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Research Article

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Response of *Anguilla bicolor* Glass Eel to Different Light Colors

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ABSTRACT

The response of eel fish (*Anguilla bicolor*) glass eel stadia to different light is fundamental knowledge for developing fishing methods and conserving fish resources. The study aimed to describe how glass eel fish react to different types of light. In the laboratory, glass eels were observed responding to red, blue, and white LED light versus no light as controls. Glass eels ranging in size from 4.0 to 6.1 cm and weighing up to 0.28 g were caught in the Pelabuhanratu estuary of the Cimandiri River. Observations were made for 31 days, beginning five days after the glass eel was captured. The Mann Whitney and Kruskal-Wallis tests were used to describe differences of the glass eel's response to light. Observations showed that glass eels responded more to dark zones with values above 80% when compared to zones given red, blue, and white LED light. The percentage of fish in red LED lights was 23±0.22% higher, with the number of fish on blue LED lights by 10±0.21% and white LED lights 8±0.15% ($p<0.05$, Kruskal-Wallis). The difference in response to light can be used for glass eel catching applications, especially lamps for eel fish aids and eel conservation to create fishing zones and eels.

Keywords: *Anguilla bicolor, eel behavior, glass eel, LED light, response to light*

ABSTRAK

Respons ikan sidat (*Anguilla bicolor*) stadia glass eel terhadap cahaya yang berbeda merupakan pengetahuan dasar dalam mengembangkan metode penangkapan ikan dan konservasi sumberdaya ikan. Tujuan penelitian adalah mendeskripsikan respons ikan sidat pada stadia glass eel terhadap cahaya yang berbeda. Pengamatan respons glass eel terhadap cahaya LED merah, biru, dan putih dibandingkan dengan tanpa cahaya sebagai kontrol dilakukan di laboratorium. Glass eel yang digunakan berukuran 4,0 – 6,1 cm dan berat mencapai 0,28 g yang ditangkap dari muara Sungai Cimandiri Pelabuhanratu. Pengamatan dilakukan selama 31 hari dimulai dari 5 hari setelah penangkapan glass eel. Respons glass eel terhadap cahaya dianalisis secara deskriptif dengan uji Mann Whitney dan Kruskal-Wallis. Pengamatan menunjukkan bahwa glass eel lebih banyak merespons pada zona gelap dengan nilai diatas 80% bila dibandingkan dengan zona yang diberi cahaya lampu LED merah, biru, dan putih. Persentase jumlah ikan pada lampu LED merah sebesar 23±0,22% lebih tinggi dengan jumlah ikan pada lampu LED biru sebesar 10±0,21% dan lampu LED putih 8±0,15% ($p<0,05$, Kruskal-Wallis). Perbedaan respons terhadap cahaya dapat digunakan untuk aplikasi penangkapan glass eel khususnya penggunaan lampu untuk alat bantu dan konservasi ikan sidat untuk membuat zona penangkapan dan jalur ruaya sidat.

Kata kunci: *Anguilla bicolor*., glass eel, lampu LED, respons terhadap cahaya, tingkah laku sidat

1. Introduction

Eel is a fish with significant economic value as an export commodity in the Indonesian fisheries sector (Sembiring et al., 2015), with aquaculture opportunities (Setiawan 2018). Eels can compete with other commodities to generate foreign exchange (Koroh and Lumenta 2014). The selling price of eels rises due to high market demand in both domestic and international markets. The international market price of eel reaches IDR 700,000/kg with a size of more than 150 grams/individual, with export destinations including Japan, Taiwan, Korea, China, and Hong Kong (DKKHL 2015). Meanwhile, in the local market, the price

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of eel seeds increased in 2008, ranging from IDR 200,000-300,000 /kg, and again in 2012-2013, ranging from IDR 1,500,000 to 3,500,000 /kg (Affandi 2015; Putri and Syamsudin 2021).

The eel is a type of fish that lives in two different environments. The larval stage lives in seawater, while the juvenile and adult stages live in brackish and freshwater (Affandi 2015). Adult eels (silver eels) will migrate to the sea to spawn (reproduce), and the seeds will migrate back to the waters via rivers. The use of eels for aquaculture activities begins with capturing fish seeds at the glass eel stage at the river's mouth.

