Journal of Fish Health
Volume 5, Issue 2, May 2025
https://doi.org/10.29303/jfh.v5i2.7294

The Effect of Different Salinity on Moulting of Mud Crab (*Scylla serrata*) in Controlled Media

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Received:
May 1st, 2024
Accepted:
May 30th, 2025

Keywords:
Moulting, Mud Crab, Salinity

ABSTRACT

Mud crab (*Scylla serrata*) is a fishery commodity that has high economic value and has a wide salinity tolerance so that its growth can be developed. The growth of mud crabs can be influenced by genetic traits such as moulting. In cultivation activities there are methods that can accelerate the moulting process such as environmental engineering (increasing and decreasing the salinity of the maintenance media) and mutilation. This study aims to determine the growth and fastest moulting time of crabs in media with different salinities in controlled media. The method used is an experimental method with a Completely Randomized Design (CRD) consisting of 5 treatments and 3 replications, namely: (Control), (P1: 5 ppt), (P2: 10 ppt), (P3: 15 ppt) and (P4: 20 ppt) which are given to mud crabs for 45 days. The results showed that at 5 ppt salinity obtained the fastest moulting time which was 24.3 days and the longest was at 20 ppt salinity for 39 days, while the highest growth was obtained in the 15 ppt salinity treatment with an average absolute weight of 27.3 grams and the lowest was in the control treatment with an average absolute weight of 18.3 grams.

INTRODUCTION

Mud crab (*Scylla serrata*) is one of the fishery commodities with high economic value and is an export commodity. Based on the report of the Ministry of Maritime Affairs and Fisheries (KKP) 2020, in 2014 mud crab exports reached 16.8 million tons with a value of US$409.81 million or around IDR 6.14 trillion, then in 2019 it increased rapidly to 756.67 tons with a value of US$613.24 million or around IDR 9.19 trillion. The high market demand for these crabs is because mud crabs have several advantages, namely having a wide salinity tolerance, high survival rate, resistance to disease and poor environments (Wenestri *et al*., 2014).

The growth of mud crabs can be influenced by genetic traits such as moulting. Moulting is the process of changing the skin (shell) in crustaceans that occurs when the crab's body size increases so that to adjust its size the crustacean will release the old shell and then be replaced by a new shell (Andriyeni *et al*., 2022). The growth of mud crabs is greatly influenced by moulting because the increase in weight, length, and width of the carapace will occur after moulting. During the growth period to adulthood, crabs will experience moulting between 17-20 times depending on environmental conditions such as water salinity (Khairiah *et al*., 2012).

In cultivation activities, there are engineering methods that can be used to accelerate the process of changing skin in crabs, namely environmental engineering such as increasing and decreasing the salinity of the maintenance media and the mutilation method. The mutilation method by cutting the walking legs of crabs can increase the production of ecdysteroid hormones that trigger moulting in crustaceans because the more wounds or parts of the crab's outer skeleton that are lost, the more active the ecdysteroid hormone works (Samidjan *et al*., 2015). In addition, environmental engineering such as water salinity can affect the physiological processes and body structure of organisms, organism activity and can affect the frequency of moulting and increase the size of crustaceans (Herlinah *et al*., 2015).

This study was previously conducted by Habibi (2015), by adding water salinity with a dose of 5 ppt every week until it reaches 56 ppt. So, it was found that the best addition of salinity to accelerate crab moulting was the addition of 5 ppt salinity to reach 25 ppt. Currently, research on engineering the aquatic environment such as salinity to accelerate mud crab moulting is still limited. Therefore, this study is important to be conducted to determine the growth and fastest moulting time of mud crabs with different salinities in controlled media with the aim of determining the effect of differences in salinity on the growth of mud crabs and determining the length of time needed for mud crabs to change their skin.

