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GROWTH PERFORMANCE AND SURVIVAL RATE OF VANNAMEI SHRIMP POST LARVAE (*Litopenaeus vannamei*) AT STAGES PL 4-10 FED WITH *ARTEMIA* SP. AND ARTIFICIAL FEED

Performa Pertumbuhan Dan Kelangsungan Hidup Post Larva Udang Vaname (*Litopenaeus vannamei*) Stadia Pl 4-10 Dengan Pemeberian *Artemia* Sp. Dan Pakan Buatan

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ABSTRACT

One of the main challenges in the production of vannamei shrimp larvae is the low quality of the resulting post larvae. This is generally caused by the feed quality and nutritional content that do not adequately meet the optimal requirements of the post larvae. This study aims to evaluate the growth performance and survival of vannamei shrimp post larvae at PL 4-10 stages with feed treatments using *Artemia* sp. and artificial powder feed, as well as to determine the best type of feed. The study was conducted in May at CV. Sumber Hatchery Bangka using an experimental method with a Completely Randomized Design (CRD), consisting of three treatments and five replications: treatment A (100% natural feed with *Artemia* sp. nauplii), treatment B (100% artificial powder feed), and treatment C (a combination of 50% natural *Artemia* sp. nauplii and 50% artificial powder feed). Post larvae were stocked at a density of 20 individuals per liter, totaling 10,000 larvae per tank. Parameters observed included absolute weight gain, absolute length increment, survival rate, and water quality. Data were analyzed using ANOVA with a 95% confidence level followed by a Least Significant Difference (LSD) test. The results showed that treatment C produced the highest absolute weight gain (0.009±0.001 g), which was significantly different ($p<0.05$) from treatments A (0.008±0.001 g) and B (0.007±0.001 g). Treatment C also resulted in the highest absolute length increment (0.456±0.044 cm), significantly different from treatments A (0.394±0.032 cm) and B (0.386±0.047 cm). The highest survival rate was found in treatment A (96±0.038%), followed by treatment B (95±0.025%) and treatment C (91±0.037%). Water quality during the study remained within the optimal range according to SNI 8678-4:2021 standards for vannamei post larva maintenance. In conclusion, the combined feed treatment yielded the best growth performance, whereas 100% natural feed resulted in the highest survival rate.

Keywords: *Artemia* sp. and Artificial Feed, Growth, Survival Rate, Vannamei Post Larvae (PL),Water Quality.

ABSTRAK

Salah satu tantangan utama dalam produksi larva udang vaname adalah rendahnya kualitas post larva yang dihasilkan. Hal ini umumnya disebabkan oleh mutu dan kandungan nutrisi pakan yang belum dapat memenuhi kebutuhan optimal post larva. Penelitian ini bertujuan untuk mengetahui performa pertumbuhan dan kelangsungan hidup post larva udang vaname stadia PL 4-10 dengan pemberian pakan *Artemia* sp. dan pakan buatan powder, serta menentukan jenis pakan terbaik. Penelitian dilaksanakan pada bulan Mei di CV. Sumber Hatchery Bangka menggunakan metode eksperimental dengan Rancangan Acak Lengkap (RAL) tiga perlakuan dan lima ulangan, yaitu perlakuan A (pakan alami naupli *Artemia* sp. 100%), perlakuan B (pakan buatan powder 100%), dan perlakuan C (kombinasi pakan alami naupli *Artemia* sp. 50% dan pakan buatan powder 50%). Post larva ditebar dengan padat tebar 20 ekor/liter, total 10.000 ekor/bak. Parameter yang diamati meliputi pertumbuhan berat mutlak, pertambahan panjang mutlak, kelangsungan hidup, dan kualitas air. Data dianalisis menggunakan ANOVA dengan tingkat kepercayaan 95% dan uji lanjut Beda Nyata Terkecil (BNT). Hasil menunjukkan perlakuan C memberikan pertumbuhan berat mutlak tertinggi (0,009±0,001 g), berbeda nyata (p<0,05) dengan perlakuan A (0,008±0,001 g) dan B (0,007±0,001 g). Perlakuan C juga menghasilkan pertambahan panjang mutlak tertinggi (0,456±0,044 cm), berbeda nyata dengan perlakuan A (0,394±0,032 cm) dan B (0,386±0,047 cm). Kelangsungan hidup tertinggi diperoleh pada perlakuan A (96±0,038%), diikuti perlakuan B (95±0,025%) dan C (91±0,037%). Kualitas air selama penelitian dalam kisaran optimal sesuai SNI 8678-4:2021 untuk pemeliharaan post larva udang vaname. Kesimpulannya, pakan kombinasi memberikan hasil pertumbuhan terbaik, sedangkan pemberian pakan alami 100% menghasilkan kelangsungan hidup tertinggi.

