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Feed/Day: A Case Study on the Growth and Water Quality of Whiteleg Shrimp (Litopenaeus vannamei) Cultivation

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Abstract

Appropriate Feed/Day (F/D) is an important factor in *Litopenaeus vannamei* cultivation activities. The amount of feed that is in accordance with shrimp needs can improve growth performance, but a small amount of feed causes low growth, while excessive feed has an impact on the quality of the aquatic environment. This study aims to determine the amount of F/D that has been arranged on the growth rate and water quality of *L. vannamei* cultivation. The study was conducted using the ex post causal design method in ponds in the Pandeglang area, Banten. The results of the study on the provision of F/D/H that has been arranged on the growth and water quality of *L. vannamei* cultivation showed positive results and had a strong effect. The low MBW value compared to the MBW estimate in the F/D program was caused by feed consumption factors. However, the FCR value based on the cumulative amount of feed and shrimp biomass produced was within the optimal range. The FCR values of ponds 1 and 2 were respectively: 1.35 and 1.58. The growth values of ponds 1 and 2 were respectively: MBW (1.62-14.3 and 1.62-12.80 grams/head), ADG (0.04-0.35 and 0.04-0.24 grams/day), size (400-70 and 330-78 heads/kg), biomass (4,038.68 and 3,718.90 kg), population (327,750 and 311,662 heads) and SR (94.31 and 89.68%). The water quality values are in the optimal range and support MBW growth based on the results of the regression analysis of R^2 = 0.9869 (pond 1) and R^2 = 0.9993 (pond 2). The results of the correlation analysis of F/D provision on growth (0.951652 for pond 1 and 0.944121 for pond 2) and water quality in both ponds are included in the optimal category for several specific parameters such as: temperature (0.496572 and -0.15046), transparancy (0.148697 and 0.564982), salinity (0.385598 and 0.385598), and nitrate (0.514148 and -0.050470).

Keywords: Feed/Day, Growth, *Water Quality, Litopenaeus vannamei*

INTRODUCTION

Feed accounts for 60–70% of aquaculture production costs per cycle. According to Diatin et al., (2008), the proportion of production costs in *L. vannamei* farming consists of: seed (12.02%), energy for paddle wheels (15.80%), feed (70.01%), and other components (2.17%). Production costs can be reduced through proper feed management. Accurate feed administration is essential to minimize production costs, optimize growth and survival rates, and reduce environmental impacts in aquaculture systems. Proper feeding can be achieved by considering specific requirements, feed type and composition, as well as calculating Daily Feed Requirement (DFR). Adequate feeding stimulates *L. vannamei* growth, whereas unutilized feed may cause environmental problems in aquatic systems.

According to Ritonga et al., (2021), feeding must be carefully and precisely managed to prevent nutritional deficiencies that result in slow and uneven growth. Conversely, excessive feeding can pollute the water, deteriorate water quality, and cause shrimp stress and growth inhibition. *L. vannamei* requires specific feed conditions such as sufficient nutrients, appropriate quantity, and feeding frequency. Shrimp feed should contain 6–8% fat, 2% vitamins, 17–43% carbohydrates, 26–45% protein, and 2% calcium minerals (Kaligis, 2015). Davis et al., (2002) stated that amino acids are also required during osmoregulation to maintain ionic

balance. Feeding is commonly applied using blind feeding and demand feeding methods based on days of culture (DOC) and shrimp biomass, with a frequency of 4–6 times per day (Ritonga et al., 2021).

Feeding according to *L. vannamei* requirements is calculated based on Daily Feed Requirement (DFR). DFR refers to the amount of feed provided to shrimp in one day, divided according to feeding frequency. The calculation aims to determine optimal feed requirements that affect growth, survival, and environmental pollution due to excessive feed. Budiyati et al., (2022) emphasized that overfeeding negatively impacts water quality, which in turn affects shrimp health. Inappropriate DFR leads to poor growth and degraded environmental quality.

Feed accumulation in aquaculture systems causes changes and fluctuations in water quality parameters such as increased ammonium, Total Organic Matter (TOM), nitrite, and phosphate. Halim et al., (2021) reported that ammonium concentrations of around 1–6 mg/L are caused by unutilized feed, leading to organic matter accumulation in aquatic environments. Elevated organic matter increases nitrite concentrations and shows positive correlations with other parameters such as nitrate and phosphate (Akbarurrasyid, Prama, et al., 2023). Changes in water quality parameters beyond growth requirements negatively affect *L. vannamei* performance. Based on these considerations, research on daily feeding is necessary to evaluate growth performance and water quality in *L. vannamei* aquaculture.