METHODS

This research activity was carried out in June-July 2024 for 45 days at the Crab Enlargement Unit of CV Alula Dua Satu, Jl. Ahmad Yani No. 21, Sayang-Sayang Village, Mataram City. The biota tested were mud crabs. This study used an experimental method with a Completely Randomized Design (CRD) consisting of 5 treatments and 3 replications, so that 15 experimental units were obtained, namely as follows:

Treatment P1 : Salinity 5 ppt and cutting of crab walking legs
Treatment P2 : Salinity 10 ppt and cutting of crab walking legs
Treatment P3 : Salinity 15 ppt and cutting of crab walking legs
Treatment P4 : Salinity 20 ppt and cutting of crab walking legs
Treatment K : Control (no treatment)

The research data were analyzed using SPSS (ANOVA), then if the test results between treatments were significantly different, Duncan's further test would be carried out with a level of <0.05 and presented in the form of tables and graphs. The research parameters tested are as follows:

Absolute Weight

According to Ramadhan *et al.* (2022) absolute weight is determined using the following formula:

$$Wm = Wt – Wo$$

Description:
Wm = Absolute growth

Wo = Average weight of mud crabs at the beginning of the study (g)
Wt = Average weight of mud crabs at the end of the study (g)

Absolute Width

According to Nova *et al.* (2023) absolute width can be calculated using the following formula:

$$L = Lt - Lo$$

Description:
L = Absolute width growth (cm)
Lt = Average crab body width at the end of the study (cm)
L0 = Average crab body width at the beginning of the study (cm)

Spesific Growth Rate (SGR)

According to Kaligis (2016), SGR can be calculated using the following formula:

$$SGR = \frac{(\ln Wt - \ln W0)}{t} \times 100\%$$

Description:
SGR = Specific Growth Rate
Wt = Average total weight on day t (last)
W0 = Average total weight on day 0 (beginning)
t = Total days of observation (days)

Feed Conversion Ratio (FCR)

According to Romadhon et al. (2022), FCR can be calculated using the following formula:

$$FCR = \frac{F}{(Wt+D)-Wo}$$

Description:
FCR = Feed conversion ratio
FCR = Total amount of feed consumed by crabs
Wt = Total weight of crabs at the end of the study (g)
D = Total weight of dead crabs (g)
W0 = Total weight of crabs at the beginning of the study (g)

Survival Rate (SR)

According to Pattirane et al. (2020) SR can be calculated using the formula:

$$SR = \frac{Nt}{No} x100\%$$

Description:
SR = Crab survival rate (%)
Nt = Number of crabs alive at the end of the study (tail)
N0 = Number of crabs alive at the beginning of the study (tail)

Water Quality Parameters

The water quality parameters measured in this study were temperature, salinity, pH and DO which were measured once a week in the afternoon at 16.00 WITA. Salinity was measured using a Refractometer, temperature was measured using a Thermometer, pH was measured using a pH Meter and DO was measured using a DO Meter.

RESULTS

Crab Moulting Time

The results of giving different salinities to the moulting time of mud crabs for 45 days showed that the moulting time obtained ranged from 24.3-39 days as can be seen in Figure

1.

