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The Survival Rate, Growth, and Health of Scalloped Spiny Lobster, Panulirus Homarus (Linnaeus 1758) in Nursery and Grow-Out in A Concrete Tank Fed with Fresh Food and Three Kinds of Dry Pellet

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Abstract

This study aimed to determine the best feed for Panulirus homarus nursery and grow-out in a concrete tank. The treatments were fresh food (A) pellets for grouper (B), pellets for shrimp (C), and pellet formula (D). The study of the nursery with an initial total length (TL) of 2.2±0.043 cm and body weight (BW) of 0.32±0.023 g, while the grow-out with an initial TL of 13.1±0.18 cm, BW of 78±2.7g. Feeding 2x/day for fresh food in the nursery was 20% biomass/day and 10% biomass/day at grow-out. For dry pellet feed in the nursery, 5% biomass/day, while in grow-out, 2% biomass/day. The observed parameters are survival rate (SR), TL, BW, THC, and the BRIX index. The results show that SR on the nursery (P<0.05) was highest in D (55.1%), followed by B (49.5%), C (37.3%), and A (23.2%), while on the grow-out (p<0.05) highest on D (94.67%), followed by B (84.25%), C (82.67%), and A (50.67%). The final biomass in the nursery (p<0.05) was highest on D (436.39), followed by B (351.95 g), C (230.89 g), and A (178.64 g), while on the grow-out (p<0.05), highest on D (9.659 kg), followed by B (7.056 kg), C (7.056 kg), and A (4.826 kg). The Best lobster health is on the D, followed by B, C, and A. From this result, the best feed is the pellet lobster formula, followed by the pellet for grouper, the pellet for shrimp, and fresh food.

Keywords: *Panulirus homarus, nursery, growth out, feed, survival rate, growth, health.*

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1. INTRODUCTION

Scalloped spiny lobster (Panulirus homarus) is a commodity of high economic value worldwide. Spiny lobster is a commodity caught with high economic value worldwide (Ma et al. 2021). The demand for lobster in Asia has increased dramatically (Pozhoth and Jeffs 2022). The fulfillment of lobster market needs is still lacking because most of the results are from the capture results. The export volume of caught lobster is much greater than that of aquaculture (Amin et al. 2022). To sufficient the demand of the world market, it is necessary to develop lobster aquaculture. The development of lobster farming should be a severe matter of understanding (Ma et al. 2021). The development of the world's lobster farming over the past 20 years has been very rapid, but not yet on a commercial scale (Landman et al. 2021). Spiny lobster sea cage culture in Indonesia has great potential to be developed. This is because Indonesia is an archipelagic country with large seas of around 5.8 million km^2, approximately 17,504 islands, a long coastline that reaches 81,000 km, and many lagoons and bays that are good for floating net cage locations for marine fish, including lobster. Scalloped spiny lobster is a very potential species to be cultivated in Indonesia because the availability of seeds in nature in sufficient quantities supports it. Lobster fry from natural catches is usually on puerulus stadia (Priyambodo, Jones, and Sammut 2020).

Lobster feeding behavior is generally constant during intermolt and fasting within a few days before molting (Kropielnicka-Kruk et al. 2022). In lobsters, generally, fresh feed provides faster growth than dry pellet feed, but the color is paler, and the resistance is weak (Landman et al. 2021). The results of the study by Marchese et al. (2019) on pearl lobsters (Panulirus ornatus) fed with artificial feed/formula resulted in lower growth but showed better performance. It is necessary to test several types of feed that suit the nutritional needs of lobsters with feed that suits the nutritional needs of lobsters, can reduce cannibalism and improve the health and survival of lobsters. The study aimed to obtain suitable feed for the nutritional needs of sand lobster lobsters on maintenance in concrete tubs. Finding feed that suits the nutritional needs of lobsters will stimulate the development of aquaculture businesses.

2. MATERIALS AND METHODS

Seeds/baby lobsters used for rearing research come from natural catches on the south coast of Bali. The baby lobster was previously acclimatized and accustomed to eating dry pellets. This study used 16 concrete tanks with a size of 2.5 x 2.5 x 1 m, carried out by using four treatments and four replications in all treatments using the water flow system with a percentage of water exchange of 200% of the total volume per day. The design used in this study was a completely randomized design with three replicates. The treatments tested in this treatment were A: fresh feed (trash fish meat and mussel meat = 3:1), B: commercial pellet for grouper, C: commercial pellet for shrimp, and D: dry pellet formula of IMRAFE. The spiny lobsters used in this study have an initial average total length of 13.1 cm, an initial weight of 78 g) and a stocking density of 25 ind/tank. Feeding is done twice daily in the morning at 08.00 and in the afternoon at 15.00, with the percentage of feeding for fresh feed as much as 10% of the total biomass and for artificial feed as 2% of the total biomass per day.

Every month the number of lobsters was counted to calculate their survival rate and were measured in total length (TL) and body weight (BW). To observe the survival rate and body weight growth, all lobsters in each tank were counted, and their biomass was weighed to observe total length; samples of 10 lobsters per tank were taken. The average lobster weight is calculated from the weight of the biomass divided by the number of lobsters in each cage. Lobster weight measurement using an electronic scale close to 0.1 g was previously applied with a towel to absorb excess water in the lobster's body. Measure the total length of the lobster using a caliper with an accuracy of 0.1 mm; measured in the mid-back from the front of the spine to the tail end.

The survival rate was calculated referred to the method of [20]: Survival rate = (Lobster number day-t/Lobster number day 0) x100%. Weight gain (g), weight gain (g per day), and daily total length gain (mm per day) were calculated referring to [20] with the formula: Body weight gain (g) = (Final mean lobster weight - initial mean lobster weight); Wt-W0. Body weight increments (g per day) = (final body weight - initial body weight)/number of days; $(W_t-W_0)/t$. Daily total length increments (mm per day) = (final total length − initial total length)/ Number of days); (TLt - TL0)/t. Calculate the feed conversion ratio (FCR) refers to the method [21]; with the formula: Feed Conversion Ratio = Total Feed Consumed/Body Weight Gain.

