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Behavioral Response of African catfish (*Clarias gariepinus*) to Electrical Flow in an Electrofishing Gear

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Abstract

African catfish are a species of fish commonly found in various aquatic environments. Fishermen employ diverse methods to catch fish in seas, rivers, and swamps, utilizing eco-friendly and non-eco-friendly tools. One such tool is electrofishing. Fish behavior is influenced by their ability to adapt to their environment. One observable aspect is the African catfish's swimming patterns and endurance in a research pond. This study was conducted in April 2024 at the Fishing Gear Materials Laboratory, Department of Aquatic Resource Utilization, Faculty of Fisheries and Marine Sciences, Universitas Riau. The research utilized an experimental method, with data collected directly in the Laboratory. African catfish were used as test subjects with a 12-volt electric fishing gear. The results showed that at a treatment distance of 30 cm, the fish required an average of 3,5 seconds to respond to the electric current. The use of electrofishing gear has been proven to cause negative physiological responses, including fainting, external injuries, and mucus release in African catfish, which has implications for the sustainability of the African catfish population. After electrofishing, the condition of the fish showed injuries and fin loss on their bodies, resulting in some fish dying during recovery, although the number of dead fish was fewer than the number of surviving fish.

1. INTRODUCTION

The African catfish has an elongated body and slippery skin that lives in fresh water. Catfish naturally live in relatively shallow waters, with shelter or dark areas, and prefer muddy substrates (Suyanto, 2011). Fishermen use various methods to catch fish, whether in the sea, rivers, or swamps, using both environmentally friendly and non-environmentally friendly tools. One such tool is electrofishing. According to Puspito (2010), an electric current is anything that can generate an electric current, where an object carrying an electric current can affect objects or the environment around the current. An electrofishing device typically consists of two metal rods that function as a cathode (negative) and an anode (positive). The electrocution process involves inserting both ends of the rods into the water, turning on the switch, and moving both ends across the water. Fish that are electrocuted will become unconscious or even die, making them easier to catch. The fundamental problem in this research is fishing using artificial electric fishing gear, and the need to know the behavioral response of the swimming endurance of young African catfish and the swimming patterns of young African catfish to electric current.

Electrical fishing was first introduced in 1863 and began to be developed in 1875 in Germany (Sudirman & Mallawa, 2004). There are two types of electrodes, namely negative and positive. The positive direction of the electric current moves according to the direction of movement of negative ions (anions), namely from the negative pole (cathode) to the positive pole (anode). If an insulating cylinder limits the current between the electrodes in the conducting medium, the current density will be homogeneous and unidirectional. However, if the electrode is immersed in the conducting medium and is not limited by an insulating cylinder, the current will not be uniform, and the electric field will be inhomogeneous. According to Atkins et al. (2023), an electrode is an electronic conductor that functions as an interface where electron transfer occurs with chemical species in an electrolyte solution or other ionic phase, allowing electrochemical reactions such as oxidation or reduction to occur.

Electrocution causes the ions in the fish's body cells to become polarized, so the fish will be affected by the electric current, which then causes a stimulant effect that can disrupt the brain's balance. This also affects the way the fish breathe (Houston, 1971). Electrocuting fish with a certain current strength will affect fish of various sizes differently. The time it takes for the fish to faint increases as its length increases. Pentury (1987) explains that fish with larger body sizes are more sensitive to electric currents than those with smaller bodies.

According to Arnaya (1980), the sensitivity of fish to electric currents is highly dependent on their body size. Electric currents will more quickly affect large fish than small fish (Primadona et al., 2017). The rapid unconsciousness of fish due to electrocution will reduce muscle damage, thus maintaining the quality of the fish. According to Nurhayati et al. (2010), severe muscle damage will cause the fish to deteriorate more quickly. In addition, a fast electrocution time will allow the user's body to receive a shorter electric current flow, thus reducing the danger. Even the smallest electric current flowing through the human body will cause negative effects on the human body. The objectives to be achieved are to determine the swimming endurance behavior, swimming patterns of African catfish, provide information to the public and related parties about the effects of homemade electric currents on the sustainability of African catfish and other freshwater fish in the long term and as an education to the public why homemade electric fishing gear is said to be illegal and dangerous for the sustainability of other freshwater biota.

2. RESEARCH METHODS

Time and Place

This research was conducted in April 2024 at the Fishing Gear Materials Laboratory, Department of Fisheries Resource Utilization, Faculty of Fisheries and Marine, Universitas Riau, Pekanbaru, Riau.