Eel seed fishing is done by fishers at night when the tide is high. Glass eel collectors use a variety of fishing gear, which varies by region. Fishers in the waters of Southern Java typically use a lift net, also known as a "betel/anco" or "sodok" which is operated by lowering the net to the riverbed with the net face facing up. The fishing gear used by Sulawesi fishers is a trap. A trap is a passive fishing device that is activated by spreading it across the river's mouth/estuary (DKKHL 2015). A kerosene lamp and searchlight are also used to aid in the capture of glass eels (Sriati 1998). Fishers use petromax or kerosene lamp to sort their catch, while white and yellow spotlights assist fishers in catching glass eel (WWF 2018).

When catching fish in the field, fishers have difficulty distinguishing between glass eels and by-catch. The use of this lamp is thought to affect the fishing process as well as the behavior of the glass eel. The effect of vertical light levels in the water column, according to Bardonnet (2005), is one factor that influences the catch. Previous research by Bardonnet (2005) revealed that the glass eel for the *Anguilla anguilla* (European eel) positive response to low light intensity, precisely 10-11 Watt/cm2 white light. However, the tropical glass eels behavioral response to light is unknown.

Based on this, further research is required to determine the response of glass eels (*Anguilla bicolor*) to various light sources. The findings of this study can provide information about the characteristics of the glass eel and the use of LED lights as a tool for catching glass eels and conserving glass eel resources. This study aimed to describe the behavioral response of Anguilla bicolor. to different light sources.

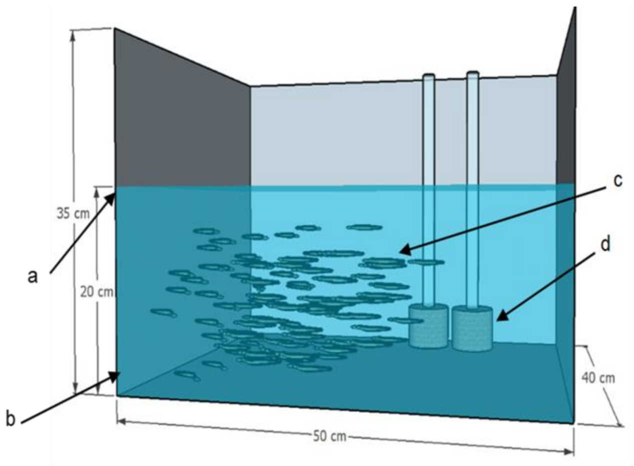
2. Material and Methods

The glass eels response to light was investigated at the Fish Behavior Laboratory, Department of Fisheries Resources Utilization, Faculty of Fisheries and Marine Sciences, IPB University, in November-December 2020.

Seven hundred (700) glass eels weighing 200 grams were divided into three different rearing aquariums. Each rearing aquarium is 50 x 40 x 35 cm3 in size, has a water volume of 40 liters, and is equipped with an aerator (Figure 1).

The darkroom and lightroom experimental aquariums are used in this experiment. The bright side gets a makeover. The aquarium is lined on the inside with Impraboard (corrugated plastic sheet 5 mm Black 1250x1500 mm) and has a slit in the bottom, right in the middle, measuring length x height of 5 x 1 cm. The water in the aquarium was 5 cm high, and the lamp was 30 cm above the water. A layer of black plastic covers the outside (Figure 2).

The light used is a multi-color system LED lamp (RGB-1185-10 Generic). The LED lamp