Hemolymph sampling to observe the total hemocyte count (THC) and BRIX index was carried out on ten lobsters per tank at the end of the study. Hemolymph sampling was carried out in 0.2 ml for each lobster, where 0.1 ml for THC analysis and 0.1 ml for the BRIX index. A sampling of hemolymph was carried out on the caudal part of the third leg using a 1 ml volume syringe filled with an anticoagulant solution with a pH of 4.6 and then stored in the refrigerator at a temperature of 4ºC. THC was calculated under a microscope that had been fitted with a hemocytometer. To calculate the total hemocyte count (THC), refer to hemolymph [22]. For the measurement of the BRIX index, a portable digital BRIX meter from Atago USA with a scale of 0-32% and an accuracy of 1% is used.

Every week, observations were made on water quality parameters: temperature, ammonia, pH, nitrite, DO, and salinity. The method of measuring water quality is carried out according to [23], which consists of water temperature, pH, salinity, and dissolved oxygen (DO); with YSI 556 portable probe unit in Ohio, USA. To measure the water quality of ammonia and nitrite was carried out on day 0 and then every ten days with a portable HACH DR1900-01H, Love land, USA. For data analysis of survival rate, growth of total length, and body weight, statistical analysis using analysis of variance (ANOVA) F test with 95% confidence interval, using Ms. Excel. For data that are significantly different, it is continued to the test of differences between treatments us the Turkish test. The water quality data analysis was carried out descriptively.

The data of the analysis of the proximate content of the feed used (Table 1) are the protein content of feed A, B, C, and D, 57.40 %, 42.7%, 33.07 %, and 46.51%, respectively. The fat content of feed A, B, C, and D was 10.27 %, 17.87 %, 8.08%, and 7.07 %, respectively. The ash content of feed A, B, C, and D was 24.01 %, 12.33%, 9.72 %, and 14.82 %, respectively. The water content of the feed (dry material) A, B, C, and D was 2.01%, 2.39%, 8.14%, and 7.57 %, respectively.

Table 1. Proximate analysis of feed used on the experiment of scalloped spiny lobster growing out in the concrete tank.

Proximate	Content (from the dry matter)			
	Fresh feed (fish and mussel (3:1) (A)	Commercial pellet for grouper (B)	Commercial pellet for shrimp (C)	Pellet IMRAFE formula (D)
Protein	57.40	42.7	33.07	46.51
Fat	10.27	17.87	8.08	7.07
Ash	24.01	12.33	9.72	14.82
Water content	2.01	2.39	8.14	7.57

3. RESULTS AND DISCUSSION

3.1. Result

3.1.1. Nursery

The results of observations of the survival rate, total length, and body weight of scalloped spiny lobsters in the nursery in concrete tanks for 14 weeks with different feed treatments can be seen in Table 2, Figure 1, 2 and 3.

Table 2. The survival rate, carapace length gain, total length gain, and body weight gain of scalloped spiny lobster (Panulirus homarus) puerulus during 14 weeks of the nursery with different food.

	Feed			
	Fresh feed (fish and mussel (3:1) (A)	Commercial pellet for grouper (B)	Commercial pellet for shrimp (C)	Dry pellet IMRAFE (D)
Survival Rate (%)	23.2[b]	49,5[a]	37.3 [b]	55.1 [c]
Initial carapace length (cm)	0,97	0,97	0,97	0,97
Initial total length (cm)	2.2	2.2	2.2	2.2
Final carapace length (cm)	2,08±0,835[c]	2,05±0,616 [b]	2,03.2±0,588[a]	2,07±0,726[c]
Final total length (cm)	5.65 ± 1.05[a]	5.35±0.98 [a]	5.11±0.93 [a]	5.85±1.23 [a]
Carapace length gain(cm)	1,11	1,08	1,06	1,10
Daily carapace length growth (mm/day)	0,098	0,090	0,088	0,092
Total length gain(cm)	3,70	3,40	2,90	4,05
Daily total length growth (mm/day)	0,295	0,283	0,241	0,338
Initial weight (g)	0.32	0.32	0.32	0.32
Initial biomass (g)	32	32	32	32
Final body weight (g)	7.70	7,11	6,19	7,92
Final biomass (g)	178.64	351.95	230.89	436.39
Body weight gain (g)	7.38[a]	6,79[a]	5.87[a]	7.60 [a]
Biomass gain (g)	146.64[a]	319.95[c]	198.89[b]	404.39[d]
Biomass gain (%)	458.25[a]	999.84[c]	921.53[b]	1263.72[d]
Daily weight growth (g/day)	0.075	0.069	0.059	0.077
Food conversion ratio	17,6	3,13[a]	3,15 [a]	3,12 [a]

