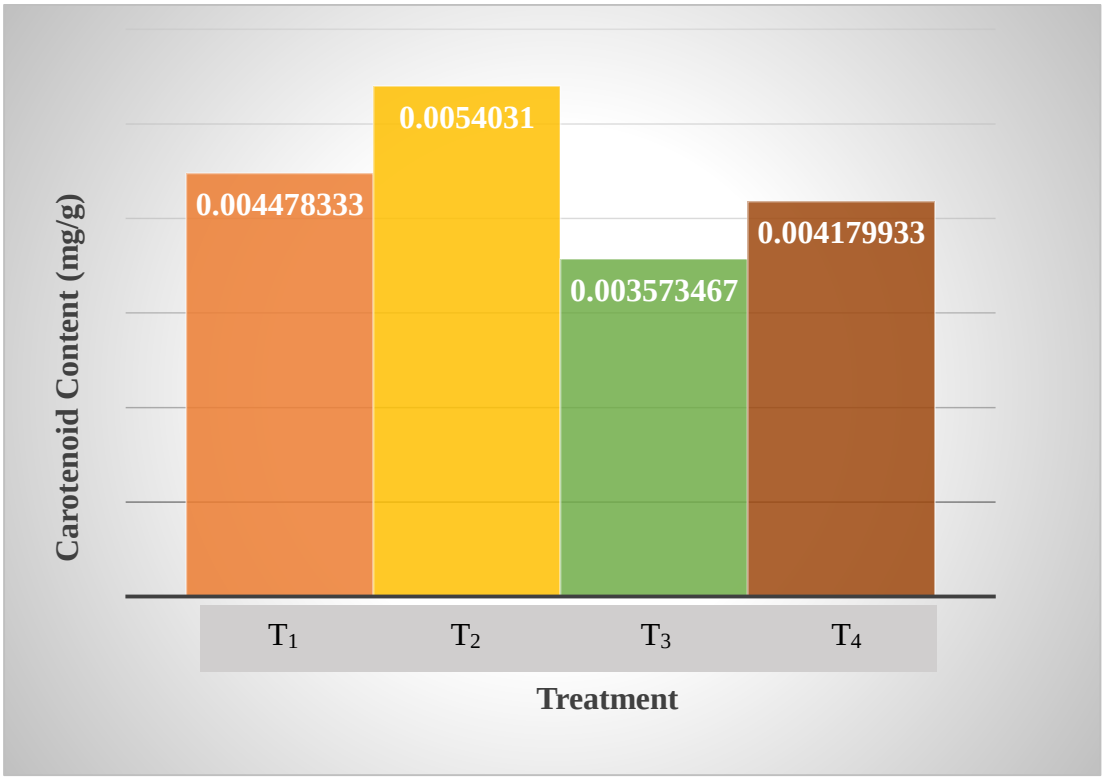


Figure-9: Carotenoid content (mg/g) in different treatments

The best visual coloration was 95.24% in T_2 (0 hrs D: 24 hrs L) and the worst was 58.82% in T_3 (7 days 24 hrs D: 7 days 12 hrs D and 12 hrs L). In carotenoid content analysis after T_2 treatment, fish of T_1 treatment gave high amount of carotenoid from others. Carotenoid content and percentage of colored fish of each treatments were also summarized in table-5:

Table-5: Carotenoid content and percentage of colored fish of platy:

Treatment	Carotenoid Content (mg/g)	Percentage of colored fish
T_1	0.00448 ± 0.0019^{b} (0.0039-0.0049)	80.95% red, 19.05% pale
T_2	**0.00541 ± 0.0003^{a} (0.0046-0.0062)**	**95.24% red, 4.76% pale**
T_3	0.0036 ± 0.0003^{bc} (0.0028-0.0044)	58.82% red, 41.18% pale
T_4	0.00417 ± 0.0002^{c} (0.0038-0.0045)	84.21% red, 15.79% pale
Level of significance	0.000	-

