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STUDY OF PHOTO PERIODIC IMPACT OF ZEBRA FISH DANIO RERIO IN AQUARIUM WATER

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ABSTRACT

The study examines the impact of different photoperiods on the behavior and physiology of zebrafish (Danio rerio) kept in aquariums. An analysis was conducted to examine the impact of various light-dark cycles on the activity levels, physiological markers, and general well-being of zebrafish. The zebrafish were exposed to three different photoperiod regimes: a 12-hour light/12-hour dark cycle (12L:12D), a 16-hour light/8-hour dark cycle (16L:8D), and continuous light (24L:0D). The study assessed activity levels, rates of oxygen consumption, and rates of growth to ascertain the influence of these light cycles. The findings revealed substantial disparities in behavior and physiology between the several groups, underscoring the crucial role of effective light control in ensuring the well-being of zebrafish in captivity.

Keywords: Photoperiod, Physiology, Growth, Oxygen, Light exposure

I. INTRODUCTION

In an aquarium, zebrafish (*Danio rerio*) rely heavily on the photoperiod, which is the amount of time that light is exposed to each hour. The effects of photoperiod on their mating habits are particularly noteworthy. The sensitivity of zebrafish to changes in their circadian rhythm is well-documented; in general, longer periods of sunshine are thought to encourage mating. They spawn first thing in the morning, right when the lights go on, since long periods of light help the gonadal growth process forward. The reproductive processes are well-regulated and enhanced by this synchronization with the light cycle, which leads to effective breeding.

Also, photoperiod has a major impact on how zebrafish larvae grow and develop. Continuous light exposure, as opposed to brief bursts of light, can speed up development rates, according to studies. Longer photoperiods promote better overall development, which leads to greater growth in both size and morphology. In order to ensure the proper development of zebrafish from larvae to adults, it is crucial to maintain an adequate light cycle.

Photoperiod is highly related to behavioral patterns in zebrafish. They follow a regular light cycle to keep up with their normal sleeping and active cycles, which are important for these critters because they are diurnal. Changes in swimming and eating habits might result from photoperiod disruptions. Because zebrafish are most active when the light is shining on them, disruptions to their natural light cycle can have serious consequences for their well-being.

Photoperiod also has a major effect on health and stress. Stress, as measured by increased levels of the principal stress hormone cortisol, can be induced in zebrafish by abrupt shifts in the light-dark cycle or by prolonged light exposure without an appropriate dark period. They may be more susceptible to illness if their immune system is compromised due to chronic stress. Therefore, zebrafish must have a constant photoperiod in order to reduce stress and keep themselves healthy.

The circadian clock that controls the internal biological cycles of zebrafish is in sync with the light-dark cycle. These rhythms regulate metabolism, reproduction, and behavior, among other physiological functions; a regular photoperiod aids in their maintenance. The significance of a regular light cycle for proper physiological functioning is highlighted by the fact that photoperiod influences gene expression associated with these activities.

Indirectly influencing both water quality and the overall aquarium environment is the photoperiod. Prolonged exposure to sunshine can encourage the growth of algae, which in turn affects oxygen levels and the general quality of the water. In order to keep the water from getting too hot, it is necessary to adjust the lighting in terms of both intensity and duration. To provide a suitable environment for zebrafish, it is crucial to control several environmental parameters.

II. IMPORTANCE OF PHOTOPERIOD IN ZEBRAFISH BIOLOGY

Because of their genetic closeness to humans, their quick developmental processes, and the simplicity with which they may be genetically manipulated, zebrafish, also known as Danio rerio, have become an essential component in the field of biological and scientific research. Photoperiod, which refers to the amount of time that passes between the occurrence of light and darkness in a 24-hour cycle, is one of the environmental elements that has the greatest influence on the biology of zebrafish when they are kept in controlled environments such as aquariums and laboratory settings. This environmental signal not only synchronizes biological cycles but also governs essential physiological processes, behavioral patterns, reproductive success, and general health. Moreover, it is responsible for regulating these activities.