Explanation:
a. Water level
b. Water volume 40 liters
c. Glass eel
d. Aerator

Figure 1. Rearing aquarium illustration

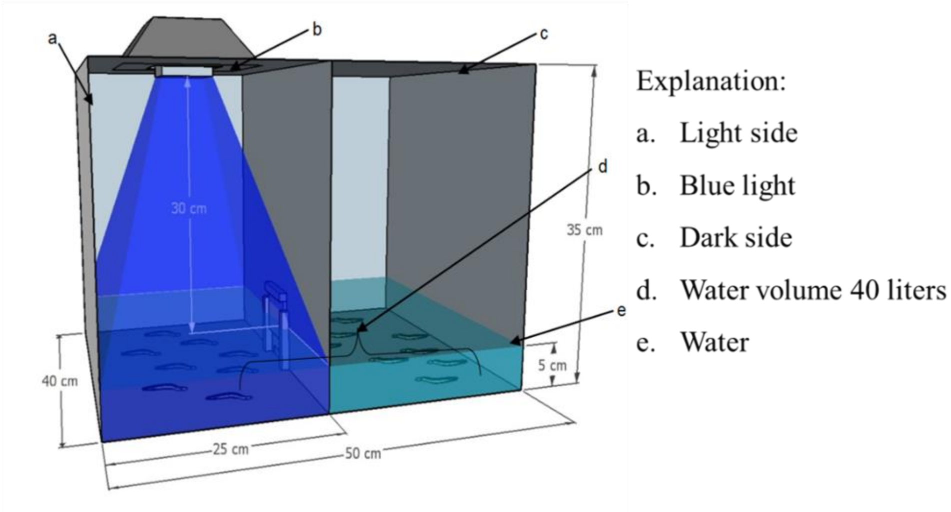


Figure 2. Research aquarium illustration

has a remote control to change the light with different colors. LED lights have a voltage of 90-240V, with a power of 10 Watts. The lights in the study were white, red, and blue LEDs. The determination of white LED lights is because fishermen use white light as a fishing auxiliary, which is easy to obtain on the market. Fishermen usually use red LED lights at the final stage of the fishing process. While fishermen use the blue LED lights to attract fish from areas far from the catchable area (Tirtana *et al.* 2020). Light measurements were taken in a dark room using an International Light Technologies device (ILT 5000 research radiometer). Sensors, receivers, and computers comprise the set of tools. The sensor distance from the lamp was 30 cm, and measurements were taken from 0^o to 180^o with a measurement interval of 10^o (Tirtana 2019). With a distance of 30 cm between the lights, the intensity value ranges from 0-1.4 $x10^{-8}$ Watt/cm^2 in red to 0-5.2 $x10^{-8}$ Watt/cm^2 in blue to 0-1.7 $x10^{-8}$ Watt/cm^2 in white. As a result, the intensity used in this study is 10^{-8} Watt/cm^2. To ensure the light is at an intensity of 10^{-8} Watt/cm^2 before treatment, the lights are measured and set in the same position for each treatment.

The twenty eel samples were placed in a container. The treatment aquarium was then filled to a depth of 5 cm with water. The samples in the container were placed in the treatment aquarium's darkroom, with the aquarium bulkhead closed. The fish were acclimatized in a dark room for 5 minutes before being treated. When the bulkhead was opened, the treatment began and was timed with a stopwatch. In a bright room, the lights are turned on at the same time as the bulkhead is opened. The bulkhead was closed after 10 minutes, and the glass eels were counted and recorded in a dark room and lightroom. The method was carried out according to previous research by Bardonnet 2005. The time required was too long, so in the second week, only 10 minutes was used with the consideration that there was no significant difference between the 20 and 10 minutes observations (P<0.005). Based on this, the treatment used in this study was observation for 10 minutes. Before the treatment, the fish were placed in a dark room for 5 minutes to re-acclimate. Each replicate group received three light color treatments for a total of nine replications in one day. The obtained data were analyzed using the following equation:

$$Z = \frac{U-E(U)}{\sqrt{Var(U)}}$$

$$E(U)= \frac{n1.n2}{2}$$

$$Var(U)= \frac{n1.n2(n1+n2+1)}{12}$$

with:
U1 = Number of sample ratings 1
U2 = Number of 2nd sample rating
n1 = 1st sample
n2 = 2nd sample

This test was used to compare the differences between two groups of samples under specific conditions, with the data obtained as ordinal data that were not normally distributed. According to Iriyanto (2007), population data is normally distributed if the average value is the same mode and median values. The results of this test categorize the samples following the proposed hypothesis (Paramita 2015).

Kruskal-Wallis Statistical test:

$$H = \frac{12}{N(N+1)} \sum_{i=1}^{k} \frac{Ri^2}{ni} - 3(N+1)$$

With:
N = number of samples
$R_{i=}$ number of ranks in group i
$n_{i=}$ number of samples in group i

The Kruskal Wallis statistic is a non-parametric test that compares two variables measured from unequal (independent) samples. The provision is that more than two groups are compared (Amri et al., 2009). The data were analyzed using the application of Statistical Product and Service Solution (SPSS).

3. Results and Discussion

The percentage of glass eel that approach the lights varies each day. Every day, the number of fish entering the red LED light zone differs significantly. The rate of glass eel that enter the bright area of the red LED light ranges between 12 and 33%; the remainder remains in the dark zone. The portion of fish entering the bright room under the blue LED light ranged from 0 to 22 %, with the rest remaining in the darkroom (Figure 3).

