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Research Paper

Effects of Electric Field Intensity on Stunning and Recovery of Rohu (*Labeo rohita*) in Freshwater Aggregation

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Abstract: This study explores the use of an electric field to aggregate freshwater fish, focusing on the species Rohu. Experiments were conducted on fish to see how different voltage levels (100V, 150V, and 200V) affect fish length, weight, stunning time, and recovery time. At 100V, Rohu had an average length of 9.26 cm, a weight of 7.81 g, took 11.97 seconds to be stunned, and 15.26 seconds to recover. When the voltage was increased to 200V, the time taken to stun the fish decreased significantly to 3.87 seconds, with only a small increase in recovery time to 16.22 seconds. These results suggest that using higher voltages can make stunning more efficient while having a minimal effect on recovery time, showing the potential of electric fields for aggregating fish in freshwater.

Keywords: Electric field, Freshwater fish, Voltage levels, Stunning time, Recovery time

Introduction:

The demand for efficient and humane fish harvesting techniques is growing in aquaculture and fisheries management. The cultivation of fish in tanks and ponds necessitates effective management to ensure smooth and efficient operations. This involves careful planning and monitoring of water quality, feeding schedules, and overall fish health to optimize productivity. In recent years, the integration of inland fish culture with agricultural practices has gained significant popularity as a means to enhance income streams for farmers. By combining fish farming with traditional agriculture, farmers can utilize resources like water and nutrients more efficiently, creating a synergistic system that benefits both activities. To support this trend, many farm ponds are now being lined with

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polythene sheets, which help retain water, minimize seepage, and create suitable environments for fish rearing. This approach not only improves the efficiency of fish culture but also contributes to sustainable resource management and increased profitability for farmers. Traditional methods like drag nets, scoop nets, cast nets, and gill nets have been widely used for harvesting fish in farm ponds. However, these methods face several limitations, particularly in deeper ponds with complex configurations such as steep slopes or plastic linings that prevent entry and complicate net deployment. For fish farmers, these challenges highlight the need for alternative methods to improve harvesting efficiency while ensuring minimal stress and harm to fish (Barton & Dwyer, 1997).

One promising alternative is the application of electric fields for fish aggregation and stunning, a technique that has been explored for various aquatic species due to its potential to reduce handling stress and physical injuries compared to traditional netting methods (Cowx & Lamarque, 1990). Electric field stunning has shown advantages in terms of speed and control, as it can quickly immobilize fish, allowing for easier capture and handling. However, optimal parameters for electric field application such as voltage, current, and exposure time must be established to ensure safe and effective stunning without long-term harm to the fish (Kolz, 1993; Snyder, 2003).

Rohu (*Labeo rohita*), a major freshwater species in aquaculture, is commonly raised in farm ponds across South Asia for its commercial value. However, studies examining the effect of electric field intensity on stunning and recovery in Rohu are limited, particularly in terms of the balance between voltage requirements and recovery times. Understanding how various voltage levels impact the stunning and recovery of Rohu could inform more sustainable and efficient practices for fish aggregation in freshwater environments (Dolan & Miranda, 2003; McMichael, 1993).

This study aims to explore the effects of different electric field intensities (100V, 150V, and 200V) on the stunning and recovery times of Rohu. By analyzing these effects in relation to fish length and weight, the research seeks to identify optimal voltage levels that achieve rapid stunning with minimal impact on recovery. The findings from this study could have significant implications for the development of practical, scalable electric field-based harvesting techniques in aquaculture.

Materials and Methods:

Electric Field Generation Setup:

An electric field was generated at the designated harvesting point in the water using a portable DC power source available on electrical trolley (Photo 01). The setup included (Photo 02):

Power Source: A portable generator or batteries supplied direct current (DC), which was adjustable to control the voltage and current output.

Electrodes: Metal plates or braided copper strips served as electrodes, with one functioning as the anode (positively charged) and the other as the cathode (negatively charged). The electrodes were submerged in water at a set distance, creating a directed electric field across the water volume (Van de Fen, 2022).

