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Shelter Differences on Growth and Survival of Red Claw Crayfish (*Cherax quadricarinatus*) in Experimental Tanks

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Abstract

Red claw crayfish *(C. quadricarinatus)* culture has a serious problem, which is the low survival rate caused by cannibalism. High levels of cannibalism begin to appear since the juvenile stadia, and when the lobster is moulting. Shelter is necessary during the cultivation process to reduce the level of lobster cannibalism. The purpose of this research is to study and analyze the differences in shelter on the growth and survival rate of freshwater lobster. The method used in the study was experimental with a completely randomized design (CRD). Consists of 5 treatments, including treatment without shelter (K), PVC pipe (A), roster (B), plastic hose (C), and *hydrilla* (D). Data were analyzed using analysis of variance in the form of one-way ANOVA. The results of this study showed that shelter differences had a significant effect on absolute weight growth (Sig. 0.002), growth rate (Sig. 0.014), biomass weight (Sig. 0.001), survival rate (Sig. 0.001), but the difference in shelter has no significant effect on absolute length growth Sig. 0.858. The results of water quality observations found that shelter differences do not significantly affect the water quality of crayfish. The highest absolute weight growth was in the paralon pipe shelter with a value of 0.93 g, the highest length growth was in the roster shelter at 1.22 cm, the highest growth rate was in the PVC pipe shelter at 0.027 g/day, the highest biomass weight was in the PVC pipe shelter 32.64 g, the highest survival rate was in the PVC pipe shelter 92.6%.

INTRODUCTION

Freshwater lobster is one type of lobster that is widely cultivated in Indonesia and other countries such as Australia, America, and England (Ghanawi and Saoud, 2012; Fadhlan *et al.*, 2021). The selling value of freshwater lobster in the export market is also lucrative, even though the export market demand is increasing every year (Setiawan, 2022). Freshwater lobster cultivation is a fairly attractive opportunity because it has a high selling price. The economic value will be higher if the exported lobater is alive with good quality and its limbs are still complete, without any damaged or missing body parts (Zulkarnain *et al.*, 2011).

However, crayfish culture has a problem with high cannibalism rates (Shun *et al.*, 2020) starting from the juvenile stage and during the molting process every 10 days. Molting failure and cannibalism occur because when the crayfish is molting, the shell

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condition of the molting results is still very soft, and the crayfish has difficulty defending itself from its enemies (Lukito and Prayugo, 2007). So, it is necessary to have a shelter as a place to protect from attacks by fellow crayfish.

The shelter is an additional media in the lobster cultivation pond that is specialized as a shelter for lobsters. According to Setiawan (2006), there are main functions of the shelter, namely as a shelter, useful for minimizing cannibalism, and serves to increase the number of lobster stocking density in the maintenance container. The type of shelter that is currently commonly used by cultivators is paralon pipes, but this type of shelter still has shortcomings in growth and survival. Crayfish belongs to a group of shrimp that have slow growth. Zaky *et al.* (2020) added the survival rate of pipe shelters ranged from 70% to 85%, absolute weight of 1,73 g and an absolute length of 1,91 cm in pipe shelters.

Another research from Fadhlan *et al.* (2021) showed that pipe shelters had a survival rate of 100%, absolute weight, and length had the highest values in pipe shelters, and the survival rate in *Hydrilla* shelters had a value of 36.67%, and absolute length had a value of 2.33% So it is necessary to have other shelter options, such as roster, algae, and plastic hose. These types of shelter materials are easy to find and cheaper than pipes. So, it needs to be studied further regarding the growth and survival of crayfish in different shelter media.

METHODOLOGY

Ethical Approval

There are no animals that were harmed or mistreated during the research. Animals tested during the study were treated properly according to the optimal environment, ranging from handling techniques, water quality, feed availability, etc.

Place and Time

This research was conducted in June-July 2023, at the crayfish culture site owned by residents of Galekan Subvillage, Bajulmati Village, Wongsorejo District, Banyuwangi Regency, East Java.