Circadian Rhythms and Biological Clock Regulation

One of the most important factors in determining the circadian rhythms of zebrafish, which are responsible for regulating their daily patterns of behavior, activity, and metabolism, is the photoperiod pattern. The behavior of zebrafish, like that of many other creatures, is diurnal. This means that they are more active during the daylight hours and have a tendency to relax during the nighttime hours. This behavioral synchronization with the cycles of light in their surroundings is essential for their survival and for the efficient functioning of their physiological systems. Disturbances in the photoperiod, such as irregular light-dark cycles or persistent exposure to light, have the potential to disturb natural rhythms, which can result in stress and potentially have an impact on health outcomes. When photoperiod is managed correctly, zebrafish are able to keep their circadian rhythms in good shape, which in turn contributes to their overall health and well-being.

Reproductive Behavior and Success

Photoperiod controls zebrafish circadian rhythms and also has a major impact on how and whether a fish is able to reproduce. In response to changes in the amount of light reaching their bodies, zebrafish display unique mating behaviors. One example is that they usually spawn just as the morning lights go on, which might be a sign that their reproductive processes are naturally timed with the start of daylight. In order to maximize reproductive readiness and the chances of successful spawning, the gonads of both sexes are stimulated by extended periods of light. Both the maintenance of breeding populations in aquaculture and the controlled laboratory research of reproductive physiology and behavior depend on our ability to understand these photoperiodic impacts.

Growth and Developmental Processes

Photoperiod plays a crucial role at every stage of zebrafish development, from embryonic to adulthood. Light has a major effect on the pace of growth and the way zebrafish larvae and juveniles develop morphologically, according to the studies. While shorter photoperiods may slow down developmental processes, continuous light conditions tend to enhance growth rates. This occurrence highlights the significance of keeping proper light cycles to guarantee that experimental zebrafish populations grow and mature in a consistent manner. Critical for evaluating zebrafish health and maturity, light exposure also affects the timing of developmental stages including coloring and fin production.

Stress Response and Health Outcomes

When it comes to regulating zebrafish health and stress response, photoperiod is equally crucial. The circadian rhythm controls the production of stress hormones like cortisol; disturbances to the circadian rhythm can cause an increase in stress levels. Zebrafish are more vulnerable to illnesses and environmental stresses when their immune systems are compromised due to chronic stress. By simulating natural light cycles, well-managed photoperiods can reduce stress reactions, boost immunity, and increase resilience. Because of their usefulness as models for studying stress-related diseases and immunological responses in humans, zebrafish are of special interest to the biomedical research community.

Gene Expression and Metabolic Regulation

Molecularly, photoperiod affects zebrafish's gene expression patterns, which in turn control a number of physiological functions. Light cycles exercise regulatory control on genes that are involved in metabolism, reproduction, and behavioral responses. As an example, metabolic pathways can optimize energy usage depending on the availability of light by exhibiting diurnal fluctuations in gene expression. Similarly, photoperiodic signals synchronize with genes that regulate reproductive hormones and behaviors, guaranteeing that reproductive processes are coordinated and carried out at the right moment. How zebrafish adapt to new environments and how artificial light regimes in captivity affect their biological processes might be better understood by delving into these molecular pathways.

Environmental Interactions and Ecosystem Dynamics

Photoperiod has an indirect impact on aquatic ecosystems in aquariums in addition to its direct impacts on zebrafish physiology. Algae and other photosynthetic organisms may flourish in environments with lengthy periods of light, which changes the dynamics of nutrients and water chemistry. This has the potential to affect zebrafish health and behavior through a domino effect on water quality factors including pH and oxygen levels. Zebrafish are beneficial for both their health and the stability of the aquatic ecosystem that supports their care and research when photoperiod is well-managed. For zebrafish and other aquatic species conservation efforts and sustainable aquaculture methods, monitoring these interactions is vital.

III. REVIEW OF LITERATURE

Awasthi, Madhu et al., (2017) For 60 days, juvenile Trichogaster lalius were maintained in a controlled environment under three different photoperiod conditions: 0L:24D, 12L:12D, and 16L:08D. The purpose of this experiment was to evaluate the growth performance of the fish. When young T. lalius were exposed to light around 16:00 hrs., they grew the most. As early as the 20th day of the experiment, it was noted that several groups of young fish subjected to varied light settings had substantially different mean body weights ($p<0.05$) from one another. The group that was exposed to light for sixteen hours had the highest absolute, specific, and relative growth rates. The results of this controlled experiment showed that juvenile T. lalius fared better when exposed to light during the first six hours of the day.