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Photo 01: Experimental setup (Electrical Trolley)

Photo 02: Performing Experiment and Taking Observation

Procedure for Electric Field Application:

Initial Fish Observation: Rohu (*Labeo rohita*) specimens of varying sizes were introduced into the test tank under controlled conditions. Baseline observations were made on their behaviour in the absence of the electric field.

Electric Field Application:

Electric current was gradually applied between the electrodes to generate an electric field across the water body. The electric field intensity was varied by adjusting the voltage and current strength, as well as by changing the distance between the electrodes. Fish responses were observed under each field intensity, recording instances of forced swimming, orientation changes, immobilization, and recovery (USGS, 2023).

Parameter Standardization:

Several parameters were tested to determine the optimal conditions for stunning and recovery. These included:

1. Voltage and Current Strength: Adjusted to find the threshold levels for effective stunning without permanent harm.
2. Electrode Distance: Modified to analyze its effect on electric field spread and fish behavior.
3. Duration of Current Application: Controlled to assess the time needed to induce stunning and the time required for recovery post-stimulation.

Data Collection and Analysis:

Key metrics such as the voltage at which fish displayed forced swimming, the immobilization threshold, and recovery times were recorded.

Observations were made to determine the influence of electric field intensity on fish of different sizes and to evaluate whether electric field application could be standardized for various Rohu specimens.

Evaluation of Effects by Fish Size:

Fish of different sizes were subjected to the electric field to assess size-based differences in response and recovery. This analysis aimed to ensure that the electric field parameters could be universally applied for efficient and humane stunning across a range of fish sizes (Cowx & Lamarque, 1990).

Laboratory Environment and Controls

Experiments were conducted in a laboratory environment to minimize external variables. Control trials without electric stimulation were performed to account for any natural fish behaviours that could be mistaken for responses to the electric field (Snyder, 2003).

The results of this standardized setup will serve as a foundation for applying electric field-based stunning in larger, practical settings for efficient and humane fish harvesting in aquaculture.

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Results and Discussion:

In this experimental study, we investigated the feasibility of using an electric field for the aggregation of freshwater food fishes under controlled laboratory conditions. The primary objectives were twofold: firstly, to assess the viability of aggregating fishes using electric fields, and secondly, to analyse the efficiency of the electric field with respect to size of Rohu. The experiment involved subjecting fish specimens to varying voltage levels (100V, 150V, and 200V) and measuring key parameters such as average length, weight, stunning time, and recovery time. The outcomes of this research provide valuable insights into the potential applications of electric fields in fish aggregation, offering implications for fisheries management and aquaculture practices.

Species Name : *Labeo rohita* (Rohu)

Voltage used : 100 V

Table No. 01 : Stunning and recovery time of Rohu at 100V voltage

Avg. Length (cm)	Avg. Weight (gm)	Avg. Stunning Time (S)	Avg. Recovery Time (S)
9.26 ±0.86	7.81 ±1.78	11.97 ±8.19	15.26 ±10.48

For this experiment, Voltage level (100V) was consistent across all Rohu experiments, providing a controlled environment for analysis. Stunning time varies across Rohu specimens, with a range from 3.09 s to 31.25 s (Table No. 01). Results showed the shortest stunning time was 3.09s, the longest stunning time was 31.25s.

