Effect of Salinity On Survival and Growth Rate of Mangrove Crab (*Scylla Olivacea*) From Megalopa To Crablet Stages

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Abstract- The main problem in today's mangrove crab hatchery is the low survival rate of larvae at the zoea and megalopa stages in entering the crablet stage caused by a less than optimum rearing environment. This study was aimed to determine the optimum salinity that produces the best survival rate and growth rate of mud crabs (S. olivacea) at the megalopa-crablet stage. Research The research was carried out at the Center for Brackish Water Aquaculture Development (CBAD), Bonddia Village, Galesong District, Takalar Regency, South Sulawesi, Indonesia. The test animals used were mangrove crabs at the megalopa stage which were stocked at a density of 5 individuals/L and reared until they entered megalopa. The research used a container in the form of a black plastic basin with a volume of 30 L filled with 12 pieces of 20 L of water. The study was designed using a completely randomized design (CRD) with 4 treatments and each treatment had 3 replications, namely: 24, 27, 30, and 33 ppt. The placement of the experimental containers was done randomly. Media salinity had a very significant effect ($p < 0.01$) on the level of osmotic action, survival, and growth rate of the mangrove crabs from megalopa to crablet stages. minimal osmotic work rate, survival rate and daily growth rate of mud crab (S. olivacea) megalopa stage to best crabet produced at 30 ppt salinity, respectively 27.07 mOsm/L H_2O, 76.67%, and 29.74%/day, with optimum salinity each reached at 28.62; 28.77; and 28.95 ppt.

Index Terms- mud crab, growth rate, salinity, survival rate

I. Introduction

Mud crab *Scylla olivacea* is a fishery commodity that has important economic value and great potential to be developed through its cultivation. One of the determining factors for the success of a mangrove crab cultivation business is the availability of seeds. So far, the need for seeds is still met from the results of catching in nature, which are limited and fluctuating. Therefore, it needs to be accompanied by efforts to produce seeds through hatcheries. Efforts to produce mud crab seeds have been carried out in hatcheries. However, the main obstacle currently faced is the low survival rate, especially in the zoea and megalopa to crablet stages. Various factors become a source of obstacles to the success of mud crab seed production, one of which is the salinity of the rearing medium.
Media salinity affects the success of mud crab seed production, this is because in nature the crabs live their lives by moving from the high-salinity sea when they hatch, and as the stages develop, they will migrate towards the coast where the salinity is lower to the mangrove areas where the salinity is brackish or even close to fresh water. Salinity is an environmental factor that affects the survival of aquatic organisms, because it is a masking factor that can modify other factors that affect the osmotic effects of aquatic organisms (Smyth and Elliot, 2016; Bal et al., 2022).

In order to support the success of mangrove crab hatchery, it is necessary to study the biotechnical aspects that influence, i.e., environmental factors, especially salinity (Misbah et al., 2017; Pati et al. 2023). Although mud crabs are euryhaline organisms that are able to adapt to a wide range of salinity (Yao et al., 2021; Eddiwan et al., 2021; Herlinah et al., 2021), the megalopa to crablet stages are still susceptible to changes in the salinity of the media so that can result in high mortality (death). One of the causes of the high mortality of crabs in the hatchery business is the sub-optimal salinity of the rearing medium causing an osmotic work level resulting in high energy use for osmoregulation. There are several things that cause mortality in organisms, one of which is the sub-optimal salinity of the rearing medium (Baylon, 2010; Thabet et al., 2018).

In this regard, in order to produce survival of mangrove crabs (*S. olivacea*) at the megalopa to high crablet stages, it is necessary to maintain media with a certain salinity that can optimally minimize energy expenditure so that the crabs can maintain their survival. Because the optimum salinity for mud crab (*S. olivacea*) maintenance media at the megalopa to crablet stages cannot be determined, it is necessary to do research on this matter. This study aims to determine the optimum salinity that produces the best survival rate and

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growth rate of mud crabs (S. olivacea) at the megalopa-crablet stage. The results of this study are expected to be one of the information materials on the maintenance of mud crabs (*S. olivacea*) megalopa to crablet stages in the hatchery business.

II. RESEARCH METHODS

This research was conducted at the Center for Brackish Water Aquaculture Development (CBAD), Bonddia Village, Galesong District, Takalar Regency, South Sulawesi, Indonesia.