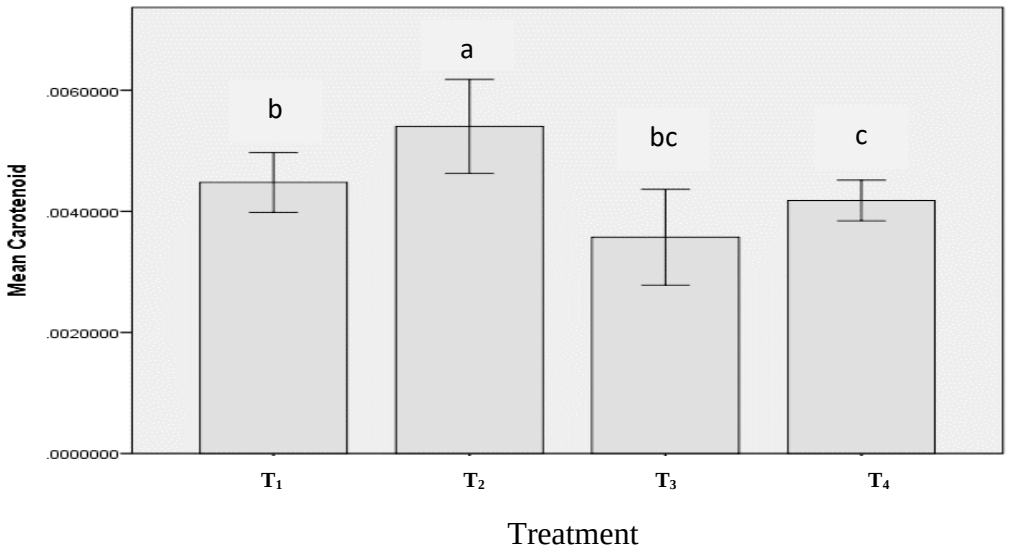


Figure-10: Effects of the photoperiod on mean carotenoid content of fish (mean ± SD) content were shown after 5 months. The carotenoid content of fish of T_2, T_3 and T_4 were compared to the controlled group (T_1). T_2 was statistically significantly different from other three treatments and there was no difference not only T_3 and T_4 but also T_1 and T_3.

CHAPTER FIVE

DISCUSSION

A number of changes have been observed, calculated and noted down in this study such as length, weight, survival rate, carotenoid content etc.

5.1 Effects of photoperiod on fish Weight:

After completion of research work, highest weight was found in T_2 (0.3587 ± 0.009^a) treated fish which is statistically different than the T_1 (0.3161 ± 0.0063^b), T_3 (0.2453 ± 0.0187^c), T_4 (0.2634 ± 0.0117^c) gm. The present work represented that fish rearing in low or without photoperiod show lower weight than the fish rearing in high photoperiod (T_2-0 hrs D: 24 hrs L, $p<0.05$) which undoubtedly indicate that photoperiod has great effects on fish growth. During research period, 10 samplings were done where 1st sampling showed higher weight gain in a result of peak growing period. From 2nd sampling to 4th sampling, lower growth rate and lower weight gain occurred because of time taken for adjustment into new physiological phase. And 4th sampling to 7th sampling showed higher weight gain in all experimental fish in which T_2 showed higher weight when comparing other treated fish because suitable environment, genetic process, maturity and gestation period. After 7th sampling, lower weight gain was found in all experimental fish during sampling time due to fluctuation of temperature and weather change. Higher weight gain was found lately in 9th sampling due to pregnancy period of platy fish. Swarti et al., (2019), reported that growth performance of youngones increased with slower rate and more or less similar, when photoperiod was short. A similar result was also obtained for sole (*Soela solea*) by Fuchs (1978). The above study justified by several workers work, according to Fernandes (1979), he did work on sea bass (*Dicentrarchus labrax*) for 18 h light period and Barlow et al., (1995) worked on larvae of barramundi (*Lates calcarifer*) for 16 hrs and 24 hrs light periods and found that larvae showed higher growth rates when photoperiod were large. The present study thus concludes that photoperiod has direct effects on increasing weight of platy.

5.2 Effects of Photoperiod on Fish Length:

During stocking of fish, initial length was 1.3 cm. In final sampling, highest length was found in T_2 (2.4 ± 0.000^a) treated fish than the T_1 ($2.267\pm.058^b$), T_3 (2.1 ± 0.000^c) and T_4

(2.133 ± 0.0577^{c}) cm treated fish. The higher photoperiod treated fish had higher length than the lower one's ($p<0.05$). The relationship among treatment are highly significant.