Flores, Edgar Abraham et al., (2017) The green mojarra Cichlasoma beani is facing significant pressure from human activities, which is impacting its wild numbers. Developing culture techniques can help reduce the decline of native species populations. Environmental variables, such as the level of light and the duration of light exposure, can influence the growth and maturation of fish in controlled environments. Hence, the objective of this work was to investigate the impact of these parameters on the growth, survival, and condition of C. beani when cultivated under varying light intensities and photoperiods. The experiment involved testing three different light intensities (1000, 1500, and 2000 lux) and three different photoperiods (24:00, 16:08, and 08:16 Light:Dark) in 40 L tanks. Each tank had 10 fish, and there were three duplicates for each treatment. The experiment lasted for eight weeks. The species exhibited no notable disparities in light intensity or photoperiod, indicating their inherent ability to adjust to these environmental conditions. The results also indicated the favorable overall growth circumstances seen throughout the trial and the responsiveness of the life cycle stage of the specimens employed in this investigation. The findings of this study suggest that the inherent adaptations of C. beani enable successful cultivation under different lighting conditions in young individuals, which might be beneficial for commercial production due to potential energy savings.

Kashyap, Ankur et al., (2015) Juvenile Catla catla were subjected to a 90-day controlled experiment to ascertain the impact of various photoperiods and darkness on their development and longevity. We used four distinct photoperiod regimes—8 hours light: 16 hours dark (8L:16D), 16 hours light: 8 hours dark (16L:8D), continuous light (24L:0D), and total darkness (0L:24D)—to test the effects on the fish. Each tank contained ten fish. The group that was exposed to total darkness had the slowest growth rate, whereas the group that was exposed to continuous photoperiod had the fastest. Starting on day 60, it was noted that these groups' mean body weight differed considerably ($p<0.05$) from the other groups. Every tank that was tested with varying photoperiods had a perfect survival rate, with the exception of one that was kept in darkness all the time, which had a 30% mortality rate. In comparison to other groups of fish that were treated to different photoperiod regimes, the group that was subjected to continuous photoperiod had the largest mean final growth rate, specific growth rate, and daily feed intake ($p<0.05$). For regulated settings, it is recommended that juvenile Indian major carp, C. catla, be reared with a continuous photoperiod for improved development and survival.

Upadhyay, Bhavna. (2011) Because fish have such a wide range of mating preferences, anyone hoping to increase their fish yield through aquaculture must be well-versed in endocrine physiology. The effects of temperature and photoperiod on reproduction were examined in this study using three sets of experiments: 19L/5D at 200C, 12L/12D at 200C, and 18L/6D at 200C. The experimental regimes were compared with a control group. Microscopic and histological examinations were used to evaluate the development of the gonadal organs. In this study, the gonadosomatic index (GSI) was determined. Compared to other photoperiodic regimes, our research found that the gonads are in a better developed state at 19L/15D at 200C temperature. There are also high GSI levels. Long photoperiods are beneficial for enhancing gonadal activity in goldfish (Carassius auratus), as a result.

Bapary, Mohammad & Takemura, Akihiro. (2010) The impact of temperature and photoperiod on the reproductive behavior of the tropical damselfish Chrysiptera cyanea, which is found in reef environments, was studied in three distinct phases. Phase I (April-May) involved increasing water temperature and photoperiod. Phase II (June-July) included increasing water temperature and a peak followed by a decrease in photoperiod. Phase III (August-September) consisted of a peak followed by a decrease in water temperature and photoperiod. When the fish were raised at temperatures of 20, 25, or 30°C with the natural amount of daylight, the reproductive circumstances varied within and between the stages, depending on the temperature and environmental patterns of the experiment. Ovaries containing vitellogenic oocytes were observed only at a temperature of 25°C during phases I to III. However, regressing and immature oocytes were observed at temperatures of 20°C and 30°C. The fish exhibited vigorous spawning activity at a temperature of 25°C, while minimal or no spawnings were seen at lower temperatures. During phase III, fish exposed to a long photoperiod

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(LD14:10) showed a prevention of decline in the gonadosomatic index and a disappearance of vitellogenic oocytes in their ovaries, in contrast to fish exposed to a short photoperiod (LD10:14). The findings suggest that maintaining a lengthy time of exposure to light and maintaining an appropriate range of water temperature are key factors that influence the continuous reproductive activity and performance of the subjects. Additionally, it was shown that high temperatures have a detrimental effect on the growth of their ovaries.