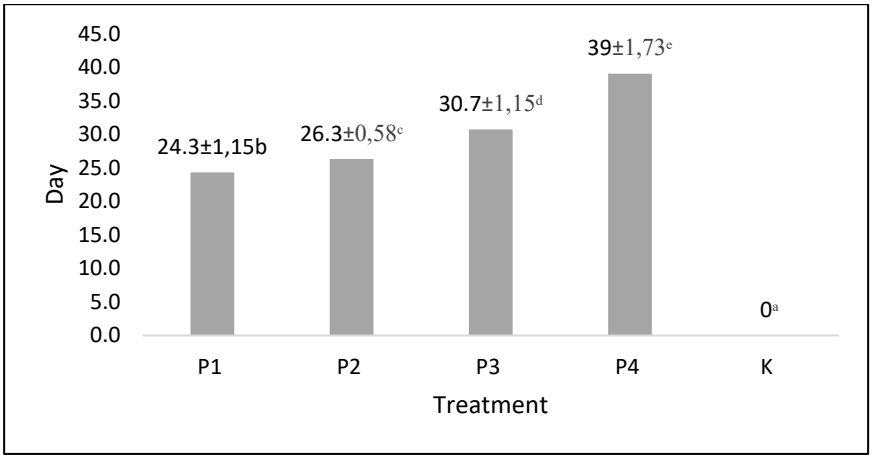

Figure 1. Moulting Time of Mud Crabs (*Scylla* spp.) with Different Salinities

Based on the results of the Analysis of variance (ANOVA) test, the results obtained are significantly different (P>0.05), In each treatment, significantly different results were obtained. The results obtained showed that the fastest skin replacement process was obtained by treatment P1 (5 ppt) with an average value of 24.3 days, treatment P2 (10 ppt) with an average value of 26.3 days, then treatment P3 (15 ppt) with an average value of 30.7 days and treatment P4 (20 ppt) with an average value of 39 days, while the control treatment had not changed skin for 45 days of maintenance.

Absolute Weight

The results of giving different salinities to the moulting time and growth of mud crabs for 45 days showed that the absolute weight obtained ranged from 18.3-27.3 g as can be seen in Figure 2.

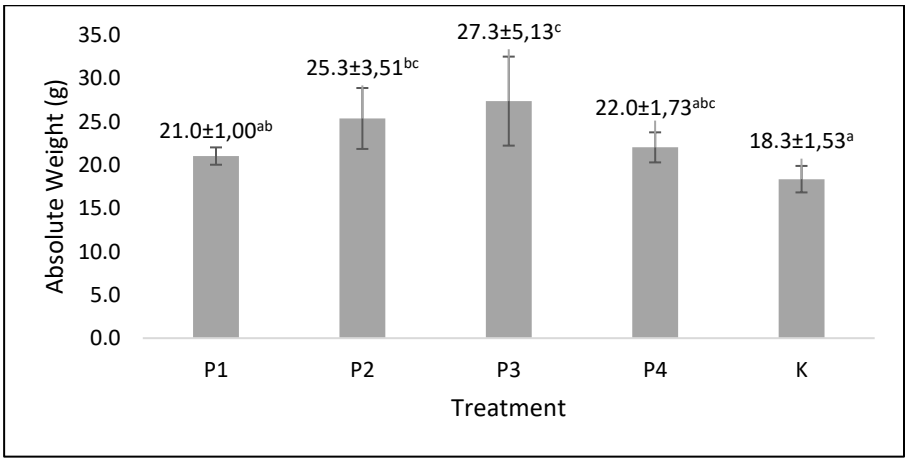

Figure 2. Absolute Weight of Mud Crabs (*Scylla* spp.) with Different Salinities

Based on the results of the Analysis of variance (ANOVA) test, the results obtained are significantly different (P>0.05), with the result that further testing using the Duncan test could be carried out. The results of the Duncan test showed that the highest absolute weight of P3 was significantly different from P1 and control but not significantly different from P2 and P4, while in the treatment with the lowest absolute weight value, namely the control treatment, the results were significantly different from P2 and P3 but not significantly different from P1 and P4, where these results indicate that the highest absolute weight growth of mud crabs was obtained in the P3 treatment with an average value of 27.3 g, followed by the P2

treatment with an average value of 25.3 g, the P4 treatment 22.0 g, then the P1 treatment with an average value of 21.0 g and the lowest was the control treatment with an average value of 18.3 g.

Absolute Width of Carapace

The results of giving different salinities to the moulting time and growth of mud crabs for 45 days showed that the absolute width of the carapace obtained ranged from 0-3.4 cm as can be seen in Figure 3.