5.3 Effects of Photoperiod on Fish Growth Performance:

In the current study period, photoperiod improved the growth performances of platy and highest final weight was found in T_2 treatment. T_2 (0 hrs D: 24 hrs L) treated fish had higher weight, weight gain, length and length gain than other fish. Fish with long day photoperiod had better growth performance than other fish because it helped to secrete growth hormone by influencing pituitary gland (Baggerman, 1980). Light also helped to find food easily. The specific growth rate is widely used dealing with the growth of aquatic organisms under experimental conditions. The highest SGR value was recorded in T_2 (0.299 ± 0.049^{a}) among four treatments T_1 (0.0837 ± 0.0175^{c}), T_3 (0.1768 ± 0.0452^{b}), T_4 (0.1862 ± 0.0071^{b}) which was strongly significant (<0.05).

5.4 Effects of Photoperiod on Survival Rate of Platy:

Survival rate was highest 87.5% in T_2-0 hrs D: 24 hrs L and T_1 - (12 hrs L: 12 hrs D) treatments. There is no significant variation in survival rate among various photoperiodic levels suggested that the longer photoperiod does not cause any lethal effects. Howell et al. (2003) stated that mortality of black seabass during the experimental period did not show significant differences between treatments nor was it connected to the photoperiod. Although the most frequent cause of death was due to confrontations between male and female during the mating (Howell et al., 2003).

5.5 Effects of Photoperiod on Fish Reproduction:

This present experiment was conducted to determine the effect of the length of photoperiod on larval duration, growth to metamorphosis and early juvenile phase. Growth of larvae was significantly faster and the duration of the larval phase was significantly shorter, under a photoperiod of T_2-0 hrs D: 24 hrs L compared to the photoperiods of T_1-(12 hrs L: 12 hrs D), T_3-7 days 24 hrs D: 7 days 12 hrs D and 12 hrs L, T_4-7 days 24 hrs D: 7 days 24 hrs L. Light is one of the most important culture management factors in that it synchronizes from embryo development to sexual maturation of fish (Guo et al., 2012; Villamizar et al., 2011). In T_2 treatment, Platy's breeding rate was highest and it took less time than other treatments to breed. In this study, brood reproduction started after 7^{th} sampling (05.08.2019) in T_2R_1 and T_2R_2

aquarium. It was showed in this research that the T_2 treated platy took shortest time which was 113 days (average) among four treatments. It also produced 25 platy fish fry which was the best among others. The long photoperiod condition is also effective in stimulating spawning, so long photoperiod warm temperature regime is a powerful tool to modify gonadal development in goldfish (Sarkar and Upadhyay, 2011). Photoperiodism is the ability of an organism to assess and use the day length as an anticipatory cue to time seasonal events in their life histories (Bradshaw and Holzapfel, 2007). The photoperiod directly influences the fish behavior, especially in their feeding and reproductive habits (McConnell, 1999). The photoperiod effect on fish species reproduction is an important factor to be studied. Developmental and maturational events are dominated and coordinated by seasonal changes in photoperiod, temperature, food supplies, rainfall, etc. (Porter et al., 1995; Vazquez et al., 2000).

5.6 Effects of Photoperiod on Coloration and Carotenoid Content of Platy fish:

Color is an important trait in the ornamental fish trade (Hoff, 1996). The results of this color observation study suggested that the fishes reared under higher level of light condition (in T_2 treatment) showed brighter in color than other photoperiodic levels. The carotenoid content analysis suggested that the fishes reared under high light level (T_2-0 hrs D: 24 hrs L) contain significantly higher carotenoid content than T_1-(12 hrs L: 12 hrs D), T_3-7 days 24 hrs D: 7 days 12 hrs D and 12 hrs L, T_4-7 days 24 hrs D: 7 days 24 hrs L. About 95.24% fish became colorful in T_2 treatment which is highest percentage among other fish. However, the mode and mechanism of actions about carotenoid content increase in skin by light intensity is in progress. Color changes in fish are often related to environmental stress, and illumination could be a primary factor regulating pigment distribution through hormone regulation (Salm et al., 2004). Color of fish skin is predominantly dependent on the presence of chromatophores containing colored pigments (Fox, 1957). The color of fish skin is generated by the absorption, reflection, and scattering of light by the pigments and microstructures within the fish integument (Fujii, 2000). Color enhancement tests showed that the carotenoid content was approximately 0.00448 ± 0.0019^{b}, 0.00541 ± 0.0003^{a}, 0.0036 ± 0.0003^{bc} and 0.00417 ± 0.0002^{c} mg g-1 respectively for fish raised under T_1, T_2, T_3 and T_4 treatment. The result obtained from the current study therefore shows that the higher light level (T_2) was more suitable for enhancing the skin color of platy fish that could be recommended for the successive development of this high-priced species.

