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# The effect of differences in silvofishery pond types and gender on the growth performance of mud crabs (*Scylla serrata*)

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ABSTRACT

Mangrove crabs are one of the important fisheries commodities in Indonesia which have made a significant contribution to the lives of coastal communities. This study aims to analyze differences in growth performance of mud crabs reared in different silvofishery ponds to find out the effect of gender and to determine the interaction patterns between silvofishery pond type and gender. This research method uses a Factorial Randomized Block Design (FRBD) which consists of two factors, namely pond type (core pond, trench pond) and sex (male, female) so that it has 6 treatment combinations and 3 replications for each treatment. The initial weight of the test mud crab was 70-75 g. Test animals were kept for 56 days in crab baskets. The results showed that the interaction between pond type and sex had a significant influence on daily growth rate and absolute weight growth but did not significantly influence the feed conversion ratio and feed utilization efficiency. Duncan's further tests showed that the type of pond had a real influence on the feed conversion ratio and feed utilization efficiency. The best Feed Conversion Ratio was found in the core pond treatment with 3.80 ± 1.05 with the highest feed utilization efficiency of 27.67 ± 3.23 %.The survival rate shows values that are not significantly different between all treatments (86.67 – 100%.). The water quality measurement values during the research were still optimal for the growth of male and female mud crabs. Treatment of core ponds with female crabs (T2K2) showed the best performance in terms of daily growth rate and absolute weight growth of mud crabs. Core pond treatment with female crabs showed the highest daily growth results of 0.82% ± 0.01% and absolute growth of 42.00 ± 1.00.

## Introduction

Mud crab (*Scylla serrata*) has become widespread in the region Indo-West-Pacific and has become an important fisheries commodity in Indonesia since the early 1980s and has the potential to support the lives of coastal communities (Keenan *et al*., 1998; Oktamalia *et al*., 2018). Mangrove crab production in the 1990-2012 period continued to soar with a total export of 588,110 tons, most of which came from nature, causing overfishing (Pati *et al*., 2023). On the other hand, the development of mangrove crab cultivation is also faced with the problem of limited land (Irwani & Suryono, 2012).

The condition of Indonesia's mangroves continues to experience damage caused by coastal development, pollution and conversion of cultivated land. This certainly requires an appropriate and integrated management pattern, where the mangrove area plays an important role as a spawning ground and nursery ground (Budihastuti *et al*., 2012; Nisa *et al*., 2024). One effort that can be made is through the

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implementation of silvofishery. Silvofishery is a combination of fisheries cultivation and mangrove conservation in the same location (GK & Chofyan, 2023; Hilmi *et al*., 2021; Paruntu *et al*., 2016; Akbar *et al*., 2024).

Mangrove crab cultivation with a silvofishery system in Indonesia has been developed, considering that the mangrove forest environment and mangrove crabs have a strong correlation and association (Chadijah *et al*., 2013). Silvofishery ponds commonly used in mangrove crab cultivation include the ditch pond and core pond types. Several studies have been conducted related to the evaluation of pond models and types, where the results show that the type of pond has an influence on various environmental factors of cultivation and economic valuation (Almadi *et al*., 2013; Hilmi *et al*., 2021; Wijaya *et al*., 2019; Akbar *et al*., 2023). Nataijannah (2011) reported that the ditch pond type had good results on crab weight gain. The results of another study, the core pond had an effect on the weight gain of mangrove crabs before and after the harvest period (Nasrulloh, 2019).

In addition to the type of pond, one of the factors that affects the growth of mangrove crabs is gender. Suprapto *et al*. (2014) reported that male crabs that were kept individually were able to grow better when compared to female crabs. Meanwhile, Sagala *et al*. (2013) reported that the growth of female crabs, both in body weight and carapace size, was better when compared to male crabs in a single room cultivation model.

The differences in results from these studies make it possible for further research to be carried out. This is also in line with efforts to develop the potential of the mangrove area at the Pasuruan Practical Field Station. Through further study of the combination of pond types silvofishery and crab sex on the growth performance of mud crabs are expected to provide positive input for the development of crab cultivation as well as provide practical recommendations for more efficient and sustainable mud crab cultivation.

## Materials and Methods

### Location and time of research

This research was conducted for 56 days, namely in March-April 2024 in the mangrove area of the Brackish Water Cultivation Practice Field Station (SLP BAP) of the Politeknik Kelautan dan Perikanan Sidoarjo, Pasuruan. Water quality analysis was carried out at the Environmental Biology Laboratory of the Sidoarjo Marine and Fisheries Polytechnic and the UPT Fish and Environmental Health Laboratory, Pasuruan District.

