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MOULTING PERFORMANCE AND SURVIVAL OF FRESHWATER CRAYFISH *Cherax quadricarinatus* FED WITH VARYING DOSES OF DICALCIUM PHOSPHATE

Performa Moulting dan Sintasan Lobster Air Tawar *Cherax quadricarinatus* yang Diberi Dosis Dicalsium Phosphate Berbeda

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ABSTRACT

The composition of feed plays a critical role in determining growth and survival rate in aquaculture species. Freshwater crayfish, specifically *Cherax quadricarinatus*, is a high-value aquaculture commodity; however, cultivation is often limited by slow growth rates and high mortality. This study aimed to evaluate the effects of incorporating dicalcium phosphate (DCP) into the feed on moulting frequency, growth, and survival of *C. quadricarinatus*. The experiment, conducted over 30 days at the Seppong Matakali Freshwater Fish Seed Center in Polewali Mandar, West Sulawesi, employed a completely randomized design with four DCP treatments (0% (A), 2% (B), 4% (C), and 6% (D) each with three replications. Data were collected on key metrics including absolute weight growth, absolute length growth, moulting frequency, survival rate, specific growth rate, and feed conversion ratio. The findings indicated that the optimal performance was achieved with 4% DCP, resulting in a moulting frequency of 0.77, absolute weight gain of 6.18 g, and absolute length gain of 0.92 cm. However, the highest survival rate of 90% was observed with the 6% DCP treatment.

Key words: Calcium, Moulting, Freshwater crayfish, Feed, Survival

ABSTRAK

Kandungan pakan berperan penting dalam menentukan pertumbuhan dan kelangsungan hidup organisme akuatik dalam kegiatan akuakultur. Lobster air tawar merupakan salah satu komoditas air tawar yang bernilai ekonomis tinggi. Namun, pertumbuhan yang lambat dan tingginya mortalitas menjadi faktor pembatas dalam produksi budidayanya. Tujuan penelitian ini adalah untuk mengetahui pengaruh pemberian dicalcium phosphate terhadap performa moulting, pertumbuhan dan kelangsungan hidup lobster air tawar Cherax quadricarinatus. Penelitian ini adalah penelitian eksperimental yang dilaksanakan selama 30 hari di Balai Benih Ikan Air Tawar Seppong Matakali, Polewali Mandar, Sulawesi Barat. Rancangan acak lengkap dengan 4 perlakuan dan 3 ulangan DCP yang terdiri dari perlakuan 0% (A), 2% (B), 4% (C) dan 6% (D) diterapkan sebagai percobaan penelitian. Data yang dikumpulkan meliputi pertumbuhan bobot mutlak, pertumbuhan panjang mutlak, frekuensi, sintasan, laju pertumbuhan harian, dan rasio konversi pakan. Hasil penelitian menunjukan bahwa pelakuan terbaik diperoleh pada pemberian 4% dicalcium phosphate dengan frekuensi moulting (0.77), bobot mutlak (6.18 g), Panjang mutlak (0.92 cm). Namun, sintasan tertinggi diperoleh pada perlakuan 6% dicalcium phosphate dengan persentase 90%.

Kata Kunci: Kalsium, Lobster air tawar, Moulting, Pakan, Sintasan

INTRODUCTION

Freshwater lobster (*Cherax quadricarinatus*), which belongs to the Parastacidae family, originates from its natural habitat in Queensland, Australia (Hutabarat *et al*., 2015). This species is easy to cultivate, either in aquariums, tarpaulin ponds, or concrete ponds (Sjahruddin *et al.,* 2024). Its maintenance is simpler compared to giant freshwater prawns or whiteleg shrimp because freshwater lobsters are resistant to disease, omnivorous, and have high egg-laying ability (Setiawan, 2021). In terms of cultivation techniques and market potential, freshwater lobsters have good prospects to be developed by the community because they provide economic benefits and open up employment opportunities without disrupting environmental sustainability (Barus *et al.,* 2023).

