p-ISSN. 2406-9825
e-ISSN. 2614-3178

Acta Aquatica: Aquatic Sciences Journal, 10:3 (December, 2023): 254-259

Acta Aquatica
Aquatic Sciences Journal

Performa pertumbuhan dan respon stress benih serukan *(Osteochilus sp)* pada media salinitas berbeda

Growth performance and stress response of serukan juvenile *(Osteochilus sp)* in different salinity media

Received: 15 August 2023, Revised: 29 October 2023, Accepted: 01 November 2023
DOI: 10.29103/aa.v10i3.12500

Khairul Samuki[a]*, Farah Diana[a], Dini Islama[a], Afrizal Hendri[a], M. Barru Airil Fizra Hasibuan[a], Aris Yusdi[a], dan Fazril Saputra[a]

[a] *Department of Aquaculture, Faculty of Fisheries and Marine Science, Teuku Umar University, Meureubo, West Aceh, 23681, Aceh, Indonesia*

Abstrak

Ikan serukan *(Osteochilus sp)* memiliki potensi sebagai komoditas budidaya dengan nilai ekonomis. Rekayasa lingkungan, seperti manipulasi media salinitas, telah berhasil meningkatkan pertumbuhan ikan air tawar. Namun, belum ada informasi tentang pengaturan salinitas optimal untuk pemeliharaan ikan serukan. Penelitian ini bertujuan menentukan media salinitas optimal berdasarkan kinerja pertumbuhan benih ikan serukan. Penelitian ini menggunakan rancangan acak lengkap (RAL) dengan empat perlakuan dan tiga ulangan. Media pemeliharaan penelitian ini meliputi kontrol, P1 (3 ppt), P2 (6 ppt) dan P3 (9 ppt). Penelitian dilakukan selama 45 hari dengan pakan komersil. Parameter uji meliputi analisis kimia pakan, analisis glukosa darah, SGR, konsumsi pakan, efisiensi pakan dan kelangsungan hidup. Data dianalisis dengan ANOVA dan uji lanjut Duncan. Konsentrasi media salinitas optimal ditentukan dengan uji Polinomial orthogonal. Hasil penelitian menunjukkan bahwa media pemeliharaan bersalinitas memberikan pengaruh yang nyata terhadap laju pertumbuhan harian (SGR) dan efisiensi pemanfaatan pakan. Konsentrasi salinitas optimal ditemukan pada 3,8 ppt, mengindikasikan bahwa ikan serukan cenderung mencapai pertumbuhan optimal pada salinitas tersebut. Respons fisiologis (stres) ikan, diukur dengan kadar glukosa darah juga berbanding lurus dengan tingkat salinitas dan kinerja pertumbuhan.

Kata kunci: *Glukosa darah; Manipulasi media; Osteochilus sp; Performa pertumbuhan; Respon stress.*

Abstract

Serukan fish *(Osteochilus sp)* has potential as a cultivation commodity with economic value. Environmental engineering, such as the manipulation of salinity media, has succeeded in increasing the growth of freshwater fish. However, there is no information about the optimal salinity setting for raising serukan fish. This study aims to determine the optimal media salinity based on the growth performance of the serukan juvenile. This study used a completely randomized design (RAL) with four treatments and three replications. The maintenance media in this study included control, P1 (3 ppt), P2 (6 ppt) and P3 (9 ppt). The study was conducted for 45 days with commercial feed. The test parameters included feed chemical analysis, blood glucose, SGR, FI, FE and SR. Data were analyzed by ANOVA and Duncan's further test. The optimal concentration of media salinity is determined by an orthogonal polynomial test. The results showed that the salinity-rearing media had a significant effect on the specific growth rate (SGR) and the efficiency of feed usage. The optimal concentration of salinity was found at 3.8 ppt, indicating that the fish call tends to achieve optimal growth at this salinity. The physiological response (stress) of fish, as measured by blood glucose levels, is also directly proportional to the level of salinity and growth performance.

Keywords: Blood glucose; Growth performance; Media manipulation; Osteochilus sp; Stress response.