### Experimental Design

This research used a factorial Randomized Block Design (RAK) consisting of two factors, namely pond type and gender. The pond type factor (T) consists of three levels, namely:

$T_1$ : Pond non-*Silvofishery*/without the presence of mangrove plants (control)
$T_2$ : Pond *Silvofishery* - core pond type (mangroves planted on the embankment/edge of the pond)
$T_3$ : Pond *Silvofishery* - ditch pond type (mangroves are planted on the embankment/edge and middle of the pond)

Meanwhile, the gender factor (K) consists of two levels, namely:

$K_1$ : Male mud crab
$K_2$ : Female mud crab

Based on these two factors, six treatment combinations were obtained, each carried out three times, as follows:

Treatment of $T_1K_1$ : Male mud crabs are kept in non-*Silvofishery* pond(control)
Treatment of $T_2K_1$ : Male mud crabs are kept in *Silvofishery* ponds - core pond type
Treatment of $T_3K_1$ : Male mud crabs are kept in *Silvofishery* ponds - ditch pond type
Treatment of $T_1K_2$ : Female mud crabs are kept in non-*Silvofishery* pond (control)
Treatment of $T_2K_2$ : Female mud crabs are kept in *Silvofishery* ponds - core pond type
Treatment of $T_3K_2$ : Female mud crabs are kept in *Silvofishery* ponds - ditch pond type

### a. Preparation of Pond Plots

The pond plots used in this study were traditional earthen ponds measuring 75 m x 75 m x 1.5 m (5,000 $m^2$) and equipped with a ditch on each side with a width of ±2 m. The types of ponds used consisted of three different types, namely non-silvofishery ponds/without mangrove plants as a control, core pond type silvofishery ponds (mangroves were planted on the embankment/edge of the pond), and ditch pond type silvofishery ponds (mangroves were planted on the embankment/edge and center of the pond). All maintenance media used were ponds with a closed system with the main water source coming from the ebb and flow of water. Pond preparation was carried out starting from the stage of preparing the plot, repairing the embankment and ditch, drying,

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and liming. The next stage was the preparation of the plot water which was carried out starting from the application of pest and competitor control in the plot, fertilization and application of probiotics before the cultivation process was carried out.

**b. Preparation of Cultivation Containers**

The mud crab cultivation container in this study used crab baskets (crab box) with materials polypropylene which consists of two compartments, namely the container (bottom) and the cover (top). The top basket measures 22 cm × 16 cm × 6.5 cm while the bottom measures 22 cm ×16 cm × 9.5 cm. The layout of the basket uses a floating system made from PVC pipe measuring 1 inch in diameter over six meters as a support for the basket, and is made in two rows lengthwise with three dividing partitions. Each compartment in each row contains 15 baskets containing one individual crab. The crab basket is placed in two parts, namely the container (bottom) submerged in water as high as 3-5 cm and the cover (top) above the water surface. The cultivation container is prepared by cleaning the container and placing waring at the bottom of the basket to protect the crabs' food.

**c. Procurement of Test Animals**

The test animals used in this research were mud crabs (*Scylla serrata*) obtained from wild caught crab collectors around the Pasuruan area, East Java. The initial weight of mud crabs is 70-75 g/head. The mangrove crabs used were first subjected to morphological selection to assess their health status, gender and completeness of their body parts.

**d. Care of Test Animals**

Prior to treatment, the test animals were acclimatized in a crab basket for 24 hours. After acclimatization, the test animals were kept for 56 days in crab baskets filled with one crab per basket. Feeding in the form of trash fish is 5% of body weight per day with a frequency of feeding twice, namely morning (40%) and evening (60%) (Djunaedi *et al.,* 2000).

**e. Sampling**

Data collection on mangrove crab growth performance is carried out every 7 days. Samples were taken as much as 30% from each treatment randomly or as many as 9 individuals for observation. Water quality data is collected every day for temperature, salinity, DO and brightness parameters. Observations of water chemical parameters were carried out every 10 days during the maintenance period.

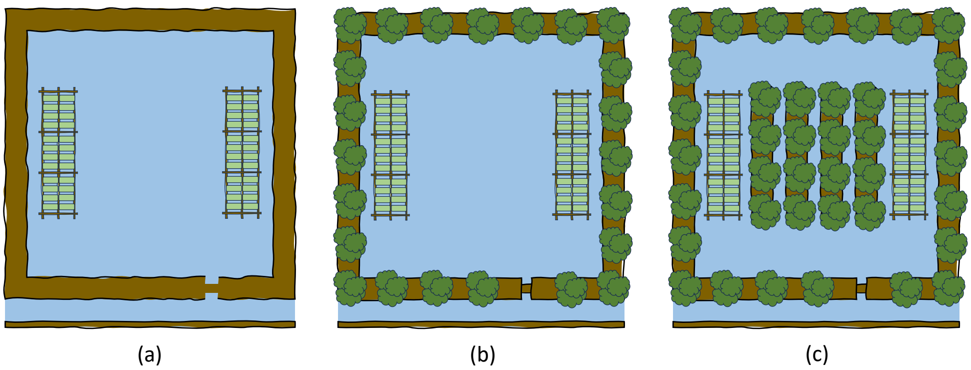


**Figure 1.** Types of ponds used in research (a) non-Silvofishery pond type (control), (b) Silvofishery pond - core pond type, (c) Silvofishery pond - ditch pond type

