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The Effects of Pond Type and Water Quality Dynamics on Vannamei Shrimp Growth: A Dummy Regression Analysis

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Abstract: Vannamei shrimp is one of Indonesia's leading aquaculture sector commodities due to its high survival rate, short cultivation time, and disease resistance. Vannamei shrimp cultivation in Indonesia adopts an intensive system favoured for high productivity. In intensive cultivation systems, shrimp ponds typically utilize concrete or high-density polyethylene (HDPE) ponds. Each type has its own positive and negative side that affects the growth and production of Vannamei shrimp. Apart from the type of pond, water quality also played an important role in the growth of Vannamei shrimp. Water quality is one of the important factors in intensive shrimp cultivation. Pond type is categorical data and has a nominal measurement scale, while water quality is numerical data with a ratio measurement scale; ordinary regression analysis is unsuitable for analyzing the effect of pond type and water quality on the growth of Vannamei shrimp. Therefore, a dummy regression model accommodates these measurement scale differences. This research aims to determine the effect of different types of ponds and water quality dynamics on the growth of Vannamei shrimp and to select the best type of pond for intensive cultivation of Vannamei shrimp. Additionally, it aims to identify the water quality parameters that most influence the growth of Vannamei shrimp so that it can serve as a reference for Vannamei shrimp farmers to achieve high productivity efficiently. The study was conducted from November 2022 to January 2023 in Banyuwangi Regency, East Java Province, Indonesia. There are three concrete ponds and 10 HDPE ponds. The research method employed in this study is a survey method utilizing simple random sampling. The parameters in this research are the quality of cultivation water, including pH, temperature and dissolved oxygen (DO). The water samples taken are then measured for water quality in the laboratory. The results of this study indicate that the average values for water quality are still within the optimal range. The average ABW in HDPE and concrete ponds ranges from 2.30 to 9.39 grams per shrimp and 2.22-9.73 grams per shrimp. Based on the study's results, it can be concluded that different pond types and water quality dynamics, specifically pH and temperature, affect shrimp growth based on ABW. However, when considering SGR values, the type of pond does not have a significant impact. The water quality parameters that affect SGR are pH and temperature.

Keywords: Dummy Regression; Pond Type; Vannamei shrimp; Water Quality.

Introduction

Vannamei shrimp is one of Indonesia's leading aquaculture sector commodities due to its high survival rate, short cultivation time, and disease resistance. These factors contribute to the popularity of shrimp cultivation [1]. Generally, Vannamei shrimp cultivation in Indonesia adopts an intensive system favoured for its high productivity [2].

Shrimp ponds typically utilize concrete or high-density polyethylene (HDPE) ponds in intensive cultivation systems. Each type has its own positive and negative side that affects the growth and production of Vannamei shrimp. Concrete ponds are favoured for their easy maintenance, durability, and minimal direct impact on water quality [3]. However, they are prone to erosion and leakage, which can be mitigated through regular maintenance [4]. On the other hand, HDPE ponds offer benefits such as reduced risk of water absorption into the soil, resistance to UV light exposure, and durability [5].

Apart from the type of pond, water quality also played an important role in the growth of Vannamei shrimp. Water quality is one of the important factors in intensive shrimp cultivation. Water quality is dynamic and fluctuates over time [6]. Good water quality parameters will make cultivation run stably and follow the water quality standard threshold values for shrimp cultivation activities, which is an important point that shrimp farmers must pay attention to [7].

Pond type and water quality play a crucial role in the growth of Vannamei shrimp. The right type of pond and good water quality will produce good shrimp growth, ultimately producing optimal productivity. Therefore, further research is needed regarding the influence of pond type and water quality dynamics on the growth of Vannamei shrimp. This research aims to determine the effect of different types of ponds and the dynamics of water quality on the growth of Vannamei shrimp

Pond type is categorical data with a nominal measurement scale, while water quality is numerical data with a ratio measurement scale. Ordinary regression analysis is unsuitable for analyzing the effect of pond type and water quality on the growth of Vannamei shrimp. Therefore, a dummy regression model accommodates these measurement scale differences. Moreover, this analysis enables us to determine the effect of different types of ponds and water quality dynamics on the growth of Vannamei shrimp and

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select the best type of pond for intensive cultivation of Vannamei shrimp. Additionally, it aims to identify the water quality parameters that most influence the growth of Vannamei shrimp so that it can serve as a reference for Vannamei shrimp farmers to achieve high productivity efficiently.