1. Introduction

Serukan fish *(Osteochilus sp)* is one of Aceh's endemic fish which has the potential to be developed into a cultivated fish commodity. This fish is economically valuable and is favoured by the people of Aceh (Diana *et al.*, 2022). Currently, most of the supply of exclamation fish in the market comes from fishing activities in nature. It is feared that this condition will reduce the mass fish population. So far, the serukan fish has not been widely developed by freshwater fish cultivators. This is because there

* *Korespondensi: Department of Aquaculture, Faculty of Fisheries and Marine Science, Teuku Umar University, 23681, Aceh, Indonesia.*
Tel: +6285276411361
e-mail: khairulsamuki@utu.ac.id

are still many obstacles that have not been understood in the maintenance system so the production of this fish is not optimal. The main constraints in keeping the captured fish are slow growth and a high mortality rate (Samsuli *et al*., 2023). The constraints faced by the exclamation fish cultivators lead to the need for a production system to support optimal growth and survival (Azhari *et al*., 2017). One production system that has been successfully applied to domesticated fish is environmental engineering (Jiang *et al*., 2022).

Many studies related to environmental engineering have been carried out and have provided optimal results for several freshwater fish such as betutu fish *(Oxyeleotris marmorata)* (Ardi *et al*., 2017), nilem fish *(Osteochilus hasselti)* (Amrullah, 2015; Prakoso and Kurniawan, 2017), tilapia (Rahim *et al.*, 2015), and rasbora fish *(Rasbora argyrotaenia)* (Intansari, 2018). One of the environmental engineering that can spur growth and increase the survival of fish is media manipulation with salinity. Agustin, (2001) revealed that the salinity in the media directly affects the process of osmoregulation of an organism. According to Nurjanah, (2014), osmoregulation is a process of controlling the balance of body fluids in the form of water and ions with the environment through regulation of the body's osmotic pressure. Stickney, (2000) explained that the process of osmoregulation plays a role in controlling and maintaining the stability of fish body fluids in physiological functions that can be used for optimal energy from feed.

Salinity has been proven to support optimal fish growth in several types of freshwater fish. A salinity concentration of 3 ppt provides an optimal specific growth rate for gourami fish, namely 6.53% (Islama *et al.*, 2014), a concentration of 3 ppt increases survival by 92.27% and a specific growth rate of 0.49% for gourami (Dewi, 2006). Furthermore, a concentration of 15 ppt increased survival by 83.33% and a specific growth rate of 2.71% in tilapia (Fitria, 2012). While the concentration of 7 ppt salinity gives optimal effect on survival parameters up to 100% and a specific growth rate of 0.54% (Fitrani *et al.,* 2009).

Some of the studies above show that the tolerance of salinity content in rearing media is different for types of freshwater fish. Then the study stated that environmental engineering through media manipulation with salinity can increase the productivity of cultivated fish. according to Kujawa, and Piech, (2022) Currently, there is callus fish farming activities to promote growth and survival. Therefore, it is necessary to regulate the optimal salinity media which affects the growth and survival of the fry. This study aims to determine the optimal media salinity for raising the seed of the serukan fish *(Osteochilus sp)* based on the growth performance of the fish.

2. Materials and Methods

2.1. Research time and location

This research was conducted from March to May 2023 in the Aquaculture Environmental Engineering Laboratory, Aquaculture Study Program, Faculty of Fisheries and Marine Sciences, Teuku Umar University, Aceh.

2.2. Preparation

Serukan juveniles used in this study were the excretory fish juveniles hatched in the Hatchery of the Faculty of Fisheries and Marine Sciences, University of Teuku Umar (FPIK UTU) with an initial weight of 0.25 ± 0.02 g and an initial length of 2.43 ± 0.18 cm. Before conducting the research, the juvenile of the cried fish was first acclimatized in a 1x1.5 m tank for 7 days with a rearing media concentration of 0 ppt.

The rearing media used in this study were filtered and dissolved fresh water and seawater media. Test media that are by the treatment are then inserted into each research container. The total volume of maintenance water media that has been dissolved in the research container is 20 litres. The freshwater media used came from the University Farm (UF) drilled well at Teuku Umar University, while the seawater used came from the waters of Ujong Karang, Suak Indrapuri Village, Johan Pahlawan, West Aceh district. The method used to obtain media concentration according to the treatment in this study used the dilution formula (Fauzi *et al*., 2022), namely :

$$V1 \text{ x } N1 = V2 \text{ x } N2$$

Notes:
V1 = Initial seawater volume (litres)
N1 = Initial seawater concentration (ppt)
V2 = The desired volume of seawater (litres)
N2 = Desired seawater concentration (ppt)

2.3. Experimental design

This study used a completely randomized design (CRD) with four treatments and three replications which consisted of rearing serukan juveniles on different media, namely:

P0 : Salinity Media 0 ppt
P1 : Salinity Media 3 ppt
P2 : Salinity Media 6 ppt
P3 : Salinity Media 9 ppt

2.4. Fish rearing

This research was conducted for 45 days at the Hatchery of the Faculty of Fisheries and Marine Sciences, Teuku Umar University. The feed provided in this study was a commercial feed with a protein content of 35% (Table 1), and the feeding frequency was twice a day at 08:00 and 17:00 WIB. The feeding method was carried out to satiation, which means feeding according to the fish's consumption ability or needs.