Kata kunci: *Artemia* sp. dan Pakan Buatan, Kelangsungan Hidup, Kualitas Air, Pertumbuhan, Post Larva (PL) Udang Vaname.

INTRODUCTION

Whiteleg shrimp (Litopenaeus vannamei) is a type of shrimp with high economic value and is widely cultivated in Indonesia. Market demand for whiteleg shrimp seeds continues to increase annually, thus offering significant development opportunities for hatchery businesses. The availability of quality seeds, characterized by good larval growth, is a crucial factor for successful shrimp cultivation (Nuntung et al., 2018). Furthermore, whiteleg shrimp also boasts several advantages compared to other shrimp commodities, including greater resistance to disease and environmental changes, the ability to be raised at high stocking densities, faster growth, stress tolerance, a relatively short rearing period, and lower protein requirements (Anam et al., 2016). National whiteleg shrimp production accounts for more than 75% of Indonesia's total shrimp production, with production reaching approximately 1.09 million tons by 2023 (KKP, 2023).

Proper management is essential to ensure high-quality shrimp seeds. This ensures a sustainable supply of whiteleg shrimp fry (Ardiansyah, 2019). Whiteleg shrimp cultivation often faces challenges due to the low quality of hatchery fry, resulting in slow shrimp growth, susceptibility to environmental changes, and high mortality rates. This poor fry quality is usually caused by the type of feed provided and inadequate production technology. Low-quality fry can potentially lead to failure in the shrimp farming process (Suriadnyani et al., 2007). In the post-larval stage, shrimp have very small mouth openings, making feed selection crucial.

According to Purba (2012), adequate feed consumption and adequate nutritional content can influence the average weight and length growth of whiteleg shrimp post-larval individuals. Whiteleg shrimp post-larval development begins with the nauplius stage, then progresses to the zoea, mysis, and finally the post-larva. The zoea and mysis stages are the most vulnerable developmental periods because the survival rate of shrimp during this period is lower than at other stages. At the zoea stage, mortality can reach up to 90% before developing into mysis (Elovaara, 2001). According to Subaidah et al. (2006), larvae at the nauplius stage do not require feeding because they still have food reserves in the form of yolk sacs. However, after reaching the zoea stage, post-larvae begin to require food intake, especially natural foods such as phytoplankton found in the water.

Natural food can be classified into two main groups: plant plankton (phytoplankton) and animal plankton (zooplankton). Both types of food play a crucial role as a source of basic nutrition for whiteleg shrimp post-larvae in their early life stages. The success of whiteleg shrimp cultivation depends heavily on successfully passing through the initial post-larvae maintenance period. One way to improve post-larvae growth and survival is by providing natural food, particularly Artemia sp. According to Hasyim (2002), Artemia sp. is an excellent natural food for shrimp post-larvae. The nutritional content of Artemia sp. The nutrient content is quite high and essential for shrimp needs, including 52.7% protein, 15.4% carbohydrate, 4.8% fat, 10.3% water, and 11.2% ash (Marihati, 2013).