MATERIALS AND METHODS

Research Location and Period

The study was conducted over three months, from September to November 2025, in Pandeglang, Banten. The research employed an ex post causal design based on the actual conditions of *L. vannamei* aquaculture. Two ponds, each measuring 2,500 m², were observed with a stocking density of 139 shrimp/m² in each pond. The cultivation activities followed identical procedures and stages in both ponds. The farming stages included pond preparation (drying, cleaning, sterilization, repair, and water filling), sterilization and media preparation, seed stocking, maintenance and growth monitoring, as well as harvest and post-harvest activities. Data collected included daily feed requirements, cumulative feed amounts, growth performance, and water quality parameters.

Feed/Day (F/D)

Daily feed requirement calculations were used to determine the feeding needs throughout the *L. vannamei* culture period. Feed requirements were estimated based on target Average Body Weight (ABW), population estimates, survival rates, and total biomass. The F/D values during the study are presented in Table 1.

Table 1. Feed Index Percentage

DOC (Day)	MBW (grams)	Populasi (Ind)	Survival Rate (%)	Biomassa (Kg)	Feeding Rate (%)	F/D (kg)	Cumulative (Kg)	Feeding Frequency
<15	0,1-1,0	347.500-327.075	100-97	34,75-327,07	5-15	12-24	12-246	2-4
16-30	1,1-2,5	327.075-326.650	97-94	35,97-816,62	5-15	26-34	272-690	4-5
31-45	2,6-5,0	326.650-316.225	94-91	849,29-1.581,12	5-10	35-43	716-1128	5
46-60	5,1-8,0	316.225-305.800	91-88	1.612,74-2.446,40	0-7	44-71	1.172-1.966	5
61-75	8,1-14,0	305.800-295.375	88-85	2.476,98-4.135,25	0-5	75-120	2.041-3.449	5
76-90	14,1-18,0	295.375-284.950	85-82	4.164,78-5129,10	0-3	95-125	3.571-5.139	5
>90	>18,1	<284.950	<82	>5.157,59	0-3	>100	>5.249	5

Growth of *L. vannamei*

Growth data of *L. vannamei* collected in this study consisted of Mean Body Weight (MBW), Average Daily Growth (ADG), size, biomass, population, Survival Rate (SR), and Feed Conversion Ratio (FCR). Growth data were obtained through sampling, which began at Day of Culture (DOC) 37 until harvest. Sampling was conducted every seven days by measuring MBW and other growth parameters.

Mean Body Weight (MBW)

Mean Body Weight (MBW) refers to the average weight of shrimp in a pond during a specific period. According to Pramudia et al., (2023), MBW can be calculated using the following formula:

$$MBW\ (grams/ind)\ =\ \frac{Weight\ of\ sampled\ shrimp\ (grams)}{Number\ of\ sampled\ shrimp\ (ind)}$$

Average Daily Growth (ADG)

Average Daily Growth (ADG) refers to the average daily weight gain of shrimp within a specific period. According to Pramudia et al., (2023), ADG can be calculated using the following formula:

$$ADG\ (grams/day)\ =\ \frac{Current\ MBW\ (grams/ind)\ -\ Previous\ MBW\ (grams/ind)}{Sampling\ Interval\ (days)}$$

Size

Size refers to the number of shrimp (individuals) contained in one kilogram of shrimp weight. According to Akbarurrasyid et al., (2023), size can be calculated using the following formula:

$$Size\ (ekor)\ = \frac{1000\ (grams)}{MBW\ (grams/ind)}$$

Biomass

Biomass refers to the total weight of shrimp harvested from a pond. According to Suantika et al., (2018), biomass can be calculated using the following formula:

$$Biomassa\ (kg)\ = \frac{Harvested\ Population\ (ind)\ x\ Harvested\ MBW\ (grams/ind)}{1000}$$

Populations

Populations refers to the total number of shrimp (individuals) maintained until the end of the culture period. According to Effendi, (2000), populations can be calculated using the following formula:

$$Populations\ (ind)\ = \frac{Harvested\ Biomass\ (grams)}{Harvested\ MBW\ (grams/ind)}$$

Survival Rate (SR)