CHAPTER SIX

CONCLUSION

A widespread and global part of international trade, fisheries, aquaculture and production is the ornamental fish sector. Ornamental fish culture which is going to make our country compete with world market as well boost our national income, prestige and also act as strong weapon in eradicating unemployment problem. Light plays an important role in successful growth, survival and breeding of life bearer fish species and their youngones, as it is known to affect skin pigmentation in several species. The present study was conducted to know the potentialities of photoperiod for better performance of ornamental platy fish. The long day (T_2-0 hrs D: 24 hrs L) light condition have great impact on breeding, growth, survival and coloration than short day photoperiod. During long day photoperiod breeding and survival rate were maximum, while on short-day light condition growth performance were smaller with slower rate.

CHAPTER SEVEN

RECOMMENDATION AND FUTURE PROSPECTS

The following recommendations can be made in conjunction with this research paper:

- Continuing this form of research will help to create an effective policy for the faster and more sustainable growth of the production of aquarium fish in our country.
- Unemployment problem can be solved by enhancing overall productivity of ornamental fish.
- Most of the ornamental fishes are imported from foreign country which costs a lot of money. In this case, photoperiod may add new dimension by improving coloration on fish body and may help to meet the requirement of the country.
- Nowadays, Feeding carotenoids diet become very popular to enhance coloration of fish. Besides light intensity may subsidiary to create pigmented fish for ornamental fisheries sector.
- Since it is a pilot study, further research may be performed to make a clear remark on a similar area.

References

Alam MR, Alam MJ, Pattadar SN, Karim MR, Mahmud S. 2016 A trend of ornamental fish business in Barisal division, Bangladesh. International Journal of Fisheries and Aquatic Studies. 4(3): 263-266 pp.

Baggerman B. 1980. Photoperiodic and endogenous control of the annual reproductive cycle in teleost fishes. In Environmental physiology of fishes. Plenum publishing Corp. 537-567 pp.

Barlow CG, Pearce MG, Rodgers LJ, Clayton P. 1995. Effects of photoperiod on growth, survival and feeding periodicity of larval and juvenile barramundi *Lates calcarifer* (Bloch). Aquaculture. 138:159-168 pp.

Bergman M. 1987. Photoperiod and tesricular fiinction in Phodopus sungorus. Advances in Anatomy, Embryology and Cell Biology. 105:1-76 pp.

Boeuf G, Le Bail PY. 1999. Does light have an influence on fish growth. Aquaculture. 177: 129-152 pp.

Bradshaw WE, Holzapfel CM. 2007. Evolution of Animal photoperiodism. Annual review of ecology: Evolution and systematics. 38: 1-25 pp.

Das AP, Biswas SP. 2016. Carotenoids and Pigmentation in Ornamental Fish. J Aquac Mar Biol. 4(4): 00093.

Dutta H. 1994. Growth in Fishes. Cerontalogy. 40: 97-112. 19 pp.

Fenwick JC. 1970. The pineal organ: photoperiod and reproductive cycles in the goldfish J. Endocrinol. 46: 101-111 pp.

Fernandes MHB. 1979. Some effects of light intensity and photoperiod on the seabass larvae (*Dicentrarchus labrax* (L.)) reared at the Centre Oceanologique de Bretagne. Aquaculture. 17:311-321 pp.

Fielder DS, Bardsley WJ, Allan GL, Pankhurst P. 2002. Effect of photoperiod on growth and survival of snapper *Pagrus auratus* larvae. Aquaculture. 211: 135-150 pp.