Research Materials

The materials used in this research are crayfish from a hatchery that is taken compositely, with a size of 1-1.2 grams totaling 340 tails, 0 ppt salinity fresh water sourced from boreholes. Aquatic plants with algae *(H. verticillata),* shrimp starter feed with a protein content of 36%, then litmus paper.

The tools used in this study include plastic tubs measuring P = 36 cm, L = 24 cm, T = 20 cm in a total of 20 pieces, aerator machine Lp 100, medium size aeration stone, paralon (5/8), soil roster (20x10 cm), plastic hose (5/8), digital scale (Joil) 0.01 gr, millimeter block, pH meter, DO meter (Neuron) and digital thermometer (Hanna HI98509).

Research Design

This study used an experimental method with a completely randomized design (CRD). The number of treatments was five shelter treatments, namely control without shelter (K), PVC pipe (A), roster (B), plastic hose (C), and *Hydrilla* (D), each treatment was repeated four times. The treatment was arranged with complete randomization, in this study randomization was done by drawing lots so that each experiment had the same chance to get each treatment. The results of the experimental basin layout draw can be seen in Table 1.

Table 1. Results of the draw of the experimental tub layout for crayfish (*C. quadricarinatus*) research.

Research Tub Layout				
B4	D1	D2	K1	A2
C1	A1	C3	K3	B3
A4	B2	A3	C4	B1
D4	C2	K2	K4	D3

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Work Procedure

Preparation of Long-Line Construction

The implementation of this research begins with preparing the research container, namely a plastic tub. Next, plastic tubs were cleaned to avoid pathogens or diseases using water and soap. Next, each tub was dried and arranged according to the results of randomization, then filled with shelter according to the research method, and then filled with 5 liters of water. The water source used was taken from a borehole with a salinity content of 0 ppt. Each container is equipped with one aeration to maintain dissolved oxygen.

Experimental tanks that have been filled with sterile water are ready, then prepare crayfish juvenile. Crayfish juveniles that have gone through selection are taken as many as 340 crayfish, then divided into each experimental tub as many as 17 crayfish per experimental tub. Lobsters are adapted for 7 days in each experimental tub, after going through the adaptation period, then research is carried out. The feeding method is carried out twice a day, in the morning at 07.00 WIB and in the afternoon at 17.00 WIB. The type of feed given during maintenance is starter pellets with a portion of feed as much as 3% of body weight. Cleaning of feces is done once a week and 50% water change every week.

Data collection of the main parameters in the form of total weight (g), length (cm), growth rate (g/day), biomass weight (g), and survival (%). Data collection was carried out once a week, the data collected during the study were growth data in the form of total weight by taking all the lobsters in each experimental tub using a sieve and then weighed using digital scales. Length data were taken by sampling 30% of the total population in each experimental tub to reduce stress levels in crayfish, then measured each tail from the head to the tip of the lobster tail using a ruler. Survival rate data were observed weekly by counting the number of live lobsters in each experimental tub until the end of the study, then water quality data were taken every morning and evening in the form of temperature using a thermometer, pH using a pH meter, and dissolved oxygen using a DO meter.

The calculation of the absolute weight value refers to the method that has been used Budi *et al*. (2019), the absolute weight growth (W) is calculated using the following formula:

$$W = W_t - W_0$$

W = Weight growth (g)
W_t = Average weight of lobster at the end time (g)
W_0 = Average weight of lobster at the end time (g)

Absolute length growth is used to calculate length gain during rearing, by referring to the formula used Budi *et al*. (2019), as follows:

$$Lm = TL_t - TL_0$$

Lm = Absolute length growth (cm)
TL_t = Total length at the end of rearing (cm)
TL_0 = Total length at the beginning of rearing (cm)

How to calculate the daily growth rate using the formula as follows:

$$ADG = \frac{W_t - W_o}{t}$$

ADG = Average daily individual weight gain (grams/day)
W_t = Average individual weight of fish at the end of the study (grams)
W_o = Average individual weight of fish at the beginning of the study (grams)
t = Maintenance time (days)