Table 1
Chemical feed analysis.

No	Parameter	Composition (%)
1	Moisture	9,12
2	Protein	38,5
3	Lipid	5,2
4	Fibre	3,3
5	Ash	11,7
6	NFE*	58,7

*NFE= Nitrogen Free extract

Weight and length data sampling is conducted every week, while water quality parameters are measured every three days (Table 2). Regarding water quality management in this study, a siphoning process is performed every 3 days to minimize the accumulation of fish faeces and to decrease water volume by 30%. Subsequently, water is replenished to compensate for the lost volume.

Table 2
Water quality methods and parameters.

No	Parameter	Units	Methods	Tools
1	*Weight*	*g*	*Insitu*	Scale
2	*Length*	*cm*	*Insitu*	Vernier calipers
3	*DO*	*Mg L^{-1}*	*Insitu*	DO Meter
4	*pH*	-	*Insitu*	pH Meter
5	*Temperature*	*^{o}C*	*Insitu*	Termometer

2.5. Test parameters

2.5.1. Chemical analysis

A chemical analysis of the feed (proximate) was conducted to determine the nutritional composition of the provided feed, following (AOAC, 2012). To measure the response to fish stress, blood glucose levels were tested on three fish from each treatment. Measurements were taken using a blood

glucose test kit (Gluco DR Auto AGM 4000), and the displayed numbers represent the blood glucose level results in units of mg/dL. The use of a glucometer for analyzing fish blood samples followed the methodology outlined in the study by Eames *et al.* (2010).

2.5.2. *Specific growth rate (SGR)*

The Specific Growth Rate (SGR) indicates the percentage of fish weight gained per day during the study period. SGR can be calculated using the formula provided by Zonneveld and Fadholi (1991):

$$SGR = \left[\sqrt[t]{\frac{Wt}{Wo}} - 1\right] x\ 100$$

Notes :
SGR = Specific Growth Rate (%)
Wt = Average weight at the end of the treatment (grams)
Wo = Average weight at the beginning of the treatment (grams)
t = Rearing period (days)

2.5.3. *Feed intake*

Feed intake (FI) refers to the amount of feed ingested by the fish during the study period. FI data collection is done by weighing the provided feed during the maintenance period.

2.5.4. *Feeding efficiency*

Feeding efficiency (FE) is calculated using the equation (Takuchi, 1988).

$$EP(\%) = \frac{(Wt + Wd) - Wo}{F} x100$$

Notes:
Wt = Fish biomass at the end of the study (g)
W0 = Fish biomass at the start of the study (g)
Wd = Biomass of fish that died during the study (g)
F = Amount of feed given during the study (g)

2.5.5. *Survival rate*

Survival rate (SR) is the percentage ratio of the number of live fish at the end of rearing to the number of dead fish at the beginning of rearing. Survival can be calculated using the following formula (Samuki *et al.*, 2021):

$$SR\ (\%) = \frac{Nt}{No}\ x\ 100$$

Notes:
SR = Survival (%)
Nt = Number of fish at the end of rearing (heads)
No = Number of fish at the start of rearing (heads)

2.6. *Data analysis*

Sampled data were processed and analyzed using analysis of variance (ANOVA) at a 95% confidence interval. Additionally, data normality and homogeneity of variance were assessed through the Kolmogorov-Smirnov test and Bartlett's test, respectively. In the presence of a significant difference (ANOVA), a subsequent Duncan test (DMRT) was conducted. An orthogonal polynomial test was performed to determine the optimal salinity media concentration. The research stages can be seen in Figure 1.

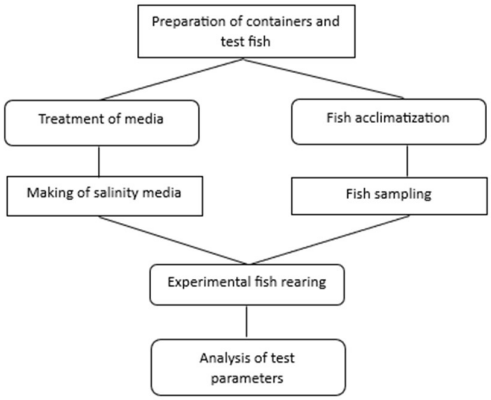

Figure 1. Research stages.