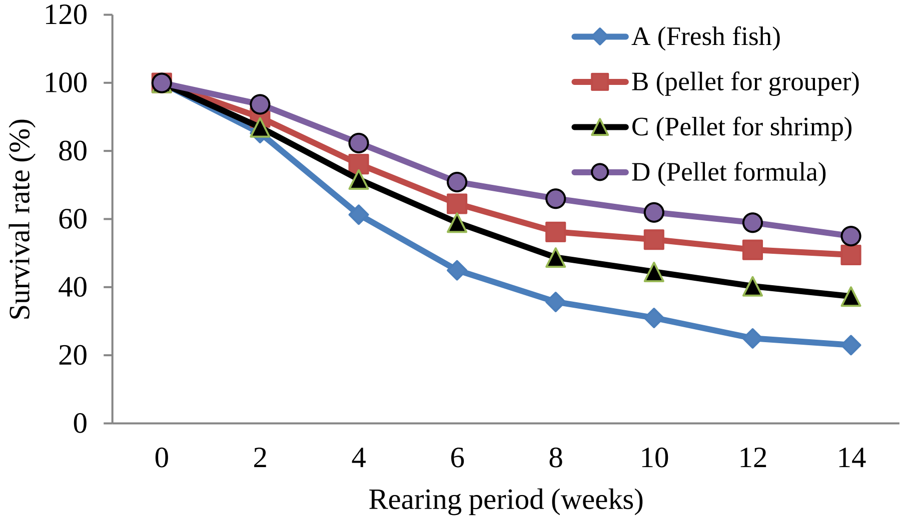

Figure 1. The survival rate of scalloped spiny lobster (Panulirus homarus) nursery in concrete tanks for 14 weeks with different feeds

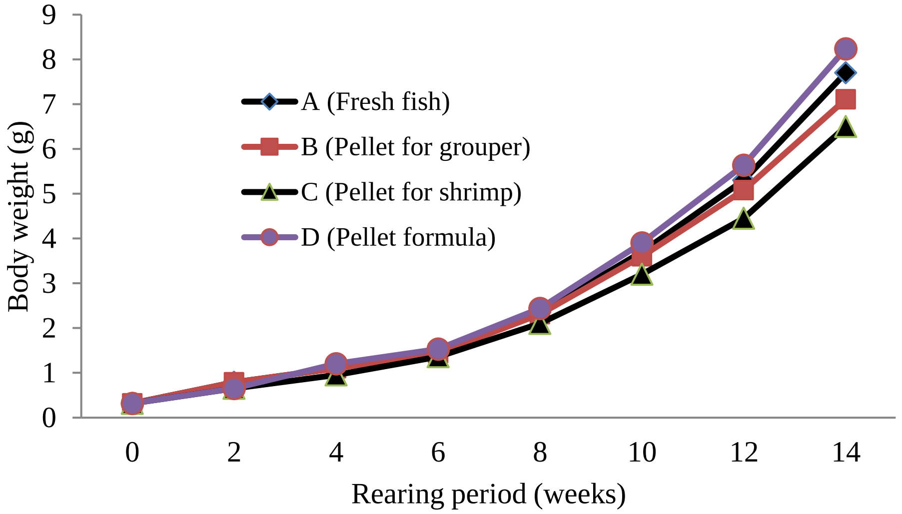

Figure 2. Body weight of scalloped spiny lobster (Panulirus homarus) nursery in concrete tanks for 14 weeks with different feeds

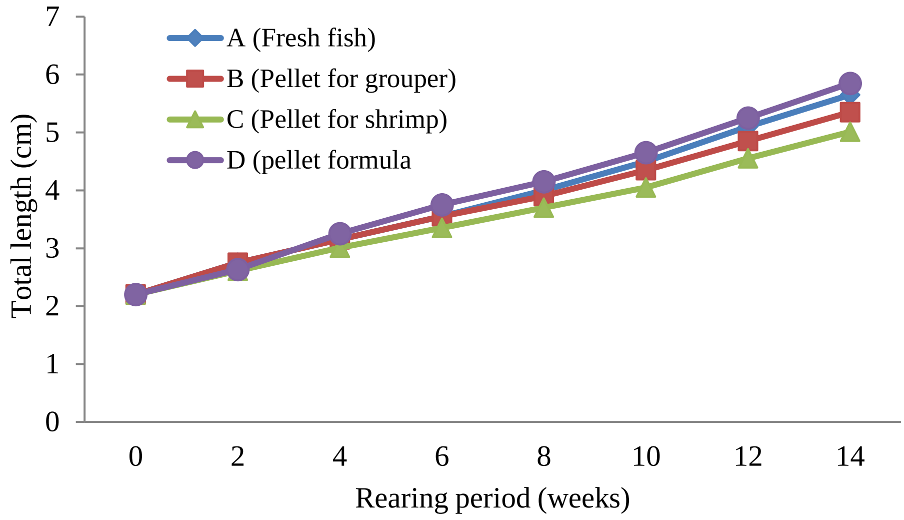

Figure 3. The total length of scalloped spiny lobster (Panulirus homarus) nursery in concrete tanks for 14 weeks with different feeds

The results of the total hemocyte count (THC) of spiny lobster (P homarus) reared in concrete tanks with different feed treatments can be seen in Table 3.

Table 3. Total hemocyte count (THC) and BRIX index of spiny lobster (P. Homarus) nursery in a concrete tank for 14 weeks with different feeds

Treatment (feed)	THC (x 10^4 / ml)	BRIX index (%)
A: Fresh food	405 ± 16^a	15.2 ± 0.43^a
B: Pellet for grouper	459 ± 19^c	17.15 ± 0.44^c
C: Pellet for shrimp	433 ± 14^b	16.52 ± 0.32^b
D: Pellet formula	476 ± 18^d	17.64 ± 0.72^d

The results of the observation of the rearing media's water quality during the experiment's five months, including temperature, DO, salinity, ammonia, phosphate, and nitrite, can be seen in Table 6.

Table 4. Water quality on scallop spiny lobster (P. Homarus) nursery in a concrete tank for 14 weeks with different feeds

Parameter	Treatment (feed)			
	A: Fresh food	B : Pellet for grouper	C: Pellet for shrimp	Pellet formula
Temperature (°C)	28,5 – 29,5	28,5 – 29,5	28,5 – 29,5	28.3 – 29.2
pH	7,9-8,3	7,8-8,2	7,9-8,2	7.9-8.2
DO (mg/L)	5,9-7,4	5,7-7,2	5,8-7,3	5.6-7.3
Salinity (ppt)	33,8-34,2	33,8-34,2	33,8-34,2	33.8-34.2
Ammonia ppm)	0,018-0,035	0,019-0,039	0,018-0,036	0.016-0.037
Phosphate (ppm)	0,25-0,38	0,27-0,41	0,26-0,40	0.26-0.41
Nitrite (ppm)	0,003-0,004	0,004-0,006	0,003-0,005	0.004-0.007

3.1.2. Grow out

Data from observations of survival rates, total length, and body weight of scalloped spiny lobsters grow out in concrete tanks for five months with different feed treatments can be seen in Table 5.