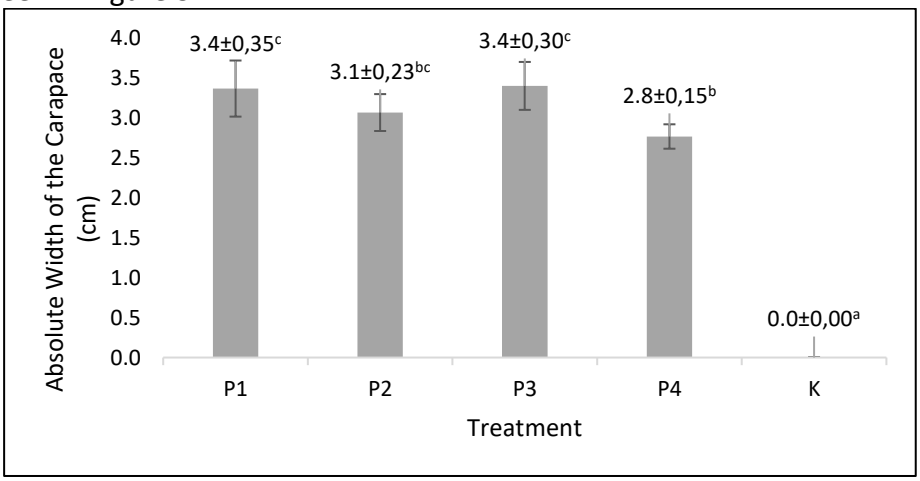

Figure 3. Absolute Width of Mud Crab Carapace (*Scylla* spp.) with Different Salinities

Based on the result ot the Analysis of Variance (ANOVA) test, the results obtained were significantly different (P>0.05) so that further testing could be carried out using the Duncan test. The highest absolute carapace length of P3 was significantly different from P4 and the control but not significantly different from P1 and P2, while in the treatment with the lowest absolute weight value, namely the control treatment, the results were significantly different from all treatments because the skin had not changed so that the carapace width did not increase during the 45-day maintenance period. The highest absolute carapace width values were P1 and P3 with an average of 3.4 cm, followed by treatment P2 with an average of 3.1 cm and the lowest was treatment P4 with an average of 2.8 cm.

Specific Weight Growth Rate

The results of giving different salinities to the moulting time and growth of mud crabs for 45 days showed that the specific growth rate obtained ranged from 0.35-0.50% as can be seen in Figure 4.

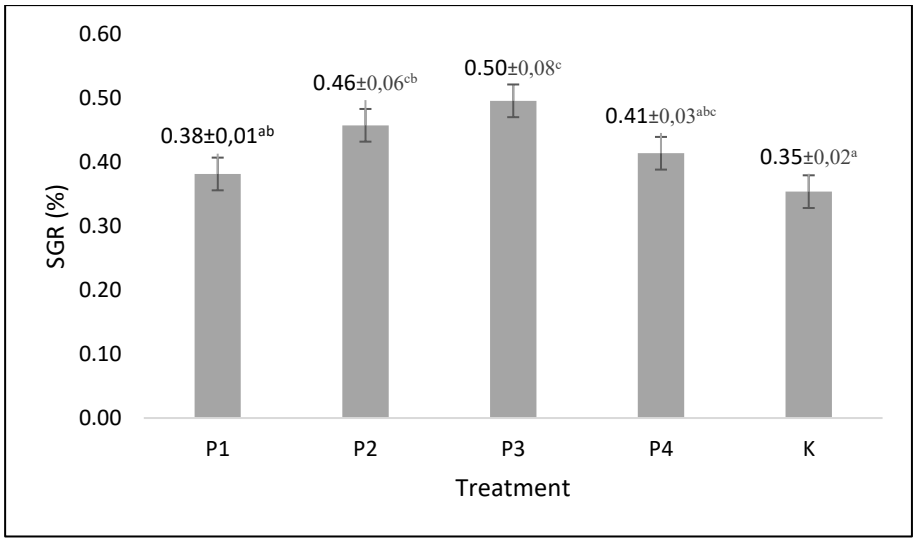

Figure 4. Specific Weight Growth Rate of Mud Crabs (*Scylla* spp.) with Different Salinities

Based on the results of the Analysis of Variance (ANOVA) test, the results obtained were significantly different (P>0.05) so that further testing using Duncan could be carried out. The results of the Duncan test showed that the highest SGR value of P3 was significantly different from P1 and control but not significantly different from P2 and P4, while in the treatment with the lowest SGR value, namely the control treatment, the results were significantly different from P2 and P3 but not significantly different from P1 and P4. The highest specific weight growth rate value in the P3 treatment obtained the highest SGR value with an average of 0.50%, followed by the P4 treatment with an average of 0.46%, P4 with an average of 0.41%, then P1 with an average of 0.38% and the lowest control treatment with an average of 0.34%.