Material and Methods

The tools used in this study were a research pool with a diameter of 106 cm and a height of 49 cm, which was used as a container for fish in the trial. Artificial electric shock with a total weight of around 1-1.2 kg. Electric equipment such as screwdrivers, bolts, boards, copper wire with each measuring 0.8 mm (primary coil) and 0.5 mm (secondary coil), a condenser, platinum, an iron plate, board/plywood, a power supply (12 V), a multimeter (electric current measuring instrument), and other essential needs. Laptops were used to process observation data and reports from the study. Stationery records important things during the study: a ruler, a 30 cm measuring tool to measure the length of the fish's body. A Mobile phone stopwatch was used to measure time during the study. A Video camera (1080P X 60 fps) was used to record the study's results. Block millimeter paper is used to measure the scale of swimming patterns in African catfish. The materials used in this study were young African catfish (C. gariepinus) with a sample size of 140 fish, 4-5 cm fish, and clean water as the research pond medium.

The method used in this study was an experimental one. This study's treatment type was the effect of distance on fish body size. The electrocution was initiated at a distance of 30 cm (inside the current stick) and 20 cm (outside the current stick). This was to ensure the fish were still in relatively good condition before being electrocuted closer to the current source stick. A study of African catfish's response, behavior, swimming endurance, and physiological conditions to electric current was conducted in a research pond lined with 5 x 5 cm square millimeter paper. An electric current was applied to the assembled stun gun at different lengths and distances with the same current. The method (Puspito, 2008) attempts to determine the relationship between current strength and the time of fainting of various fish sizes on a laboratory scale.

Procedures

Prepare the research pool, clean stains, rust, and debris from the equipment used (research pool). Prepare the assembled electric shock device equipped with a 12V power supply. Next, make a 5 cm x 5 cm grid using block millimeter paper, which is attached to the pool study's bottom. Fish preparation, African catfish samples obtained from the field were acclimatized in a pond measuring 106 cm x 50 cm to eliminate stress on the fish during transfer and transportation from the field.

The fish that will be tested are adapted in the pool for 10-15 minutes without electricity, then given an electric current according to the treatment of the length of the fish and the distance that has been determined to see the fish's response to the electric current in the electric shock assembly. Measurement of fish reaction to electric current, obtained from each length of electric shock to the test fish (sec) and the total body length (TL) of catfish with distance treatment. Then, the behavioral response of swimming endurance in the test fish to the electric current was obtained.

Observation data from each fish test at the same current strength, with different fish lengths and distances. Data processing was then performed using a laptop installed with Microsoft Word 2016 and Microsoft Excel 2016 software.

3. RESULTS AND DISCUSSION

Pulsed AC Curtain Induction Pattern in Water

Alternating current (AC) is an electric current whose direction changes back and forth over time. The direction of the AC is not constant, but changes regularly between two maximum values in opposite directions. According to Caputi et al. (2013), the body convulsions of fish exposed to electricity are caused by the head of the fish having nerves that receive electrical stimuli, and the body having a lateral line as a receiver of electrical stimuli. According to SFCC (2007), fish respond to electricity at 4 volts in the water. The electrical detection sense in fish is a passive type of sense, that is, it can only sense the presence of electricity around it and does not emit an electric current from its body (Webb, 2008; Caputi et al., 2013). The electric current distribution in freshwater forms an exponential line as in Figure 1 (Nofrizal et al., 2024).

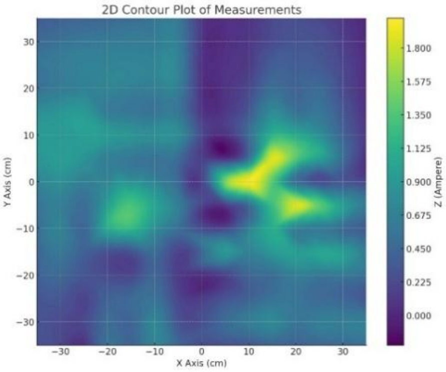

Figure 1. Distribution of electric current strength in the research pool

Figure 3 shows the variation in electric current strength at various points in the pool with different colors representing different current intensities, and the color scale on the right shows the numerical value. As seen in the figure, the center of the highest current is clearly visible in the area with a concentration of current around the coordinates (around x = 10 cm and y = 0 cm). This area is marked with yellow and green. The right scale shows 0.9 - 1.8 amperes at its center point in the young scale. The current in the figure spreads in all directions, but its intensity decreases with increasing distance from the center. This is indicated by the color change from yellow to green and finally blue in areas farther from the current.