Table 5. The survival rate, carapace length, total length, and body weight of scalloped spiny lobster (Panulirus homarus) grow out in concrete tanks for five months with different feeds.

	Feed			
	Fresh feed (fish and mussel (3:1) (A)	Commercial pellet for grouper (B)	Commercial pellet for shrimp (C)	Pellet formula (D)
Survival Rate (%)	51.3±3.06[a]	84.3±3.79[b]	82.7±3.51[b]	94.7±4.51[c]
Initial carapace length (cm)	5.6	5.6	5.6	5.6
Initial total length (cm)	13.1	13.1	13.1	13.1
Final carapace length (cm)	7.70	7.07	7.02	7.97
Final total length (cm)	17.6±1.31[a]	16.5±1.23[b]	16.1±1.26[c]	18.1±1.30 [d]
Carapace length gain(cm)	2.1	1.47	1.42	2.32
Daily carapace length growth (mm/day)	0.140	0.098	0.095	0.155
Total length gain(cm)	4.5	3.4	3.0	5.0
Daily total length growth (mm/day)	0.30	0.227	0.20	0.33
Initial weight (g)	78.0	78.0	78.0	78.0
Initial biomass (kg)	3.9	3.9	3.9	3.9
Final weight (g)	190.5±6.48[a]	168.6±5.65 [b]	144.2±5.27 [c]	204.1±6.84 [d]
Final biomass (kg)	4.826	7.056	5.956	9.659
Body weight gain (g)	112.5	90.6	66.1	126.0
Biomass gain (kg)	0.926	3.156	2.056	5.759
Biomass gain (%)	23.7	80.9	52.72	147.67
Daily weight growth (g/day)	0.750	0.604	0.441	0.840
Food conversion ratio	14.9	2.99	3.15	2.83

The graph of the survival rate every month of spiny lobster (Panulirus homarus) grow out in concrete tanks for five months with different feed treatments can be seen in Figure 4.

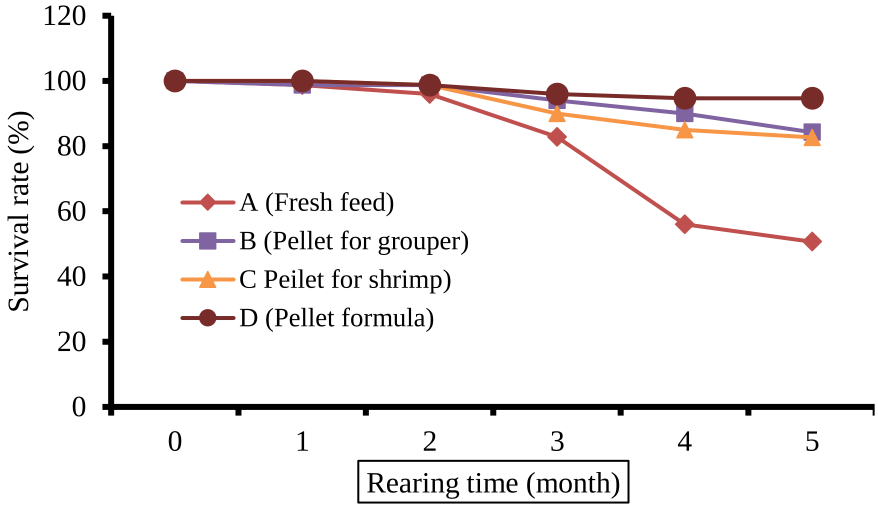

Figure 4. The survival rate of scalloped spiny lobster (Panulirus homarus) grow out in concrete tanks for five months with different feeds

The graph of the body weight every month of spiny lobster (Panulirus homarus) grow out in concrete tanks for five months with different feed treatments can be seen in Figure 5

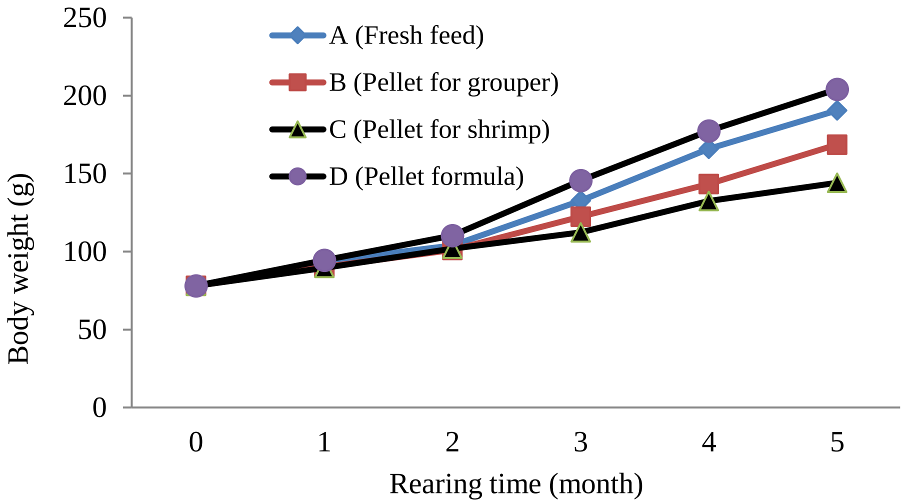

Figure 5. The body weight of scalloped spiny lobster (Panulirus homarus) grow out in concrete tanks for five months with different feeds