Fox DL. 1957. The pigments of fishes. Academic Press Inc. 2 p.

Fuchs J. 1978. Influence de la photoperiode sur la croissance et la survie de la larve et du juvenile sole (*Solea solea*) en elevage. Aquaculture. 15:63-74 pp.

Fujii R. 2000. The regulation of motile activity in fish chromatophores. Pigment Cell Research. 13: 300-319 pp.

Galib SM. 2010. Aquarium Fisheries in Dhaka City, Bangladesh. Feature/Trade/Ornamental fish and Aquarium, Bangladesh Fisheries

Information Share. Available from: http://en.bdfish.org/2010/10/aquarium-fisheries-dhaka-bangladesh/

Galib SM, Mohsin ABM, 2011. Cultured and Ornamental Exotic Fishes of Bangladesh. LAP-Lambert Academic Publishing. 167 pp.

Gouveia L, Empis J. 2003. Relative stabilities of microalgal carotenoids in microalgal extracts, biomass and fish feed: effect of Storage Condition. Innovative Food Science Emerging Technology. 4: 227-233 pp.

Gouveia L, Rema P. 2005. Effect of microalgal biomass concentration and temperature on ornamental goldfish (*Carassius auratus*). Aquaculture Nutrition. 11: 19 – 23 pp.

Gross MR, Sargent RC. 1965. The evolution of male and female parental care in fishes. American Zoologist. 25:807-822 pp.

Guo B, Wang F, Dong S, Zhong D. 2012. Effect of fluctuating light intensity on molting frequency and growth of *Litopenaeus vannamei*. Aquaculture. 330:106-110 pp.

Gupta SK, Jha AK, Pal AK, Venkateshwarlu G. 2006. Use of natural carotenoids for pigmentation in fishes. Natural Product Radiance. 6(1): 46-49 pp

Hill GE. 2002. A Red Bird in a Brown Bag: The Function and Evolution of Colorful Plumage in the House Finch. Oxford University Press. 318 p.

Hoff FH. 1996. Conditioning, spawning and rearing of fish with emphasis on marine clownfish. Aquaculture Consultants Inc. 212 p.

Howell RA, Berlinsky DL, Bradley TM. 2003. The effect of photoperiod manipulation in the reproduction of black sea bass, *Centropristis striata*. Aquaculture. 218: 651-669 pp.

Immelman K. 1963. Tiersche Jahresperiodik in Okologischer Sicht. 91: 91-200 pp.

Kawamura T, Otsuka S. 1950. On acceleration of the ovulation in the goldfish Jpn. J. Ichthyol. I: 157-165 pp.

Kallman KD, Kazianis S. 2006. The Genus Xiphophorus in Mexico and Central America. Zebrafish. 3(3).

Kumar V, Follet BK. 1993. The nature of photoperiodic clocks in vertebrates. Zoo Soc Calcutta B.S. Haldane Comm. 217-227 pp.

Lam TJ, Hoar WS, Randall DJ, Donaldson EM. 1983. Environmental influences on gonadal activity in fish. Fish physiology: Behavior and fertility control. Academic Press, Inc. New York, 9B: 1-65 pp.

Marchesan M, Spoto M, Verginella L, Ferrero EA. 2005. Behavioural effects of artificial light on fish species of commercial interest. Fisheries Research. 73: 171–185 pp.

Martínez AJM, Britton G, Vicario IM, Heredia FJ. 2005. Color and carotenoid profile of Spanish Valencia late ultrafrozen ornge juice. Food Research International. 38: 931-936 pp.

McConnell RHL. 1999. Estudos ecológicos de comunidades de peixes tropicais. São Paulo: EDUSP. 535p.

McGraw KJ, Ardia DR. 2003. Carotenoids, immunocompetence and the information content of sexual colors: and experimental test. American Nature. 162: 704-712 pp.

Mostafizur MR, Rahman SM, Khairul MI, Rakibul HMI, Nazmul MA. 2009. Aquarium business: A case study in Khulna district, Bangladesh. Bangladesh Research Publication Journal. 2(3): 564-570 pp.