Survival Rate (SR) refers to the proportion of shrimp that survived until the end of the culture period compared to the number of shrimp initially stocked. According to Pramudia et al., (2023), SR can be calculated using the following formula:

$$SR\ (\%) = \frac{Final\ Shrimp\ Population\ (ind)}{Initial\ Shrimp\ Population\ (ind)} x\ 100\%$$

Feed Convertion Ratio (FCR)

Feed Conversion Ratio (FCR) refers to the ratio between the amount of feed, or cumulative feed, provided to shrimp during the culture period and the total shrimp biomass harvested. According to Hou et al., (2023), FCR can be calculated using the following formula:

$$FCR = \frac{Total\ Feed\ Supplied\ (kg)}{Harvested\ Shrimp\ Biomassa\ (kg)}$$

Water Quality in *L. vannamei*

Water quality is a critical factor that must be properly managed in *L. vannamei* aquaculture. Water quality monitoring is conducted through in situ and ex situ observations of aquatic parameters. The parameters and methods used for monitoring water quality in *L. vannamei* ponds are presented in Table 2.

Table 2. Parameters and methods of water quality monitoring

No	Parameters	Observation Technique	Observation Method	Notes
1	Temperature (˚C)	*In situ*	Multi probe*	Measured Daily
2	Transparancy (cm)	*In situ*	Secchi disk**	Measured Daily
3	*power of Hydrogen*	*In situ*	Multi probe*	Measured Daily
4	Dissolved Oxygen (mg/L)	*In situ*	Multi probe*	Measured Daily
5	Salinity (ppt)	*In situ*	Refraktometer*	Measured Daily
6	Nitrite (mg/L)	*Ex situ*	Spectrofotometer*	Weekly Sampling
7	Nitrate (mg/L)	*Ex situ*	Spectrofotometer*	Weekly Sampling

Notes: *Akbarurrasyid et al., (2023); **Inayah et al., (2023)

Data Analysis

Data analysis was performed using regression statistical analysis on F/D data against growth parameters and water quality. Regression analysis was conducted to determine the relationship between F/D and growth parameters, including Mean Body Weight (MBW), Average Daily Growth (ADG), Survival Rate (SR), biomass, and Feed Conversion Ratio (FCR), as well as the relationship between F/D and water quality parameters. The results of the regression analysis are expected to provide evaluation and insights regarding the calculation of F/D in relation to the growth performance and water quality in *L. vannamei* aquaculture.

RESULT AND DISCUSSION

Feed/Day (F/D)

The amount of feed provided during the culture period of *L. vannamei* was determined using a feeding program based on target Mean Body Weight (MBW), estimated population size and survival rate, biomass,

feeding frequency, and Feeding Rate (FR) percentage. The feeding program was classified according to the culture age or Days of Culture (DOC) to determine the daily feed allocation (F/D). The results of the feeding program arrangement for F/D are presented in Figure 1.

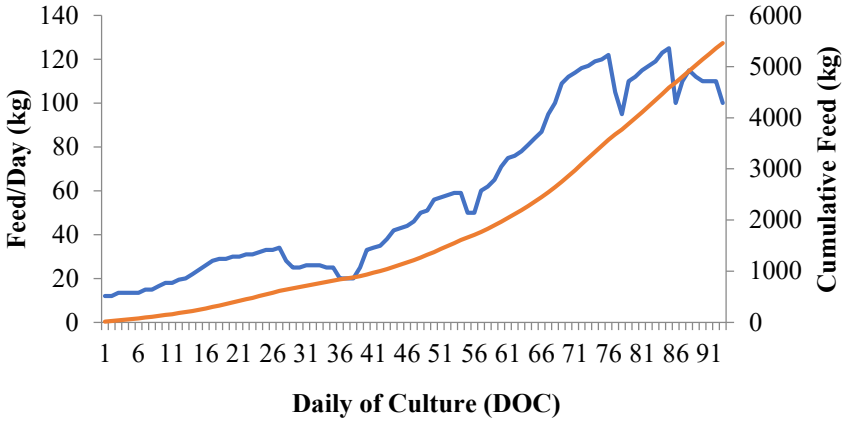


Figure 1. Feeding Program (F/D)

L. vannamei requires sufficient nutrition to support optimal growth, which is closely related to the culture age. During the early culture stage (<15 days, larval stage), shrimp require a high Feeding Rate (FR) of approximately 75–15% with a feeding frequency of 2–4 times per day (estimated Survival Rate of 97–100%). Larvae demand a higher feed percentage relative to body weight (ranging from 0.1–1.0 g), due to their elevated nutritional requirements for growth and development at this stage. According to Nuhman, (2009), *L. vannamei* requires a high feeding percentage during the initial stocking phase, approximately 20–50% of biomass per day, which gradually decreases to about 3% as the culture period progresses. At Days of Culture (DOC) 16–30, the FR percentage decreases to 15–25% of body weight, as Mean Body Weight (MBW) and biomass continue to increase.