The graph of the total length every month of spiny lobster (Panulirus homarus) grow out in concrete tanks for five months with different feed treatments can be seen in Figure 6

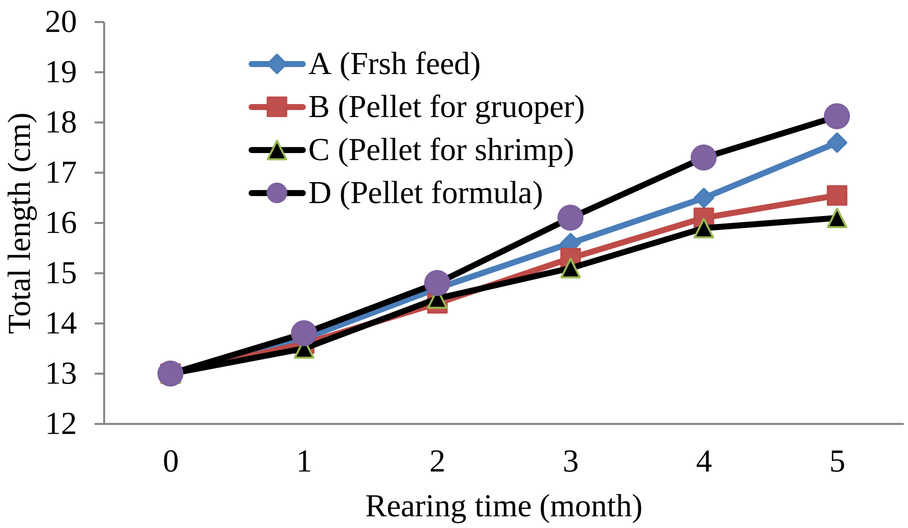

Figure 6. The total length of scalloped spiny lobster (Panulirus homarus) reared in concrete tanks for five months with different feeds

The results of the total hemocytes count (THC) of spiny lobster (P Homarus) grow-out in concrete tanks with different feed treatments can be seen in Table 6.

Table 6. Total hemocyte count (THC) and BRIX index of scalloped spiny lobster (P. Homarus) grow out in a concrete tank for five months with different feed combinations.

Treatment (feed)	THC (x 10^4 / ml)	BRIX index (%)
A: Fresh food	414±11[a]	16.2±0.29[a]
B: Pellet for grouper	471±14[c]	17.9±0.31[c]
C: Pellet for shrimp	439±15[b]	17.1±0.34[b]
D: Pellet formula	498±17[d]	18.8±0.33[d]

The results of the observation of the grow-out media's water quality during the experiment's five months, including temperature, DO, salinity, ammonia, phosphate, and nitrite, can be seen in Table 7.

Table 7. Water quality on growth out of baby scalloped spiny lobster grow out in the concrete tank for five months with different feeds

Parameter	Treatment (feed)			
	A: Fresh foo	B : Pellet for groupe	C: Pellet for shrim	Pellet formul
Temperatur	28.4 – 29.4	28.4 – 29.4	28.4 – 29.4	28.4 – 29.4
pH	8.0-8.2	8.0-8.2	8.0-8.2	8.0-8.2
DO (mg/L)	5.6-7.3	5.5-7.0	5.4-7.1	5.6-7.1
Salinity	33.8-34.2	33.8-34.2	33.8-34.2	33.8-34.2
Ammonia	0.018-0.039	0.019-0.037	0.018-0.035	0.019-0.038
Phosphate	0.25-0.35	0.27-0.38	0.26-0.39	0.27-0.40
Nitrite	0.004-0.006	0.004-0.006	0.003-0.005	0.004-0.007

3.2. Discussion

3.2.1. Nursery in concrete tank

Table 2 and Figure 1 show that the survival rate of lobsters at the nursery in a concrete tank for a 14-week nursery in concrete tank showed a significant difference ($P<0.05$)

among the treatments. Significant differences (P<0.05) in survival rates were seen between treatments A versus B, C, and D. The highest survival rate was in treatment D (pellet formula for spiny lobster) with a survival rate of 55.1%, %, followed by B (commercial pellets for grouper) (49.5%), C (commercial pellets for shrimp) (37.3%) and the lowest in A (fresh feed) (23,1%).

This result shows that commercial pellet for grouper, commercial pellet for shrimp, and pellet formula for spiny lobster is suitable for scallop spiny lobster feed nursery in concrete tank, but pellet formula for spiny lobster is most suitable for scallop spiny lobster feed at nursery in the concrete tank; because can produce the highest survival rate of scalloped spiny lobster. The survival rate of the nursery in concrete tanks (Figure 1) in the nursery for 14 weeks saw a sharp decrease in the survival rate where the survival rates on treatments A, B, C, and D were 23.1%, 49.5%, 37.3%, and 55.1% respectively. This is related to the inability of lobster fry to adapt so that appetite is still low and cannibalism is high. At the 10th and 14th weeks of the nursery, relatively gentle survival indicates successful adaptation. This condition occurs because of the cannibalism of the lobsters at the time of molting, while the conditions in the first month that most lobsters have not molted. This condition is evidenced by not finding a dead lobster body in the tank. The molt frequency and inter-molt time depend on the age and size of the spiny lobster; the younger lobsters generally have a high molting frequency, so cannibalism is higher than the more giant lobsters (Amiri, Musdalifah, and Amin 2022). In a spiny lobster culture with individual systems, the incidence of cannibalism can be reduced to 100% (Twiname et al. 2022).

In Table 2 and Figure 2, it can be seen that lobster body weight data in the nursery in the concrete tank during 14 weeks of rearing showed that there was a significant difference (P<0.05) between treatments. The highest final body weight was in treatment D with a final weight of 7.92 g followed by A (7.70 g), B (7.11 g), and lowest at C (6.5 g).