Feed Conversion Ratio (FCR)

The results of giving different salinities to the moulting time and growth of mud crabs for 45 days showed that the FCR obtained ranged from % as can be seen in Figure 5.

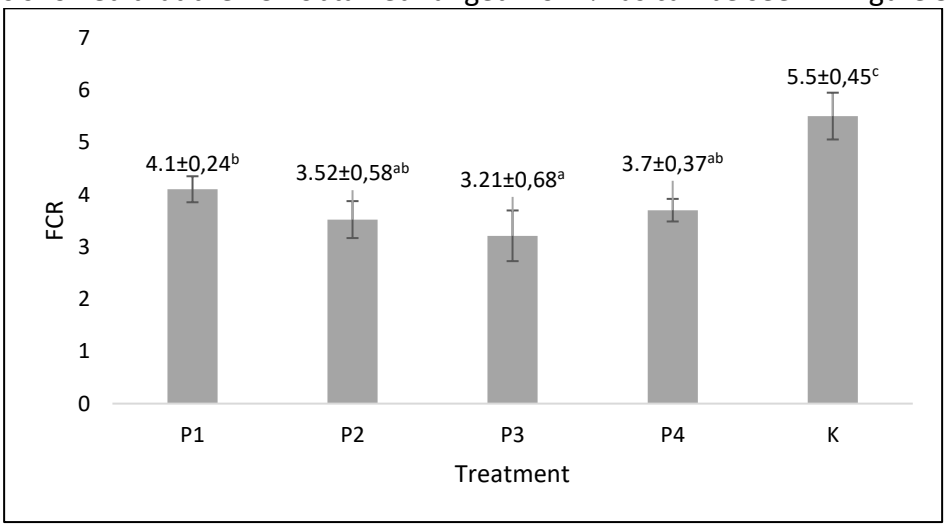

Figure 5. Feed Conversion Ratio (FCR) of Mud Crabs (*Scylla* spp.) with Different Salinities

Survival Rate (SR)

The results of giving different salinities to the moulting time and growth of mud crabs for 45 days showed that the survival rate obtained was 100% as can be seen in Figure 6.

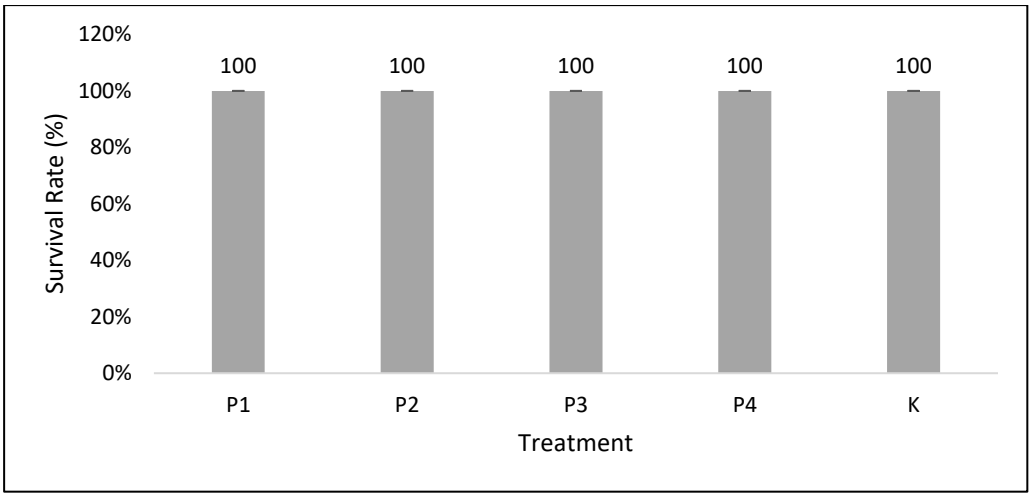

Figure 6. Survival Rate (SR) of Mud Crabs (*Scylla* spp.) with Different Salinities

Based on the results of the the Analysis of Variance (ANOVA) test, the results obtained from the mud crab survival rate test were not significant (P<0.05) or there was no effect given by the provision of different salinities on the mud crab survival rate.