Specifically, freshwater lobsters have their own advantages such as high tolerance to water quality and a maintenance phase that does not go through the nauplius, zoea, mysis, and post-larva stages like most shrimp (Susanto, 2010; Sopandi, 2023). In addition, this lobster is low in calories and fat and rich in nutrients such as biotin, calcium, iron, niacin, phosphorus, protein, vitamins A, B6, and B12, making it a favorite among the public. The dense and tender meat of freshwater lobsters with a savory taste is also an attraction compared to giant prawns or other lobsters (Hutabarat *et al.,* 2015). The high demand in both domestic and international markets encourages wider cultivation efforts.

Although freshwater lobster cultivation efforts continue to be carried out to meet market demand, in reality this need has not been met, especially because the growth of freshwater lobsters (red claw) is relatively slow (Mahendra & Widyanti, 2018). This is thought to be due to the inefficient use of materials and energy from feed and less than optimal environmental management (Restari *et al*., 2019). Another common problem is the slow moulting process, which takes about three days. This process is complicated by low calcium levels in the feed, which causes a fishy odor during moulting. This odor attracts other lobsters, increasing the risk of cannibalism and mortality (Wie, 2007; Zaidy & Hadie, 2009).

Various efforts have been made to overcome the problem of slow growth of freshwater lobsters, including research on calcium supplementation in feed which has been proven effective in giant prawns (Fajri *et al*., 2019). Research shows that the addition of calcium from the bones of goat fish (*Abalistes stellaris*) can increase the growth rate and survival rate of giant prawns by up to 97.5% (Noviana *et al.,* 2018). However, information on the addition of calcium to freshwater lobster feed is still limited, so further research is needed.

Calcium is an important inorganic element in the formation of the exoskeleton of freshwater lobsters (Bagaskara *et al.,* 2024). Calcium absorption in shrimp is carried out through the gills, epidermis layer, and through the digestion process of calcium contained in feed (Khotimah & Ma'ruf, 2018). Calcium also plays a role in regulating blood clotting, heart rate, kidney tubule function, nerve muscle function, activity of several enzymes, and cell function in the lobster's body (Noviana *et al*., 2018). Although calcium is available in the environment, its dominant role remains through feed for processes and growth. One effective effort is the addition of dicalcium phosphate to feed, which has been proven to strengthen the shells of chicken eggs and bone formation. This method is effective because calcium from feed can be absorbed quickly and processed in the lobster's body (Hakim, 2009; Hastuti *et al.*, 2024).

Based on the description, further studies on the use of additional calcium in feed are needed to improve seed survival, feed consumption efficiency, and its impact on freshwater lobster growth.

RESEARCH METHODS

Time and Location of Research

This research activity was carried out for 30 days at the Seppong Matakali Freshwater Fish Seed Center, Polewali Mandar Regency, West Sulawesi Province.

Tools and Materials

The tools used in this study were aquarium, pH meter, thermometer, do meter, aeration stone, aeration hose, ¾ inch pipe, digital scale, ruler, water hose, seser, and blower. The materials used in this study were commercial feed, lobster seeds, Dicalcium Phosphate (DCP), and egg white.

Experimental Design

The experimental design used in this study was a Completely Randomized Design (CRD) with 4 treatments. Treatment A (control or without calcium administration), treatment B (test media with a dose of 2%), treatment C (test media with a dose of 4%), and treatment D (test media with a dose of 6%).