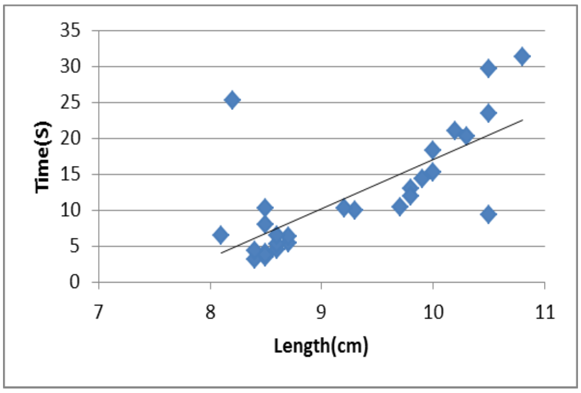

Fig. 01 : Stunning time of Rohu at 100 V

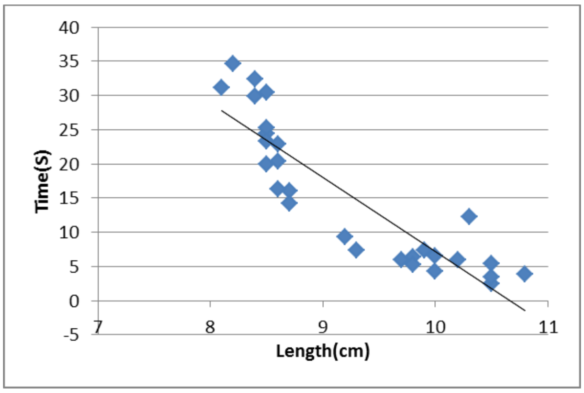

Fig. 02 : Recovery time of Rohu at 100 V

There was a noticeable trend in the data where, generally, as the length of the Rohu fish increases, the stunning time tends to increase as well (Fig. No. 01), for example fish, with a length of 10.8 cm, had a stunning time of 31.25 seconds, while Fish, with a length of 8.5 cm, had a stunning time of 3.98 seconds. There appears to be a positive correlation between fish length and stunning time, suggesting that larger Rohu specimens may require more time to become stunned when exposed to the electric current. Recovery time shows a diverse range from 2.41s to 34.57s for Rohu. Fish required the longest recovery time of 34.57s, while Fish recovered the quickest 2.41s. Similarly, there is a trend indicating that as the length of the Rohu fish increases, the recovery time tends to increase (Fig. No. 02). Fish, with a length of 10.8 cm, had a recovery time of 3.87 seconds, while Fish, with a length of 8.2 cm, had a recovery time of 34.57 seconds. This data suggests a positive correlation between fish length and recovery time, implying that larger Rohu specimens may take longer to recover from the stunning effect induced by the electric current.

Effect of Electric Fields on *Labeo rohita* at 100V

At 100V, the average stunning time was 11.97 ± 8.19 seconds, and the recovery time was 15.26 ± 10.48 seconds. Larger specimens exhibited prolonged stunning and recovery times, with a significant positive correlation between fish size and these durations. For instance, a fish with a length of 10.8 cm required 31.25 seconds to become stunned, whereas a smaller fish of 8.5 cm length took just 3.98 seconds. This trend aligns with findings by Lines and Kestin (2004), who reported similar size-dependent variations in trout due to differences in electrical conductivity and mass.

The wide range of recovery times (2.41–34.57 seconds) suggests substantial individual variability. Similar patterns have been observed in electrofishing studies, where metabolic rates and stress responses influence recovery. This emphasizes the need for tailored voltage levels to minimize stress and ensure humane handling during operations.

Species Name : *Labeo rohita* (Rohu)
Voltage used : 150 V

Table No. 02 : Stunning and recovery time of Rohu at 150V voltage

Avg. Length (cm)	Avg. Weight (gm)	Avg. Stunning Time (S)	Avg. Recovery Time (S)
8.97 ±0.87	7.69 ±1.64	4.29 ±1.04	16.22 ±5.92

The data in table no. 02 indicates individual variability in stunning and recovery times among Rohu (*Labeo rohita*) specimens exposed to a voltage of 150V. The consistency in voltage (150V) across experiments provided a controlled setting for analyzing fish responses. The data showed variations in stunning time with different fish lengths. Fish with a length of 8.3 cm had the shortest stunning time of 2.94 seconds, indicating a relatively quick response to the electric current. Whereas Fish with a length of 10.2, exhibited the longest stunning time of 6.13 seconds, suggesting a slower response to the electric current. It was observed that, there seems to be a tendency for stunning time to increase with an increase in fish length in some instances. However, it's important to note that this relationship is not consistent across all data points. Some longer fish have shorter stunning times, and some shorter fish have longer stunning times (Fig. No. 03).