Water Quality

During the maintenance period, water quality checks are carried out once a week or every time sampling is carried out. The water quality parameters measured include temperature, pH and DO.

Table 1. Water Quality Parameters

No	Parameter	Value	Optimum Range
1.	Temperature (°C)	26.3-29.3	26-32°C (Katiandagho, 2014)
2.	pH	6.9-7.9	6.8-8.2 (Hastuti *et al*., 2016)
3.	Dissolved Oxygen (mg/l)	7.4-9.4	> 5 mg/L (Katiandagho, 2014)

DISCUSSION

Moulting Time

The time of crab molting is one of the factors that affects crab production, which in this study is the main parameter observed. Based on the study, it can be seen that the salinity of the 5 ppt media for maintaining mud crabs that have all their walking legs mutilated experienced the fastest molting time, with an average of 24.3 days, while the control treatment did not experience molting for 45 maintenance periods. This is because crabs in their natural habitat experience molting for 60 days so that the molting time is longer than the need for mutilation and decreased salinity (Nova *et al*., 2023). Based on research by Habibi *et al*. (2013), that control crabs without treatment showed a difference in the length of molting time which was longer than crabs that were given treatment where control crabs needed 60 to 83 days with an average of 72 days to molt, so that maintaining crabs in different salinity media can accelerate the process of molting crabs.

The relationship between salinity and the molting time of mud crabs shows that the higher the salinity of the maintenance medium, the longer the molting time of mud crabs, meaning that the salinity of the medium has a significant effect on the length of time for crab molting. This is in accordance with the statement of Ario *et al*. (2019), which states that environmental engineering such as water salinity can affect physiological processes, organism activity, affect the frequency of molting and increase the size of crustaceans.

The salinity of this media is closely related to the osmotic pressure and osmoregulation process carried out by crabs in the media, the higher the salinity in the maintenance media, the higher the osmotic pressure in the maintenance media. The results of the study showed that the one that gave the shortest skin change time was a salinity of 5 ppt, so it is estimated that at this salinity the environmental conditions are isoosmotic so that the use of energy for osmoregulation is low and growth is optimal, while in the treatment with a salinity of 20 ppt it is hyperosmotic. This statement is in accordance with the statement of Mahdaliana *et al*. (2022), that salinity is one of the factors that influences the life of aquatic organisms including crabs, the effect will affect the growth of crabs because the growth of crabs depends on how the energy is used in their bodies where the efficiency for growth and organ regeneration will be efficient if the crab lives in a medium that is not far from its isoosmotic point.

Viewed from the beginning, crabs that had all their walking legs cut began to regenerate (growing new walking leg buds) showing differences for each salinity treatment. At a salinity of 5 ppt, walking leg buds began to grow on the 10th day, at a salinity of 10 ppt on the 12th day, while for salinities of 15 ppt and 20 ppt on the 14th day. Based on observations of the growth of mud crabs that were given mutilation treatment, they would experience a change in body organs after 7 days after treatment, which was marked by the growth of abnormal toes. After being observed, skin changes would occur after the leg organs in the crab had grown perfectly, shell hardening took place about 1-2 days after the skin change process occurred. The skin change process would be accompanied by an increase in body weight, width and length of the carapace in the crab. This is in accordance with the nature of crustaceans that experience growth by molting, an increase in body size will only be seen after the skin change process is complete. This is in accordance with the opinion of Jolpano *et al*. (2023), which states that biologically, mutilation of walking legs can stimulate crab organs to grow back. After the crab's walking legs are removed, the crab will be stimulated to improve its body morphological function by changing its skin so that a new body part will be formed in the form of a soft-shelled crab. Research on accelerating molting in crabs using the method of injecting forest fern leaf extract conducted by Romadhon *et al*. (2022), produced the fastest molting time, which was 17 days, this is thought to be due to the injection of forest fern extract directly into the crab's body, where forest ferns are one type of fern plant that contains ecdysteroid hormones, these hormones are useful for accelerating the molting of mud crab skin.