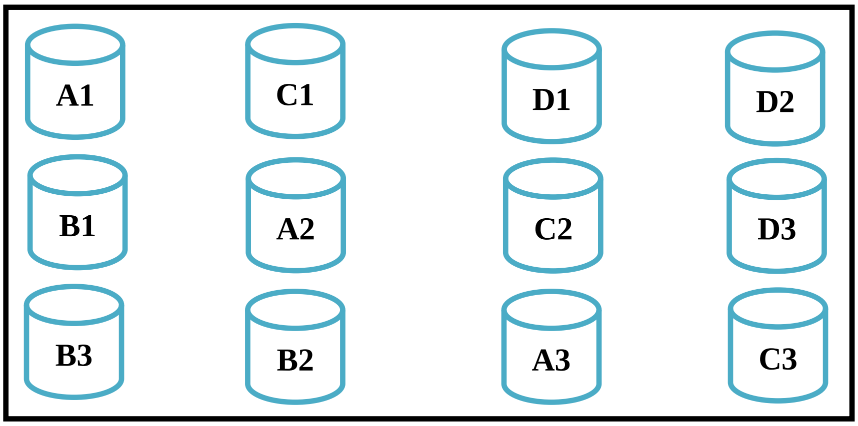

Figure 1. Completely Randomized Design (CRD)

Work Procedure

Container Preparation

Containers and tools were washed with soap, soaked in clean water for 1 day, and sterilized. A total of 12 aquariums (40×20×25 cm) were filled with water as high as 15 cm and equipped with an aerator. The total number of fry used was 120, placed according to the experimental layout.

Preparation of Test Animals

The test animals used in this study were seeds obtained from the seeding of the Seppong Matakali Freshwater Fish Seed Center (BBIAT Seppong) Polewali Mandar Regency, West Sulawesi Province. The number of freshwater lobsters tested was 120 with a density of 10 per aquarium. The length of the seeds was ± 2 cm with a weight of 0.45 grams per head and was 1 month old.

Preparation of Test Feed

The test feed was made by mixing 1000 g of commercial feed that had been ground with DCP in doses of 2%, 4%, and 6%. Water as much as 70% of the amount of feed and 1 egg white as an adhesive were added to the mixture. This mixture was re-molded using a feed molding machine, then cut to the size of mung bean seeds. The molded feed was dried in the sun for ±3 days to prevent rancidity and mold. Once dry, the feed was ready to use by giving 3% of the body weight of freshwater lobsters (Setiawan, 2010).

Distribution

The freshwater lobster fry are acclimatized first to adjust to the new environment. Furthermore, the lobster fry are weighed to determine the initial mass, then put into an aquarium with a density of 10/aquarium.

Maintenance and feeding

The maintenance of lobster fry is carried out for 30 days. The test feed used is 100% Fengli brand sinking pellet feed that has been mixed with DCP. The frequency of feeding is 3 times a day, namely at 08.00, 17.00, and 22.00 according to the prepared dose.

Data collection techniques

The method used for this study is the experimental method. Growth data collection is carried out once a week, while survival data is carried out at the end of the study. Growth data can be obtained using the following formula:

1. Absolute weight gain or weight gain (Effendie, 1979)

$$W = W_t - W_o$$

Information:
W = Growth (gr)
W_t = Average weight of fish at the end of maintenance (gr)
W_o = Average weight of fish at the beginning of maintenance (gr)

2. Absolute length growth (Zonneveld *et al.*, 1991)

$$P_m = P_t - P_o$$

Information:
P_m = Absolute length growth (cm)
P_t = Average length of individuals at the end of maintenance (cm)
P_o = Average length of individuals at the beginning of the study (cm)

3. Frequency of moulting (Handayani & Syahputra, 2018)

$$MFq = \frac{Xmolt}{Ntot}$$

Information:
MFq : Frequency of moulting (times/tail)
Xmolt : Total number of moulting prawns (times)
Ntot : Number of giant prawns during the research period

4. *Survival rate* (SR) (A'yunin et al., 2017)

$$SR(\%) = (\frac{N_t}{N_o}) \times 100$$

Information:
SR : Survival rate.
N_t : Number of seeds at the end of research
N_o : Number of seeds at the beginning of the research

5. Specific Growth Rate (Achmad *et al*., 2021)

$$SGR = \frac{L_n W_t - L_n W_o}{t} \times 100$$

Information:
SGR = Specific daily growth rate (%day)
W_t = Average weight of fish at the end of the study (gr/fish)
W_o = Average weight of fish at the beginning of the study (gr/fish)
t = Time (length of maintenance)

6. Feed Conversion Ratio (Putra *et al*., 2021)

$$FCR = \frac{F}{W_t - W_o}$$

Information:
FCR = Feed Conversion Ratio
F = Weight of feed given (gr)
W_t = Biomass of test animals at the end of maintenance (gr)
W_o = Biomass of test animals at the beginning of maintenance (gr)

7. Water Quality

Water quality measurements were conducted every 8:00 am, 3:00 pm and 9:00 pm. Water quality measurements were carried out every day during the research.