The Fainting Time of African Catfish in Response to Electric Current

Increasing the strength of the electric current can increase the number of fish that faint because the electric field radiation will be absorbed more by the body, especially the brain, muscles, and other tissues with high water content (Nuryandani, 2005). Fainting can be grouped into four categories: mild fainting, severe fainting, loss of balance, and no reflex movements or death (Achmadi, 2005). From the results of the research that has been carried out, it can be explained that there are several stages of fish behavioral responses until the fish faints. These stages start from 1, 1a, 1b, 2a, and 2b (Figure 2).

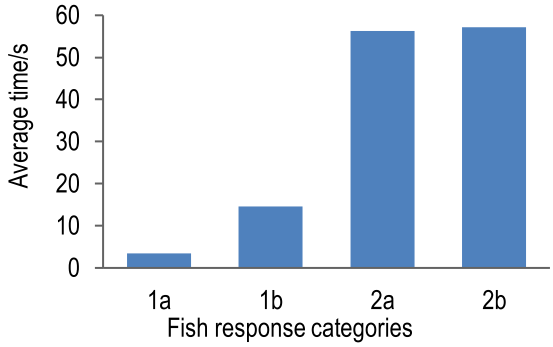

Figure 2. Fish fainting response category levels

Information: 1a = condition of fish in a mild, fainting or calm state; 1b = condition of fish fainting or restless; 2a = condition of fish partially losing balance or panicking; 2b = condition where the fish has lost its balance completely or is almost unconscious.

Fish Fainting Time with Voltage in Current Distribution Pattern

The higher the voltage applied, the faster the fish will faint. Using electric current can cause more fish to faint because the electric current received by the fish's body will also be greater and more frequent, resulting in the fish fainting more quickly (Ikawati, 2007). The relationship between the time the fish fainted and the voltage in the 30 cm distance treatment test (inside the current stick) can be seen in Figure 3.

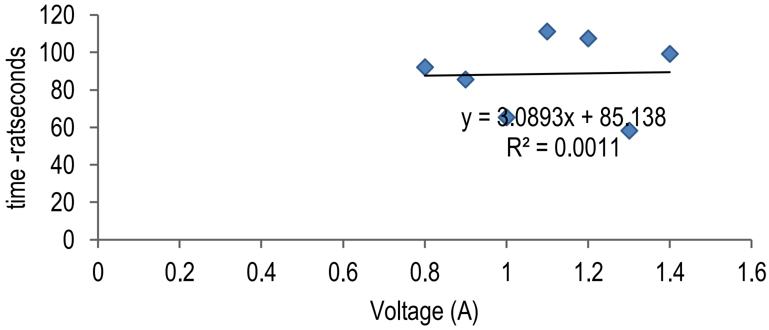

Figure 3. Relationship between the average fainting time of fish and voltage in the 30 cm distance treatment test (inside the current stick)

Figure 3 shows that the trend is very weak, with a linear regression line that appears almost horizontal. Y represents the fainting time, and X represents the voltage. The equation of the linear line is y = 3.0893 x + 85.138 with a determination coefficient (R2) of 0.0011. The correlation coefficient (r) of 0.0331 represents the relationship between the average fainting time. The linear relationship between the average fainting time of fish and voltage is not significant. Other factors may have a greater influence on the average fainting time in the experimental context.

Fish Recovery Time with Voltage on Current Distribution Pattern

The recovery time of fish after electric shocks varies depending on several factors, such as the size of the fish; larger fish generally require a longer recovery time than smaller fish. Water conditions and environmental factors such as temperature, pH, and oxygen levels also influence the speed of fish recovery. The relationship between fish recovery time and voltage in the 30 cm distance test (inside the current stick) is presented in Figure 4.