3. Results and Discussion

3.1. *Results*

The growth performance of the juvenile reared in various salinity media for 45 days is presented in Table 3. A significant effect (Sig<0.05) on the growth performance of the juvenile fish was observed in several parameters, except for initial weight (B0) and survival (SR).

Table 3
Growth performance of juvenile fish reared with different maintenance media.

Parameters	Treatment			
	P0	P1	P2	P3
Wo (g)	0.27±0.00^{a}	0.23±0.01^{a}	0.27±0.02^{a}	0.25±0.00^{a}
Wt (g)	0.69±0.02^{ab}	1.04±0.00^{c}	0.87±0.23^{bc}	0.48±0.02^{a}
SGR (%)	1.03±0.05^{b}	1.63±0.04^{c}	1.31±0.20^{b}	0.70±0.19^{a}
FI (g)	17.77±1,18^{b}	13.58±0.46^{a}	14.60±1.09^{a}	18.03±0.47^{b}
FE (%)	2.41±0.29^{a}	5.95±0.24^{b}	4.22±1.45^{ab}	2.90±1.50^{a}
SR (%)	100±0.0	100±0.0	100±0.0	80±20

Note: Initial weight (Wo); final weight (Wt); specific growth rate (SGR); feed intake (FI); feed efficiency (FE); survival rate (SR). Different letters within the same row indicate significant differences between treatments (Sig<0.05). The values presented in the table represent the average and standard deviation.

The results of the orthogonal polynomial test on specific growth rate (SGR) indicated that the optimal media salinity concentration was approximately 3.8 ppt (Figure 2). This suggests that the suckling fish tend to achieve their highest growth within the range of media salinity concentrations at 3.8

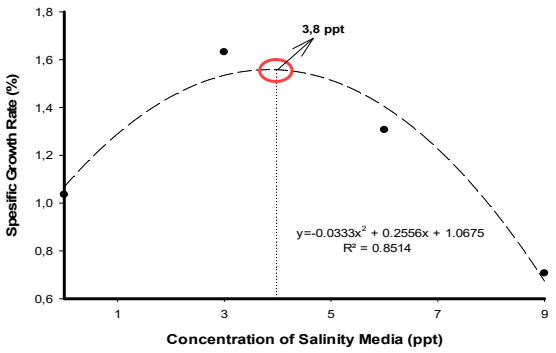

Figure 2. Optimal salinity media concentration based on orthogonal polynomial analysis test.

The results of blood glucose analysis as a stress response in fish also showed a direct proportionality to the growth performance parameters (Figure 3). The ANOVA analysis results demonstrated that different salinity media significantly affected the stress response of the crimson fish. The fish blood glucose levels exhibited an upward trend as the salinity level increased in the rearing medium.

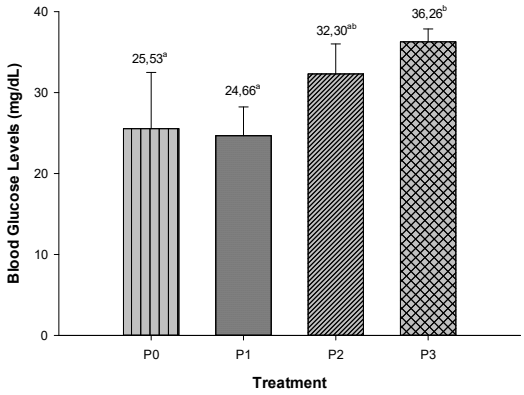

Figure 3. Blood glucose levels of the juvenile fish in each treatment.

Based on the data collected from water quality measurements throughout the 45-day study, it was evident that parameters such as dissolved oxygen (DO), pH, and temperature exhibited values that were conducive to the survival of fish fry (Table 4).

Table 4
Average values of water quality parameters.

Parameter	Treatment			
	P0	P1	P2	P3
DO (mg/L)	4.25-5.52	4.32-5.11	4.26-5.20	4.25-5.35
pH	6.5-8.1	6.6-7.9	6.5-8.2	6.3-7.9
Temperature (°C)	28.3-30.3	28.1-30.1	28.5-30.2	28.5-30.1

Note: DO, Dissolved oxygen (mg/L)

3.2. Discussion

Salinity serves as a water quality parameter influencing metabolic and osmoregulation processes within fish organisms. Salinity levels are closely tied to osmotic pressure, which in turn relates to ion solubility in water. Firdaus (2016) revealed that higher salinity levels correlate with elevated osmotic pressure. Evans (2011) indicated that discrepancies in ion content and total osmotic concentration between the fish's environment and its body govern ion flow (diffusion) and water movement (osmosis) across the fish gill epithelium. Freshwater fish are hyperosmotic in comparison to their surroundings, resulting in the outflow of salt (NaCl ions) through the gill epithelium. Consequently, freshwater fish tend to consume more water to replenish salt requirements while excreting low-salt (NaCl ions) urine.