In the maintenance of whiteleg shrimp postlarvae, two types of feed are provided: natural feed and artificial feed. Adequate feed availability is a crucial factor in increasing production. According to Gustrifandi (2011), one of the obstacles to shrimp postlarvae production is low yields due to high mortality rates. This condition is caused by a lack of adequate feed supply, both in terms of quantity and quality. Therefore, the feed used in maintenance must be high-quality, nutritious, and meet shrimp consumption standards. It must be continuously available to avoid hindering the production process and support optimal growth. To increase whiteleg shrimp production, providing feed that meets postlarvae needs is crucial. Chanratchakool et al. (2005) stated that growth, postlarvae survival, and water quality are significantly influenced by the quality and quantity of feed provided. Based on this, research on the provision of Artemia sp. and artificial feed in the maintenance of post-larvae of whiteleg shrimp needs to be conducted to determine the growth performance and survival of post-larvae of whiteleg shrimp at the PL 4-10 stage, as well as to determine the best type of feed that can meet the energy needs of post-larvae in order to produce post-larvae of whiteleg shrimp with good quality.

RESEARCH METHODS

Place and Time

This research was conducted in May 2025 at CV. Sumber Hatchery Bangka, Tuing Hamlet, Mapur Village, Riau Silip District, Bangka Regency, Bangka Belitung Islands. A map of the research location can be seen in Figure 1.

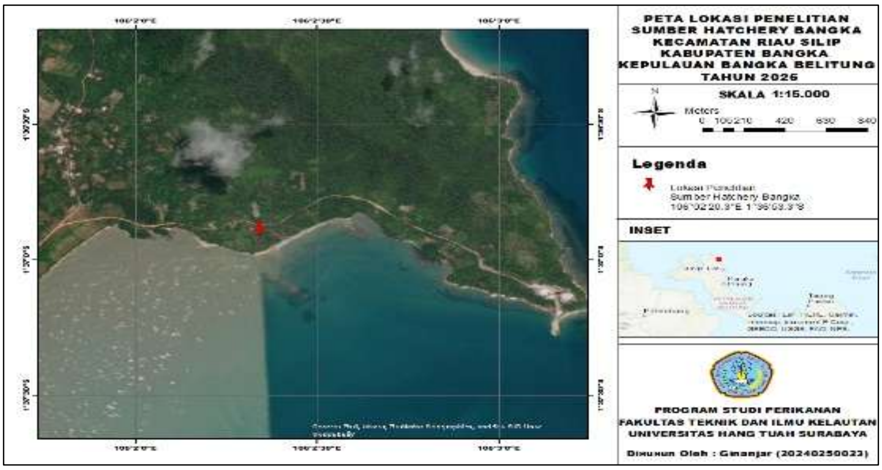

Figure 1. Map of research location

Tools and Materials

In this study, various tools and materials were used to support the successful maintenance of post-larvae of whiteleg shrimp. The tools used included a 2x1x0.4 m3 fiber tank as a maintenance container, aeration as a producer of dissolved oxygen, a digital scale with an accuracy of 0.001 grams to weigh the weight of feed and ingredients, Pro DSS (YSI) to measure multifunctional water quality parameters in real-time such as temperature, salinity, pH, and DO, and spectrophotometry to measure nitrate and ammonia. In addition, a plastic cup was used for the test feed container, stationery for recording data, a ruler for measuring the length of the post-larvae, a basin for the container during the sampling process, a skopnet and scoop for taking post-larvae samples, a cellphone camera as a documentation tool, label paper for marking the container, and a siphon hose for the siphoning process. Each tool has a specific function that is very important in supporting the smoothness and accuracy of the research. Meanwhile, the main materials used include 150,000 post-larvae of PL 4 stage as test biota, seawater as a maintenance medium that replaces the natural environment of vaname shrimp post-larvae, as well as natural feed in the form of Artemia sp. nauplii and artificial feed in powder form which is given as a source of nutrition to support the growth and survival of post-larvae optimally during the research period.