The test animal used was the megalopa stage mangrove crab. The Megalopa was obtained from hatching and maintenance at the Brackish Water Cultivation Center (BBAP), Takalar. The test animals were stocked at a density of 5 individuals/L and reared until they entered the megalopa.

The media water used was seawater with a salinity of 33 ppt and fresh water. Seawater stocks were obtained from the waters around the study site, while fresh water was obtained by distilling water from drilled wells at CBAD Takalar.

To get the salinity of the media to match the treatment, dilution was carried out. Dilution is carried out based on the following formula:

$$\mathbf{N_1 \ X \ V_1 = N_2 \ X \ V_2}$$

Note: N1 is the media salinity to be reduced (ppt), N2 is the desired media salinity (ppt), V1 is the volume of media water (L), and V2 is the volume of water that needs to be added (L)

To maintain the oxygen solubility of the experimental media, each aquarium was given aeration from a "root blower". To maintain the quality of the media in the experimental container, the remaining feed and excrement of the test crabs were removed every day by siphoning using a plastic hose and changing the water as much as 20% of the total volume every day. Before siphoning is done, aeration is stopped first.

The research used a container in the form of a black plastic basin with a volume of 30 L filled with 12 pieces of 20 L of water. The containers are equipped with aeration equipment.

The feed used in this study was Artemia salina nauplius and artificial feed in the form of flakes. The Artemia nauplius was obtained from hatching cysts of the Great Salt Lake strain produced by the USA. Feeding was done twice a day at 07.00 and 17.00 at a density of 5 ind/mL, while artificial feed was given at a dose of 15 ppm/day.

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The study was designed using a completely randomized design (CRD) with 4 treatments and each treatment had 3 replications. Thus, this study consisted of 12 experimental units. The treatments tried were differences in media salinity, namely: 24, 27, 30, and 33 ppt. The placement of the experimental containers was done randomly.

The variables observed in this study were the rate of osmotic action, survival and growth of mangrove crabs.

The level of osmotic work was determined from the difference between the osmolarity value of the crab hemolymph and the osmolarity of the treatment medium (Lignot et al. 2000). Osmolarity measurements were carried out using an osmometer (SOP OSMOTAT 30).

Mud crab survival rate is calculated using the following formula:

$$\mathbf{SR = N_t / N_o \ x \ 100}$$

$SR = N_t /N_o$ x 100

Note: S is mud crab survival rate (%), Nt is the number of mud crabs that lived to the end of the study (tails), and No is the number of mud crabs at the start of the study (tails)

The growth rate is calculated using the formula proposed by Huyn and Fotedar (2004) as follows:

$$\mathbf{SGR = 100 \ x \ (lnW_t - ln \ W_o)/t}$$

Note: SGR is the growth rate of mangrove crabs (%/day), Wt is the average weight of crabs at the end of the study (g), Wo is the average weight of crabs at the start of the study (g), and t is the length of time they are reared (days).

Absolute weight growth is calculated using the following:

$$\mathbf{W = W_t - W_o}$$

Note: W is the absolute weight growth of mangrove crabs (g), W_t is the average weight of the crabs at the end of the study (g), and W_o is the average weight of the crabs at the beginning of the study (g)

As supporting data during the research, several parameters of the water quality of the maintenance media were measured including: temperature, pH, dissolved oxygen and ammonia. Temperature was measured using a thermometer, pH with a pH meter, dissolved oxygen with a DO meter and ammonia with a spectrophotometer. Measurements of temperature, pH and dissolved oxygen were carried out twice a day, namely in the morning at 07.00 and in the evening at 15.00, while measurements of ammonia were carried out at the beginning, middle and end of the study.

The data obtained were analyzed using variance and W-Tuckey test. To determine the optimum salinity for mud crabs, a response test was carried out. The water quality parameters were analyzed descriptively based on the viability of the mangrove crab megalopa.

III. RESULTS AND DISCUSSION

Results

Osmotic Work Level

The osmotic work levels of mud crabs (*S.olivacea*) megalopa stage to crablets reared at various salinities are presented in Table 1.