Tabel 1. Water Quality

No	Parameter	Tool	Measurement time
1	Temperature	Thermometer	8:00 am, 3:00 pm, 9:00 pm
2	Dissolved Oxygen	DO Meter	8:00 am, 3:00 pm, 9:00 pm
3	pH	pH Meter	8:00 am, 3:00 pm, 9:00 pm

Data analysis

The data obtained were analyzed using One Way ANOVA at a 95% confidence level, and if there was a significant effect, the analysis was continued with the Tukey test. Statistical tests were carried out with the help of SPSS Version 16.00. Water quality parameters were analyzed descriptively based on the viability of freshwater lobsters.

RESULT

The results of the research on the growth performance of freshwater lobster seeds (*Cherax quadricarinatus*) through the addition of calcium in the feed are presented in Table 2.

Table 2. Absolute weight growth (W), absolute length growth (PM), moulting frequency (MFq), survival rate (SR), specific growth rate (SGR), feed conversion ratio (FCR) of freshwater lobsters (*Cherax quadricarinatus*) during the study.

Parameters	**Treatment**			
	A	**B**	**C**	**D**
W (gr)	2.13	5.91	6.18	3.92
Pm (cm)	0.60	0.72	0.96	0.92
MFq (times/ tail)	0.40	0.43	0.50	0.77
SR (%)	43 ± 5.77 [a]	67±28.86 [a]	90±0.00 [b]	73 ±0.5.77 [ab]
SGR (% days)	0.70 ± 0.12 [a]	1.90±0.17 [b]	2.20±0.68 [b]	1.33 ±0.11 [ab]
FCR	15.42 ± 5.12 [b]	5.28±0.86 [a]	5.19±1.37 [a]	8.38 ±0.90 [ab]

Based on data on absolute weight growth (W), absolute length growth (Pm), moulting frequency (MFq), survival rate (SR), specific growth rate (SGR), feed conversion ratio (FCR) of freshwater lobster (*Cherax quadricarinatus*) during the study, a histogram was made as follows.

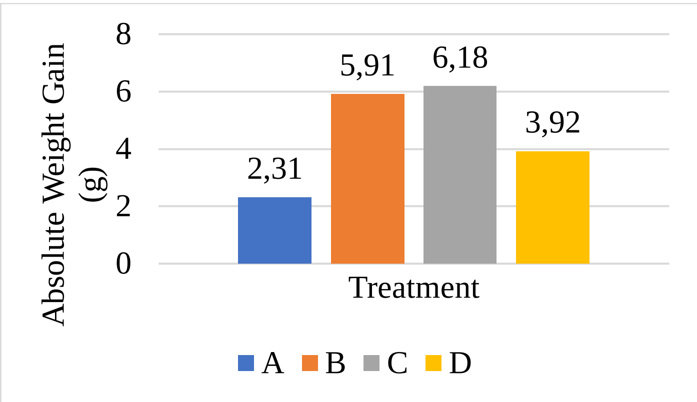

Figure 2. Absolute weight growth (W) of freshwater crayfish on treatment feed for 29 days

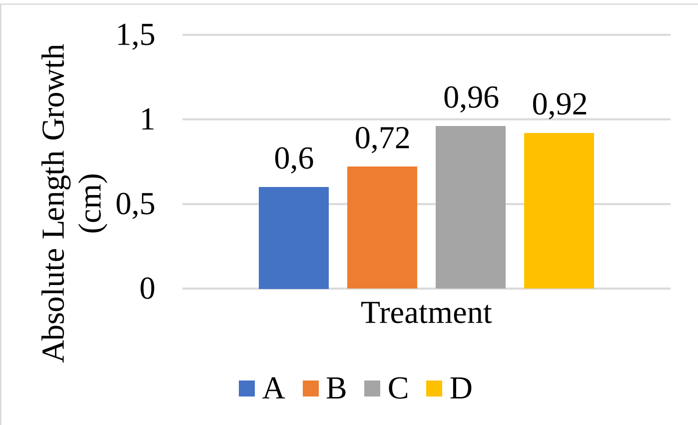

Figure 3. Absolute length growth (PM) of freshwater lobsters in response to feed treatments for 29 days.