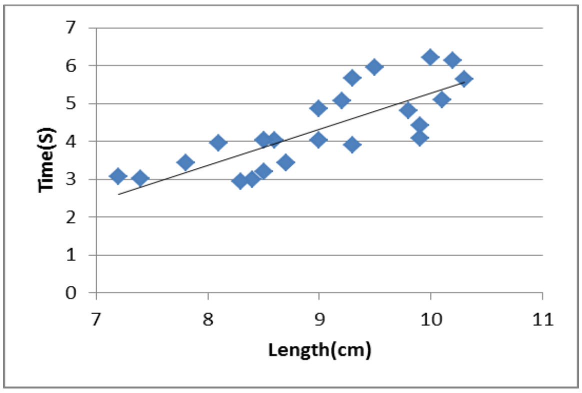

Fig. 03 : Stunning time of Rohu at 150 V

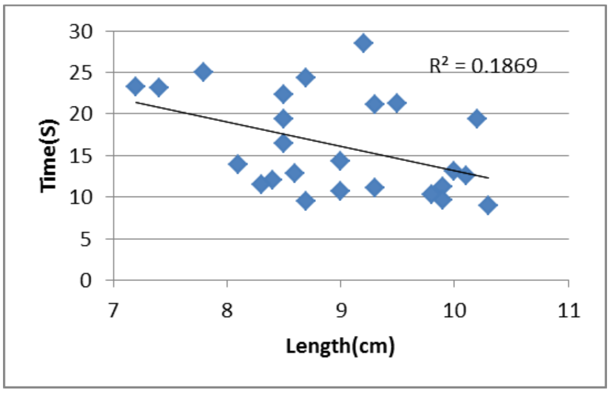

Fig. 04 : Recovery time of Rohu at 150 V

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The relationship between fish length and recovery time seems to be variable and not strictly linear (Fig. No. 04). While some instances in the data may suggest longer recovery times for shorter fish, there were also cases where shorter fish had relatively shorter recovery times. One smaller fish had a relatively short recovery time of 11.54 seconds, indicating a quicker recovery from the stunning effect. On the other hand, moderate size Fish showed the longest recovery time of 28.49 seconds, suggesting a more extended period required for recovery.

Effect of Voltage on Stunning Efficiency at 150V

At 150V, the stunning time reduced significantly to 4.29 ± 1.04 seconds, indicating that higher voltages enhance the stunning effect. However, the relationship between fish size and stunning time was inconsistent. For example, a fish measuring 8.3 cm had the shortest stunning time of 2.94 seconds, while a larger fish of 10.2 cm exhibited a longer stunning time of 6.13 seconds. This inconsistency may be attributed to variations in physiological thresholds and current distribution, as discussed by Soetaert et al. (2015).

Recovery times at 150V (16.22 ± 5.92 seconds) showed less dependence on size, indicating that the electric field's intensity may offset physiological differences. This finding diverges from observations at lower voltages, highlighting the complex interplay between electric field strength and fish recovery dynamics.

Species Name : *Labeo rohita* (Rohu)
Voltage used: 200 V

In the conducted electric fishing experiments on Rohu specimens at various lengths and weights exposed to a voltage level of 200 W, several noteworthy observations and trends have emerged (Table No. 03). The stunning time and recovery time exhibit variability across different fish sizes, highlighting individual responses to the electric current.

Table No. 03 : Stunning and recovery time of Rohu at 200V voltage

Avg. Length (cm)	Avg. Weight (gm)	Avg. Stunning Time (S)	Avg. Recovery Time (S)
9.31 ±0.90	8.19 ±1.06	3.87 ±1.52	15.72 ±9.60

Among the smallest fish in the study, with a length of 8.6 cm, fish demonstrated the shortest stunning time of 1.93 seconds and recovery time of 23.67 seconds. In contrast, the largest fish in the dataset, measuring 11.1 cm in length, exhibited a stunning time of 7.02 seconds and a recovery time of 5.21 seconds. Interestingly, the trend suggests that smaller fish tend to have shorter stunning and recovery times, while larger fish showed relatively longer durations for both processes. For instance, Fish, with a length of 8.2 cm, had the longest recovery time at 33.68 seconds. Overall, the data underscores the diverse responses of Rohu to electric fishing, indicating the importance of considering both fish size and electric voltage levels in optimizing the efficiency of such sampling techniques (Fig. No. 05 and 06).