The growth of the total length of the spiny lobster (Panulirus homarus) nursery in concrete tanks for 14 weeks fed with different feeds can be seen in Figure 3. In Table 2 and Figure 3, it can be seen that the total length data of lobsters in the experiment for 14 weeks of rearing showed that there was a significant difference (P<0.05) among the treatments. The highest final total length was on treatment D with a final total length of 5.85±1.23 cm, followed by A (5.65±1.05), B (5.35±0.98 cm), and lowest on treatment C (5.11±0.93 cm).

Observations of lobster health conditions shown by the total number of hemocytes (THC) values in Table 3 showed that the total number of hemocytes was significantly different among treatments (<0.05). The highest total number of hemocytes was in D (476±18) x 10^4 cells per ml followed by treatment B (459±19) x 10^4 cells per ml, treatment C (433±14) x 10^4 cells per ml, and lowest in treatment A, (405±16) x 104 cells per ml. Total Hemocycte Count (THC) is an essential parameter in determining the stress levels in crustaceans (Supriyono et al. 2022). The value of THC is an essential factor in determining the status of the crustacean immune system. It is an important parameter in determining the status of health and immune conditions (Supriyono et al. 2022). High glucose levels in crustaceans indicate stress conditions. High glucose levels in crustaceans indicate stress conditions. The THC on male and female was not signifikan different (Fitzgibbon et al. 2017). The value of the BRIX index can be used to determine the vitality status of lobsters related to decisions on harvesting and transportation/shipping of lobsters (Shields and Behringer 2004).

One way to determine if a lobster is under stress is to know the concentration of THC (Supriyono et al. 2022). On spiny lobster, Jasus edwardsii, THC, and index hemolymph were reduced after 120 days of exposure to environmental disorders and nutritional disorders (Fitzgibbon et al. 2017). Stressful conditions in lobsters due to mishandling and response to environmental changes can trigger increased cardiovascular activity and increase the amount of THC (Pascual-Jiménez et al. 2012). Most lobsters and marine invertebrates do not have sterile hemolymph (Jung et al. 2021). In spiny lobster exporters, the quality of lobster health can be sorted through the hemolymph brix index (Jung et al. 2021). Stressful conditions in lobsters due to mishandling and response to environmental changes can trigger increased cardiovascular activity and increase the amount of THC. Several things can cause stress in lobsters: environmental stress, handling stress, and bacterial infection stress (Montgomery-Fullerton et al. 2007). Influence on lobsters can affect the viability of their cells (Jung et al. 2021). The number of hemocytes from hemolymph lobsters can decrease drastically when exposed to the attack of milk hemolymph syndrome (MHS) (Nunan et al. 2010). Artificial transmission of the disease in lobsters can be done by injecting hemolymph from the sick to the healthy (Shields and Behringer 2004). In lobster P. cygnus, the average THC concentration is 5.6±0.7 x 106 cells mL-1; at concentrations outside this range, it is unstable (Pascual-Jiménez et al. 2012).

The result of observations of lobster health conditions by the BRIX index of spiny lobster (P Homarus) nursery in a concrete tank with different feed showed in Table 3. The highest BRIX index was 17.64±0.72 % in treatment D, followed by 17.15±0.44% in treatment B, 16.52±0.32% in treatment C, and lowest 15.2±0.43 % in treatment A (<0.05). The brix index value is an indicator that can be used to determine stress conditions in lobsters. The stress level in lobsters is related to some reallocation of metabolic energy, including growth and reproduction. It is associated with increased homeostatic processes, including respiration, movement, and replacement of damaged tissue. Under stress conditions, lobsters produce glucose from glycogenolysis and gluconeogenesis processes when homeostasis is improved during stress (Pascual et al. 2022). Research on stress stimulation for 24 hours in lobster Homarus americanus can stimulate a decrease in hemolymph glucose levels, from which initially 0.85 mmol/l decreased to 0.4 mmol/l (Pascual-Jiménez et al. 2012).

The BRIX index value in lobsters is related to the amount of sugar in the hemolymph, which can affect protein levels. The BRIX index value in lobsters is related to protein levels in hemolymph and inter molting time. High BRIX index values in lobsters generally contain high levels of hemolymph protein. The BRIX index value is also related to the molting cycle. Generally, healthy lobsters have a high BRIX index value, a normal molting cycle, and a high success rate in the molting process. The BRIX Index's highest value generally occurs just before molting time, and its value will decrease after molting time (Berthod et al. 2021).

The observation of the water quality on scallop spiny lobster (P. Homarus) nursery in concrete tanks for 14 weeks with different feeds, including temperature, DO, salinity, ammonia, phosphate, and nitrite (Table 4) showed promising results in a good range of values for spiny lobster growth. The scalloped, spiny lobsters can still grow well in water medium maintenance with a temperature of 25.5-29.5 °C, pH of 7.5-8.5, DO of 4.5-7.5 ppm, and salinity of 25-35 ppt (Slamet et al. 2021). Conditions of maintenance media for P. Homarus spiny lobsters that can still grow well are in a salinity range of 30-35 ppt (Senevirathna, Kodikara, and Munasinghe 2017). The observation of water quality parameters in this study showed that it was still in optimal conditions for lobster life. The results of the observation of the pH value of the water medium in this study were in the range of 7.8-8.3, which was still in a stable condition (Table 4). Spiny lobster (Panulirus spp) juveniles can grow well at pH 7.07-7.86 (Thesiana et al. 2019).