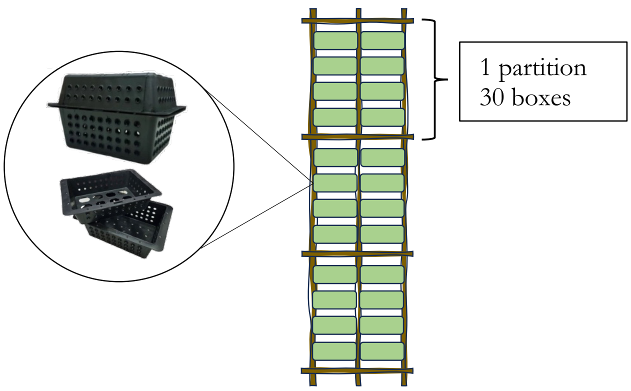


**Figure 2.** Design of cultivation containers and layout of mud crab rearing baskets (*Scylla serrata*).

**Parameter Test**

The main parameters in this research include weight gain, growth rate, survival and feed utilization efficiency. The supporting parameters are water quality during the maintenance period. The test parameters carried out in this research include:

a. Specific Growth Rate (Huisman, 1987)

$$SGR\ (\%) = \left[ \sqrt[t]{\frac{w_t}{w_0}} - 1 \right] \times 100\%$$

where ($W_0$) average weight of the 0 th crab, ($W_t$) the average weight of the t-th crab, and (t) is the preservation time.

b. Absolute Weight Growth (Effendie, 1979)

$$Absolute\ Weight\ (g) = w_t - w_0$$

where ($W_0$) average weight of the 0 th crab, ($W_t$) the average weight of the t-th crab.

c. Survival Rate (Goddard, 1996)

$$SR\ (\%) = \left( \frac{n_t}{n_0} \right) \times 100$$

where ($n_0$) initial number of crabs, and ($n_t$) final number of crabs.

d. Feed Conversion Ratio (Zonneveld *et al.* 1991)

$$FCR = \frac{f}{(B_t + B_m) - B_0}$$

where (f) the amount of feed during the rearing period, ($B_t$) crab biomass at the end of treatment, ($B_m$) biomass of crabs that died during treatment ($B_0$) crab biomass at the start of treatment.

e. Feed utilization efficiency (Tacon, 1987)

$$FE\ (\%) = \frac{W_t - W_0}{f} \times 100\%$$

where ($W_0$) the initial weight of the crab, and ($W_t$) final weight of crabs, and (f) amount of feed used during rearing.

f. Water quality

The water quality parameters measured in this research include water physics and chemistry. Complete details of water quality parameters in Table 1.

**Table 1.** Water Quality Parameters for Mud Crab Rearing

| Parameter | Measurement method | Measurement time | Unit of Measure |
|---|---|---|---|
| **Physics** | | | |
| Temperature | DO meter | 2 times/day | °C |
| **Chemistry** | | | |
| pH | pH meter | 2 times/day | - |
| Dissolved oxygen | DO meter | 2 times/day | mgL$^{-1}$ |
| Salinity | Refractometer | 2 times/day | Ppt |
| Nitrate | Spectrophotometry | 1 time/10 days | mgL$^{-1}$ |
| Nitrite | Spectrophotometry | 1 time/10 days | mgL$^{-1}$ |
| Alkalinity | HCl titration | 1 time/10 days | mgL$^{-1}$ |

**Data Analysis**

Data from this study were analyzed using two-way ANOVA followed by Duncan's post-hoc analysis with a confidence level of 95% ($P < 0.05$). To identify significant differences between treatments. Analysis of water quality observation data was carried out descriptively based on references/standards for the viability of mangrove crabs. Data are presented as mean ± SD.

**Results**

The results of observing the performance of mud crab cultivation in pond types with different genders based on growth patterns, daily growth rates, absolute weights, survival rates, feed conversion ratios and feed utilization efficiency can be seen in Figure 3, Table 2 and Table 3. Water quality data during mud crab rearing can be seen in Table 4.

In Figure 3, it can be seen that the weight growth patterns of mud crabs in various pond types and sex differences are treated. At the start of rearing (day 0), the weight of both male and female mud crabs ranged between 72.89 ± 1.57 grams for all treatments. Relatively stable weight gain was seen until the 21st day in most treatments, while on the 28th day, a clearer increase in growth began to be seen in all treatments.