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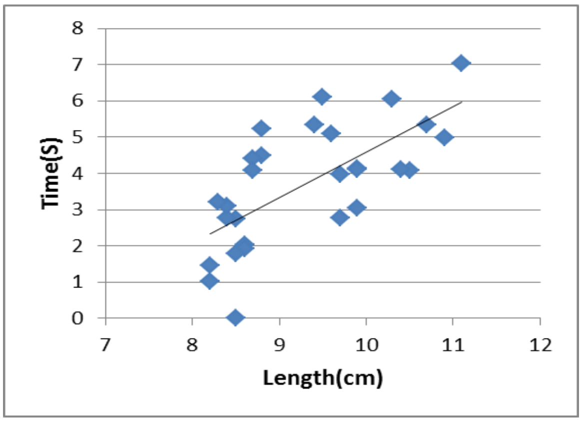

Fig. 05 : Stunning time of Rohu at 200 V

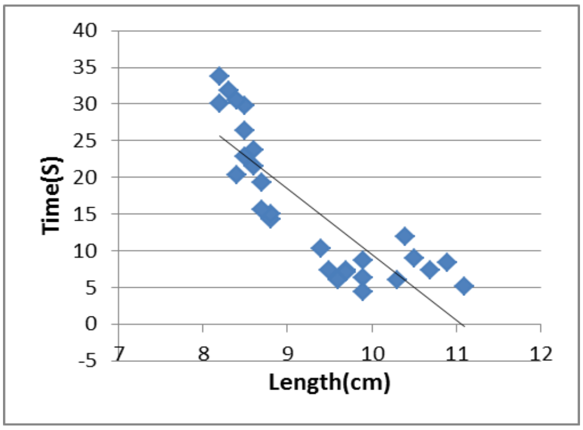

Fig. 06 : Recovery time of Rohu at 200 V

Effect of Voltage on Stunning Efficiency at 200V

At 200V, stunning times further decreased to 3.87 ± 1.52 seconds, demonstrating the voltage's efficacy in achieving quicker immobilization. Smaller fish displayed shorter stunning times, such as 1.93 seconds for an 8.6 cm fish, compared to larger specimens that required up to 7.02 seconds. Recovery times (15.72 ± 9.60 seconds) also varied, with smaller fish generally recovering more quickly, contrary to trends observed at 100V and 150V. This suggests that higher voltages may induce rapid physiological changes in smaller fish, reducing recovery duration (Spencer, 2008).

Effect of voltage on stunning time and recovery time

The stunning time and recovery time of fish exposed to different voltage levels were analyzed using ANOVA to determine any significant differences. Before the main analysis, the sizes of the fish with respect to length and weight used in the three experiments were compared to ensure uniformity. The results showed that no significant differences in the size of fish among the groups subjected to varying voltages, confirming their comparability. (Fig.07-10)