The results of the observation of the water media temperature during the study were found in the range of 28.3-29.5°C, which was still in a good range for lobster growth (Table 4). The measurement of media water temperature during the study also showed relatively stable and good conditions for lobster growth. The fastest growth of P. homarus was achieved at 28°C (Ma et al. 2021). The results of observations of water salinity during the study were found to be 33.8-34.2, which was still in a good range for lobster growth (Table 4). Lobster. P ornatus has a relatively wide tolerance of water salinity conditions ranging from 30 to 40 ppt (Ooi et al. 2019).

In this study, the pellet formula for spiny lobster (treatment D) produced a higher survival rate and growth (body weight and total length) than treatments A, B, and C. Shrimp and spiny lobsters have similar behavioral responses to attractant stimuli. Commercial shrimp pellets have also been tested on juveniles of P. ornatus, P. cygnus, and J. Edwards, with the result that lobsters quickly eat the commercial shrimp pellet feed but still in significantly lower growth and survival than those fed fresh shellfish (Hinchcliffe et al. 2020).

From these results, it can be seen that the nutritional content of commercial shrimp pellets is still not sufficient for lobster life. Spiny lobsters will only be attracted to eat shrimp pellets for 1-2 hours, after which they will stop eating, whereas those of fresh feed clams the lobster will continue to be attracted to eating for 10 hours or more. In Homarus gammarus, optimal growth was achieved when fed a diet containing 55% crude protein and relatively low-fat content (Goncalves et al. 2020). In P. ornatus, in testing, feeds with protein content from 47% to 53% achieved the best growth at higher protein content with 10% fat content (Kropielnicka-Kruk et al. 2022). In J. Edwards, the fat content of the feed did not significantly affect the growth response compared to the protein content of the feed. The best growth was achieved at the crude protein content of 52% (Goncalves et al. 2020).

3.2.2. Grow out

Table 5 and Figure 4 shows that the survival rate of lobsters in the experiment for five months of rearing showed a significant difference ($P<0.05$) among the treatments. Significant differences ($P<0.05$) in survival rates were seen between treatments A versus B and C versus D, while those that were not significantly different ($P>0.05$) were between B and C. The highest survival rate was in treatment D (pellet formula for spiny lobster) with a survival rate of 94.7±4.51%, then lower in B (commercial pellets for grouper) (84.3±3.7)%, followed by C (commercial pellets for shrimp) (82.7 ±3.51 %) and the lowest in A (fresh feed) (51.3±3.06%).

This result shows that commercial pellet for grouper, Commercial pellet for shrimp, and pellet formula for spiny lobster is suitable for scallop spiny lobster feed at reared in a concrete tank, but pellet formula for spiny lobster is most suitable for scallop spiny lobster feed at reared in the concrete tank; because can produce the highest survival rate of spiny scallop lobster. The survival rate during grow out (Figure 4) showed that the survival rate was still almost 100% in the first month (still 100% on B and 98.7% on C and A). The survival rate in the second month was still very high (still 98.7% on B, C, D, and 96% on A), and then a sharp decrease in survival rates in the following sampling.

This condition occurs because of the cannibalism of the lobsters at the time of molting, while the conditions in the first month that most lobsters have not molted. This condition is evidenced by not finding a dead lobster body in the tank. The molt frequency and inter-molt time depend on the age and size of the spiny lobster; the younger lobsters generally have a high molting frequency, so cannibalism is higher than the more giant lobsters (Amiri, Musdalifah, and Amin 2022). In a spiny lobster culture with individual systems, the incidence of cannibalism can be reduced to 100% (Twiname et al. 2022).

From the study results, the growth of lobsters fed with commercial pellet feed for grouper and pellets for shrimp could not be as good as in lobsters fed with fresh feed. The metabolism of spiny lobsters fed with dry pellets of not yet can be as good as that fed with fresh feed (Gora et al. 2018). (Nankervis and Jones 2022) Although artificial feed still does not produce as good growth as fresh feed, research on feed formulas must continue to be carried out; to better start the crayfish's growth (Nankervis and Jones 2022).

Proteins are essential macronutrients for lobsters and should be above 40%. The carbohydrate requirement of lobster feed starts from 24% to 35%. The lower the protein content of the feed will require the higher the feed carbohydrates (Goncalves et al. 2020).

In Table 5 and Figure 5, it can be seen that the body weight data of lobsters in the experiment for five months of rearing showed that there was a significant difference (P<0.05) among the treatments. The highest final body weight was in treatment D (IMRAFE pellet formula) with a final body weight of 204.1±6.84 g, then lower in A (fresh feed) (190.5±6.48 g), followed by treatment B (pellet commercial for grouper) (168.6±5.65 g) and the lowest in C (pellet commercial for shrimp) (144.2±5.27 g).

The growth of the total length of spiny lobster (Panulirus homarus) cultured in concrete tanks for five months fed with different feeds can be seen in Figure 6. In Table 5 and Figure 6, it can be seen that the total length data of lobsters in the experiment for five months of rearing showed that there was a significant difference (P<0.05) among the treatments. The highest final total length was on treatment D (pellet formula of IMRAFE Gondol) with a final total length of 18.1±1.30 cm, then lower in A (fresh feed) (17.6±1.31 cm), followed by treatment B (pellet commercial for grouper) (16.5±1.23) and lowest on treatment C (pellet commercial for shrimp) (16.1±1.26 cm.

The observational data in Table 6 showed that the total hemocyte count obtained was almost the same among the treatments (>0.05). The mean of total hemocyte count was (414±11) x 10^4 cells per ml in treatment A, (471±14) x 10^4 cells per ml in treatment B, (439±15) x 10^4 cells per ml in treatment C, and (498±17) x 10^4 cells per ml in treatment D.