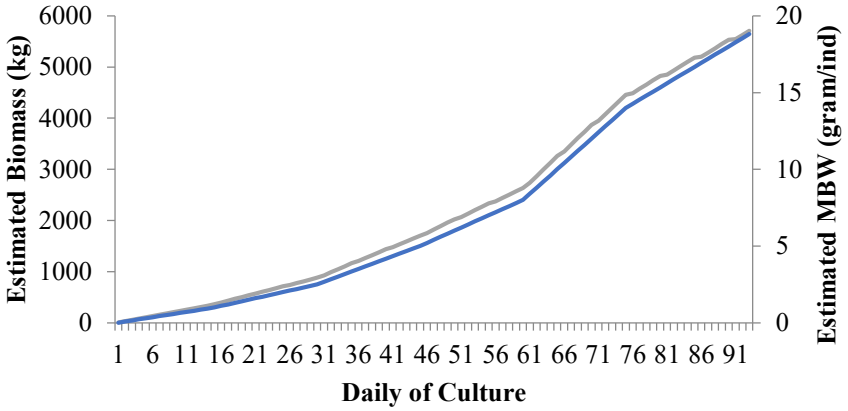


Figure 2. Estimated biomass and MBW

The feeding program established for *L. vannamei* is closely related to the increase in body weight and the estimated MBW values. At Days of Culture (DOC) 16–30, the estimated MBW ranged from 1.1–2.5 g per individual (biomass 35.97–816.62 g), with an estimated Survival Rate (SR) of 94–97% and a feeding frequency of approximately 4–5 times per day (Figure 2). For DOC >30, the feeding program was implemented with a frequency of 5 times per day, with feed amounts adjusted according to target MBW and estimated SR. However, the Feeding Rate (FR) percentage was reduced in line with the increase in DOC. A lower FR percentage does not imply a reduction in feed quantity; rather, it indicates a higher daily feed requirement (F/D). This is due to the relationship between FR percentage, biomass, target MBW, and estimated SR. According to Gompi et al., (2023), the amount of feed provided is relatively controlled based on FR percentage, shrimp body weight, and anchovy percentage. This approach ensures that feed is optimally utilized according to the nutritional needs of shrimp, thereby supporting growth performance.

Growth of *L. vannamei*

L. vannamei cultured in ponds exhibited an increase in body weight in line with the extension of the culture period (Table 2). The results of this study showed growth rates consistent with previous reports. The MBW values obtained ranged from 1.62–14.3 g/individual in Pond 1, while in Pond 2 they ranged from 1.62–12.80 g/individual over a culture period of 94 days. The MBW values indicated that *L. vannamei* effectively utilized the feed provided for growth and development. According to Fatimah et al., (2022), the MBW of *L. vannamei* reached 26.65 g/individual at DOC 110. The increase in shrimp body weight corresponded to the size values obtained. The results showed that size ranged from 400–70 individuals/kg in Pond 1, while in Pond 2 it ranged from 78–330 individuals/kg. The increase in body weight of *L. vannamei* was directly related to the Average Daily Growth (ADG). According to Prasetya et al., (2022), shrimp body weight gain is directly associated with metabolism, which affects growth rate. The ADG values obtained ranged from 0.04–0.35 g/day in Pond 1, while in Pond 2 they ranged from 0.04–0.24 g/day. These ADG values were within the optimal range, which was attributed to favorable environmental conditions and adequate feed quality. Budiyati et al., (2022) reported that environmental factors such as temperature and oxygen availability, as well as sufficient nutritional feed, influence shrimp metabolism and consequently impact growth.