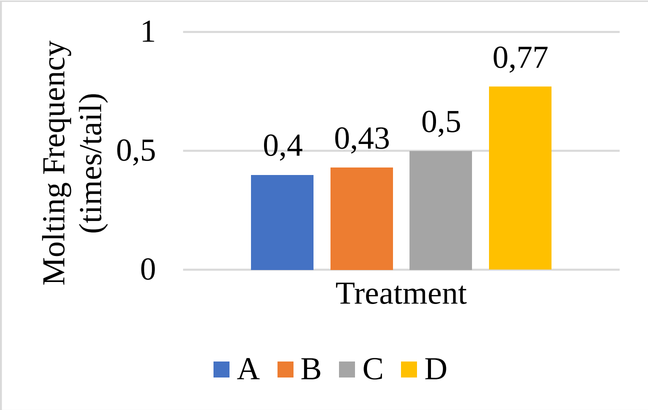

Figure 4. Moulting frequency (MFq) of freshwater lobsters in response to feed treatments for 37 days

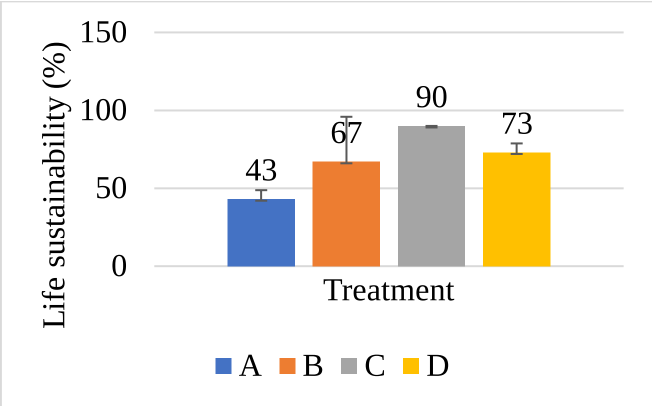

Figure 5. Survival rate (SR) of freshwater lobsters to treatment feed for 37 days

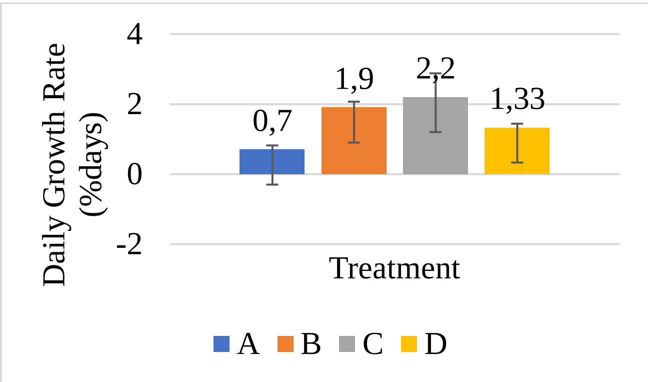

Figure 6. Daily growth rate (SGR) of freshwater lobsters to treatment feed for 37 days

