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Physiological Performance of Asian Redtail Catfish (*Hemibagrus nemurus*) Reared in Saline Water

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ABSTRACT

The physiological activities of fish determine the range of energy required during metabolic processes, especially in osmoregulation during the fish's adaptation period to saline environment. This research aimed to determine the effect of salinity on the physiological performance of the Asian redtail catfish (*Hemibagrus nemurus*). The results obtained showed that the physiological performance of fish against media changes in the form of increasing salinity. The research was conducted for 30 days from June to July 2022 at the Cultivation Technology Laboratory, University of Riau, Indonesia. The juveniles used were 7-8cm in size, as many as 200 individuals, using different salinity treatment levels of 3, 6, 9, 12, and 15ppt with 4 replications. The research results showed that the best physiological performance of the Asian redtail catfish was found at the salinity of , with a cortisol level of 12.56mg mL^{-1} and an oxygen consumption level of 0.9mg O_2 g^{-1} $hour^{-1}$. Meanwhile, the optimal plasma and media osmolarity was observed at a salinity of 9ppt, which was also associated with the lowest levels of cortisol and oxygen consumption.

INTRODUCTION

The Asian redtail catfish (*Hemibagrus nemurus*) is one of the high-value freshwater fish commodities in Indonesia that lives in lakes and rivers in Sumatera and Kalimantan **(Tang, 2000)**. However, this fish can also be found in brackish waters around river mouths so that it has the potential to be cultivated in salinity water. **Muhtarom (2014)** stated that the Asian redtail catfish is likely to be cultivated in waters that have salinity such as sea water and brackish water including coastal areas. Asian redtail catfish, it is still found in estuarine waters with a salinity of 12ppt (Tang, 2003), while for freshwater fish generally have tolerance to salinity up to 25ppt **(Saprianto & Susiana, 2013)**. This shows that the Asian redtail catfish are able to adapt to certain salinities and are able to metabolize to produce energy in the process of respiration and osmorality.

Salinity is the total concentration of ions dissolved in water and is expressed in units of per mile or ppt or g L^{-1} **(Ambardhy, 2004)**. Salinity levels differ from region to region because they are influenced by water currents and movements and evaporation **(Pamungkas, 2012)**. Fish require a lot of energy to adapt to environments that are different from their natural habitat, thus affecting the osmoregulation rate of fish. The salinity suitable for fish growth depends on the species, age and external factors such as temperature. Thus, fish will balance body pressure with their environment in the pressure imbalance phase **(Pamungkas, 2012)**.

Freshwater fish have hyperosmotic properties where the osmotic pressure in the fish's body is higher than its environment, so that dilution of body fluids will occur when water enters the fish's body. Physiological processes will be disrupted when dilution of body fluids takes place continuously; therefore, an osmoregulation process is needed, and accordingly, the osmorality of the body and the environment is in a static state. The decrease in salinity levels of seawater to fresh water will affect the balance of osmotic pressure of the body and the environment associated with osmoregulation **(Rayes *et al.*, 2013)**. Aquatic animal organisms will experience stress if there is an imbalance in the concentration of solutions in the body, especially in fish that are kept outside their habitat **(Pamungkas, 2012)**. Therefore, it requires a lot of energy during the metabolic process. **Sulastri (2006)** suggested that energy consumption in fish is determined by the physiological activity of fish. The current study aimed to determine the effect of salinity on the physiological performance of the Asian redtail catfish. The results obtained here showed the physiological performance of the Asian redtail catfish (*Hemibagrus nemurus*) maintained using salinity water.

MATERIALS AND METHODS

Time and location

This research was conducted from June to July 2022. Maintenance and experimental procedures, including weight measurements and oxygen consumption assessments of Asian redtail catfish, were carried out at the Aquaculture Laboratory, Faculty of Fisheries and Marine Sciences, University of Riau, Indonesia.