**Table 2.** Specific growth rate, absolute weight growth and survival rate

| Parameter | Treatment | | | | | |
|---|---|---|---|---|---|---|
| | T1K1 | T2K1 | T3K1 | T1K2 | T2K2 | T3K2 |
| Specific growth rate | 0,56%±0,01$^{d}$ | 0,71%±0,05$^{b}$ | 0,64%±0,05$^{c}$ | 0,51%±0,01$^{d}$ | 0,82%±0,01$^{a}$ | 0,67%±0,01$^{bc}$ |
| Absolute weight growth | 26,13 ± 0,42$^{d}$ | 36,53 ± 3,23$^{b}$ | 31,43±2,33$^{c}$ | 23,47±0,42$^{d}$ | 42,00±1,00$^{a}$ | 32,80±2,84$^{c}$ |
| Survival rate | 91,11%±3,85$^{a}$ | 93,33%±6,67$^{a}$ | 91,11%±3,85$^{a}$ | 95,56%±3,85$^{a}$ | 93,33%±0,00$^{a}$ | 95,56%±3,85$^{a}$ |

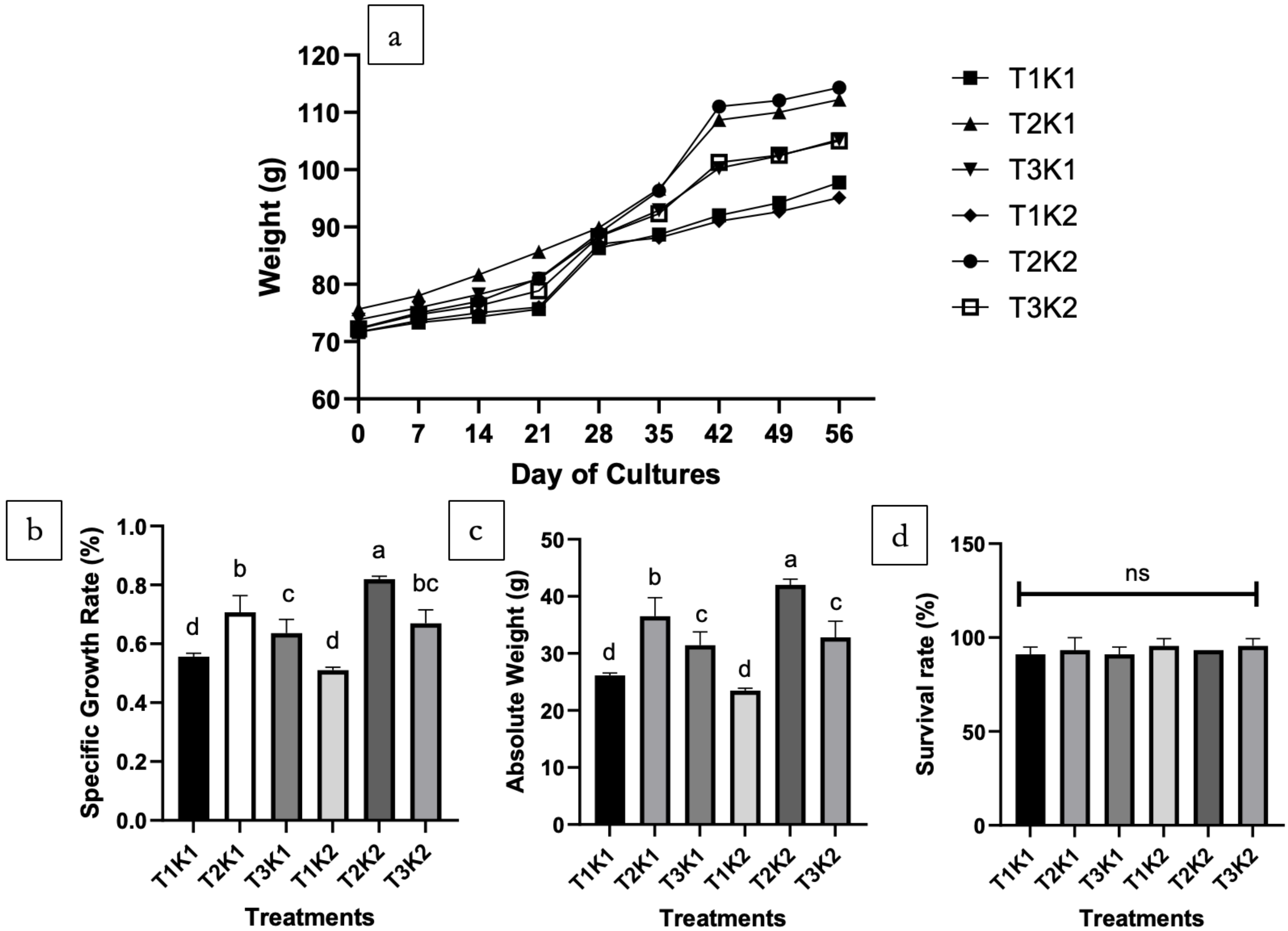


**Figure 3.** Performance of mud crab cultivation in different types of ponds and gender; (a) Growth pattern of mud crab; (b) Specific Growth Rate; (c) Absolute Weight Growth; (d) Survival Rate. T1K1 (Male mud crabs in non- Silvofishery pond (control)), T2K1 (Male mud crabs in core pond type), T3K1 (Male mud crabs in ditch pond type); T1K2 (Female mud crabs are kept in non- Silvofishery pond (control)), T2K2 (Female mud crabs in core pond type), T3K2 (Female mud crabs in ditch pond type).