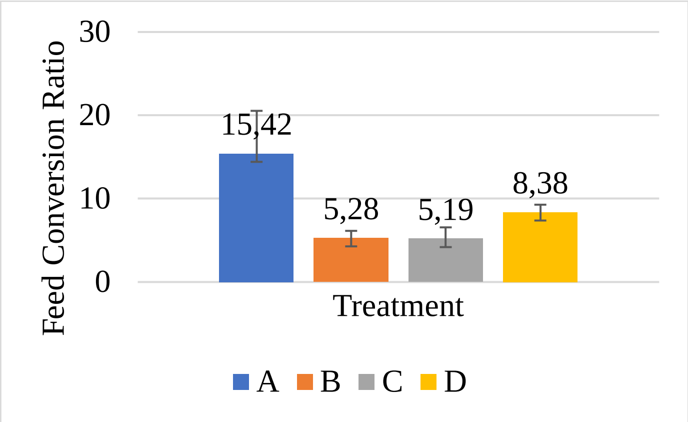

Figure 7. Feed conversion ratio (FCR) of freshwater lobsters to treatment feed for 37 days

During this research, measurements of water quality parameters were also carried out, namely temperature, dissolved oxygen (DO), and acidity level (pH).

Table 3. Average water quality parameters in the study

Parameter	Treatment				Optimum Value	Reference
	A	B	C	D		
Temperature (°C)	26.95	26.93	26.87	26.94	24-29	Faiz *et al.* (2021)
DO (mg/L)	7.72	8.30	7.62	7.66	>4	Taufiq *et al.* (2016)
pH	8.75	8.18	8.11	8.08	7-8	Miptah *et al.* (2024)

DISCUSSION

Absolute Weight

Based on the ANOVA test, absolute weight growth did not show significant differences between treatments (P>0.05). Lobster body weight increased over time (Niron, 2023). After 29 days with sampling every 7 days, treatment C (4% DCP) produced the highest average weight gain of 6.18 grams, followed by treatment B (2% DCP) of 5.91 grams, treatment D (6% DCP) of 3.92 grams, and treatment A (control) of 2.13 grams.

This absolute weight growth is higher than previous research by Sarmin *et al.* (2020), which reported 2.54–3.99 grams. This is influenced by the protein content of the feed used in this study of 40%, exceeding the 25% used previously. The high protein content is in accordance with the recommendations of Manomaitis (2001), to support the growth of lobsters weighing more than 1 gram. The addition of DCP also helps harden the lobster shell.

External factors such as water quality and feed composition also affect growth (Zaky *et al.*, 2020). During the study, water quality was monitored to support the needs of *Cherax quadricarinatus* lobsters. Commercial feed was used according to the age of the lobster to ensure adequate nutrition. However, growth was uneven between treatments due to territorial competition in finding food. The territorial nature of lobsters causes larger ones to prey on smaller ones, thus creating differences in body weight (Siburian, 2019).

Absolute Length Growth

Length measurements were taken from the tip of the rostrum to the uropods. Based on the ANOVA test, absolute length growth did not differ significantly between treatments (P>0.05). After 29 days of maintenance with sampling every 7 days, the best length increase was recorded in treatment C (4% DCP) with an average of 0.96 cm, followed by treatment D (6% DCP) of 0.92 cm, treatment B (2% DCP) of 0.72 cm, and treatment A (control) of 0.60 cm.

Lobster growth can be measured through moulting, length gain, and weight gain (Satwika, 2014). However, data shows that mixing commercial feed ingredients with calcium (DCP) is less than optimal, so that the feed is easily destroyed in the water and is not consumed optimally by the lobster. This causes insufficient food sources, inhibits growth, and triggers cannibalism in freshwater lobsters (Amanda *et al.*, 2024). Lack of feed consumption caused the growth of lobster body length and weight to be insignificant in the ANOVA test. This indicates that feed formulation and stability need to be improved to support optimal lobster growth.

Moulting Frequency

During maintenance, new moulting or skin replacement data were obtained. Based on the results of the moulting measurement data in Figure 3, the results of the ANOVA test data showed a significant effect on the moulting frequency ($P < 0.05$). The best moulting frequency was experienced in treatment D (6% DCP) with an average moulting of 0.77 times, the second highest moulting frequency was in treatment C (4% DCP) with an average moulting of 0.50 times, the third moulting frequency was in treatment B (2% DCP) with an average moulting of 0.43 times, and the lowest moulting frequency was in treatment A (0% control) with an average moulting of 0.40 times.