Observations on the specific growth rate (SGR) demonstrated the significant influence of distinct salinity media on the growth of scalloped fish *(Osteochilus sp)* over the 45-day rearing period. ANOVA analysis confirmed the substantial impact of varying salinity media on the specific growth rate of the fry. The control treatment exhibited an SGR of 1.03 ± 0.05%, while the P1 treatment indicated a higher specific growth rate of 1.63 ± 0.04%. These findings suggest that a salinity concentration of 3 ppt within the rearing medium notably enhances the growth of the juvenile.

According to Prananingtyas *et al.* (2019), a salinity media concentration of 3 ppt can stimulate growth in freshwater fish. This notion is further corroborated by Setijaningsih (2019), highlighting the advantageous effects of using 3 ppt media for optimal growth in gourami. Nursidi *et al.* (2021) supported this by indicating that a salinity medium with a concentration of 3 ppt can stimulate enzyme activity and heighten fish metabolic rates. This heightened metabolic rate positively impacts oxygen intake, nutrient absorption, and the fish's digestive system performance, ultimately leading to more efficient utilization of consumed nutrients and thereby promoting optimal fish growth and development.

The use of salinity media also influences fish feed consumption. In this study, the control treatment displayed an average feed consumption of 17.77 g. Conversely, treatment P1, employing 3 ppt salinity, exhibited lower feed consumption by the fry at 13.58 g, followed by treatment P2 at 6 ppt, showing a slightly reduced feed intake compared to the control at 14.60 g. However, treatment P3 at 9 ppt indicated increased feed consumption, reaching an average of 18.03 g. Nursidi *et al.* (2021) suggested that higher salinity concentrations in the feeding medium lead to increased fish feed consumption. Elevated salinity levels heighten osmotic pressure within the fish's body, necessitating greater energy expenditure to regulate bodily osmotic fluids. This stimulation prompts the brain to amplify appetite, thereby influencing greater food intake.

The observations on the feed utilization efficiency parameter (EP) reveal that the employment of rearing media with varying salinity levels affects the feed utilization efficiency value in the serukan fish *(Osteochilus sp)*. The data analysis results demonstrate that the control treatment (2.41%) did not significantly differ from the P2 treatment (4.22%) and P3 treatment (2.90%) in terms of feed utilization efficiency, with salinity levels of 6 ppt and 9 ppt respectively. However, a significant distinction in feed utilization efficiency emerged between the control treatment and the P1 treatment (5.95%) with a salinity of 3 ppt.

These findings unveil that the lower environmental salinity (3 ppt) in the P1 treatment positively impacts the feed utilization efficiency of the sucker fish. According to Nugroho and Chilmawati (2016), the heightened feed utilization efficiency in this study could stem from a better alignment between environmental salinity and the nutritional requirements of the fish. Setiyadi *et al.* (2017) demonstrated that fish tend to optimize digestion, nutrient absorption, and feed utilization for growth and bodily functions more effectively at lower concentrations of media salinity.

Conversely, treatments P2 and P3, characterized by higher salinity levels, may exert suboptimal effects on feed utilization efficiency. This might be attributed to the physiological response of fish to heightened osmotic changes in their environment. Rahim *et al.* (2020) propose that increased salinity can impact osmotic regulation and fish digestion, consequently affecting feed utilization efficiency. This notion aligns with Aihua and Buchmann (2001), indicating that freshwater fish generally exhibit enhanced feed utilization efficiency in low salinity environments.

The survival rate of fish in this study indicates that the utilization of rearing media with varying salinity levels did not yield any significant effects across treatments for serukan fish *(Osteochilus sp)*. These results suggest that the serukan fish can tolerate the salinity variations within the range tested in this study. Different salinity levels do not significantly impact fish survival rates. Despite the potential impacts of salinity fluctuations on various aspects of fish physiology and behaviour, it appears that the scalloped fish possess sufficient resilience to handle the given salinity variations.

This discovery provides valuable insight into the adaptability of serukan fish to salinity changes, which could offer advantages in aquaculture contexts. However, further research might be necessary to comprehensively understand the mechanisms underlying fish adaptation to salinity variations, along with exploring potential interactions between salinity and other factors that might influence fish survival.