Biomass weight is the total weight of all individuals in each experimental tank at the end of the study. Biomass weight is calculated using the following formula:

$$\text{Biomass weight (Production)} = N \times BT$$

N = Final number of individuals (fish)
BT = Average individual body weight (g)

Survival is calculated referring to the formula that has been used Liu *et al.* (2020). Survival can be calculated by the following formula:

$$\text{Survival (\%)} = \frac{N_t}{N_0} x100\%$$

N_t = final number of crayfish
N_o = initial number of crayfish

Data Analysis

Data were analyzed by Analysis of Variance at a 95% confidence interval. If the effect is significant, then the analysis is continued with the Tukey test. Analysis with the

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application of Statistical Packages for Social Sciences (SPSS) version 29.

RESULTS AND DISCUSSIONS

Absolute Weight Growth

The absolute weight growth of crayfish with the provision of different shelter types, during 35 days of rearing can be seen in Table 2.

Table 2. Results of analysis of variance of absolute weight growth of crayfish *(C. quadricarinatus)* with different shelters.

Treatment	Absolute Weight (g)
K	0.74[ab]
A	0.93[b]
B	0.90[ab]
C	0.76[ab]
D	0.69[a]

Description: Different letters indicate significant differences (Sig < 0.05), K (without shelter), A (paralon pipe shelter), B (roster shelter), C (plastic hose shelter), D (*hydrilla* shelter), ab and b (different) b and a (very different).

Evaluation from the data obtained, the highest absolute weight growth was found in the treatment of PVC pipe shelter at 0.93 g, Roster shelter at 0.90 g, then plastic hose shelter at 0.76 g, control without shelter at 0.74 g, and the lowest was the *Hydrilla* shelter at 0.69 g. The highest absolute weight growth was found in the treatment of PVC pipe shelter at 0.69 g.

The results of the analysis of variance showed that shelter differences had a significant effect on the absolute weight growth of crayfish with a Sig value. 0.014. In addition, The Tukey test results show that the pipe shelter has an authentic influence on the absolute weight growth of crayfish. This is because when crayfish experience molting, crayfish have a safe hiding place, so there is no need to reduce excess energy to get away from other crayfish. Pipe and roster shelters have many holes, so they can be used as a safe hiding place for crayfish (Fadhlan *et al.*, 2021), that roster shelters have enough space and burrows to make crayfish safer when visited by other crayfish during molting.

Absolute Length Growth

The absolute length growth of crayfish with the provision of different shelter types, for 35 days of rearing can be seen in Table 3.

Table 3. Results of analysis of variance of absolute length growth of crayfish *(C. quadricarinatus)* with different shelters.

Treatment	Absolute Length (cm)
K	1.02[a]
A	1.03[a]
B	1.22[a]
C	1.00[a]
D	1.15[a]

Description: Different letters indicate significant differences (Sig < 0.05), K (without shelter), A (PVC pipe shelter), B (roster shelter), C (plastic hose shelter), D (*hydrilla* shelter), a (no differences).

The data obtained shows that the highest absolute length growth is in the roster shelter treatment at 1.22 cm. Furthermore, the algae shelter treatment was 1.15 cm, the paralon pipe shelter was 1.03 cm, the control was 1.02 cm, and the lowest was the plastic hose shelter at 1.00 cm.

Shelter differences can significantly affect the absolute growth of crayfish, however, shelter differences do not affect the

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absolute length growth of crayfish. This can be proven from the results of the analysis of variance of sig. 0.858, this result is greater than the 5% confidence level. In addition to environmental factors, the level of feed utilization is one of the important factors that can affect the absolute length growth of crayfish seeds.