Research Design

The method used in this study was experimental, namely conducting experiments aimed at determining the symptoms or effects arising from certain treatments (Notoatmodjo, 2010). Data were collected through direct observation and a Completely Randomized Design (CRD) was used with three feed treatments and five replications for each treatment, resulting in a total of 15 experimental units. The treatments tested were as follows.
A : Natural feeding of Artemia sp. Nauplii 100%.
B : 100% powder artificial feed.
C : Providing natural feed of Artemia sp. nauplii 50% and artificial powder feed 50%.

The determination of the feed treatment was based on several previous studies showing that natural feed, Artemia sp. nauplii, has a high nutritional content that can support optimal post-larval growth of whiteleg shrimp (Darsiani et al., 2024). Powdered feed was chosen due to its ease of use and its complete and consistent nutritional content, making it effective in mass cultivation (Putri et al., 2020). The combination of the two types of feed in treatment C was designed to test nutritional synergy in supporting optimal growth and increasing post-larval supervivability (Darsiani et al., 2024). The difference from previous studies lies in the focus on testing the proportions of the natural and artificial feed mixture at the post-larval stage PL 4-10 in whiteleg shrimp, with the number of experimental units and analytical methods adjusted to obtain more representative and applicable results in the field.

Research Variables

Research variables consist of independent, dependent, and control variables. Independent variables are variables that influence or cause changes in or the emergence of dependent variables (Sugiyono, 2007). The independent variables in this study were the provision of different types of feed to post-larvae of whiteleg shrimp: 100% natural feed of Artemia sp. nauplii, 100% artificial powder feed, and a 50% combination of both. The dependent variables are variables that are influenced by or result from the independent variables (Sugiyono, 2007). The dependent variables in this study were observations of growth (absolute weight and absolute length) and survival of whiteleg shrimp.

Absolute weight gain

To determine the absolute weight growth of vaname shrimp at the beginning and end of maintenance, it is calculated using the equation according to Effendi (2004), as follows:

$$W_m\ (g) = W_t - W_0$$

Information:
W_m : Weight gain (g)
W_t : Weight of post-larvae of vaname shrimp at the end of the study (g)
W_0 : Weight of post-larvae of vaname shrimp at the beginning of the study (g)

Absolute length increase

Absolute length increase is the difference between body length at the end of the study and body length at the beginning of the study. Absolute length increase is calculated using the equation according to Effendi (2004):

$$P_m\ (cm) = L_t - L_0$$

Information:
P_m : Absolute length increase (cm)
Lt : Average final length (cm)
L_0 : Initial average length (cm)

Survival rate (SR)

The survival rate is the ratio of the number of individuals surviving at the end of the rearing period to the number of individuals at the beginning. Survival is related to mortality, which indicates the number of post-larvae (Effendi, 2004). The equation used to calculate survival is as follows:

$$SR\ (\%) = \frac{Nt}{N0}\ x\ 100\%$$

Information:
SR : Survival rate (%)
N_t : number of post shrimp larvae at the end of maintenance (tail)
N_0 : number of post shrimp larvae at the start of maintenance (tail)

Control variables in this study are factors that are controlled so as not to affect the relationship between the independent and dependent variables. These include materials, equipment, research conditions, and treatment variations that are conditioned the same. During the study, no water changes were performed, only water was added after siphoning once a week to remove dirt and feed residues. Water quality parameters maintained included a temperature of approximately 30-33°C, salinity of 28–34 ppt, pH 7.5–8.5, dissolved oxygen (DO) >5 ppm, nitrite <1 mg/L, and ammonia <1 mg/L. Temperature, salinity, pH, and DO were measured daily using a Pro DSS (YSI) multifunction water quality monitoring device, which is capable of measuring these parameters accurately and in real time in the field. Meanwhile, nitrite and ammonia levels were measured three times a week using a spectrophotometric method, which provides quantitative results regarding the concentration of nitrite ions (NO2-) and ionic ammonia (NH4+) in the culture water.