Figure 3 shows that the number of glass eel in each LED lamp varies. This distinction is highlighted because the sample is chosen at random every day, and the glass eel whose data has been collected is not reused. After obtaining the data per day from the light room and darkroom, the overall data was obtained by taking the average of each LED lamp (Figure 4).

The glass eel did not react to the three colors of the LED light based on the average number of glass eel collected in the part of the aquarium that was treated with color light. The number of glass eels collected in each LED light color, which does not reach 50% of the

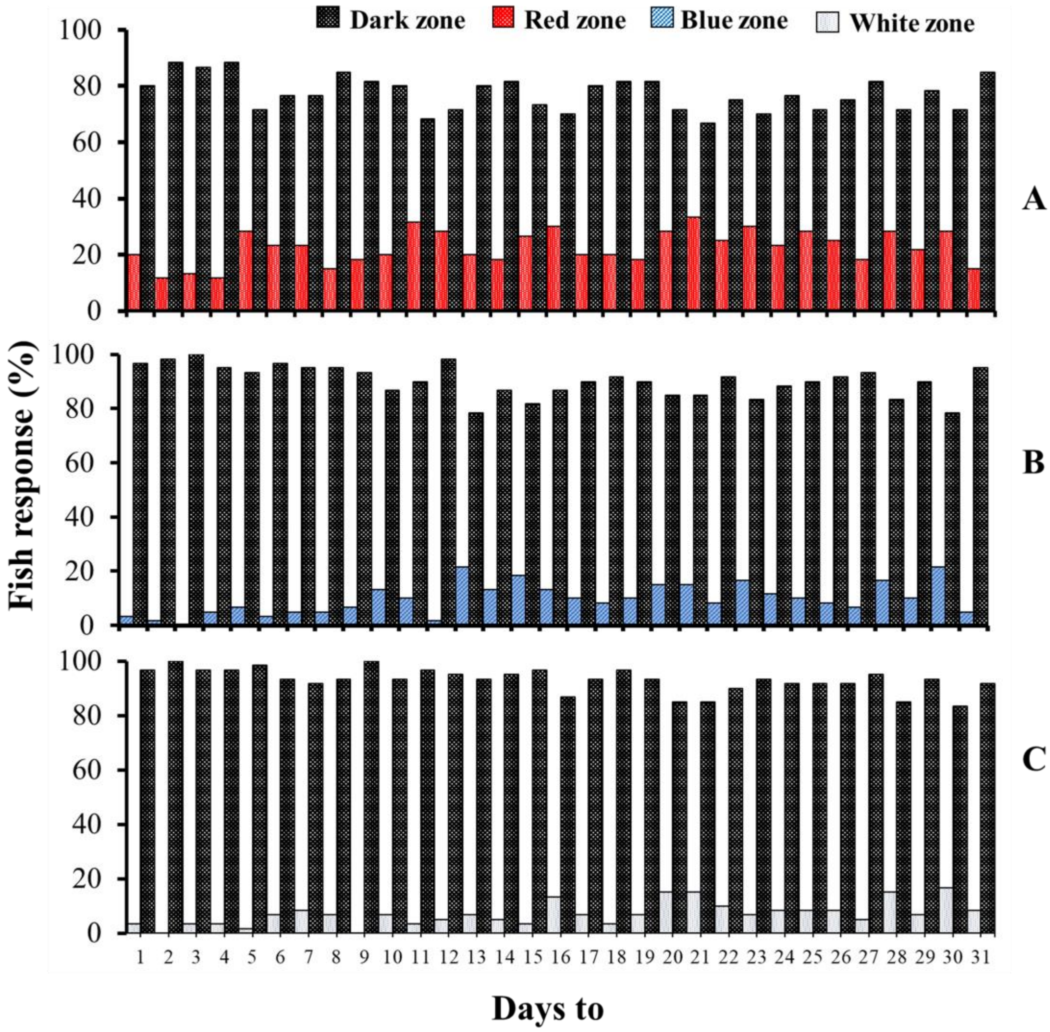


Figure 3. Amount of glass eel response on (A: red LED; B: Blue LED; C: White LED) and Dark Zone