Jeniffer PN, Kumar M, Kumar KL. 2012. The effects of photoperiod on the growth rate of Black Molly *Pocellia sphenops* (Valenciennes, 1846) from larvae to adult in mass culture ıntternational Journal of Advanced Life Sciences (IJALS). 5(2): 136 p.

Olivotto IKE, Cardinali M, Barbaresi L, Maradonna F, Carnevali O. 2003. Coral reef fish breeding: the secrets of each species. Aquaculture. (224): 69 – 78 pp.

Paripatananont T, Tangtrongpairoj J, Sailasuta A, Chansue N. 1999. Effect of astaxanthin on the pigmentation of goldfish Carassius auratus. Journal of World Aquaculture Society. 30: 454 – 460 pp.

Pavlidis M, Greenwood L, Mourot B, Kolkkaric, Meenn F, Divanach P, Scott AP. 2000. Seasonal variations and maturity stages in relation to differences in serum levels of gonadal steriods, vitellogenin and thyroid hormones in the common dentex (Dentex dentex). Gen. comp Endocrinol. 118: 14-25 pp.

Petrell RJ, Ang KP. 2001. Effects of pellet contrast and light intensity on salmonid feeding behaviours. Aquaculture Engineering. 25: 175 – 186 pp.

Porter M, Randall C, Bromage N. 1995. The efifects of pineal removal and enucliation on circulating melatonin levels in Atlantic salmon. Aquaculture. 75 p.

Pyle EA. 1969.The effect of constant light or constant darkness on the growth and sexual maturity of brooktrout. Fish Res. 33.25-29 pp.

Reiter RJ. 1995. Functional pleiotropy of the neuroendocrinology receptor in Neuroendocrinology. 16: 383-415 pp.

Salm ALVD, Martnez M, Flik G, Bonga SEW. 2004. Effects of husbandry conditions on the skin color and stress response of red porgy, *Pagrus pagrus.* Aquaculture. 241: 371-386 pp.

Schlosberg H, Duncan MC, Daitch BH. 1949. Mating Behavior of Two Live-Bearing Fish, *Xiphophorus hellerii* and Platypoecilus maculatus. Physiological Zoology. 22 2): 148-161 pp.

Sarkar A. 2011. Role of Photoperiod in Enhancement of Reproduction in Goldfish (*Carassius auratus*). Society of Applied Sciences. 2(3): 544-547 pp.

Schartl M, Walter RB, Shen Y. 2013. "The genome of the platyfish, *Xiphophorus maculatus*, provides insights into evolutionary adaptation and several complex traits" Nature Genetics. 45 (5):567-572 pp.

Stephens WJ. 1952. Mechanisms regulating the reproductive cycle in the crayfish *Cambarus* I. The female cycle physiol. Zool, 25: 70.

Swati, Sinha A, Jha AN, Jain AK. 2019. Effect of Photoperiods on Growth and Maturation of Guppy (*Poecilia reticulata*), International Journal of Advance Engineering and Research Development. 6(01).

Thomas G. 2020. Effect of Formulated Feeds on Growth Performance and Pigmentation in Ornamental Fishes - A Cohort Study. Oceanogr Aquacul Res. 1(1); 1-3 pp.

Torrissen OJ, Naevdal G. 1984. Pigmentation of salmonids-genetical variation in carotenoid deposition in rainbow trout. Aquaculture. 38: 59-66 pp.

Vazquez FJS, Ligo M, Madrid JA, Tabata M. 2000. Pinealectomy does not affect the entrainment to light nor the generation of the Circadian demand feeding rhythms of rainbow trout. Physical Behav. 69: 455-461 pp.

Villamizar N, Blanco VB, Migaud H, Davie A, Carboni S. 2011. Effects of light during early larval development of some aquacultured teleosts. Aquaculture. 315: 86–94 pp.

Whittier JM, Crews D. 1987. Hormones and reproduction in fishes, amphibians, and reptiles. Seasonal reproduction: pattems and control. Plenum Press, New York. 385-409 pp.

Yaron Z, Cocos M, Salzer H. 1980. Effects of temperature and photoperiod on ovarian recrudescence in the cyprinid fish Mirogrex terrae-sanctae. Fish Biology. 16(4): 371-382 pp.