Table 1. Average osmotic work level of mud crabs (*S. olivacea*) stadia megalopa-crablet reared at various salinities

Salinities (ppt)	Osmotic Work Level (mOsm/L H20)
24	82.22 ± 3.06[a]
27	47.17 ± 4.05[b]
30	27.07 ± 2.49[c]
33	82.66 ± 3.51[a]

Note: The same letter in the same column indicates no difference significant between treatments at 5% level (p <0.05)

The media salinity had a very significant effect (P <0.01) on the osmotic work level of the megalopa to crablet stage mangrove crabs. Furthermore, the results of the W-Tuckey advanced test. Furthermore, the results of the W-Tuckey test showed that the survival of mud crabs reared at salinities of 27 and 30 ppt showed significant differences (p <0.05) with salinities of 24 and 33 ppt. However, the survival rate of mud crabs reared at a salinity of 24 ppt was not significantly different (p > 0.05) from 33 ppt.

The relationship between media salinity and mud crab survival is quadratic with the equation Y = -2.522x2 – 144.370x + 2097.500 (r2 = 0.91) (Figure 1). Based on this equation it can be predicted that the minimum osmotic work level of the megalopa to crablet stage mud crabs will be achieved at a salinity of 28.62 ppt.

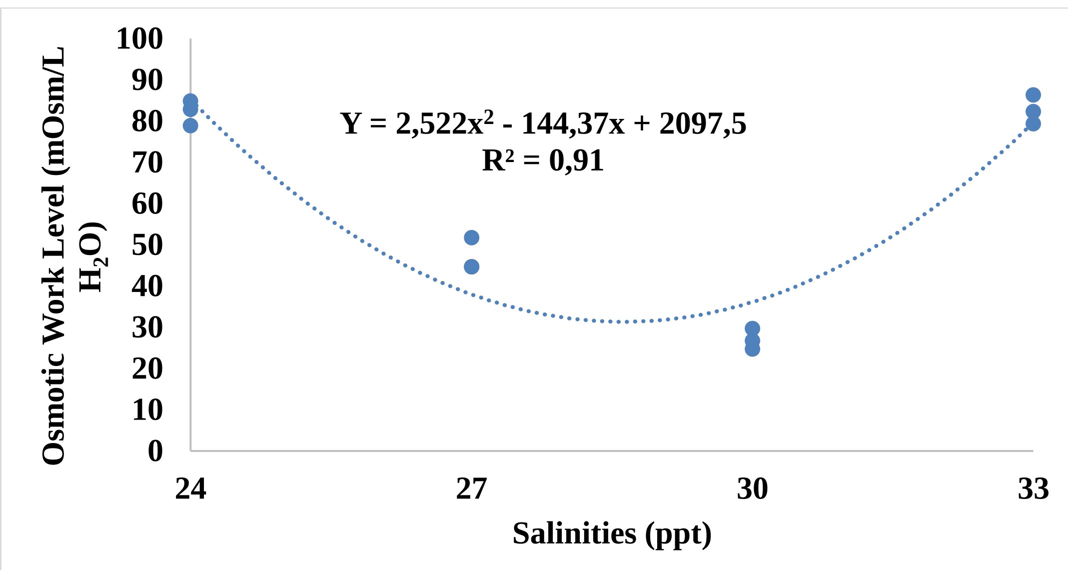

Figure 1. Correlation curve between salinity and crab osmotic work level megalopa-crablet mangroves

Survival and Growth Rate

The average survival rate and growth rate of mud crabs (*S.olivacea*) from megalopa to crablets reared at various salinities is presented in Table 2.

Table 2. Average survival rate and growth rate of mangrove crabs (*S. olivacea*) megalopa-crablet stages maintained at various salinities

Salinites (ppt)	Survival Rate (%)	Growt Rate (%/hari)
24	31.67 ± 2.89[c]	23.59 ± 0.46[c]
27	48.33 ± 5.77[b]	26.65 ± 0.34[b]
30	76.67 ± 2.89[a]	29.74 ± 0.15[a]
33	33.33 ± 2.89[c]	24.65 ± 0.57[bc]

Note: The same letter in the same column indicates no significant difference between treatments at 5% level (p <0.05)

Media salinity had a very significant effect ($p < 0.01$) on the survival of mangrove crabs from megalopa to crablet stages. Furthermore, the results of the W-Tuckey test showed that the survival of mud crabs reared at salinities of 27 and 30 ppt showed significant differences ($p < 0.05$) with salinities of 24 and 33 ppt. However, the survival rate of mud crabs reared at a salinity of 24 ppt was not significantly different ($p > 0.05$) from 33 ppt.
The relationship between media salinity and mangrove crab survival is quadratic with the equation $Y = -1.713x^2 + 98.583x - 1351.900$ ($r^2 = 0.71$) (Figure 2). Based on this equation, it can be predicted that the optimum salinity for juvenile mud crab (*S. olivacea*) from the megalopa to crablet stages is 28.77 ppt.