As stated by Priyanto *et al*. (2016), crayfish growth can be influenced by the ability to utilize food. Lack of food utilization will indirectly slow down the growth process of crayfish. Thus, the process of length growth is not optimal due to non-optimal feed utilization. Cultivated lobster length growth tends to be slow. According to Kizhakudan and Patel (2011) this is due to various factors, one of which is nutrition and the environment.

Growth Rate

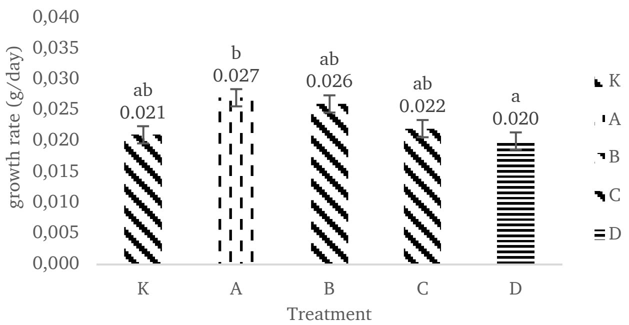

Figure 1. Results of analysis of variance of crayfish *(C. quadricarinatus)* growth rate with different shelters.

Description: Different letters indicate significant differences (Sig < 0.05), K (without shelter), A (PVC pipe shelter), B (roster shelter), C (plastic hose shelter), D (*hydrilla* shelter), ab and a (different), b and a very different).

Based on the figure above, the data obtained shows that the highest growth rate is found in the pipe shelter at 0.027 g/day, then in the roster shelter at 0.026 g/day, plastic hose shelter at 0.022 g/day, control without shelter at 0.021 g/day, and the lowest is in the algae shelter at 0.020 g/day.

The results of the calculation of the analysis of variance of the effect of shelter differences on the growth rate of crayfish growth obtained a sig value. 0.014, this indicates that the difference in shelter has a real influence on the growth of the absolute weight of crayfish. In addition, the Tukey test results show that the treatment of Paralon pipe shelter is significantly different from other treatments, this indicates that the growth rate in the paralon pipe shelter has better results. If a hiding place is provided in the pond, the crayfish will remain silent during molting, besides that if the molting process of the crayfish runs smoothly, the value of shell growth, according to the value of the growth rate (Hamsia *et al*., 2015). besides that, the role of molting is very important for the growth of crayfish. During maintenance, crayfish only molt 1 – 2 times in 30 days (Asnawi *et al*., 2023). According to Santi *et al*. (2021), the more often crayfish molt, the better the growth rate.

Biomass Weight

The growth of crayfish biomass weight, with the provision of different shelter types, for 35 days of rearing can be seen in Table 4.

The difference in shelter type has a very significant effect on biomass weight growth. This is evidenced by the results of the analysis of variance obtained at sig.<0.001, much smaller than the 5% confidence level. Based on the table above, the data obtained shows that the highest biomass weight growth is found in the pipe shelter at 32.64 g, followed by the roster shelter at 28.37 g, plastic hose shelter at 23.17 g, control without shelter at 21.35 g, and the lowest is in the *Hydrilla* shelter at 20.86 g. This shows that the pipe

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shelter has the highest biomass weight growth. This shows that the pipe shelter has a higher effect on biomass weight.

Table 4. Results of analysis of variance of biomass weight growth of crayfish *(C. quadricarinatus)* with different shelter types.

Treatment	Biomass (g)
K	32.64[c]
A	28.37[bc]
B	23.17[ab]
C	20.86[a]
D	32.64[c]

Description: Different letters indicate significant differences (Sig < 0.05), K (without shelter), A (PVC pipe shelter), B (roster shelter), C (plastic hose shelter), and D (*hydrilla* shelter).

Biomass weight growth is strongly influenced by growth rate and survival rate. According to Sulanjari and Sutimin (2008), the results of biomass weight can be analyzed from the average growth per tail and survival rate. In line with the results of this study, the growth rate and survival rate of crayfish in the pipe shelter are very high. This is reinforced by the results of the Tukey test obtained, that the biomass of treatment D (*hydrilla* shelter) is not significantly different from treatment K (without shelter), significantly different from treatment C (plastic hose shelter), significantly different from treatment A (PVC pipe shelter), B (roster shelter), shelters D and K do not have hiding place like shelter A, B, C. These results reinforce that treatment A (PVC pipe shelter), namely the pipe shelter, is the best shelter treatment.