Table 2. Growth of *L. vannamei*

No	Parameters	Pond 1	Pond 2	Optimal Value	Noted
1	Mean Body Weight (gram/ind)	1.62-14.3	1-62-12.80	11.33-26.65*	Optimal
2	Average Daily Growth (gram/day)	0.04-0.35	0.04-0.24	0.110-0.355*	Optimal
3	Size (ekor/kg)	400-70	330-78	520-51**	Optimal
4	Biomass (kg)	4.038,60	3.718,90	3.344-7.683**	Optimal
5	Population (ind)	327.750	311.662	381.915-403.335**	Optimal
6	Survival Rate (%)	94.31	89.68	>86.65*	Optimal
7	Feed Convertion Ratio	1.35	1.58	Maks. 1.47*	Optimal

References: *Fatimah et al., (2022); **Prama et al., (2023)

The final shrimp population at the end of the culture period in Pond 1 was 327,750 individuals, which was higher compared to Pond 2 with 311,662 individuals. This difference was attributed to mortality factors or lower SR values. Nevertheless, the overall final shrimp population was considered high relative to the initial stocking density of 375,000 individuals. According to Prama et al., (2023), shrimp populations between DOC 65–93 ranged from 381,915–403,335 individuals for an initial stocking density of 450,000 individuals. Shrimp population is closely related to SR values in *L. vannamei* aquaculture. The SR in Pond 1 was 94.31%, while in Pond 2 it was 89.68%. These SR values are categorized as high. Furthermore, Prama et al., (2023) reported that the best SR values in shrimp culture are >86.65%. SR significantly influences shrimp biomass in addition to MBW. The biomass of *L. vannamei* in Pond 1 was 4,038.60 kg, while in Pond 2 it was 3,718.90 kg. These biomass values indicate optimal shrimp growth. In general, optimal growth of *L. vannamei* is associated with the feeding program, which calculates daily feed requirements (F/D) based on target or estimated MBW, estimated population and survival rate, biomass, feeding frequency, and Feeding Rate (FR).

The results of this study showed that the estimated MBW in the feeding program and the actual growth of *L. vannamei* (Figure 3) did not differ significantly from the MBW values obtained during grow-out. The difference between actual MBW and estimated MBW in Pond 1 ranged from 2.049–5.523 g/individual, while in Pond 2 it ranged from 1.808–6.009 g/individual. The variation in MBW differences between ponds indicates that the amount of feed provided was not fully aligned with the targeted MBW growth. This discrepancy was influenced by several factors, such as reduced shrimp appetite, decreased metabolism, excessive daily feed allocation, and environmental quality. According to Witoko et al., (2018), aquatic environmental conditions such as low temperature negatively affect shrimp metabolism, leading to reduced appetite and consequently lower growth rates.

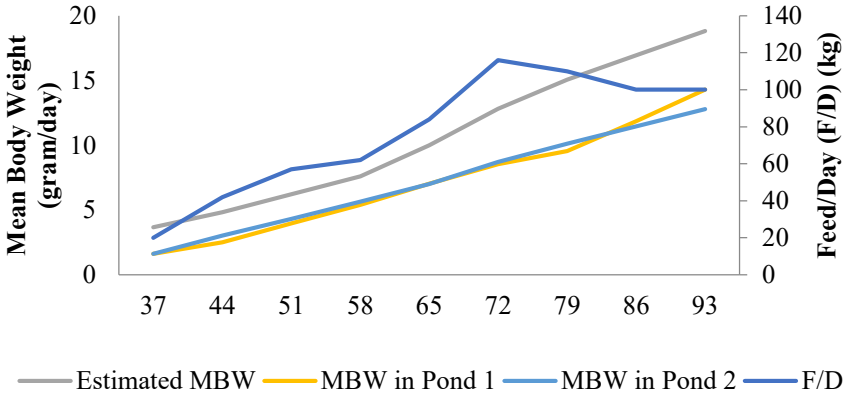


Figure 3. Estimasi MBW in feeding program pakan and actual MBW

The lower growth MBW compared to the estimated MBW resulted in higher cumulative feed input. In Pond 1, the cumulative feed reached 5,459 kg, while in Pond 2 it was 5,883 kg. Cumulative feed is directly related to the Feed Conversion Ratio (FCR), which measures the efficiency of feed utilization in converting feed into shrimp biomass. The FCR obtained was within the optimal category, with values of 1.35 in Pond 1 and 1.58 in Pond 2. A lower FCR indicates that feed conversion into shrimp biomass occurred efficiently, whereas a higher FCR suggests that feed was not fully utilized. According to Budiardi et al., (2008), unutilized feed can deteriorate water quality, leading to higher mortality rates, reduced survival, and ultimately lower production levels.