Freshwater lobsters have an outer skeleton (shell), so they must go through the moulting process to grow and develop (Budi *et al.*, 2019). This moulting process requires quite a lot of energy so that the lobster can survive. The energy taken comes from feed and its environment through the mineralization process. To form a new shell, lobsters will need calcium (Andriyeni *et al*., 2022). Lobsters will absorb calcium from their old shells with a special organ in the lobster's body called a gastrolith. Gastroliths are half-spherical in shape and white in color like lumps of salt (Wie, 2007). In addition to calcium, lobsters will also undergo a mineralization process to form new membranes using calcium absorbed from the shell and the environment in which they live (Hakim, 2009).

The moulting process is a process where lobsters will leave their old shells and form new shells that are larger in size (Andriyeni *et al*., 2022)). Lobsters will have new shells that are not yet very hard, which takes time to harden the shell. Shell hardening is supported by shell components, namely calcium, protein, and chitin (Trijoko & Nurcholis, 2018). During the molting process, lobsters will lose some of their energy and around 90% of the calcium in their bodies, so they need quality feed intake (Muliani *et al*., 2021). During this process, lobsters tend to be inactive and prefer to stay in hiding. The importance of this calcium is because lobster shells are composed of calcium which is the main component of the shell and affects the moulting process (Trijoko & Nurcholis, 2018). So the lobster moulting process in this study tends to be more inclined to the D 6% treatment of (DCP) in the feed. This is because the dose of calcium added to the feed is too high, making lobster growth only focus on the moulting phase so that the energy used for weight and length growth has been divided.

The frequency value of freshwater lobster moulting reported by Hakim (2009) was 6.33 times higher than this study, which was 0.40-0.77 times. This is because the previous study used freshwater lobsters measuring 2.5 cm. Meanwhile, in this study, freshwater lobsters measuring 3-4 cm were used. The large and non-diverse sizes were due to the difficulty in finding uniform seeds when this study was conducted. Rihardi *et al*. (2013), the frequency of carapace replacement will be slower with increasing lobster age, in adult juveniles moulting occurs every 10 days once, while after adulthood it occurs 4-5 times a year. When they have become parents and have spawned, they usually moult 1-3 times a year.

Survival Rate

Based on the data results in Figure 5 related to survival measurements, the results of the ANOVA test data showed a significant effect on survival (P <0.05). The data showed a decrease in the number of lobsters that survived in control treatment A (without calcium), treatment B (2% calcium), treatment C (4% calcium) and D (6% calcium). If at the beginning of maintenance the survival rate was 100%, then after 29 days of maintenance treatment A decreased to 43%, B 67%, and D 73% survival. The highest survival rate was in treatment C at 90%.

Hakim (2009), stated that the survival rate of freshwater lobsters ranging from 80-93.33% is still good. According to this statement, if seen in treatment C 4%, feeding with the addition of calcium can increase the survival of freshwater lobsters (*Cherax quadricarinatus*). Freshwater lobsters have very high cannibalistic traits (Timumun *et al.,* 2022). This trait can lead to death in freshwater lobsters. The cannibalistic nature of lobsters can be minimized by the availability of feed. Feeding is done 3 times a day, namely in the morning, afternoon and evening with a dose of 3% of body weight (Yusafri *et al.,* 2022). Although lobsters are classified as nocturnal biota, feeding in the morning is important to suppress the cannibalistic nature of lobsters. Aggressive behavior will be more apparent when the feed supply is inadequate, thus encouraging cannibalistic behavior (Putra *et al*., 2023). In addition to cannibalism, the death of freshwater lobsters is also caused by their inability to moult perfectly. The survival rate of freshwater lobsters is influenced by water level, density level, type of feed, size of feed and water quality (Masser & Rouse, 1997). According to Jones and Rescue (2000), survival is influenced by environmental conditions, feed availability, parasites, population size, age, willingness to adapt to the environment, and handling during maintenance (Sarmin *et al*., 2020).