Blood glucose levels assessed after the juvenile rearing phase reveal that the utilization of rearing media with varying

salinity levels affects the stress level of the juvenile. The study's findings demonstrate that the impact of salinity-based rearing media differs in its influence on fish stress responses, as evidenced by variations in blood glucose levels across different treatments.

While the control treatment (P0) did not exhibit significant differences from the P1 and P2 treatments, it displayed a marked discrepancy in comparison to the P3 treatment, where a salinity level of 9 ppt led to higher stress response indicated by blood glucose levels reaching 36.26 mg/dL. These results indicate that environmental shifts toward higher salinity, as observed in the P3 treatment, can elicit heightened stress levels in fish.

This study aligns with Ardi *et al.* (2017), proposing that environments undergoing extreme changes, including significant shifts in salinity, can trigger stress responses in fish. This response is reflected by elevated blood glucose levels as a stress indicator. According to Polakof et al. (2012), Bartonkova *et al.* (2016), and Aslamyah *et al.* (2018), this influence is additionally influenced by alterations in hormonal balance and physiological mechanisms within the fish's body, responding to shifting environmental conditions.

The measurements of water quality parameters throughout the fish rearing period yielded a range of 4.25 to 5.52 mg/l for dissolved oxygen (DO), 6.3 to 8.2 for pH, and 28.1 to 30.2 °C for temperature. Based on Samsuli *et al.,* (2023) it can be inferred that the water quality parameters within this study remain within suitable ranges for the maintenance of the serukan juvenile.

Water quality stands as a pivotal factor in upholding the health and growth of fish within rearing systems. Adequate dissolved oxygen levels are particularly critical, as oxygen is essential for the fish's respiration process (Rizki *et al*.,2020). The observed DO values ranging from 4.25 to 5.52 mg/l indicate that the rearing environment adequately meets the oxygen requirements of the serukan fish, thereby supporting their health and normal activity.

Similarly, pH parameter values ranging between 6.3 and 8.2 suggest that the rearing environment for serukan fish falls within acceptable limits. Based on Marimuthu *et al.,* (2019) Appropriate pH levels contribute to maintaining environmental stability and fish physiological functions. This pH range ensures that the water remains within tolerable acidity or alkalinity levels, preventing the inhibition of enzyme activity and biological processes in fish.

Likewise, the temperature parameters spanning from 28.1 to 30.2°C appear to be suitable for nurturing serukan fish. Proper water temperature plays a pivotal role in optimizing fish metabolic rates, enhancing digestive activity, and promoting growth (Soedibya *et al.*, 2018). Within this temperature range, the serukan fish stand a favourable chance of acclimating and thriving (Samsuli *et al.,* 2023).

4. Conclusion

The utilization of different salinity media significantly impacts SGR, FI, FE, and stress response in juvenile serukan. Orthogonal polynomial analysis revealed that the optimal salinity concentration for enhancing serukan fish growth is approximately 3.8 ppt.

Acknowledgement

The author would like to thank the LPPM at Teuku Umar University for their generous financial support in facilitating this research. The successful execution of this study was made possible through the assistance of the study program league activities during the 2023/2024 Fiscal Year.

Bibliography

Agustin, Y. 2001. Pengaruh salinitas dan kesadahan terhadap kelangsungan hidup dan pertumbuhan ikan hias sumatra *(Barbus tetrazona* Bleeker*)*. [*Disertasi*]. Fakultas Perikanan dan Ilmu Kelautan. Institut Pertanian Bogor. Bogor.

Aihua, L., and Buchmann, K. 2001. Temperature-and salinity-dependent development of a Nordic strain of *Ichthyophthirius multifiliis* from rainbow trout. *Journal of Applied Ichthyology*, 17(6).

Amrullah, R. 2015. Gula darah dan mortalitas benih ikan nilem *(Osteochilus hasselti)* Yang di pelihara pada media salinitas berbeda. *Jurnal Mina Sains*, 1(2): https://doi.org/10.30997/jms.v1i2.5.

AOAC International. 2012. *Official methods of analysis of AOAC International* (19th ed.). AOAC Official Methods of Analysis.

Ardi, I., Setiadi, E., Kristanto, A.H., dan Widiyati, A. 2017. Salinitas optimal untuk pendederan benih ikan betutu *(Oxyeleotris marmorata)*. *Jurnal Riset Akuakultur*, 11(4): https://doi.org/ 10.15578/jra.11.4.2016.347-354.