Total Hemocycte Count (THC) is an essential parameter in determining the stress levels in crustaceans (Supriyono et al. 2022). The value of THC is an essential factor in determining the status of the crustacean immune system. It is an important parameter in determining the status of health and immune conditions (Supriyono et al. 2022). High glucose levels in crustaceans indicate stress conditions. High glucose levels in crustaceans indicate stress conditions. Total THC pada lobster jantan dan betina tidak berbeda signifikan (Fitzgibbon et al. 2017). The value of the BRIX index can be used to determine the vitality status of lobsters related to decisions on harvesting and transportation/shipping of lobsters (Shields and Behringer 2004).

One way to determine if a lobster is under stress is to know the concentration of THC (Supriyono et al. 2022). On spiny lobster, Jasus edwardsii, THC, and index hemolymph were reduced after 120 days of exposure to environmental disorders and nutritional disorders (Fitzgibbon et al. 2017). Stressful conditions in lobsters due to mishandling and response to environmental changes can trigger increased cardiovascular activity and increase the amount of THC (Pascual-Jiménez et al. 2012). Most lobsters and marine invertebrates do not have sterile hemolymph (Jung et al. 2021). In spiny lobster exporters, the quality of lobster health can be sorted through the hemolymph brix index (Jung et al. 2021). Stressful conditions in lobsters due to mishandling and response to environmental changes can trigger increased cardiovascular activity and increase the amount of THC. Several things can cause stress in lobsters: environmental stress, handling stress, and bacterial infection stress (Montgomery-Fullerton et al. 2007). Influence on lobsters can affect the viability of their cells (Jung et al. 2021). The number of hemocytes from hemolymph lobsters can decrease drastically when exposed to the attack of milk hemolymph syndrome (MHS) (Nunan et al. 2010). Artificial transmission of the disease in lobsters can be done by injecting hemolymph from the sick to the healthy (Shields and Behringer 2004). In lobster P. cygnus, the average THC concentration is 5.6±0.7 x 106 cells mL-1; at concentrations outside this range, it is unstable (Pascual-Jiménez et al. 2012).

The result of the BRIX index of spiny lobster (P Homarus) reared in a concrete tank with different feed showed in Table 3. The result on observation of the BRIX index was 16.2±3.29 % in treatment A, 17.9±0.31 % in treatment B, 17.1±0.34 % and in treatment C and 18.8±0.33 % in treatment D; not significantly different among treatment (>0.05). The brix index value is an indicator that can be used to determine stress conditions in lobsters. The stress level in lobsters is related to some reallocation of metabolic energy, including growth and reproduction. It is associated with increased homeostatic processes, including respiration, movement, and replacement of damaged tissue. Under stress conditions, lobsters produce glucose from glycogenolysis and gluconeogenesis processes when homeostasis is improved during stress (Pascual et al. 2022). Research on stress stimulation for 24 hours in lobster Homarus americanus can stimulate a decrease in hemolymph glucose levels, from which initially 0.85 mmol/l decreased to 0.4 mmol/l (Pascual-Jiménez et al. 2012).

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The observation of the water quality of the rearing media during five months of the experiment, including temperature, DO, salinity, ammonia, phosphate, and nitrite (Table 4), showed promising results in a good range of values for spiny lobster growth. The scalloped spiny lobsters can still grow well in water medium maintenance with a temperature of 25.5-29.5 °C, pH of 7.5-8.5, DO of 4.5-7.5 ppm, and salinity of 25-35 ppt (Slamet et al. 2021). Conditions of maintenance media for P. Homarus spiny lobsters that can still grow well are in a salinity range of 30-35 ppt (Senevirathna, Kodikara, and Munasinghe 2017). The observation of water quality parameters in this study showed that it was still in optimal conditions for lobster life. The results of the observation of the pH value of the water medium in this study were in the range of 8.0-8.2, which was still in a stable condition (Table 4). Spiny lobster (Panulirus spp) juveniles can grow well at pH 7.07-7.86 (Thesiana et al. 2019).

The results of the observation of the water media temperature during the study were found in the range of 28.4-29.4°C, which was still in a good range for lobster growth (Table 7). The measurement of media water temperature during the study also showed relatively stable and good conditions for lobster growth. The fastest growth of P. homarus was achieved at 28°C (Ma et al. 2021). The results of observations of water salinity during the study were found to be 33.8-34.2, which was still in a good range for lobster growth (Table 7). Lobster. P ornatus has a relatively wide tolerance of water salinity conditions ranging from 30 to 40 ppt (Ooi et al. 2019).

In this study, commercial pellet feed for shrimp (treatment C) produced a higher survival rate than fresh feed (treatment A), although its growth was still slower. Shrimp and spiny lobsters have similar behavioral responses to attractant stimuli. Commercial shrimp pellets have also been tested on juveniles of P. ornatus, P. cygnus, and J. Edwards, with the result that lobsters quickly eat the commercial shrimp pellet feed but still in significantly lower growth and survival than those fed fresh shellfish (Hinchcliffe et al. 2020).

From these results, it can be seen that the nutritional content of commercial shrimp pellets is still not sufficient for lobster life. Spiny lobsters will only be attracted to eat shrimp pellets for 1-2 hours, after which they will stop eating, whereas those of fresh feed clams the lobster will continue to be attracted to eating for 10 hours or more. In Homarus gammarus, optimal growth was achieved when fed a diet containing 55% crude protein and relatively low-fat content (Goncalves et al. 2020). In P. ornatus, in testing, feeds with protein content from 47% to 53% achieved the best growth at higher protein content with 10% fat content (Kropielnicka-Kruk et al. 2022). In J. Edwards, the fat content of the feed did not significantly affect the growth response compared to the protein content of the feed. The best growth was achieved at the crude protein content of 52% (Goncalves et al. 2020).

4. CONCLUSION

Good feeding can improve the health and survival, and growth of lobsters. The feed formula for spiny lobster shows the best performance. The development of the Feed formula for spiny lobster can spur the development of lobster aquaculture in the community. The development of lobster farming can overcome market supply shortages and increase the country's exports and foreign exchange.

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