Water Quality of *L. vannamei*

The water quality in aquaculture systems undergoes varying fluctuations during the cultivation period. Physical and chemical variations in water quality are expected to remain within the required ranges for *L. vannamei* farming activities. The results of water quality observations (Table 3) indicate that the parameters fall within the optimal range prescribed for aquaculture operations. According to Ariadi et al., (2023), stable and ideal water quality concentrations exert a positive influence on shrimp productivity levels.

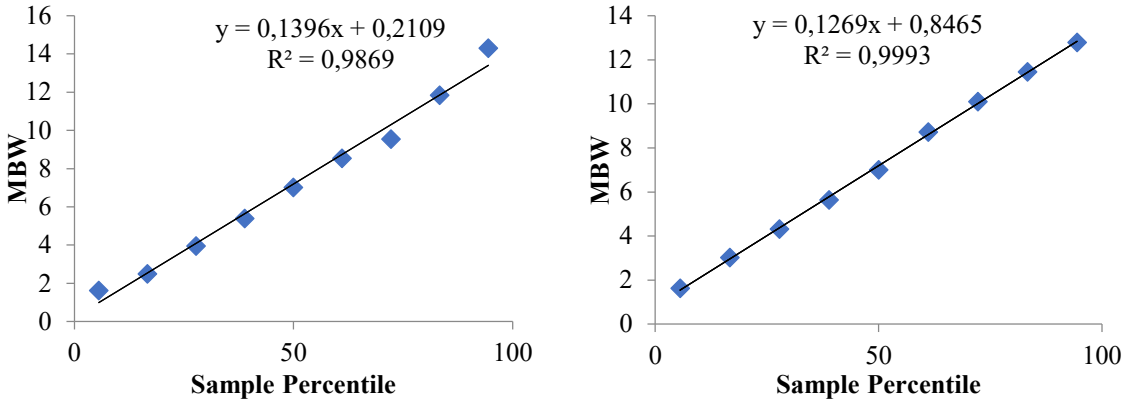
Table 3. Result of water quality observation

No	Parameters (unit)	Ponds		Optimal Value	Noted
		Pond 1	Pond 2		
1	Temperature (˚C)	28-32 30.15±0.98	28-31 29.76±0.89	≥27*	Optimal
2	Transparancy (cm)	30-50 38.84±6.81	35-50 40.38±3.80	30-50*	Optimal
3	*power of Hydrogen*	7.8-8.8 8.41±0.26	7.8-8.8 8.41±0.26	7.5-8.5*	Optimal
4	Dissolved Oxygen (mg/L)	4.2-5.5 4.86±0.41	4.2-5.5 4.86±0.38	≥4*	Optimal
5	Salinity (ppt)	33-35 34.07±0.64	33-35 34.07±0.55	26-32*	Optimal
6	Nitrite (mg/L)	0.01-0.21 0.041±0.056	0.01-0.04 0.02±0.01	≤1*	Optimal
7	Nitrate (mg/L)	15-27 19.76±4.32	15-27 19.07±3.06	3.9-15.5**	Optimal

References: *Kementerian Kelautan dan Perikanan, (2016); **Febrinawati et al., (2020)

The observations of water quality indicated optimal levels for aquaculture activities as required. The recorded temperature ranged between 28–32 °C (30.15 ± 0.98 °C) in Pond 1, while Pond 2 ranged between 28–31 °C (29.76 ± 0.89 °C). According to Patty & Akbar, (2018), fluctuations in water temperature are influenced by weather conditions, wind, atmospheric factors, and solar radiation intensity. Sunlight penetration affects water transparency. The observed transparency values ranged from 30–50 cm (38.84 ± 6.81 cm) in Pond 1 and 35–50 cm (40.38 ± 3.80 cm) in Pond 2. Kementerian Kelautan dan Perikanan, (2016) states that the ideal transparency for vannamei shrimp aquaculture is between 30–50 cm. Low transparency levels are associated

with other parameters such as dissolved oxygen. Dissolved oxygen concentrations obtained ranged from 4.2–5.5 mg/L (4.86 ± 0.41 mg/L) in Pond 1 and 4.2–5.5 mg/L (4.86 ± 0.38 mg/L) in Pond 2. According to Herlina et al., (2023), higher dissolved oxygen concentrations can stimulate the oxidation process of nitrite into nitrate.