Data Analysis

Data were analyzed quantitatively using SPSS version 27. The analysis began with a normality test using the Kolmogorov-Smirnov test to detect data distribution; data were declared normal if the significance value was >0.05 (Sugiono, 2013; Arifin, 2017). Next, a homogeneity test was performed to ensure that the variances between groups were equal, with a significance criterion of >0.05 for homogeneous data (Arifin, 2017). To test for differences in means between groups, an ANOVA test was used, which tests the hypothesis of a significant difference between groups (Junri, 2017). The significance criteria for ANOVA are: <0.01 is very significant, 0.01–0.05 is significant, and >0.05 is not significant. If the ANOVA results are significant, the analysis continued with the Least Significant Difference (LSD) test, which compares the means of two groups to determine which pairs are significantly different. However, the LSD test is less appropriate if there are many variable categories (>6) because it can produce biased conclusions.

RESULT

Absolute Weight Gain

Absolute weight growth was calculated by comparing the average initial weight of the rearing with the average final weight of the rearing. Based on the research results listed in Table 1, treatment C showed the highest weight growth with an average of 0.009±0.001 g, followed by treatment A at 0.008±0.001 g, and treatment B with the lowest at 0.007±0.001 g. These data are visualized in the histogram in Figure 2, which illustrates the difference in absolute weight growth between treatments during rearing. These results indicate that the combination of natural and artificial feed (treatment C) has the most positive effect on the weight growth of post-larvae of whiteleg shrimp.

Table 1. Absolute Weight Gain.

Absolute Weight Gain							
Treatment	**Replication**					**Average**	**SD**
	1	**2**	**3**	**4**	**5**		
A	0,007	0,008	0,008	0,008	0,007	0,008 g	0,001
B	0,007	0,007	0,008	0,008	0,008	0,007 g	0,001
C	0,010	0,009	0,010	0,009	0,010	0,009 g	0,001

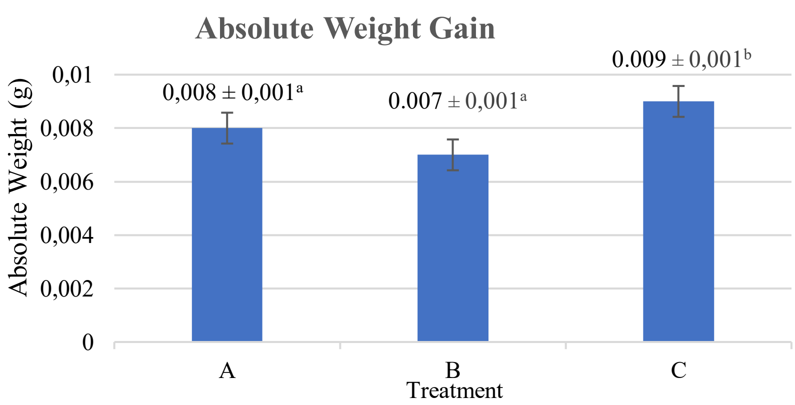

Figure 2. Absolute weight growth histogram

Absolute Length Increase

Absolute length increase is the increase in length that occurs from the beginning to the end of the post-larval maintenance period of whiteleg shrimp. Based on the data in Table 2, treatment C produced the highest absolute length increase, namely 0.456 ± 0.044 cm, followed by treatment A with 0.394 ± 0.032 cm, and treatment B with the lowest at 0.386 ± 0.047 cm.

This increase occurred over 7 days of maintenance and is visualized in the histogram in Figure 3, which shows significant differences between treatments.

Table 2. Absolute Length Increase

Treatment	Absolute Length Increase						
	Replication					Replication	SD
	1	2	3	4	5		
A	0,36	0,39	0,41	0,44	0,37	0,394 cm	0,032
B	0,34	0,33	0,41	0,43	0,42	0,386 cm	0,047
C	0,52	0,40	0,47	0,44	0,45	0,456 cm	0,044