Absolute Weight

Growth is the increase in volume and size over a certain period of time where crab growth is closely related to the molting event. Based on the data obtained, it can be seen that the highest absolute weight growth of mud crabs was obtained by treatment P2 (10 ppt) of 25.3 grams, P3 (15 ppt) 27.3 grams and P4 (20 ppt) 22.0 grams, then the lowest was the control treatment (28 ppt) of 18.3 grams.

The high absolute weight values in P2, P3 and P4 are not only due to efficient feed utilization but also due to skin changes during the maintenance period, while in the control treatment there was no skin changes so that the absolute weight results obtained were significantly different. The process of increasing body weight in crabs occurs due to the development of the integument (outer layer) in crabs that do not harden accompanied by the absorption of water content, minerals and important ions as a result of differences in osmotic pressure influenced by salinity. This means that the higher the salinity of the crab's living medium, the higher the osmotic pressure will be so that the use of energy for growth is reduced and more is used for osmoregulation. This is in accordance with the statement of

Kaligis (2016), that osmotic pressure is the work of the crab's osmoregulation system to maintain the osmolarity of its internal environment, and this process requires energy for active transport of ions. The magnitude of the level of osmotic work in the osmoregulation process will affect the level of energy expenditure. If the osmotic pressure is very high, the energy expenditure for osmoregulation is high, reducing the portion of energy for growth. When compared with research conducted by Sitaba *et al*. (2017), showed that the highest average absolute growth was 5.69 grams at a salinity of 10 ppt and the lowest at a salinity of 30 ppt with a value of 2.60 grams, meaning that the higher the salinity of the crab's living medium, the lower the absolute weight value obtained.

Specific Growth Rate (SGR)

Specific Growth Rate (SGR) is defined as the change in organism weight, size, or volume along with the change in time in each day of the maintenance period. Based on the data obtained high SGR values in treatments P2, P3 and P4 with an average of 0.41-0.50% in a day while the control treatment had a low SGR value with an average of 0.35% in a day. The difference in specific growth rate in the treatments is also supported by the difference in feed conversion value and efficiency of protein utilization in the feed. This shows that the utilization of energy from feed consumed by crabs in treatments P2, P3 and P4 is mostly used for growth rather than for osmoregulation. This is in accordance with the statement of Djunaedi *et al.* (2015), that at a salinity of 15 ppt the osmotic work rate is low, while the treatment with high salinity the osmotic work rate becomes high. The specific growth rate in treatments P2, P3 and P4 is also supported by a lower FCR value compared to other treatments so that the feed given can be processed into energy which is then utilized properly for growth. Energy expenditure for osmoregulation can be suppressed if the organism is maintained in isoomotic media so that feed utilization becomes efficient and growth increases (Mahdaliana *et al*., 2022). When compared with research conducted by Sitaba *et al*. (2017), it shows that the highest average SGR is 0.26% at a salinity of 10 ppt and the lowest at a salinity of 30 ppt with a value of 0.12%, meaning that the higher the salinity of the crab's living medium, the lower the SGR value obtained.

Feed Conversion Ratio (FCR)

Feed Conversion Ratio (FCR) is a comparison of the amount of feed given to the amount of meat produced. Based on the results obtained, the highest FCR value was in the control treatment with an average of 5.5 and the lowest was in the P2, P3 and P4 treatments with an average of 3.21. Rivaldi *et al.* (2022) , stated that the smaller the feed conversion value, the more efficient the utilization of feed into meat and vice versa, the greater the feed conversion value, the less efficient the feed given. Giving different salinity treatments and mutilation of all crab walking legs gave a significant FCR value. This can be caused because the crabs are kept at different salinities so that they obtain energy through the feed consumed and their expenditure is used for various different activities including for osmoregulation purposes. This is in accordance with the statement of Paralita *et al*. (2021), which states that rapid growth is determined not only by the efficiency of feed utilization, but also by low osmotic pressure. When compared to research conducted by Adila *et al*. (2020), that with the same feeding treatment, the FCR produced was 7.38, resulting in the most optimal crab growth compared to the 5% and 10% treatments, so this shows that the similarity of the results obtained is not significantly different, which means it is still within the normal range for crab FCR.