*Note: letters that are not the same after numbers in the same column and row indicate significantly different according to the 5% DMRT test.

**Table 3.** Mean difference test of pond type treatment with Duncan's test on Feed Conversion Ratio and Feed Utilization Efficiency

| Parameter | Treatment | | |
|---|---|---|---|
| | Control pond | Pond Core | Ditch Pond |
| Feed Conversion Ratio | 9,03 ± 2,03[a] | 3,80 ± 1,05[c] | 6,23 ± 1,81[b] |
| Feed Utilization Efficiency (%) | 11,48 ± 0,42[c] | 27,67 ± 3,23[a] | 17,07 ± 2,33[b] |

Note: letters that are not the same after numbers in the same column and row indicate different values real according to 5% DMRT test

**Table 4.** Water Quality Data During Mud Crab Rearing

| Water Quality Parameters | Unit | Treatment | | | Level optimal | Reference |
|---|---|---|---|---|---|---|
| | | Control pond | Pond Core | Ditch Pond | | |
| Temperature | °C | 30,20 ± 0,88 | 29,03 ± 0,96 | 29,45 ± 1,07 | 25-35 | Shelley and Lovatelli (2011) |
| Dissolved Oxygen | mg $L^{-1}$ | 4,14 ± 0,80 | 5,12 ± 0,79 | 4,62 ± 0,60 | >4 | Shelley and Lovatelli (2011) |

| Water Quality Parameters | Unit | Treatment | | | Level optimal | Reference |
|---|---|---|---|---|---|---|
| | | Control pond | Pond Core | Ditch Pond | | |
| Salinity | g $L^{-1}$ | 41,45 ± 2,68 | 30,00 ± 1,98 | 35,57 ± 2,39 | 15 - 25 | Shelley and Lovatelli (2011) |
| pH | - | 8,11 ± 0,39 | 8,22 ± 0,33 | 8,06 ± 0,41 | 7,5 - 9 | Shelley and Lovatelli (2011) |
| Brightness | cm | 25,43 ± 3,13 | 26,69 ± 3,98 | 25,84 ± 2,95 | 20-30 | Shelley and Lovatelli (2011) |
| Nitrate | mg $L^{-1}$ | 5,60 ± 0,67 | 2,30±0,21 | 3,95 ± 0,27 | <10 | Rumondang *et al.* (2023) |
| Nitrite | mg $L^{-1}$ | 0,12 ± 0,01 | 0,05 ± 0,01 | 0,07 ± 0,01 | < 10 mg/L at salinity > 15 ppt; < 5 mg/L at salinity < 15 ppt | Shelley and Lovatelli (2011) |
| Alkalinity | mg $L^{-1}$ | 151,5 ± 54,95 | 129,68 ± 5,36 | 140,29 ± 29,14 | >80 (ideal 120) | Shelley and Lovatelli (2011) |

The results of the two-way ANOVA analysis of variance on specific growth rate and absolute weight showed that different types of ponds had a significant influence (P<0.05) on specific growth rate and absolute weight. Meanwhile, gender did not show a significant effect on specific growth rate and absolute weight (P>0.05). However, the interaction between pond type and gender had a significant effect (P<0.05) indicating that gender modified the effect of pond type on specific growth rate and absolute weight. The results of Duncan's further analysis showed that the core pond type treatment with female crabs (T2K2) was the best treatment to support the specific growth rate of mangrove crabs, followed by the ditch pond type and control ponds with the lowest specific growth rate.

Based on the results of the analysis, the survival rate showed that in all treatments, the combination of pond type and sex of mud crabs did not have a significant difference between treatments. The survival rate during the study for all treatments showed good values, namely in the range of 86.67 – 100%.

The feed conversion ratio and feed utilization efficiency based on the results of the two-way ANOVA analysis of variance showed that different types of ponds had a significant influence (P<0.05) on both. Meanwhile, gender and the interaction between the two treatments showed no significant influence (P>0.05) on both the feed conversion ratio and feed utilization efficiency.