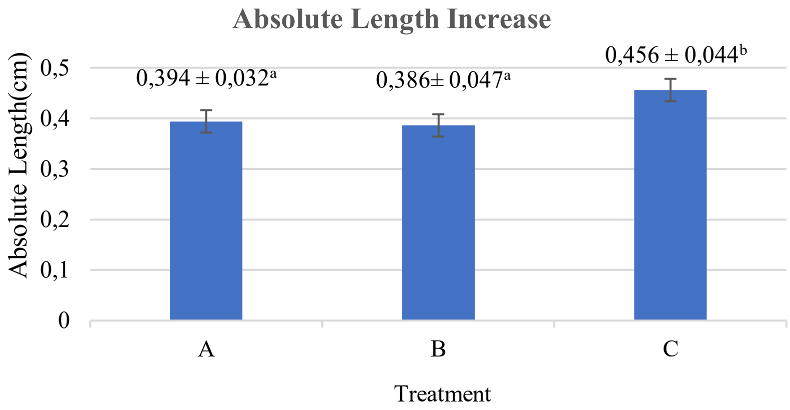

Figure 3. Histogram of absolute length increase

Survival Rate

The postlarval survival rate of whiteleg shrimp is the percentage of larvae still alive at the end of the rearing period, where low survival is caused by high mortality during rearing. Based on the data in Table 3, treatment A showed the highest survival rate at 96±0.038%, followed by treatment B at 95±0.025%, and treatment C with the lowest at 91±0.037%. The histogram in Figure 4 shows significant differences between the treatments. This variation in survival rate is influenced by the type of feed during rearing, where natural feed tends to support higher survival than artificial or combined feed. Thus, feed choice plays a significant role in determining the success of postlarval survival of whiteleg shrimp.

Table 3. Survival Rate

Treatment	Survival Rate						
	Replication					Average	SD
	1	2	3	4	5		
A	99%	94%	90%	97%	99%	96%	0,038
B	98%	98%	95%	93%	93%	95%	0,025
C	87%	94%	90%	96%	89%	91%	0,037

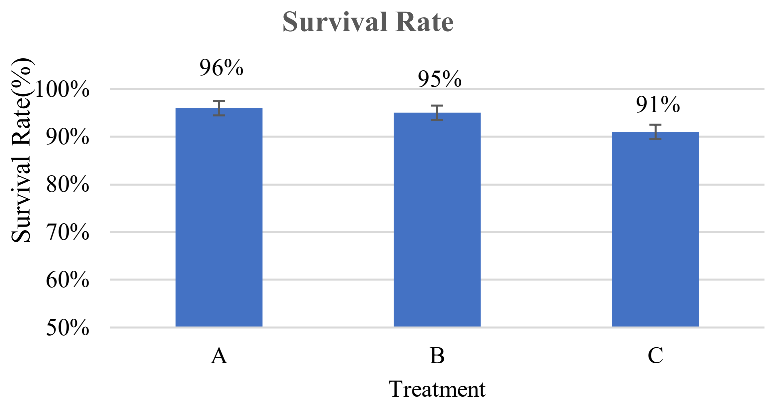

Figure 4. Survival histogram

Water Quality

Water quality is a crucial factor supporting the growth and survival of postlarvae of whiteleg shrimp during cultivation. Observed parameters included temperature, salinity, pH, dissolved oxygen (DO), nitrite, and ammonia. During the 7-day cultivation period, all treatments (A, B, and C) demonstrated water quality values (Table 4) within the optimum range according to SNI 8678-4:2021 and FAO (2020) standards.

Table 4. Maintenance water quality

No.	Parameter	Treatment			Optimum Range
		A	B	C	
1.	Temperature (°C)	30-32,5	30-32,8	30-32,6	30-33
2.	Salinity (ppt)	32	32	32	28-34
3.	pH	8,06-8,48	8,09-8,48	8,02-8,48	7,5-8,5
4.	Dissolve Oxygen (DO) (mg/L)	5,51-6,29	5,67-6,26	5,54-6,31	>5
5.	Nitrite (mg/L)	0-0,083	0-0,102	0-0,096	<1
6.	Ionic Ammonia (mg/L)*	0-0,282	0-0,830	0-0,433	<1

Source: SNI 8678-4:2021, FAO (2020)*, regarding water quality requirements for shrimp post-larva maintenance