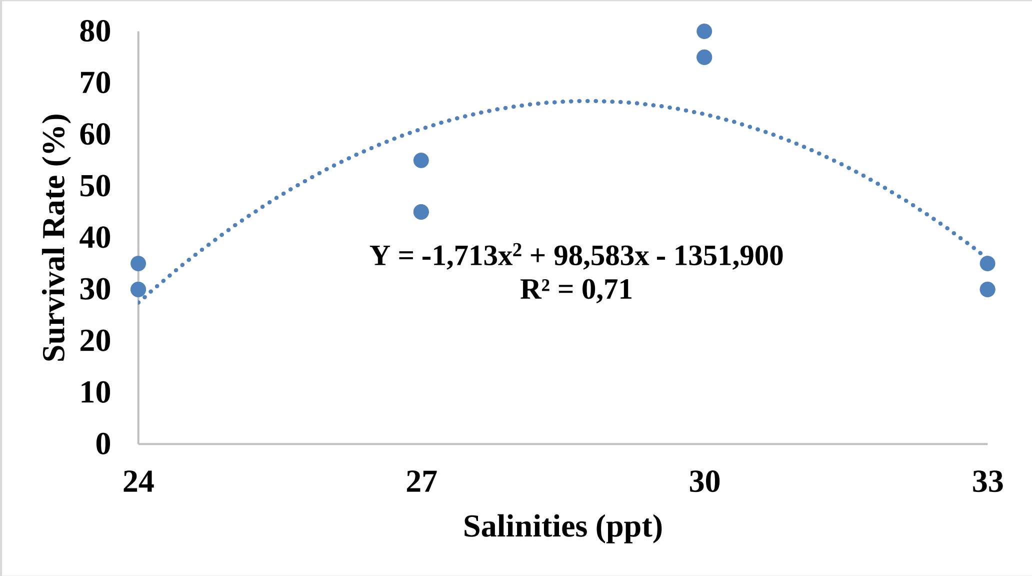

Figure 2. Correlation curve between salinity and mud crab survival megalopa-cablet stage

Media salinity had a very significant effect ($p<0.01$) on the daily growth rate of mangrove crabs from megalopa to crablet stages. Furthermore, the results of the W-Tuckey test showed that the 30 ppt salinity showed a significant difference ($p < 0.05$) with all treatments. Salinity of 24 ppt did not show a significant difference ($p > 0.05$) with a salinity of 33 ppt but was significantly different from 27 ppt. Likewise, the salinity of 27 and 33 ppt did not show a significant difference in the growth rate of mangrove crabs (*S. olivacea*) from megalopa to crablet stages.
The relationship between salinity and daily growth rate of mud crabs (S. olivacea) megalopa to crablet stages has a quadratic pattern with the equation $Y = -0.2266x^2 + 13.1240x - 161.2900$ with $R^2 = 0.83$ (Figure 3). Based on this equation, it can be predicted that the optimum salinity for the growth rate of the megalopa to maximum crablet growth rate can be achieved at 28.95 ppt.

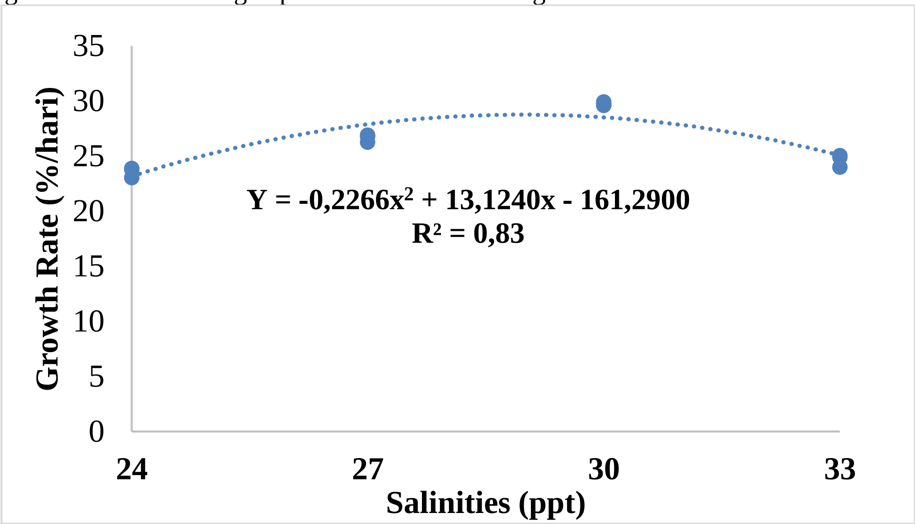

Figure 3. Relationship curve between salinity and crab growth rate mangrove (*S. olivacea*) stage megalopa to crablet