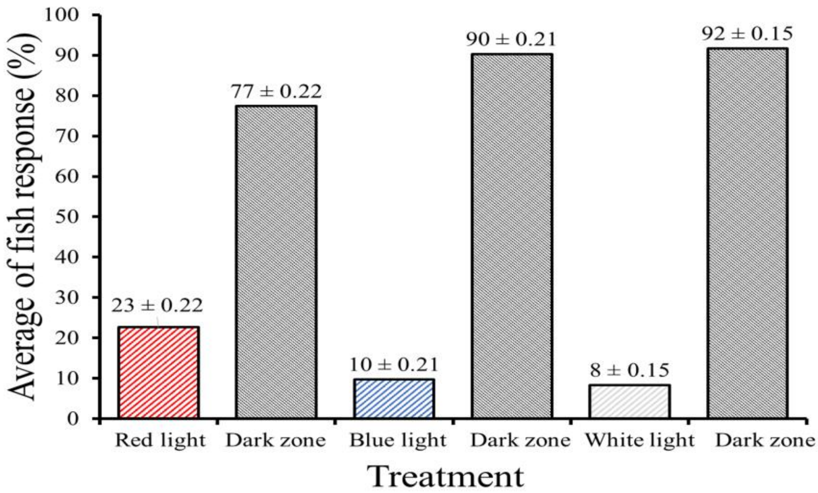


Figure 4. Total Response of Eel on LED Colors

eels in the bright zone, reveals this. However, the number of glass eel that respond to red LED lights is higher than that of other colored LED lights.

Using Kruskal-Wallis statistical analysis, the color comparison of red, blue, and white LED lights was tested. The data is tested to determine whether the glass eel prefers red, blue, or white light. The obtained value was 0.00 with P0.05, indicating that the treatment of red, blue, and white LED lights is significantly different. The number of fish visible on the red, blue, and white LED lights is displayed (Figure 5).

Based on Figure 5, it can be seen that the median values for each color of LED light are not the same. The red LED owns the highest median value, followed by the blue LED. White LED lights own the lowest median value. The number of fish that gathered up to 7 individuals indicated a significant difference in the red LED light. The treatment given to 620 glass eel samples showed that the red LED light was the preferred light for the glass eel when viewed from its mean and median values.

The visual observations of glass eels revealed that different light colors with the same intensity elicited different responses in the fish. Fish are attracted to light when it is turned on for 1 to 5 minutes, according to Eva (2009). The light exposure treatment for glass eel fish lasted 10 minutes before turning off for 5 minutes. It was then turned back on with a different LED light. Because the experimental aquarium conditions were small and there was no difference between light exposure times of 20 minutes and 10 minutes, the exposure was limited to 10 minutes. The number of fish that congregate in the bright zone or the area treated with light color indicates how eels react to light.

The difference in the three treatment pairs in the dark and light zones in Figure 1 shows that fish congregate more in the dark zone. Rosemmary (1952) reported the same thing; his research revealed that 60 percent of the glass eels were in the dark zone. One factor influencing the glass eel's preference for the dark zone is that it lives in estuarine waters. Because estuarine waters have a high turbidity

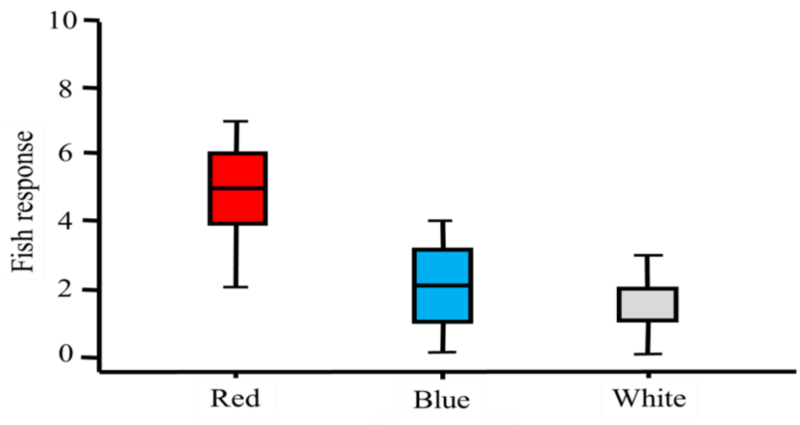


Figure 5. The ratio of number of fish in red, blue, and white LED

level, water clarity is poor. The condition of these waters causes them to be dark (Eric et al., 2005). The glass eel prefers dark waters because of its adaptation to a nocturnal or nocturnal life (Dou and Tsukamoto 2003).