DISCUSSION

Absolute Weight Gain

The absolute weight growth of post-larvae of whiteleg shrimp is the average change in weight between the beginning and the end of cultivation. In the study, treatment C, which used a combination of 50% Artemia sp. nauplii natural feed and 50% powdered artificial feed, produced the highest growth of 0.009±0.001 g, followed by treatment A (100% Artemia sp. natural feed) with a growth of 0.008±0.001 g, and treatment B (100% powdered artificial feed) with the lowest growth of 0.007±0.001 g. Further BNT tests showed that different types of feed significantly affected the absolute weight growth of post-larvae of whiteleg shrimp. This growth was influenced by internal factors such as heredity and external factors such as water and feed quality (Panjaitan, 2012). Adequate feed consumption and adequate nutritional content played a significant role in increasing post-larvae growth (Purba, 2012). The combination of natural and artificial feeds provides a synergistic effect by leveraging the advantages of each: Artemia contains essential fatty acids such as EPA (Eicosapentaenoic acid) and DHA (Docosahexaenoic acid), as well as bioactive compounds that support the development of the digestive system and post-larval metabolism (Dhont & Lavens, 2016;

Figueiredo et al., 2020), while the artificial feed is formulated to provide complete and stable nutrition in the water, thus sustainably meeting the needs of post-larvae.

Treatment A demonstrated good growth but was less than optimal compared to the combination because the nutritional quality of Artemia can vary and may lack synthetic micronutrients or vitamins without artificial feed supplementation (Rombenso et al., 2018). Treatment B produced the lowest growth, which may be due to the post-larvae's preference for live feed that stimulates a feeding response and an underdeveloped digestive system to digest artificial feed (Zhang et al., 2019). The feed combination in treatment C combines the high digestibility of natural feed with the high nutritional value of artificial feed, providing significant growth and facilitating feed transition, which is crucial in modern hatchery management (Silva et al., 2021). Visually and from data in Table 1, growth in treatment C was consistent across all replicates, reflecting the continued effectiveness of the feed and serving as a benchmark for industrial aquaculture practices. Furthermore, this combination helps maintain water quality by reducing uneaten feed waste (Liu et al., 2023). Considering growth efficiency, digestibility, and sustainability, the use of a combination of natural and artificial feed is the most optimal strategy for cultivating postlarvae of whiteleg shrimp.

Absolute Length Increase

Absolute length gain is an important indicator for assessing the success of whiteleg shrimp postlarvae rearing, reflecting linear body growth during the rearing period. This length gain is generally driven by the development of the abdominal segments and exoskeleton, which is influenced by various factors, including the type of feed provided. Based on the research results (Table 2), treatment C showed the highest length gain with an average of 0.456±0.044 cm, followed by treatment A at 0.394±0.032 cm, and treatment B at the lowest at 0.386±0.047 cm. Further LSD testing confirmed that treatment C was significantly different from the other treatments, while treatments A and B were not significantly different.

These results indicate that feeding a combination feed provides more optimal length growth than a single feed. Absolute length gain is consistent with absolute weight gain, indicating a positive relationship between weight gain and length of postlarvae. The low length gain in the artificial feed treatment is likely due to inadequate nutritional content and the low palatability and digestibility of the feed in postlarvae whose digestive system is immature. Natural feeds such as Artemia sp. nauplii are superior in terms of palatability and bioactive content, essential fatty acids, and digestive enzymes that support the development of the postlarvae digestive system (Figueiredo et al., 2020). However, natural feeds have nutritional limitations that depend on culture quality and harvest time (Rombenso et al., 2018). On the other hand, artificial feeds can meet the needs of vitamins, minerals, and amino acids measurably, but are less attractive to postlarvae, which are more responsive to live, moving feeds (Silva et al., 2021). In general, these results align with those of Lin et al. (2020), who showed that combined feeds increase nutrient efficiency, support linear growth, and reduce the risk of nutrient deficiencies or excesses. Therefore, a combination of natural and artificial feeds is an effective option to support optimal growth of whiteleg shrimp postlarvae in the early stages of cultivation.