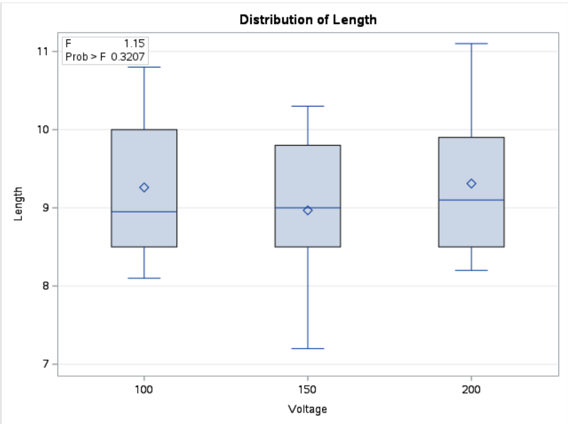

Fig.07: Distribution of Length

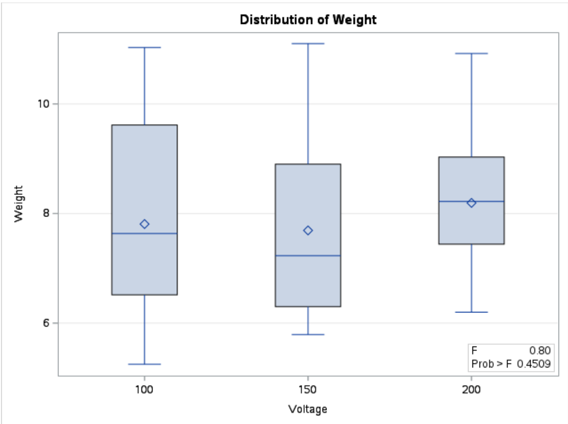

Fig.08: Distribution of Weight

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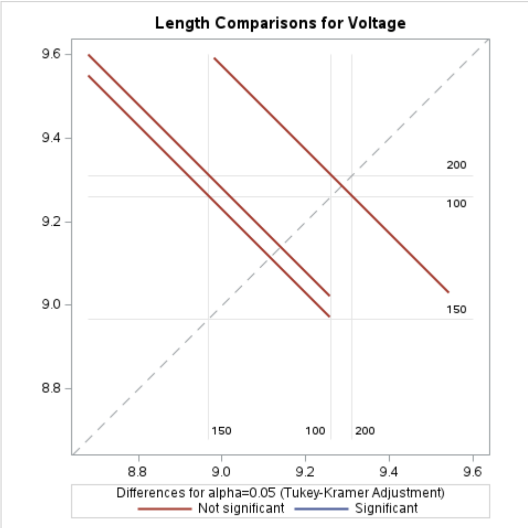

Fig.09: Length Comparison for Voltages

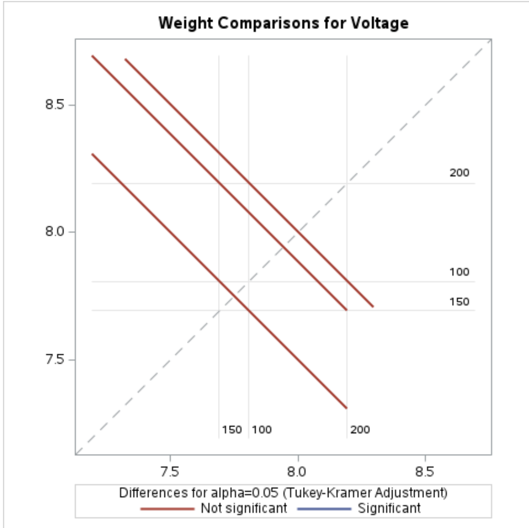

Fig.10: Weight Comparison for Voltages

Subsequently, the effects of voltage levels on stunning time and recovery time were evaluated. The analysis revealed that the stunning time at 100 volts was significantly different compared to the stunning times at 150 and 200 volts. However, there was no significant difference in stunning times between fish exposed to 150 volts and 200 volts. (Fig.11-12)