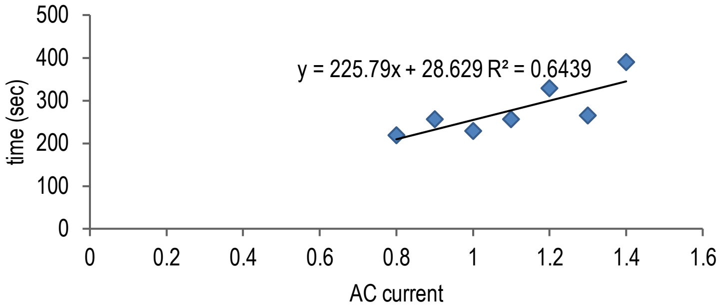

Figure 4. The relationship between the average recovery time of fish from fainting and the voltage in the 30 cm distance treatment test (inside the current stick)

Figure 4 shows that with increasing AC voltage, the recovery time tends to be longer.. The regression line equation is y = 225.79 x + 28,629. The coefficient indicates that for every 1 ampere increase, the recovery time is estimated to increase by 225.79 seconds. The coefficient of determination (r^2) = 0.6439 identifies approximately 64.39% of the variation in fish recovery time. The higher the voltage, the longer the recovery time required. The coefficient of determination value ranges from 0 to 1, indicating how well the linear regression line in the figure above fits.

Fish Fainting Times Based on the Total Body Length of the Fish

The effect of electrocution on fish is the polarization of the ions in their body cells. After that, the electric current will provide a stimulus that will disrupt the brain's balance, causing the fish to faint or die (Wilford, 1970). The time of catfish fainting is highly dependent on their body length (Santoso, 1999). The relationship between the fish's fainting time and length in the 30 cm distance treatment test (inside the current stick) is presented in Figure 5.

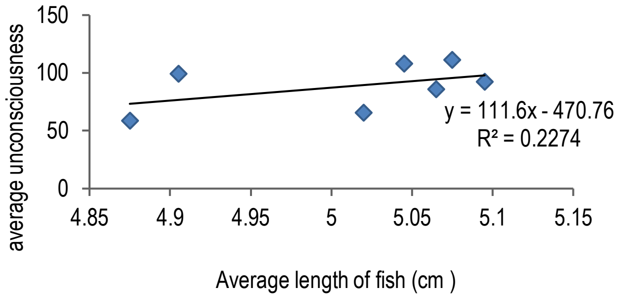

Figure 5. The relationship between the average time of fainting of fish from fainting to the length of the fish in the test, at a 30 cm distance from the treatment (inside the current stick)

The graph above shows a very weak positive trend, the tendency for the average fainting time of fish to increase slightly with increasing average length of fish. The regression line equation y = 111.6x – 470.76, with a coefficient value, shows that the fainting time is estimated to increase, and the constant from the graph above is approaching 0 ampere. The coefficient of determination (R^2) = 0.2274, then the correlation coefficient value (r) of 0.4768 represents the relationship between the average fainting time of fish and the average length of fish.

Fish Recovery Time Based on Total Body Length

Electrocution of catfish disrupts muscle function, causing them to become weak and eventually faint. Catfish can recover if electrocution is stopped, as their metabolism returns to normal. This is indicated by the operculum moving to allow breathing and responding to stimuli (Sukmawati & Sari, 2007). The relationship between fish recovery time and length in the 30 cm distance test (inside the current stick) is presented in Figure 6.

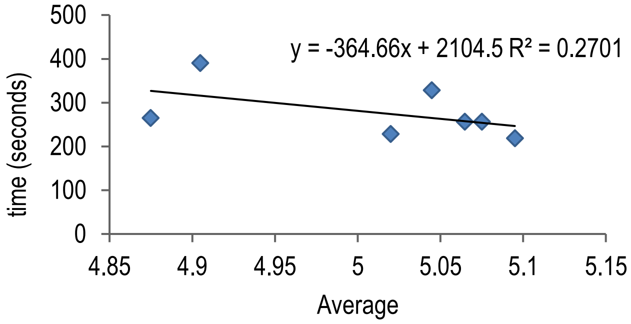

Figure 6. The relationship between the average recovery time of fish from fainting and the length of the fish in the 30 cm distance treatment test (in the current stick)

Figure 6 shows a weak negative trend. As the average length of the fish increases, the recovery time tends to be shorter. The regression line equation is y = -364.66x + 2104.5. For every 1 cm increase, the recovery time will decrease by -364.66 seconds. The coefficient of determination (r^2) value is 0.2701, approximately 27.01% of the fish's recovery time by the average length of the fish.