Survival Rate

Survival rate (SR) is the comparison level of the number of crabs that survive at the beginning of maintenance and at the end of maintenance. Based on the results obtained from

the treatment (control), different salinity treatments of 5 ppt, 10 ppt, 15 ppt and 20 ppt have an SR value of 100%, which indicates that no crabs died during the maintenance period. Survival is the ability of aquatic biota to survive from the beginning to the end of maintenance. The results of mud crab maintenance show that survival in all treatments is 100%. The mutilation and salinity reduction treatments carried out did not affect the survival rate, this is thought to be due to the provision of feed that has good nutritional content, water quality that meets the standard quality standards for mud crab living media so that crabs can survive well, in addition to good feed and environment. Wijaya *et al*. (2011), argue that reducing salinity or mutilation does not cause death because crabs can minimize the effects of stress due to their ability to increase the body's resistance to stress. Where the high value of hemocytes (red blood cells) in the test crabs resulted in the formation of phagocyte cells that are able to control pathogen attacks, both bacteria and viruses, and can also improve the immune system (Hastuti *et al.,* 2019). The survival rate during the maintenance period is quite high, this is also thought to be due to the controlled environment and maintenance media so that the water quality during the maintenance period is good in each treatment.

Water Quality

Water quality parameters observed in mud crab maintenance are DO, pH, and temperature. Based on Table 6, the water quality during mud crab maintenance is suitable for the mud crab's living medium and is still within the tolerance threshold of mud crabs. This water quality supports the survival and growth of the mud crabs being maintained. Water quality is one of the environmental factors that greatly influences the physiology of aquatic organisms. Therefore, water quality is the most important thing in the cultivation of crustacean species because it will affect the quality of life and optimal growth. According to Romadhon *et al*. (2022), several water quality parameters that can be used to assess the quality of water are temperature, salinity, DO, pH and ammonia.

The pH condition during maintenance is 7.2-7.9, this is because the water used during the study was fresh water that had been mixed with seawater so that the desired salinity was obtained so that the pH of the media water was high. According to Hastuti *et al.* (2016), which states that a good pH value in crab cultivation must always be maintained in the range of 6.8-8.2, the growth of mud crabs will reach the maximum point if the pH conditions are also in the optimum range. This is related to the acid and alkaline levels in the waters, because the pH of the water greatly influences the survival of mud crabs.

In addition to pH, dissolved oxygen can also affect the survival and growth of mud crabs. The range of dissolved oxygen during the study was 7.4-9.2 mg/L, in the first week of DO measurements the value obtained was 7.4 which was the lowest DO value during maintenance, this was suspected because the water in the maintenance media at that time was being lowered which would affect the DO content in the water, although DO only reached 7.4 mg/L but did not affect the growth, molting time and survival of mud crabs. This is in accordance with the opinion of Katiandagho (2014), that mud crabs require a minimum dissolved oxygen level of 4.0 mg/L and the dissolved oxygen (DO) content for the best growth is> 5 mg/L. The DO value during the study was in the normal range for crab growth and provided a good survival rate.

The temperature during the study ranged from 27.3-29.1°C, this is still in the optimal stage for the maintenance of mud crabs where temperature is one of the important abiotic factors that affect the survival, growth and molting activities of crustaceans. Katiandagho (2014) stated that the optimum temperature for crabs is 26-32°C if the water temperature is

lower than 20°C, it will cause the activity and appetite of mud crabs to decrease drastically so that at that time growth will stop even though the crabs can still survive.

CONCLUSION

Based on the research that has been conducted, it can be concluded that differences in salinity have a significant effect on crab growth, where P2, P3 and P4 have high absolute weight growth values, so that the higher the salinity, the lower the crab growth. The fastest molting time was at a salinity of 5 ppt for 24.3 days and the longest was at 20 ppt for 39 days, while in the control treatment there was no molting for 45 days of maintenance, so the higher the salinity, the longer the distance between crab molting.

ACKNOWLEDGEMENT

The author would like to thank the parties who have helped in the implementation of the research and the preparation of this article, especially CV. Alula 21 which has provided facilities and infrastructure to support the implementation of this research.

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