Survival

The survival of crayfish by giving different types of shelters, for 35 days of maintenance can be seen in Table 5.

Table 5. Results of analysis of variance of the survival of crayfish *(C. quadricarinatus)* with different shelters.

Treatment	Survival (%)
K	64.7[a]
A	92.6[b]
B	79.4[ab]
C	69.1[a]
D	66.2[a]

Description: Different letters indicate significant differences (Sig < 0.05), K (without shelter), A (PVC pipe shelter), B (roster shelter), C (plastic hose shelter), D (hydrilla shelter), a and ab (different), a and b (very different).

The results of the analysis of variance of the effect of shelter differences on survival obtained Sig. 0.001. This indicates that the difference in shelter has a real influence on the survival rate of crayfish. The survival rate in the treatment of paralon pipe shelter has a higher value than other shelters at 92.6%, then roster shelter at 79.4%, then plastic hose shelter at 69.1%, *hydrilla* shelter at 66.2%, then the lowest survival rate is in the control treatment at 64%. The highest survival rate was found in the treatment of PVC pipe shelter, this result is in line with the research of Andriyeni *et al*. (2022), stating that the survival rate of crayfish is said to be high if the survival rate ranges from 80% - 93.33%.

In the control treatment, the survival rate was the lowest. This is because, in addition to higher stress levels, treatment without shelter allows higher contact between other lobsters it can reduce survival rates because crayfish have a highly cannibalistic nature. In stressful conditions in lobsters, resulting in decreased appetite the body condition weakens and eventually will experience death (Yudhistira, 2022). Another factor causing death is the body's inability to adapt to its environment (Hosamani *et al*., 2017). This is also reinforced by the opinion of Hutabarat *et al*. (2015) that survival is influenced by 2 factors, namely biotic factors (age and adaptation) and abiotic factors (feed, stocking density, and water quality).

The decrease in survival rate in the following weeks is due to cannibalism. One of the causes of cannibalism is the difference in lobster size, where when larger lobsters are hungry they will eat smaller lobsters during molting (Rachmawati *et al*., 2011). This can happen because when crayfish experience the molting phase, it is characterized by dead lobsters with incomplete bodies. This statement is in line with Andriyeni *et al*. (2023), the stating that deaths that occur in crayfish are caused by cannibalism in the crayfish itself. Dhewantara *et al*. (2021) added that the cannibalism factor will reduce the crayfish population, so competition for food will decrease.

Tukey test showed that treatment D (*hydrilla* shelter) was not significantly different from treatment K (without shelter) and C (plastic hose shelter), significantly different from treatment B (roster shelter), and significantly different from treatment A (PVC pipe shelter). This shows that the shelter of paralon pipes and shelter roster can significantly affect the survival rate of freshwater lobsters. In line with the results of research Adiyana *et al*. (2014), paralon shelter proved to reduce stress with better conditions when compared to other treatments, because lobsters that are molting usually choose to avoid other lobsters (Partini *et al*., 2019).

Water Quality

Water quality parameters measured for each sampling during the study include temperature, pH, and dissolved oxygen. Water quality measurements use the observation method by making direct observations. Water quality data can be seen in Table 7.

Table 7. Results of analysis of variance of water quality parameters of crayfish *(C. quadricarinatus)* with different shelters.

Treatment	Temperature (^{0}C)	pH	Dissolved Oxygen (ppm)
K	27.0-28.2	7.7-7.9	4.4-6.1
A	26.0-28.3	7.7-7.9	4.1-6.1
B	27.0-28.3	7.7-7.9	4.6-5.9
C	26.4-28.3	7.4-7.9	4.2-6.1
D	27.1-28.2	7.6-7.9	4.2-6.1

Description: K (without shelter), A (PVC pipe shelter), B (roster shelter), C (plastic hose shelter), D (*hydrilla* shelter).