Data retrieval

Data collection was carried out using the Asian redtail catfish from the Tibun Fish Seed Center, Kampar, with size of 7- 8cm as many as 200 fish. Maintenance was carried out in an aquarium with a stocking density of 1 fish/ 3L. The study employed a completely randomized design (CRD) with five treatments and four replications. The treatments consisted of different salinity levels: 3, 6, 9, 12, and 15ppt. Asian redtail catfish were fed commercial feed till satiation three times daily for a period of 30 days. Osmolarity measurements were conducted by collecting blood plasma and maintenance media samples. The samples were then stored in Styrofoam containers containing dry ice for preservation before being sent to the UPT Integrated Laboratory, Diponegoro University, Semarang, for analysis. Using the calculation method outlined in th study of **Anggoro and Nakamura (2005)**, the osmotic work level (OWL) was determined using the formula:

OWL = [Blood osmolality - Media osmolality]

Where:

- **OWL**: Osmotic Work Level, mOsm/l H_2O
- **Blood osmolality**: Blood osmolality, mOsm/l H_2O
- **Media osmolality**: Maintenance media osmolality, mOsm/l H_2O

Measurement of cortisol hormone levels is done in the same way, namely collecting blood plasma from the caudal vein using a 1mL syringe at a 45° angle. The plasma was then inserted into microtubes pre-rinsed with 10% EDTA and inserted into sterofoam that has been given dry ice, then research samples were sent to the Physiology Laboratory, Faculty of Veterinary Medicine, Syiah Kuala University, Banda Aceh, for analysis. Oxygen consumption was measured using water with salinity levels according to the treatment groups. Fish were placed in 10-liter containers filled with 5 liters of water, with five fish per container. Each container was tightly sealed to prevent direct contact between the air and the water surface. Oxygen levels were recorded every hour for four hours, and the oxygen consumption rates were subsequently calculated. Oxygen consumption levels were calculated based on the **NRC (1977)** method:

$$\mathbf{OC = V \times (DO_{t0} - DO_{tt}) / (W \times t)}$$

Where:

- **OC** = Oxygen consumption (mg O_2/g/hour)
- **V** = Volume of water in the container (L)
- $\mathbf{DO_{t0}}$ = Initial dissolved oxygen concentration (mg/L)
- $\mathbf{DO_{tt}}$ = Dissolved oxygen concentration at time t (mg/L)
- **W** = Weight of test fish (g)

Data analysis

The data obtained were in the form of quantitative data consisting of the level of osmolarity work, cortisol hormone levels and the level of oxygen consumption. Quantitative data were analyzed using SPSS analysis of variance (ANOVA) at a 95% confidence interval. When significant differences were detected, further analysis was conducted using the Least Significant Difference (LSD) test to identify differences between treatments and to determine the best-performing treatment.

RESULTS

Osmotic working rate

The results of the F-variance analysis showed that the calculated F-value (29,331.67) was greater than the F-table value (4.89) at a 1% significance level, indicating that the means differed significantly. Further analysis using the Least Significant Difference (LSD) test confirmed that each salinity treatment was significantly different from the others. The osmotic work rate of the Asian redtail catfish (*Hemibagrus nemurus*) during the study is presented in Fig. (1).