Pond 1 Pond 2

Figure 4. Regression results of water quality and growth

The nitrite concentration obtained in Pond 1 ranged between 15–27 mg/L (19.76 ± 4.32 mg/L), while Pond 2 ranged between 15–27 mg/L (19.07 ± 3.06 mg/L). Elevated nitrate concentrations were positively correlated with nitrite parameters (Akbarurrasyid et al., 2023). The nitrite concentration recorded in Pond 1 ranged between 0.01–0.21 mg/L (0.041 ± 0.056 mg/L), whereas in Pond 2 it ranged between 15–27 mg/L (19.07 ± 3.06 mg/L). Nitrite concentration is associated with other parameters such as pH (Farabi & Latuconsina, 2023). The pH values in Pond 1 ranged from 7.8–8.8 (8.41 ± 0.26), and in Pond 2 also ranged from 7.8–8.8 (8.41 ± 0.26). Overall, the water quality parameters obtained were within the optimal category for the growth of *L. vannamei*. The regression analysis of water quality against growth showed that water quality parameters had a very strong relationship. The coefficient of determination (R^2) in Pond 1 was 0.9869, while in Pond 2 it was 0.9993. According to Akbarurrasyid et al., (2023), parameters such as salinity, nitrate, nitrite, temperature, and dissolved oxygen exhibit strong correlations with growth performance indicators including Mean Body Weight (MBW), Average Daily Growth (ADG), and Survival Rate (SR).

Relationship Between Feed/Day (F/D), Growth, and Water Quality

Feed/Day (F/D) plays a crucial role in the growth of *L. vannamei* and the maintenance of aquaculture water quality. Underfeeding leads to inhibited shrimp growth, whereas overfeeding results in unutilized feed accumulation at the pond bottom, which negatively affects water quality. The F/D program must be carefully designed by considering shrimp biomass, feeding methods, dosage, frequency, timing, and the aquaculture technology applied. The formulation of a daily F/D program aims to achieve growth targets, ensure survival, and minimize adverse impacts on water quality. Research findings demonstrated that the F/D program has a very strong correlation with both growth and water quality. The regression analysis of F/D against growth and water quality revealed a very strong relationship, with R^2 values of 0.99997 in Pond 1 and 0.99276 in Pond 2. According to Budiyati et al., (2022), both feeding frequency and dosage should be adjusted to shrimp requirements, as excessive feeding negatively impacts water quality and consequently shrimp growth performance.

Table 4. Correlation results of Feed/Day (F/D) with growth and water quality in Pond 1

	F/D	*MBW*	*pH*	*DO*	*Temp.*	*Salinity*	*Transp.*	*Nitrite*	*Nitrate*
F/D	1								
MBW	0.9516	1							
pH	-0.2321	-0.0666	1						
DO	-0.6356	-0.4463	0.5624	1					
Temp.	0.4965	0.5087	-0.0417	-0.2075	1				
Salinity	0.3855	0.40957	0.3232	-0.3743	0.68211	1			
Transp.	0.1486	0.1328	-0.0284	-0.2090	0.44326	0.5286	1		

Nitrite	-0.4990	-0.6178	-0.2554	-0.1578	-0.8453	-0.4921	-0.3294	1	
Nitrate	0.5141	0.4912	0.1006	-0.5621	0.2282	0.7130	0.54174	-0.1468	1

The correlation results of Feed/Day (F/D) with growth and water quality in Pond 1 (Table 4) and Pond 2 (Table 5) showed varying levels of association. In Pond 1, F/D exhibited a positive correlation with Mean Body Weight (MBW) growth (0.951652) and water quality parameters such as temperature (0.496572), salinity (0.385598), transparency (0.148697), and nitrate (0.514148). Feed administration influenced nitrogen concentrations in shrimp ponds. Unutilized feed contributed to increased nitrate concentrations and transparency. Transparency levels were affected by sunlight intensity, which was related to temperature and evaporation processes, subsequently impacting salinity levels. According to Akbarurrasyid et al., (2023), salinity has a positive correlation with water temperature in *L. vannamei* ponds. Meanwhile, MBW growth was influenced by temperature (0.04335), salinity (0.44594), and transparency (0.66880). Salinity affects shrimp growth performance and is associated with other parameters such as transparency and temperature. Akbarurrasyid et al., (2025) further emphasized that salinity plays an important role in the moulting process, which is closely related to osmoregulation, growth, and survival.