Based on water quality data, it can be seen that the temperature in both control ponds and core pond ponds and trench pond ponds ranges between 25-35°C. Overall dissolved oxygen is at a value of >4 mg $L^{-1}$. The average salinity in core ponds and ditch ponds is 30,00 ± 1.98 and 35,57 ± 2.39 g $L^{-1}$, while in the control pond type (41,45 ± 2,68 g $L^{-1}$) exceeds the optimal limit. The pH values in the three ponds showed a pH ranging from 8,06 to 8,11. Brightness ranges from 25,43 ± 3,13 to 26,69 ± 3,98 cm. Meanwhile, nitrate levels in the three ponds ranged from 2,30 to 5,60 mg $L^{-1}$. Nitrite concentrations are in the range of 0,05-0,12 mg $L^{-1}$. Overall, the three types of ponds have alkalinity ranging from 129,68 to 151,5 mg $L^{-1}$.

## Discussion

The growth of mud crabs during the research in the three types of ponds increased. The weight gain progressed slowly until day 21 in most treatments, while on the 28$^{th}$ day, a clearer increase in growth began to be seen in all treatments. This is probably because at the start of rearing, mud crabs need time to adapt to the new environment such as water quality, temperature, salinity, etc. This adaptation process causes mud crabs to reduce their feeding activity and focus their energy on osmoregulation so that initial growth tends to increase slowly. This can be seen during the feeding process, there is leftover food in the crab box. This is in accordance with Romadhon *et al.* (2022) where crabs need the ability to adapt to salinity conditions in their environment to maintain optimal balance in the body, which is known as osmoregulatory capacity. Aditya *et al.* (2012) reported that in the first week of the study, mud crabs experienced a decrease in weight due to adjustments to their feed and environment.

In general, the graph shows that female crabs show a higher final weight than male crabs in the same type of pond, although the difference is not very significant. The specific growth rate and absolute weight growth also showed that the core pond type (T2) with female mud crabs had a higher daily growth rate compared to other treatments. This shows that female crabs in core ponds have better growth capabilities than male crabs. The female crabs used for research are still small so it is possible that they have not yet reached sexual maturity, so more energy is allocated to body growth. This is in accordance with research Maulana *et al.* (2012) where the weight growth rate of female mud crabs is higher compared to male crabs, this is because the female crabs used are younger and have not yet reached sexual maturity. In this study, the mud crabs used had an average weight of 72.89 ± 1.57 grams, which was lower than Maulana's research, namely 150-210 gr/head.

Other research according to Tiurlan *et al.* (2019) in Kendal Waters, Central Java showed that mangrove crabs were found to be physiologically mature at a carapace width of between 85-138 mm. However, many individuals have carapace widths ranging from 91-100 mm with mud crab weights ranging from 100-350 grams.

Growth in female crabs in core ponds is also possible because the crabs experience molting. Molting or the process of changing shells in mud crabs (*Scylla serrata*), plays an important role in growth and development. During molting, there was a significant increase in the length, width and weight of the crab's body. Internal factors that influence the molting process include heredity, age, relative growth rate, gender, reproduction, resistance to disease and ability to utilize feed. Meanwhile, external factors include water quality, density and the amount and composition of amino acids/proteins contained in the feed (Djunaedi, 2016). According to Dhewantara *et al.* (2021), the highest absolute growth rate was found in female mud crabs compared to male crabs, this is possible due to the influence of feeding in the form of trash fish.

Specific growth rate and absolute weight growth in the control treatment (non-silvofishery pond) in both male and female crabs looks lower when compared to silvofishery ponds (core pond type and ditch pond type). This shows that non-silvofishery have a less supportive environment than ponds that use the system silvofishery. The core pond has a larger open area with mangrove vegetation around it, which functions as shade, to produce organic material, and as a shelter. Organic material from mangroves increases the availability of natural food such as detritus, which is the main food source for mud crabs. This accelerates body weight growth compared to ditch pond systems which have a more limited area and non-silvofishery pond systems with minimal vegetation. According to Irwani & Suryono (2012) and Karim *et al.* (2016), mangrove crabs that are reared in waters that have mangroves have better growth when compared to waters that do not have mangroves. This is because in waters with mangroves, crabs utilize natural food in addition to the trash fish food provided. Sunarto *et al.* (2015) states that the organic matter content in the waters around mangroves is influenced by the number of mangroves present, where the more mangroves there are, the more mangrove litter falls and this affects the organic matter content. The organic material content of litter plays a role in maintaining the fertility of mangrove waters. However, if it is too high, the organic content can cause eutrophication, which affects the abundance of aquatic biota (Supriyantini *et al.*, 2017).

The core pond type in this study had the best growth when compared to other treatments. The core pond type used has mangroves on the edge of the pond where the middle area of the pond is mostly empty and is used for cultivation ponds. Mangrove cover in the core pond is around 30%. Mud crab (*S. serrata*) have a close relationship with the mangrove ecosystem, which provides habitat, food sources and protection for them. Mangrove density and cover can influence the abundance and growth of mangrove crabs. Several studies show a positive correlation between mangrove density and the abundance of mangrove crabs. Saragi & Desrita (2018) reported a strong correlation with a value of 0.79 or 79% between mangrove density and mud crab abundance. Besides that, Miranto *et al.* (2014) explained that mangrove crabs are animals that are highly dependent on mangrove forest vegetation, where the extensive canopy cover provides optimal food sources and protection.