Aslamyah, S., Karim, M.Y., Badraeni., and Tahya, A.M. 2018. Effect of fermented seaweed addition on blood glucose level, hepatosomatic index, and gastric evacuation rate of milkfish, *Chanos chanos* larvae. *AACL Bioflux*, 11(1).

Azhari, A., Muchlisin, Z.A., and Dewiyanti, I. 2017. Stocking density effect on survival and growth of seurukan *(Osteochilus vittatus)* fry. *Jurnal Ilmiah Mahasiswa Kelautan dan Perikanan Unsyiah*, 2(1): 12-19.

Bartonkova, J., Hyrsl, P., and Vojtek, L. 2016. Glucose determination in fish plasma by two different moderate methods. *Acta Veterinaria Brno*, 85(4). https://doi.org/10.2754/avb201685040349.

Dewi, E.S. 2006. Pengaruh salinitas 0, 3, 6, 9, dan 12 ppt terhadap pertumbuhan dan kelangsungan hidup benih ikan gurame *(Osphronemus gouramy)* ukuran 3-6 cm. [*Skripsi*]. Institut Pertanian Bogor. Bogor.

Diana, F., Mahendra, M., dan Oktavinanda, G. 2022. Minapadi productivity with a combination of legowo technology and local fish. *In E3S Web of Conferences*, 339: 1004.

Eames, S.C., Philipson, L.H., Prince, V.E., and Kinkel, M.D. 2010. Blood sugar measurement in zebrafish reveals dynamics of glucose homeostasis. *Zebrafish*, 7(2). https://doi.org/10.1089/ zeb.2009.0640.

Evans, D.H. 2011. Osmotic, ionic and nitrogenous-waste balance | Osmoregulation in Fishes: An Introduction. In Encyclopedia of Fish Physiology: From Genome to *Environment*, (1–3). https://doi.org/10.1016/B978-0-12-374553-8.00210-0.

Fauzi, M., Nuraini., Aryani, N. 2022. Pengaruh teknik adaptasi salinitas terhadap kelangsungan hidup dan pertumbuhan larva bawal air tawar *(Colossoma Macropomum)*. *Jurnal Akuakultur Sebatin*, 2(2): 55-64.

Firdaus, S. 2016. Optimasi salinitas untuk kelangsungan hidup dan pertumbuhan benih ikan nilem *Osteochilus hasselti* CV. [*Skripsi*]. Institut Pertanian Bogor. Bogor.

Fitrani, M., Nirmala, K., dan Affandi, R. 2009. Rekayasa lingkungan budidaya untuk meningkatkan mutu produk ikan patin *(Pangasius hypophthalmus)*: peranan salinitas. *Prosiding Forum Inovasi Teknologi Akuakultur*, 0(0): 461–474. http://ejournal-balitbang.kkp.go.id/index .php/fita/article/view/5377.

Fitria, A.S. 2012. Analisis kelulushidupan dan pertumbuhan benih ikan nila larasati *(Oreochromis niloticus)* F5 D30-D70 pada berbagai salinitas. *Journal of Aquaculture Management and Technology*, 1(1): 18–34. https://www.neliti.com/publications/92834/.

Intansari, M. 2018. Kinerja produksi ikan galaxy rasbora *Danio margaritatus* yang dipelihara pada salinitas berbeda. [*Skripsi*]. Institut Pertanian Bogor. Bogor.

Islama, D., Nirmala, K., dan Widiyati, A. 2014. Peningkatan pertumbuhan benih ikan tengadak, *Barbonymus schwanenfeldii* (Bleeker 1853) melalui pengaturan salinitas dan kalsium. *Jurnal Iktiologi Indonesia*, 14(2): 135-143.

Jiang, Y., Yuan, C., Qi, M., Liu, Q., and Hu, Z. 2022. The effect of salinity stress on enzyme activities, histology, and transcriptome of silver carp *(Hypophthalmichthys molitrix)*. *Biology*, 11(11): 1580.

Kujawa, R., and Piech, P. 2022. Influence of water salinity on the growth and survivability of asp larvae *Leuciscus aspius* (Linnaeus, 1758) under controlled conditions. *Animals*, 12(17): 2299.

Marimuthu, K., Palaniandya, H., and Muchlisin, Z.A. 2019. Effect of different water pH on hatching and survival rates of African catfish *Clarias gariepinus* (Pisces: Clariidae). *Aceh Journal of Animal Science*, 4(2): 80-88.