The response of glass eels to differences in light color was also compared in this study. The red LED light has the highest percentage of fish. Glass eels flock to red LED lights, presumably due to their eyes' adaptation to living in low-light conditions. The wavelength of the red LED light is 620 nm, but the frequency is low up to 484 THz, and the penetrating power is low, so it will be absorbed after penetrating the waters (Sahin and Figueiro 2013). Because there is less light entering the water, the glass eel fish congregate and move closer to the light source than other treatments. Red light with a longer wavelength can improve fish vision in the dark (Giri et al., 2002). Sukardi et al. (2017) state that red light is typically used in the final stages of catching due to the low frequency of red light, which causes fish to approach the light source.

Compared to red LEDs, the response of glass eels to blue LED lights did not have a large percentage of fish numbers. This is since the blue LED light has a short wavelength of 470 nm, but its frequency reaches 668 THz and its penetrating power in deep waters, so it is not affected by the water conditions preferred by glass eel fish (Sahin and Figueiro 2013). The water conditions chosen by glass eels are estuarine waters that are typically shallow and cloudy. Particles absorb blue light in unclean waters simultaneously (Kelly et al. 2012). Glass eels are thought to be sensitive to direct exposure to blue LED lights in clear water in this study's treatment.

The percentage of fish that congregate around white LED lights is lower than that of fish that gather around red and blue LED lights. Because the glass eel stadia is sensitive to white light, it avoids bright environments (Bardonnet et al. 2005). White light is light that can be seen. Similarly, Marchesan et al. (2005) discovered that seabass fish are sensitive to white light because their eyes can only adapt to dim light conditions. It is suspected that this also applies to glass eels.

According to this study, glass eels prefer red lights. Migratory glass eel fish is influenced by the physiological preparation of fish, physical and chemical factors such as tides, and the influence of moon phases (Rosemmary 1952). On the other hand, glass eels require moonlight to survive, so artificial light on fish is used to study the fish's reaction to different colors of light. The glass eel is more sensitive to red light than the green-blue light spectrum, according to the findings. However, white light can save glass eels (Bardonnet 2005).

On the lift net, fishers typically use the red light at the end of the fishing process. It is hoped that this can be done on glass eel catching as direct fishing auxiliary gear. However, the results of this study revealed that red light had a higher percentage of glass eel than the other treatments, indicating that glass eel congregated more in the dark zone. However, red light can be further developed during the glass eel capture process. For example, it is used directly in fishing, where a red light is mounted on a pole, such as a monitor, and fishers conduct the fishing process in coastal waters. So far, fishers' use of lights in catching glass eels has been limited to illuminating the area of the catch and detecting the presence of glass eels caught by fishing gear (Darmono 2012). It is suspected that the intensity of red light in this study is still too high, so more research is needed to demonstrate that red light with low intensity can be used directly in capture. According to Guntur et al. (2015), high-intensity light can drive fish away from the light source. This is because each fish has a different light tolerance limit.

This research also demonstrates the potential application of light in glass eel conservation to protect fish resources to reduce glass eel mortality while migrating. The use of high-intensity white light can conserve glass eel fish, for example, by applying it to the dam area so that the glass eel avoids the area and can even direct the migration process (Haro et al., 2000).

The response of fish to light is the basic science of fish behavior. This study is more appropriate for conserving glass eel resources. Glass eels require only a small amount of light to move, as evidenced by their light response. This study still employs a relatively bright light source (10-8 Watt/cm2), indicating that fish prefer the dark zone. Further studies use a lower light for the glass eel because it is more easily adapted to the glass eel eye. This study still has flaws, particularly in determining when to use the glass eel when approaching the light source. Furthermore, there is a lack of knowledge about the movement and swimming patterns of the glass eel fish's behavior, necessitating additional research in the treatment laboratory using a camera.

4. Conclusion

The response of glass eels to different intensities of light produced significantly different results. After being exposed to each light color, 80 % of the glass eels congregate in the dark zone. However, when it comes to LED lights with different light colors, glass eels prefer red light over blue and white light. The percentage of fish in red LED lights was 23 %, 10 %in blue LED lights, and 8 % in white LED lights.

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