IV. RESEARCH METHODOLOGY

A total of 165 Zebrafish were utilized in this experiment and were kept in normal aquarium tanks under carefully regulated environmental conditions. Three experimental groups were created, each exposed to distinct photoperiod conditions: Group 1 (12 hours of light and 12 hours of darkness), Group 2 (16 hours of light and 8 hours of darkness), and Group 3 (control group, 24 hours of light and 0 hours of darkness). To reduce variability, the quantity of zebrafish, their age, and the distribution of sexes were made consistent in all tanks. Every day, we did behavioral observations and used video monitoring software to measure activity levels and social contacts. Weekly measurements were taken to evaluate metabolic and developmental changes by assessing physiological factors like as oxygen consumption rates and growth rates.

V. DATA ANALYSIS AND INTERPRETATION

Table 1: Behavioral Responses

Experimental Group	Average Activity Level (counts/min)
12L:12D	35 ± 5
16L:8D	42 ± 6
24L:0D	28 ± 4

Table 1 displays the mean activity levels of zebrafish, measured in counts per minute, under various photoperiod circumstances. The zebrafish that were subjected to a light and dark cycle of 16 hours of light followed by 8 hours of darkness (16L:8D) had the most elevated levels of activity, with an average of 42 ± 6 counts per minute. This suggests that a prolonged time of light generates higher levels of activity in comparison to the other circumstances. Fish exposed to a 12-hour light and 12-hour dark cycle (12L:12D) exhibited moderate levels of activity, with an average of 35 ± 5 counts per minute. On the other hand, zebrafish that were subjected to uninterrupted light (24L:0D) exhibited the least amount of activity, with an average of 28 ± 4 counts per minute. These findings indicate that an overabundance of light exposure might inhibit regular activity patterns, either as a result of altered circadian cycles or heightened stress levels.

Table 2: Physiological Parameters

Experimental Group	Oxygen Consumption Rate (mg/L/hr)	Growth Rate (% increase in body length)
12L:12D	0.25	10
16L:8D	0.28	12
24L:0D	0.22	8

Table 2 presents a concise overview of the physiological reactions of zebrafish when exposed to various photoperiod circumstances. This includes the measurement of oxygen consumption rates and growth rates. Zebrafish subjected to a light-dark cycle of 16 hours of light and 8 hours of darkness (16L:8D) had the highest rate of oxygen consumption at 0.28 mg/L/hr. Additionally, these zebrafish saw the largest growth rate, with a 12% increase in body length. This implies that prolonged exposure to light increases metabolic activity and stimulates development. Fish kept in a well-regulated light-dark cycle of 12 hours of light and 12 hours of darkness (12L:12D) had a modest oxygen consumption rate of 0.25 mg/L/hr and a growth rate of 10%. In contrast, zebrafish that were subjected to uninterrupted illumination (24L:0D) had the least oxygen consumption rate, at 0.22 mg/L/hr. Additionally, these fish displayed the slowest development rate, with a mere 8% increment in body length.

VI. CONCLUSION

This study has yielded significant findings about the effects of photoperiod on zebrafish (Danio rerio) in tank settings. Through the examination of several light cycles, namely 12 hours of light followed by 12 hours of darkness (12L:12D), 16 hours of light followed by 8 hours of darkness (16L:8D), and continuous light (24L:0D), noteworthy discoveries have been made about the impact on zebrafish behavior and physiology. The zebrafish exposed to the 16L:8D photoperiod had increased activity levels and metabolic rates, indicating an ideal equilibrium that enhances natural behaviors and development. Conversely, prolonged exposure to light resulted in reduced levels of activity and development rates, suggesting the possibility of stress and disturbance to biological cycles. These findings emphasize the crucial significance of keeping proper light cycles in aquarium environments to promote the well-being of zebrafish and improve the reproducibility of research.

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