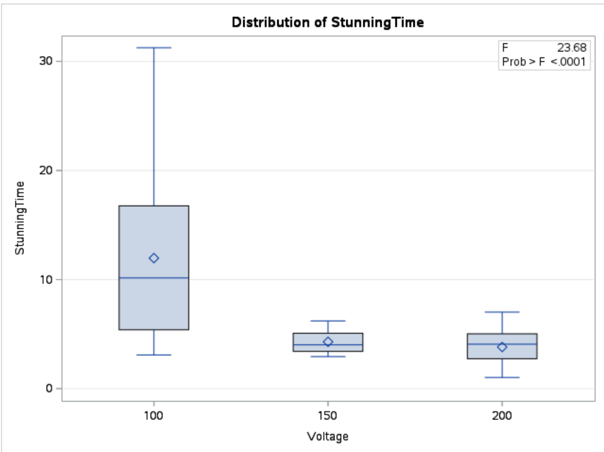

Fig.11: Distribution of Stunning Time

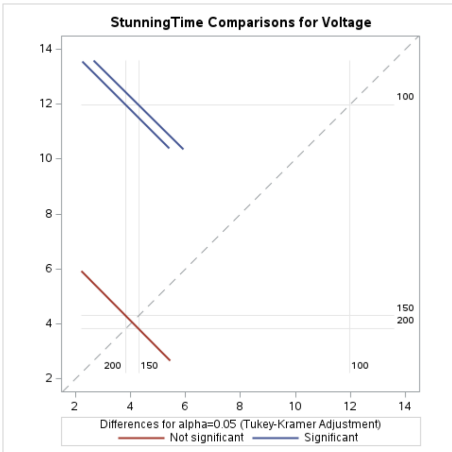

Fig.12: Stunning Time Comparison for Voltage

In contrast, the recovery times of fish across all three voltage levels (100, 150, and 200 volts) showed no significant differences. This suggests that while voltage affects the time required to stun fish, it does not significantly influence their recovery time. (Fig.13-14)

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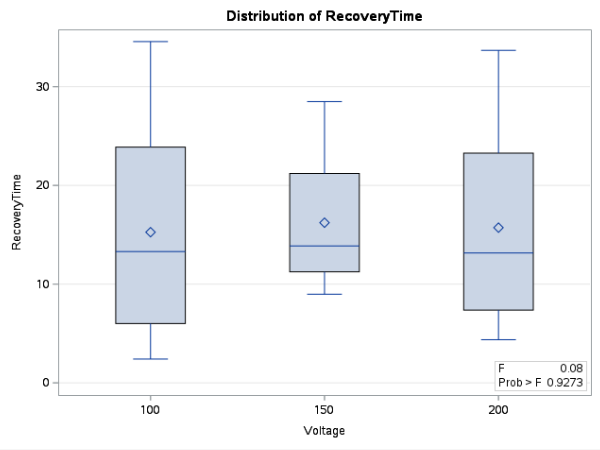

Fig.13: Distribution of Recovery Time

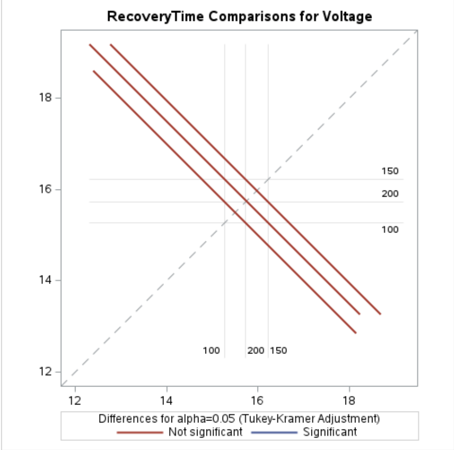

Fig.14: Recovery Time Comparison for Voltage

Implications for Fisheries and Aquaculture

The results confirm that electric fields can effectively aggregate and temporarily immobilize *Labeo rohita*. Voltage levels significantly influence stunning and recovery times, with higher voltages providing more consistent results across sizes. This aligns with prior research highlighting the importance of voltage optimization for humane handling and efficient sampling in fisheries (Damsgård et al., 2004).

Future studies should investigate the effects of water conductivity and other environmental variables to refine these methods further. Understanding species-specific responses will also be crucial in implementing electric field techniques in sustainable fisheries management and aquaculture practices.

Conclusion:

At 100V, the average length was 9.26 cm, the weight was 7.81 gm, stunning time was 11.97 seconds, and recovery time was 15.26 seconds. As the voltage increased to 200V, significant reduction in stunning time (3.87 seconds) and a marginal increase in recovery time (16.22 seconds) was observed.

Based on the analysis, the best combination for minimum voltage in relation to stunning time and recovery time would be 150 volts. At this voltage, the stunning time is not significantly different from 200 volts, indicating that it is equally effective in achieving quick stunning. However, 150 volts is more energy-efficient compared to 200 volts, making it a more practical choice. Additionally, the recovery time of fish at 150 volts does not differ significantly from other voltage levels, ensuring that the process remains humane and does not adversely impact the fish's ability to recover. Thus, 150 volts emerges as the optimal voltage, balancing effectiveness, energy efficiency, and animal welfare considerations.

These findings suggest that the electric field has varying effects on different species of freshwater food fishes and is influenced by the applied voltage. The study provides valuable information on the efficiency of the electric field for fish aggregation under controlled laboratory conditions, with potential implications for fisheries management and aquaculture practices.

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