Table 5. Correlation results of Feed/Day (F/D) with growth and water quality in pond 2

	F/D	*MBW*	*pH*	*DO*	*Temp.*	*Salinity*	*Transp.*	*Nitrite*	*Nitrate*
F/D	1								
MBW	0.9441	1							
pH	-0.2321	-0.0464	1						
DO	-0.6356	-0.4345	0.5624	1					
Temp.	-0.1504	0.0433	0.4895	0.3163	1				
Salinity	0.3855	0.4459	0.3232	-0.3743	0.6240	1			
Transp.	0.5649	0.6688	-0.0466	-0.3332	0.3000	0.3050	1		
Nitrit	-0.5523	-0.5010	-0.0503	0.2957	0.4045	-0.2430	0.2292	1	
Nitrat	-0.0504	-0.0917	0.3560	-0.2147	0.1060	0.1765	0.3818	0.3718	1

In Pond 2, Feed/Day (F/D) showed a positive correlation with Mean Body Weight (MBW) growth (0.94412) and water quality parameters such as salinity (0.385598) and transparency (0.564982). Feed administration influenced transparency levels in shrimp ponds. Excessive feeding can increase turbidity and reduce transparency values. Transparency concentration is affected by high organic material derived from excessive feed. According to Halim et al., (2021), the addition of organic matter and plankton density influences fluctuations in water transparency and impacts pH concentration. The correlation results of F/D with water quality in Pond 2 differed from those in Pond 1, particularly in temperature and nitrate parameters. The temperature in Pond 2 was lower (29.76 ± 0.89 °C) compared to Pond 1. Temperature differences affected shrimp metabolism, resulting in lower MBW growth. Nurhasanah et al., (2021) reported that lower temperatures reduce shrimp feed consumption rates, while excessively high temperatures cause feeding activity to cease, thereby inhibiting growth.

Nitrate concentrations also differed between Pond 1 and Pond 2, which was attributed to increased organic matter from unutilized feed. Indications of unutilized feed were reflected in the lower MBW growth in Pond 2. Halim et al., (2022) noted that nitrite concentrations can be identified based on water color; darker water indicates higher organic matter content in ponds and inhibited nitrification processes. Other water quality parameters such as temperature (0.04335), salinity (0.44594), and transparency (0.66880) also influenced growth. Properly designed F/D programs significantly affect shrimp growth and water quality in *L. vannamei* aquaculture. MBW growth was lower compared to the estimated MBW-based feeding program, while water quality parameters such as temperature, transparency, salinity, and nitrate were shown to influence growth. Regression analysis results indicated that F/D strongly affects growth and water quality, while correlation analysis revealed positive associations between F/D and specific water quality parameters.

CONCLUSION

The Feed/Day (F/D) designed for *L. vannamei* aquaculture demonstrated positive and strong effects on growth and water quality. The lower MBW values compared to the estimated MBW in the F/D program were attributed to feed consumption factors. However, the Feed Conversion Ratio (FCR), based on cumulative feed and shrimp biomass, remained within the optimal range. The FCR values in Pond 1 and Pond 2 were 1.35 and

1.58, respectively. Growth performance in Pond 1 and Pond 2 was recorded as follows: MBW (1.62–14.3 g/individual and 1.62–12.80 g/individual), ADG (0.04–0.35 g/day and 0.04–0.24 g/day), size (400–70 and 330–78 individuals/kg), biomass (4,038.68 and 3,718.90 kg), population (327,750 and 311,662 individuals), and Survival Rate (SR) (94.31% and 89.68%). Water quality parameters in Pond 1 and Pond 2 were, respectively: temperature (30.15 ± 0.98 and 29.76 ± 0.89 °C), transparency (38.84 ± 6.81 and 40.38 ± 3.80 cm), pH (8.41 ± 0.26 and 8.41 ± 0.26), dissolved oxygen (4.86 ± 0.41 and 4.86 ± 0.38 mg/L), salinity (34.07 ± 0.64 and 34.07 ± 0.55 ppt), nitrite (0.041 ± 0.056 and 0.02 ± 0.01 mg/L), and nitrate (19.76 ± 4.32 and 19.07 ± 3.06 mg/L). These water quality values were within the optimal range and supported MBW growth, as indicated by regression analysis results with $R^2 = 0.9869$ (Pond 1) and $R^2 = 0.9993$ (Pond 2). Correlation analysis of F/D with growth showed strong positive associations (0.951652 for Pond 1 and 0.944121 for Pond 2). Correlations with water quality parameters in both ponds were within the optimal category for specific parameters such as temperature (0.496572 and –0.15046), transparency (0.148697 and 0.564982), salinity (0.385598 and 0.385598), and nitrate (0.514148 and –0.050470).

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