Physics-Chemistry of Water

During the research, several physico-chemical parameters were measured in the crab rearing media, including: temperature, pH, dissolved oxygen, and ammonia. The results of measuring the water quality parameters are presented in Table 3.

Table 3. The value of the physico-chemical parameters of the mud crab rearing media (*S. olivacea*) during the study

Salinities (ppt)	Parameters			
	Temperature (ºC)	pH	DO (ppm)	Ammonia (ppm)
24	27.82 – 29.70	7.25 – 8.10	5.23 – 6.73	0.003 – 0.032
27	27.73 – 29.50	7.26 – 8.15	5.34 – 6.75	0.004 – 0.036
30	27.72 – 29.70	7.26 – 8.12	5.32 – 6.73	0.003 – 0.035
33	27.73 – 29.70	7.25 – 8.14	5.34 – 6.77	0.004 – 0.038

IV. Discussion

Salinity is one of the environmental factors that affect the life of aquatic organisms including mangrove crabs. The salinity of the media through changes in the osmolarity of the water media will determine the level of osmotic work and will affect the use of energy for adaptation, which in turn will determine the survival and growth of crabs (Hastuti et al., 2015; Misbah et al., 2017). The level of osmotic work experienced by mud crabs is proportional to the difference in osmolarity between the media and body fluids (Hastuti 2019; Niu et al., 2020).

Based on Table 1, the highest osmotic work levels of the megalopa to crablet stages were produced at salinities of 24 and 33 ppt while the lowest was at salinities of 30 ppt. This indicates that the media with a salinity of 24 and 33 ppt are outside the optimum range so that at this salinity the level of osmotic work of crabs is high (Herlinah et al., 2021).

In media with osmotic work levels outside the isoosmotic range, crabs perform osmotic work for osmoregulation purposes (Rivera-Ingraham and Jehan-Hervé, 2017; Daiwan et al., 2022). At a salinity of 24 ppt the mangrove crabs are hyperosmotic to their environment, in which condition the crab body fluids are more concentrated than their environment so that water tends to enter the crab's body. In the media with a salinity of 33 ppt, the crabs are hypoosmotic to their environment, and in these conditions, the crab's body fluids tend to escape into the media. Based on the regression equation (Figure 1) it shows that the osmotic work rate of mud crabs from megalopa to crablet stages will decrease as the salinity increases up to 30 ppt, and when passing ppt salinity will increase the osmotic work level. The coefficient of determination of R2 = 0.91 indicates that 91% of the media salinity will affect the level of osmotic work of the mangrove crabs from megalopa to crablet stages. The minimum osmotic work level of the megalopa to crablet stage mud crabs was 26.622 mOsm/L H2O reached at 30.91 ppt.

The survival of mud crabs is mainly influenced by physico-chemical parameters of water, adequate feed, and media osmotic pressure (Varadharajan et al., 2013 Yulianto et al. 2019). The resulting survival rate provides an overview of the results of the interaction between the carrying capacity of the environment and feed. The availability of sufficient feed and the carrying capacity of the environment, especially salinity, will make energy use efficient so that crabs can use it to maintain their survival (Thabet et al., 2017). Salinity is one of the important abiotic factors that affect aquatic organisms (Velasco et al., 2019). Therefore, it is necessary to determine the optimum salinity according to the needs of organisms to support their survival (Phuc 2015; Rahi et al., 2021).

Based on Table 2, the highest mud crab survival rate was produced at a salinity of 30 ppt, while the lowest was at a salinity of 24 and 33 ppt. The low survival rate of organisms due to changes in salinity is a reflection of these organisms on osmotic changes in their environment (Rahi et al. 2021). Media with inappropriate salinity can cause death for crabs. Therefore, crabs will try to adapt by adjusting the process of osmoregulation to their environment. The process of osmoregulation requires a certain amount of energy. Increased osmotic work will cause a transfer of energy for osmoregulation (Rivera-Ingraham and Lignot, 2017). Thus mud crabs can experience a lack of energy which results in mortality.