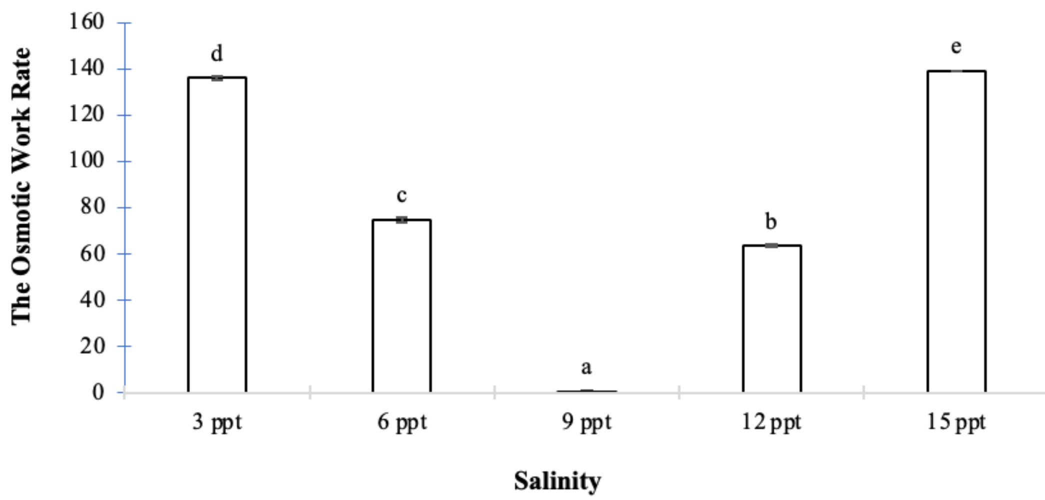

Fig. 1. The working rate of osmorality of the Asian redtail catfish (*H. nemurus*) during the study (different superscript letters following mean values (± standard error, n=3) in the same row indicate significant differences (P <0.05).

At salinities of 3 and 15ppt, the osmotic work rate of the Asian redtail catfish (*Hemibagrus nemurus*) reached the highest values of 136 and 139 mOsm H_2O^{-1}, respectively. Under these conditions, the fish were forced into a hypoosmotic osmoregulation pattern, where the osmolarity of the surrounding media was greater than that of the fish's body fluids. In this situation, the Asian redtail catfish expend considerable energy to maintain internal homeostasis. **Suharyanto and Tjaronge (2009)** stated that salinity has a strong influence on osmotic pressure, with higher salinity leading to higher osmotic pressure. Similarly, **Anggoro and Nakamura (2005)** noted that differences between the salinity of the media and the fish's internal iso-osmotic conditions significantly affect osmotic performance; higher osmotic pressure demands greater energy expenditure for osmoregulation.

Osmoregulation is the process by which fish and other aquatic organisms maintain the balance of salts and water in their bodies relative to their environment. In freshwater fish, the external environment is typically hyperosmotic compared to body fluids, causing water to enter the body and salts to be lost. If unchecked, this leads to dilution of body fluids and disruption of physiological functions. Conversely, in marine fish under hypoosmotic conditions, salt diffuses into the body while water is lost through the kidneys, gills, and skin. To compensate, marine fish excrete concentrated urine and drink seawater to maintain internal salt and fluid balance **(Fujaya, 2004)**.

In this study, the lowest osmotic work rate was recorded at a salinity of 9ppt, where the plasma osmolarity of the fish was approximately 0.5 mOsm H_2O^{-1}. This condition corresponds to an isosmotic regulation pattern, where a balance is achieved between the osmolarity of the fish and the surrounding medium.

Overall, varying salinities significantly influenced the osmotic performance of Asian redtail catfish. Higher salinity levels increased the osmotic workload, indicating that the fish constantly adapted their osmoregulatory mechanisms to environmental conditions. As reported by **Rachmawati *et al.* (2012)**, fish subjected to higher salinity levels experience greater osmotic pressure, requiring higher energy expenditure to maintain internal equilibrium.

Cortisol hormone levels

The levels of the hormone cortisol of the Asian redtail catfish during the study can be seen in Fig. (2).