Freshwater lobsters also have territorial sensitivity to their territory. This trait encourages lobsters to fight each other to win territory so that they can die (Budi *et al*., 2019). The cause of the decreasing survival rate of freshwater lobsters in this study was the territorial behavior of lobsters towards their territory. Larger lobsters will attack smaller lobsters to defend their territory, as well as competition in finding food sources. Territorial competition in lobsters occurs in horizontal areas or at the bottom of the pond, because freshwater lobsters have a bottom feeder feeding type. Bottom feeder behavior is the behavior of eating food located at the bottom of the waters (Prananti, 2022).

Daily Growth Rate

Based on the data results in Figure 6 related to the measurement of daily growth rate, the results of the ANOVA test data were significantly different from the daily growth rate (P <0.05). The daily growth rate was obtained from the calculation results using the Specific Growth Rate (SGR) formula. The data results show that the best daily growth rate for the average biomass was in treatment C (2.20 grams).

The growth of freshwater lobster seeds fed with additional calcium obtained good results. The highest daily weight growth rate was in treatment C, which was 2.08 grams. When compared to previous studies, the results obtained were lower, namely 1.05 grams (Putra *et al.,* 2021). This proves that the level of DCP consumption has a significantly different effect on the daily growth rate. It is suspected that the addition of calcium to the feed can increase the percentage of moulting and balance growth, so that the feed used to build body tissue can produce better growth (Achmad *et al.,* 2021).

Feed Conversion Ratio

The feed conversion ratio (FCR) indicates the efficiency of feed converted into meat (Nurhasanah *et al.,* 2021). Based on the ANOVA test, FCR showed a significant difference between treatments (P <0.05). During the 29-day maintenance, treatment A (control) recorded the highest amount of feed at 15.42 grams, while treatment C (4% DCP) had the lowest amount of feed at 5.19 grams. These results indicate that the lower the FCR value, the better the efficiency of the feed consumed by the lobster, because the feed is more optimally digested (Nurhasanah *et al.,* 2021).

The feed used in the study was Feng Li commercial feed, with a minimum protein content of 41%, a minimum fat content of 7%, a maximum fiber content of 3%, a maximum ash content of 13%, and a maximum water content of 10%. This content is in accordance with the nutritional needs of lobsters (protein 30-40%) and is supplemented with DCP according to the treatment dose (Rosmawati, 2019). Feeding is done three times a day as much as 3% of the lobster's body weight (Setiawan, 2010). During the study, no lobster deaths were found due to failure, as evidenced by the absence of soft-bodied lobster carcasses. This shows that feed nutrition supports growth and prevents mortality due to calcium or protein deficiency (Sarmin *et al.,* 2020).

Water quality

During 37 days of maintenance, the water quality was within a good range for freshwater lobster growth. The temperature ranged from 26.87–26.95°C, pH between 8.08–8.75, and dissolved oxygen (DO) between 7.62–8.30 mg/L. This temperature is in accordance with the ideal range for lobster maintenance, which is 24–29°C (Faiz, 2021). Temperature affects the body's metabolism; low temperatures can reduce appetite and slow down metabolism, while temperatures outside the optimal limit can reduce the energy used for growth (Dahri *et al*., 2024; Faris *et al.,* 2023).

The water used came from a drilled well at the Seppong Freshwater Fish Seed Center with a pH of around 8. Lobsters can live at a pH of 6–9, with an optimal range of 7–8 (Miptah *et al*., 2024). pH below 6 can cause death, while pH above 9 reduces appetite, thus affecting growth (Jamiaan *et al*., 2023). During maintenance, no extreme pH changes were found. Dissolved oxygen (DO) was maintained with an aerator in each aquarium, with a DO range of >7 mg/L, which is considered good for growth. Freshwater lobsters are tolerant to low DO, but for optimal growth, DO should be >4 mg/L (Taufiq *et al*., 2016).

CONCLUSION

Addition of calcium to feed can increase growth at a dose of 4% dicalcium phosphate (DCP). However, there was no significant difference (P>0.05) in weight and length growth. However, there was a significant difference (P<0.05) in survival, feed conversion ratio, specific growth rate, and moulting frequency.

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