The significant interaction between pond type and sex indicates that the effect of pond type on mud crab growth is different between males and females. This may be due to differences in habitat or behavioral requirements between the sexes that cause them to respond differently to certain pond conditions. Apart from pond type and gender, other factors such as salinity, food availability and population density can also influence the growth of mud crabs. According to Akbar & Muskita (2016), mangrove crab growth is influenced by internal and external factors. Internal factors include heredity, gender, age, resistance to disease and ability to utilize food. Meanwhile, external factors include food, water quality, feed and space.

During maintenance, the water quality in the core pond is in the best condition compared to other treatments, so it is able to support the growth of mangrove crabs. This is possible because the core type of pond has mangrove type vegetation *Rhizophora* sp. in the ideal amount where the cover is around 30%. Planting *Rhizophora* sp. in this system not only functions as an abrasion barrier, but also improves water quality through a natural filtration process. In addition, this system supports sustainable cultivation practices by utilizing the ecological functions of mangroves to support pond productivity (Sunarto *et al*., 2015). Mangroves, especially types *Rhizophora* sp., has the ability to absorb nutrients and pollutants from water, thereby helping to maintain good water quality. The dense and complex roots of mangroves function as a natural filter, holding sediment and preventing erosion, which in turn reduces water turbidity. In addition, mangrove leaf litter that falls into the water will decompose into organic material that can be utilized by aquatic organisms, including mangrove crabs (Saputri & Muammar, 2019).

The survival rate during the study for all treatments showed good values, namely in the range of 86.67 – 100%. Death of mud crabs (*S. serrata*) during the rearing period is thought to be due to molting failure. The molting process in mud crabs requires a lot of energy which is obtained from the food given to the mud crabs (*S. serrata*).Nguyen *et al.* (2022) found that energy requirements vary during the molting cycle, and nutrient deficiencies at critical stages can lead to molting failure. Other research by Nguyen *et al.* (2014) shows that molting frequency is influenced by the level of feed or energy intake. Molting is triggered when an energy threshold is reached, and a reduction in feed supply can lengthen the intermolt period, which may increase the risk of molting failure.

In addition to the failure of molting, the survival of mangrove crabs (*S. serrata*) is thought to be due to fluctuations in salinity. The molting process in crustaceans, including mud crabs, is influenced by environmental conditions such as salinity and temperature. Sudden changes in salinity can disrupt the osmotic balance, causing stress that can inhibit the molting process or cause molting failure. Molting failure can increase mortality, as crabs become vulnerable to predation and infection during this period. Eddiwan *et al.* (2021) examining growth and survival *S. serrata* at various levels of salinity. They found that decreasing salinity by 4 ppt from 33 ppt produced the best growth, but did not affect survival rates. This suggests that although mud crabs can tolerate changes in salinity, there are optimal limits for growth that need to be considered in farming practices. In addition, other research shows that the combination of temperature and salinity affects the growth and survival of mud crab juveniles. They found that higher temperatures and salinity tended to increase growth, but could decrease survival if outside tolerance limits (Ruscoe *et al*., 2004; Syafaat *et al*., 2021).

Based on the results of the two-way ANOVA analysis of variance, it shows that different types of ponds have a significant influence ($P<0.05$) on the feed conversion ratio and feed utilization efficiency. Based on the average feed conversion ratio, it can be seen that the core pond type has the lowest FCR value compared to other treatments. Matter this shows that on the treatment of the core pond type of the feed core given more efficient compared with treatment in other types of ponds. Feed Conversion Ratio is an important indicator in cultivating mud crabs (*Scylla serrata*). Higher FCR values indicate lower feeding efficiency, meaning more feed is required to produce a given growth. Conversely, a lower FCR value indicates better feed efficiency. According to Saputra *et al.* (2018) the more high feed conversion ratio (FCR) value, the less so efficient giving feed. These results are then put to use support growth. Pasi *et al.* (2022) stated that growth occurred allegedly because the nutritional content in the feed was able to be utilized properly by the crabs. Mud crabs utilize fat, protein and carbohydrates as energy sources for embryonic development, with most of this energy used for shell formation.