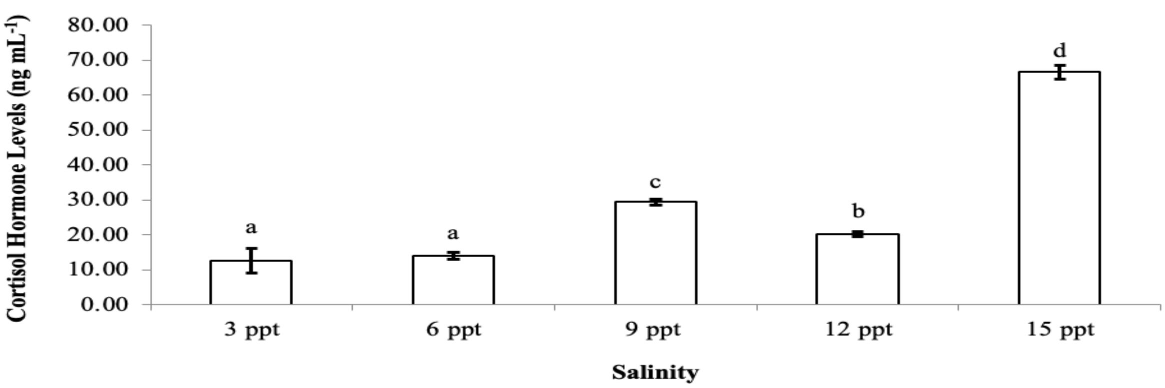

Fig. 2. The content of the hormone cortisol in the Asian redtail catfish (*H. nemurus*) during the study (different superscript letters following mean values (± standard error, n=3) in the same row indicate significant differences *(P*<0.05)

Fig. (2) shows that the lowest cortisol hormone level in the Asian redtail catfish (*Hemibagrus nemurus*) was recorded at 3ppt salinity (12.56 mg mL^{-1}), while the highest level was observed at 15ppt salinity (66.65 mg mL^{-1}). Cortisol levels increased with rising salinity, indicating a stronger stress response by the fish under higher salinity conditions. Based on initial observations during the acclimation phase, fish introduced into media with salinities of 6, 9, 12, and 15ppt initially appeared inactive, likely reflecting an acute stress response to the new salinity levels. However, by the following day, the fish at most salinities resumed active movement, suggesting partial adaptation.

The 3ppt salinity treatment was identified as the most favorable, as evidenced by the lowest cortisol levels, implying reduced stress. This may be due to the 3ppt salinity closely resembling the natural environment of Asian redtail catfish, enabling better physiological adaptation. According to **Tina *et al.* (2006)**, cortisol is a hormone secreted by the adrenal glands that plays a vital role in glucose metabolism, blood pressure regulation, immune function, and the stress response in fish.

As salinity increased, cortisol levels in Asian redtail catfish also rose, impacting feeding behavior; stressed fish were observed to refuse feed, leading to insufficient energy intake necessary for survival and growth. Consequently, fish growth slowed because their metabolism was not functioning optimally under stress. **Mudjiman (2008)** emphasized that protein serves as a primary energy source for fish, and the efficiency of protein use is strongly influenced by the amino acid profile of the diet.

Adaptation to higher salinity environments increases energy demands for osmoregulation. Fish must allocate energy not only for basic survival but also for growth and development under stressful conditions. Furthermore, **Syawal *et al.* (2012)** stated that changes in plasma cortisol levels are often used as primary indicators of stress in fish, with secondary indicators including elevated glucose levels.

Oxygen consumption

The lowest oxygen consumption rate of the Asian redtail catfish (*Hemibagrus nemurus*) was recorded at a salinity of ppt, at 0.9 mg O_2 g^{-1} $hour^{-1}$, while the highest rate was observed at a salinity of 12ppt, reaching 1.9 mg O_2 g^{-1} $hour^{-1}$. According to **Putra (2015)**, an increase in oxygen consumption corresponds to an elevated metabolic rate, as stressed fish require more energy to adapt to changes in their environment. The oxygen consumption rates across different salinities are presented in Fig. (3).