The high survival rate of mud crabs at 30 ppt salinity illustrates that this salinity is ideal for supporting the life of mud crabs (S. olivacea) in the megalopa to crablet stages. At this salinity, the level of crab osmotic work is low, causing low energy use for osmoregulation so that energy is available to maintain its survival. Meanwhile, the osmotic work of crabs at salinities of 24 and 33 ppt had high osmotic work so that crabs needed considerable energy in their osmoregulation process. According to Wang et al. (2019; Herlinah et al. (2021), media salinity will affect the level of osmotic work of crabs, if the osmotic work is high then mud crabs use a certain amount of energy for their osmoregulation purposes. Based on the regression equation (Figure 2) shows that the survival of mud crabs from megalopa to crablets will increases with increasing salinity up to 30 ppt, and when exceeding ppt salinity decreases survival. The coefficient of determination of $R^2 = 0.71$ indicates that 71% of media salinity will affect the survival of mud crabs from megalopa to crablet stages and the remaining 29% is influenced by feed and other environmental factors. The maximum survival of mud crabs from megalopa to crablet stages will be achieved at a salinity of 28.77 ppt

Based on Table 2, the highest growth rate of mangrove crabs from the megalopa stage to crablets was produced at a salinity of 30 ppt and the lowest at 24 and 33 ppt. The high absolute growth rate of mangrove crabs from megalopa to crablet stages at a salinity of 30 ppt is due to the fact that this salinity is the optimal salinity for crab growth. At this salinity, the osmotic work of mangrove crabs is low so that the use of energy for osmoregulation is low so that energy is available to grow. In contrast to the salinity of 24 and 33 ppt ppt, the osmotic work of crabs is high, so much energy is used for osmoregulation. Salinity has an influence on the growth of aquatic organisms (Hasbullah et al., 2018; Velasco et al., 2019). Based on the regression equation (Figure 3) it shows that the growth rate of mangrove crabs from the megalopa to crablet stages will increase as the salinity increases up to 30 ppt, and when it passes the ppt salinity it will decrease its growth rate. The coefficient of determination of $R^2 = 0.81$ indicates that 71% of media salinity will affect the survival of mud crabs from megalopa to crablet stages and the remaining 19% is influenced by feed and other environmental factors. The maximum growth rate of mud crabs from the megalopa stage to crablets can be achieved at a salinity of 28.95 ppt.

The water quality parameters of the rearing medium are still in the suitable range for mud crabs. Table 3 above shows that the temperature of the media for raising mud crabs at the megalopa-crablet stage ranges from 27.72 to 29.70oC. The value of this range is still feasible for the life of the megalopa-crablet crab. Syafaat (2021; Win et al. 2021) suggests that a good temperature for keeping mud crabs is between 25 and 32 oC.

The pH values obtained during the study ranged from 7.25 to 8.15. Hastuti (2019) stated that the proper pH for the maintenance of mangrove crabs from the megalopa to crablet stages ranges from 7.0-9.0. Meanwhile Karim et al (2017) suggested that megalopa stage mangrove crabs should be maintained in media with a pH range of 7.5-8.5.

Dissolved oxygen obtained during the study ranged from 5.23 to 6.77 ppm. The range value is appropriate for the life of megalopa stage crabs. Karim et al (2017) suggested that for the maintenance of megalopa stage crabs to crablets the oxygen content should be greater than 3 ppm

Ammonia levels obtained during the study ranged from 0.003 to 0.038 ppm. The value of this range is still feasible to support the life of mud crabs. According to Pedopoli and Ramudu (2014; Karim et al (2017), in order for mud crabs (Scylla spp) to live well, it is recommended that the concentration of ammonia in the rearing medium be no more than 0.1 ppm.

V. CONCLUSION

Based on the results of the research, it can be concluded that the minimum osmotic work rate, survival rate and daily growth rate of mangrove crabs (*S. olivacea*) from megalopa to crabet stages are best produced at a salinity of 30 ppt, respectively 27.07 mOsm/L H2O, 76.67 %, and 29.74%/day, with optimum salinity each reached at 28.62; 28.77; and 28.95 ppt.

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