The results of the research also show that in the core ponds the efficiency of feed utilization has the highest value, this can be caused by more optimal environmental conditions such as water quality, availability of dissolved oxygen and salinity for mangrove crabs. Water quality data (Table 4) shows that the salinity value in the core pond is in the optimal range when compared with other treatments. According to Hastuti *et al.* (2015), mud crabs live in environments with variations in salinity, so their bodies need energy for the osmoregulation process, namely maintaining the balance of ions and body fluids. If the energy used for osmotic work is too high, the energy available for growth will decrease. If the osmotic work is lower, for example at optimum salinity, then more energy from the feed can be used for growth, so that the efficiency of feed utilization increases. On the other hand, if the osmotic work is high due to inappropriate salinity, much of the energy from the feed will be used for osmoregulation, so that feed efficiency decreases (Rahmawati & Anggoro, 2013).

Good utilization efficiency in core ponds can also be seen in the feed conversion ratio value. High feed utilization efficiency is usually indicated by a low feed conversion ratio. If the feed is digested and absorbed effectively, crab growth increases without the need for excessive feed consumption, so the FCR value is better. In core ponds, the FCR value has the lowest value when compared with other treatments. According to Ariadi *et al.* (2019) and Arianto *et al.* (2019) stated that the value of the feed conversion ratio is inversely proportional to the efficiency of feed utilization where the lower the FCR value indicates better feed quality and more efficient for mangrove crabs in utilizing the feed they consume to support their growth.

Water quality refers to the physical, chemical and biological conditions of water that affect the life of aquatic organisms. In rearing mud crabs (*Scylla serrata*), water quality is a crucial factor that influences the growth, survival and productivity of crabs. Based on water quality data, it can be seen that the temperature in both control ponds and core ponds and trench ponds is still within the optimal range of 25-35°C for mud crabs (*Scylla serrata*). Temperature supports crab growth, but higher temperatures in control ponds could be caused by pond environmental conditions such as sunlight intensity or shallower pond depth, which increases water temperature. This is in accordance with the statement of Farabi & Latuconsina (2023), where one of the factors that influences water temperature is the depth of the water where sunlight penetrates to the surface and heats up faster when compared to deeper layers. According to Aulia dan Diamahesa (2024), the optimal temperature for the growth of mangrove crabs is between 25-35°C.

Overall dissolved oxygen is above the optimal level of >4 mg/L, which is good for crab growth. The lower dissolved oxygen content in the control ponds may be related to higher biological activity, which consumed more oxygen. According to Astuti & Lismining (2018), biological activities in ponds, such as respiration of organisms and decomposition of organic matter, can consume significant amounts of oxygen, thereby reducing DO levels (Yulfiperius *et al.*, 2004). In addition, high environmental factors can reduce the solubility of oxygen in water, while the metabolic activity of organisms increases, increasing oxygen demand. High salinity can also reduce oxygen solubility (Karim, 2008; Maniagasi *et al.*, 2013).

The average salinity in the core and parity ponds was 30.00 ± 1.98 and 35.57 ± 2.39 g $L^{-1}$, while in the control pond type it was (41.45 ± 2.68 g $L^{-1}$) exceeds the optimal limit. The higher salinity in the control pond could be influenced by high water evaporation due to the absence of shade from mangrove trees around the pond. According to Rahman *et al.* (2024), an increase in salinity can occur due to the influence of evaporation. Brightness is at optimal condition ranges from 25,43 ± 3,13 to 26,69 ± 3,98 cm. The pH value in both ponds shows a pH of 8.06-8.11 which is still within the optimal range of 7.0-8.5. Stable pH can be caused by the pond's natural buffer system and high alkalinity which supports pH stability. According to Yudana & Jayanti (2024), alkalinity is a buffer for changes in water pH and can also be used as an indicator of trophic status.

Nitrate levels in the three types of ponds have optimal values because they are still below the maximum limit, namely <10 mg $L^{-1}$, this shows good water management and an adequate denitrification process. Nitrite levels are also still at a safe level for the growth of mangrove crabs. According to Jumraeni *et al.* (2020), ammonia, nitrite and nitrate concentrations that are at optimal limits indicate an effective nitrification process.

Overall, the three types of pools have alkalinity ranging from 129.68 to 151.5 mg $L^{-1}$, which is still at an optimal level, this shows the buffer's good ability to maintain pH stability, supporting optimal conditions for crab growth. Yulfiperius *et al.* (2004) states that alkalinity has a main function as a buffer for water pH fluctuations. The higher the alkalinity, the higher the water's ability to buffer so that the pH fluctuations are lower. Optimal alkalinity is able to support optimal survival and growth of organisms.

## Conclusion

This research shows that the interaction between pond type and sex has a significant influence on daily growth rate and absolute weight growth but does not significantly influence the feed conversion ratio and feed utilization efficiency. Duncan's further tests showed that the type of pond had a real influence on the feed conversion ratio and feed utilization efficiency. The survival rate shows values that are not significantly different between all treatments. The water quality measurement values during the research were still optimal for the growth of male and female mud crabs. Treatment of core pond ponds with female crabs showed the best performance in terms of daily growth rate and absolute weight growth of mud crabs.

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