The elevated oxygen consumption observed at a salinity of 1ppt is likely due to the increased osmotic stress at this salinity, prompting fish to expend more energy for survival and growth. In contrast, at a salinity of 15ppt, oxygen consumption declined to a level similar to that observed at 6ppt (approximately 1.0 mg O_2 g^{-1} $hour^{-1}$). This reduction is attributed to a high mortality rate at 15ppt, where 32 fish deaths were recorded, resulting in fewer surviving fish and thus lower oxygen consumption. Despite the high oxygen demand at 12ppt, this salinity level still falls within the tolerance limits of Asian redtail catfish. **Tang (2003)** reported that Asian redtail catfish naturally inhabit freshwater environments such as swamps, reservoirs, rivers, lakes, and river estuaries with brackish waters, often experiencing salinities up to 12ppt.

Changes in environmental salinity induce physiological adjustments in osmoregulation for Asian redtail catfish. When exposed to salinities different from their natural habitat, fish must regulate the movement of salts and water across their bodies, a process that demands considerable energy and results in elevated metabolic activity. Consequently, oxygen consumption increases at higher salinity levels. Sufficient energy availability is critical for supporting growth under these conditions. As noted by **Apriyanto and Nunung (2012)**, fish require significant energy resources to adapt successfully to environments with salinity levels different from their native habitats.

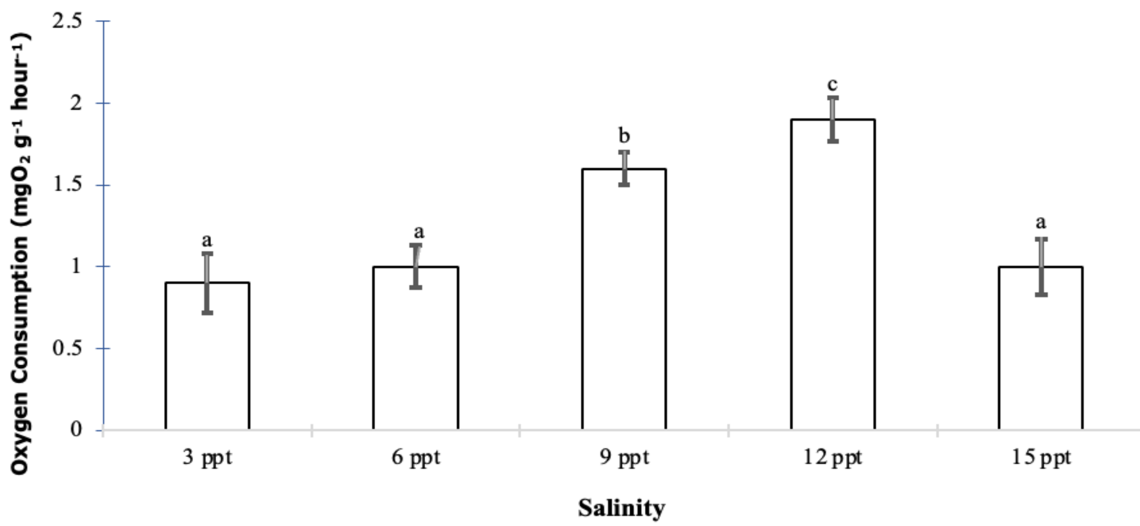

Fig. 3. The rate of oxygen consumption in the Asian redtail catfish (*H. nemurus*) during the study (different superscript letters following mean values (± standard error, n=3) in the same row indicate significant differences ($P<0.05$)

CONCLUSION

The best physiological performance of the Asian redtail catfish (*Hemibagrus nemurus*) was observed at a salinity of 3ppt, with cortisol levels recorded at 12.56mg mL^{-1} and oxygen consumption rates at 0.9 mg O_2 g^{-1} $hour^{-1}$. In terms of plasma osmolarity, the optimal condition was found at a salinity of 9ppt, where the lowest cortisol levels indicated minimal stress. However, the combination of low cortisol levels and low oxygen consumption suggests that a salinity of 3ppt represents the most ideal environment for the growth and physiological stability of the Asian redtail catfish.

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