Survival Rate

Survival rate is a crucial parameter in shrimp farming, serving as an indicator of successful rearing and production efficiency. This parameter is calculated by comparing the number of individuals still alive at the end of the culture period to the initial number. The data in Table 3 shows that treatment A yielded the highest survival rate at 96±0.038%, followed by treatment B at 95±0.025%, and treatment C at the lowest at 91±0.037%.

The high survival rate in treatment A is due to the easily digestible nature of the natural Artemia feed, which contains bioactive compounds such as digestive enzymes, polyunsaturated fatty acids (HUFA), and natural antioxidants. The active movement of Artemia in the water also stimulates the post-larvae's feeding instinct, thereby reducing feeding stress and supporting resilience to environmental stress. Treatment B, with a well-formulated artificial feed, also achieved nearly equivalent survival rates, thanks to its content of essential nutrients such as vitamins, minerals, and probiotics/immunostimulants that support the post-larvae's immune system. However, the effectiveness of artificial feed is highly dependent on particle size, water stability, and management to prevent water quality contamination. Meanwhile, treatment C with a combined feed actually showed the lowest survival rate. This is likely related to the poor transition between the two feed types, resulting in some post-larvae not receiving optimal nutrition. Furthermore, inappropriate feeding management can cause stress or nutritional deficiencies, increasing mortality. Another study (Liu et al., 2023) also confirmed that differences in feed type and texture affect feeding behavior and growth uniformity, which impact survival. In addition to feed type, maintaining water quality is also crucial, particularly the removal of residual feed and metabolites, which is also critical to supporting survival. Therefore, combined feeding must be accompanied by strict feeding management and water quality control to be effective.

Water Quality

Water quality is a crucial factor, in addition to feeding management during cultivation. This is because water quality significantly determines the quality and survival of whiteleg shrimp postlarvae. Water quality plays a crucial role in supporting the life and growth of whiteleg shrimp postlarvae. Poor water quality will result in low survival, growth, molting frequency, and an increase in the number of harmful microbes or fungi, especially since shrimp postlarvae are still highly susceptible to environmental changes (Widodo et al., 2011). During the study, key water quality parameters, such as temperature, ranged between 30–32.8°C, in line with the optimal range of 30–33°C, which supports shrimp metabolism and growth (SNI 8678-4:2021). Salinity was stable at 32 ppt, still within the optimal limit of 28–34 ppt, which is important for maintaining osmotic balance and energy efficiency of postlarvae (Zhang et al., 2019). The measured pH values ranged from 8.02–8.48, in accordance with the safe range of 7.5–8.5, because suboptimal pH can interfere with appetite and the molting process (Taqwa et al., 2012). The dissolved oxygen (DO) content during maintenance was in the range of 5.51–6.31 mg/l, meeting the minimum standard of >5 mg/l which is very important for shrimp metabolism (Suwoyo et al., 2013). The measured nitrite concentration was below 0.102 mg/l, still within the safe limit of less than 1 mg/l, although increased nitrite can be toxic and interfere with respiration (Edhy et al., 2010), so the presence of nitrifying bacteria is very important in the nitrification process. Ionic ammonia ($NH4^{+}$) is also maintained below 1 mg/l in accordance with FAO and SNI standards (FAO, 2020; SNI 8678-4:2021), as excess ammonia can damage gills, reduce the blood's ability to transport oxygen, and increase tissue oxygen consumption (Edhy et al., 2010). Therefore, proper and consistent water quality control is crucial to support optimal growth and survival of post-larvae of whiteleg shrimp.

CONCLUSION

Based on the results of the ANOVA test with a 95% confidence level and further LSD testing, it was found that the provision of different types of feed significantly affected the growth of post-larvae of whiteleg shrimp, but did not significantly affect survival. The combination of natural feed of Artemia sp. nauplii and artificial powder feed (50%:50%) produced the best growth, followed by 100% natural feed and 100% artificial feed with the lowest growth results. This feed combination is effective in maximizing growth without reducing survival.

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