Swimming Pattern of African Catfish before Electric Current Flows

Fish swimming patterns are the specific movements characteristic of fish to move in water, which are influenced by body morphology, environment, and the purpose of the fish's movement. The swimming pattern of African catfish before being electrocuted is a controlled, calm, and normal swimming pattern. Fish swim, moving their bodies left and right in a regular manner, starting from the head to the tail. Fish swimming patterns vary greatly depending on the type of fish and its condition. Catfish fry swim in groups to help the fry develop and adapt to their environment. The shape of the catfish swimming pattern before being electrocuted is shown in Figure 7. African catfish swimming pattern before being electrocuted

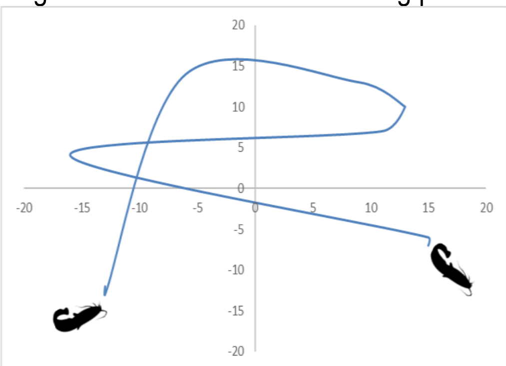

Figure 7. Swimming pattern of the African catfish before being electrocuted

The swimming pattern of the African catfish in the treatment test (Figure 7) at a distance of 30 cm (inside the current stick) shows normal swimming conditions, swimming actively as seen in the graph. The fish's movements appear regular and controlled; the fish's trajectory and movements are not spread out compared to when electrocuted.

Swimming Pattern of African Catfish when Subjected to Electric Current

The effect of electrocution on fish is the polarization of the ions in their body cells, which provides a stimulus that disrupts the balance of the fish's body, causing the fish to swim uncontrollably and restlessly, even if the fish tries to move away from the electricity source. When an African catfish is electrocuted, the fish's body produces a significant amount of mucus. This phenomenon is a natural physiological response of the fish's body to acute stress and tissue damage. According to Ellis (1999), fish mucus is an integral part of the fish's innate immune system, which plays a vital role in resistance when the fish feels threatened and diseased. The mucus released from the body of an African catfish when electrocuted is a sign of desperate self-defense and an indication of serious damage suffered by the fish due to exposure to electricity. The swimming pattern of an African catfish can be seen in Figure 8. The swimming pattern of an African catfish when electrocuted.

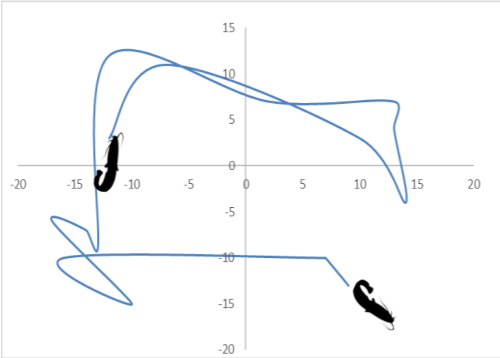

Figure 8. Swimming pattern of the African catfish when electrocuted

The swimming pattern of the African catfish in the treatment test (Figure 8) at a distance of 30 cm (inside the current stick) shows that the fish's movement is irregular. The blue line shows the fish's movement forming a path away from the electric current. The fish's movement is uncontrolled and uncoordinated, causing the fish to be unable to maintain a normal swimming pattern.

4. CONCLUSIONS

The use of electrocution fishing gear has been shown to cause negative physiological responses in the form of fainting, external injuries, and mucus release in *African catfish*, which has implications for the sustainability of the African catfish population. This study proves that juvenile African catfish measuring 4-5 cm do not die immediately; it takes time for the fish to die. The condition of the fish after being electrocuted is injured, resulting in the loss of fins on their bodies, so that during recovery, some fish die, but the number of dead fish is less than the number of live fish. The difference between juvenile African catfish and other fish when electrocuted is that African catfish experience excessive mucus release. This indicates cellular damage and the body's last defense response for the fish's body. This study shows that the use of electrocution fishing gear is non-selective. The results of this study can provide information for the development of fishing methods using environmentally friendly fishing gear and be a consideration in the use of electrocution fishing gear in capture fisheries.

Research results show that the electric current from electrofishing gear causes serious disruptions to African catfish's behavior and physiological condition, such as loss of consciousness, physical injuries, and impaired recovery time. Therefore, electrofishing gear should be banned because it can potentially disrupt the balance of aquatic ecosystems and threaten the sustainability of fish resources. Increased education and supervision of environmentally unfriendly fishing practices are needed to maintain fisheries sustainability.

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