Nugroho, R.A., and Chilmawati, D. 2016. Efisiensi pemanfaatan pakan dan pertumbuhan lele dumbo *(Clarias Gariepinus)* strain sangkuriang yang dipelihara pada media dengan salinitas yang berbedadalam kolam plastik. *Pena Akuatika: Jurnal Ilmiah Perikanan Dan Kelautan*, 13(1).

Nurjanah, S.K. 2014. Optimalisasi salinitas untuk kelangsungan hidup dan pertumbuhan benih ikan tengadak (*Barbonymus schwanenfeldii* Bleeker). [*Skripsi*]. Fakultas Perikanan dan Ilmu Kelautan. Institut Pertanian Bogor. Bogor.

Nursidi, N., Ratnasari, R., Alimuddin, A., and Yusuf, A. 2021. Aktivitas enzim amilase, lipase dan protease ikan nila *(Oreochromis niloticus)* yang dipelihara pada air tawar dan payau. *Lutjanus*, 25(2). https://doi.org/10.51978/jlpp.v25i2.276.

Polakof, S., Panserat, S., Soengas, J.L., and Moon, T.W. 2012. Glucose metabolism in fish: A review. *In Journal of Comparative Physiology B: Biochemical, Systemic, and Environmental Physiology*, 182(8). https://doi.org/10.1007/s00360-012-0658-7.

Prakoso, V.A., dan Kurniawan, K. 2017. Pengaruh stressor suhu dan salinitas terhadap perkembangan embrio ikan nilem *(Osteochilus hasselti)*. *Jurnal Sains Natural*, 5(1). https://doi.org/10.31938 /jsn.v5i1.99.

Prananingtyas, D., Prayogo, and Rahardja, S. 2019. Effect of different salinity level within water against growth rate, survival rate (FCR) of catfish *(Clarias sp.)*. *IOP Conference Series: Earth and Environmental Science*, 236(1). https://doi.org/10.1088/1755-1315/236/1/012035.

Rahim, T., Tuiyo, R., dan Hasim. 2015. Pengaruh salinitas berbeda terhadap pertumbuhan dan tingkat kelangsungan hidup benih ikan nila merah *(Oreochromis niloticus)* di Balai Benih Ikan Kota Gorontalo. *Jurnal Ilmiah Perikanan Dan Kelautan*, 3(1).

Rizki, R.R., Diatin, I., Budiardi, T., and Effendi, I. 2020. Improved performance of botia fish *Chromobotia macracanthus* with the utilization of blood clam shell in the recirculation system. *Jurnal Akuakultur Indonesia*, 19(2): 160-170.

Samsuli, S., Diansyah, S., dan Harun, H. 2023. Variasi padat tebar terhadap pertumbuhan dan kelangsungan hidup ikan serukan *(Osteochilus kappeni)* pada system resirkulasi. *Mahseer: Jurnal Ilmu-Ilmu Perairan Dan Perikanan*, 5(2): 13-21.

Samuki, K., Setiawati, M., Jusadi, D., and Suprayudi, M.A. 2021. The evaluation of α-Lipoic acid supplementation in diet on the growth performance of giant gourami *(Osphronemus goramy)* juvenile. *Aquaculture Research*, 52(4). https://doi.org/10.1111/are.15006.

Setijaningsih, L. 2019. Salinity effect evaluation on the survival rate and hematology of snakeskin gourami juvenile *Trichopodus pectoralis*. *Jurnal Akuakultur Indonesia*, 18(2). https://doi.org/10.19027/jai.18.2.193-201.

Setiyadi, N., Basuki, F., dan Suminto. 2017. Studi perbandingan pertumbuhan dan kelulushidupan ikan nila *(Oreochromis niloticus)* pada strain larasati, hitam lokal dan merah lokal yang dibudidayakan di tambak. *Journal of Aquaculture Management and Technology*, 4(4).

Soedibya, P.H.T., Listiowati, E., Pramono, T.B., Prayogo, N.A., and Harisam, R.T. 2018. Growth performance of Catfish *(Clarias gariepenus)* cultured of high density with biofloc system. *In E3S Web of Conferences*, 47: 2002.

Stickney, R.R. 2000. Encyclopedia of aquaculture. 1063. https://www.wiley.com/en-us/Encyclopedia+of+Aquaculture-p-9780471291015.

Takeuchi, T. 1988. Laboratory work chemical evaluation of dietary nutrition. Kanagawa International Fisheries Training Center.

Zonneveld, N., and Fadholi, R. 1991. Feed intake and growth of red tilapia at different stocking densities in ponds in Indonesia. *Aquaculture*, 99(1–2). https://doi.org/10.1016/0044-8486(91)90289-J.