Shelter differences have no significant effect on crayfish water quality. Water quality can affect its ability to move, grow, and develop (Tampubolon and Maitindom, 2023). However, the water quality values in this study such as temperature, pH, and dissolved oxygen, are still within the tolerance limits of crayfish. Therefore, good quality water is needed to reduce the formation of disease in research. Based on the results of the study, it was found that the value of water quality parameters Temperature in the control treatment ranged from 27.0 – 28.2 °C, then the pipe shelter ranged from 26.0 – 28.3 °C, the roster shelter ranged from 27.0 – 28.3 °C, the plastic hose shelter ranged from 26.4 – 28.3 °C, and the algae shelter was 27.1 – 28.2 °C.

The value of water quality parameters is still within the tolerance limits of crayfish. According to Putra *et al*. (2021), the ideal temperature for raising crayfish is 20 – 30 °C, water temperatures below 20 °C or more than 30 °C can inhibit crayfish growth and reduce their appetite. Partini *et al*. (2019) said the molting process requires a fairly

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warm temperature, which is around 28 °C – 30 °C.

The pH water quality parameters in the control treatment ranged from 7.7 – 7.9, then the pipe shelter ranged from 7.7 – 7.9, the roster shelter ranged from 7.7 – 7.9, the plastic hose shelter ranged from 7.4 – 7.9, and the *hydrilla* shelter ranged from 7.6 – 7.9. From the data obtained, it does not show pH values that are significantly different from all treatments. According to Setiawan (2010), the pH value ranges from 7.5-8.3, considered to be in the optimal range for crayfish growth. In its natural habitat crayfish live at a pH ranging from 6.7 – 7.8 (Lengka *et al*., 2013).

Dissolved oxygen in this study is still in the good range for crayfish culture. According to Mazlum and Şİrİn (2020), crayfish will experience stress at oxygen levels below 3 mg/L. The dissolved oxygen range in the control treatment ranged from 4.4 – 6.1 mg/L, then the pipe shelter ranged from 4.1 – 6.1 mg/L, the roster shelter ranged from 4.6 – 5.9 mg/L, the plastic hose shelter ranged from 4.2 – 6.1 mg/L, and the algae shelter 4.4 – 6.1 mg/L. Dissolved oxygen content is interrelated with other water quality parameters, especially the high and low temperatures in a body of water (Jabbar *et al*., 2022).

CONCLUSION

Based on the observations that have been made, it can be concluded that different types of shelters can significantly affect the growth of absolute weight sig. 0.002, growth rate sig. 0.014, biomass weight sig. <0.001, survival sig. 0.001, but the difference in shelter has no significant effect on absolute length sig. 0.858. The results of water quality observations found that shelter differences do not significantly affect the water quality of crayfish.

The highest absolute weight growth was in the paralon pipe shelter with a value of 0.93 g, the highest length growth was in the roster shelter at 1.22 cm, the highest growth rate of paralon pipe shelter was 0.027 g/day, the highest biomass weight of PVC pipe shelter 32.64 g, the highest survival rate was in the paralon pipe shelter 92.6%. In addition, the roster shelter treatment has a fairly good absolute weight growth value of 0.90 g, absolute length of 1.22 cm, growth rate of 0.026 g/day, biomass weight of 28.37 g, and survival rate of 79.4%. Compared to other shelters, roster shelters can be used as an alternative, type of shelter for crayfish culture.

CONFLICT OF INTEREST

There is no conflict of interest among all authors upon writing and publishing the manuscript.

AUTHOR CONTRIBUTION

The contributions of each author are as follows: Siggit Dwi Raharjo in data collection, analysis, and drafting of the manuscript. Erika Saraswati and Mega Yuniartik participated in the experimental design.

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