Research Methods

The study was conducted from November 2022 to January 2023 in Banyuwangi Regency, East Java Province, Indonesia. There are three concrete ponds and 10 HDPE ponds. The research method employed in this study is a survey method utilizing simple random sampling. The parameters in this research are the quality of cultivation water, including pH, temperature and dissolved oxygen (DO). The water samples taken are then measured for water quality in the laboratory. Water quality measurements are carried out in the morning and daytime (pH and temperature), while for Do, it is carried out in the daytime in these ponds. Average Body Weight and Specific Growth Rate measured shrimp growth. Average Body Weight (ABW)and Specific Growth Rate (SGR) were calculated by the following formula:

Average Body Weight [8].

$$\text{ABW} = \frac{\text{Shrimp sampling weigh (g)}}{\text{Numbers of shrimp}}$$

Spesific Growth Rate [9].

$$\text{SGR} = \frac{\ln \text{final weight} - \ln \text{initial weight}}{\text{days of experiment}} x\ 100$$

All research variables were measured every three days from DOC 32 to DOC 53. The Water quality and shrimp sampling points can be presented in Figure 1 and 2.

Dummy Regression

In regression analysis, categorical variables can be very useful as predictors. Dummy variables can represent qualitative variables. These variables typically have two possible values: 0 and 1. The numerical values (0 and 1) are not intended to represent a quantitative order of the categories but rather to identify category or class membership. The dummy regression model in this study is as follows [10]:

$$Y_i = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 D_i$$

Where:

Y_i : Vannamei Shrimp Growth (ABW and SGR)
β_0 : intercept
$\beta_1, \beta_2, \beta_3, \beta_4$: regression coefficients
X_1, X_2, X_3 : predictor variables (pH, temperature, DO)
D_i : Dummy variable (1 = HDPE, 0 = Concrete)

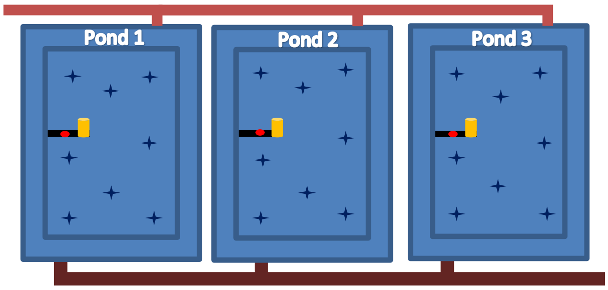


Figure 1. Concrete Ponds.

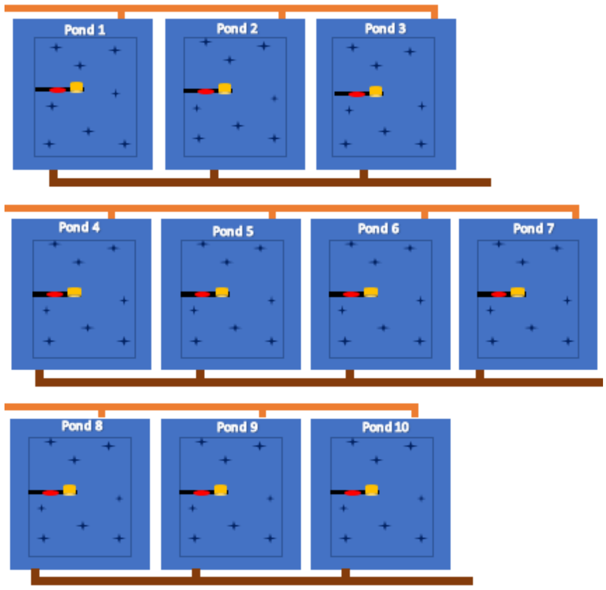
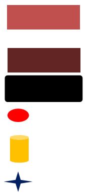


Figure 2. HDPE Ponds.



: shrimp pond inlet channel
: shrimp pond outlet channel
: feed tray bridge
: Sampling point
: Auto feeder
: Paddlewheel

Results and Discussion

The investigation yielded several outcomes, including water quality (pH, temperature, DO) and shrimp growth (ABW and SGR). An explanation of the research observation data that was collected is provided below:

Water Quality

Effective water quality management ensures aquaculture compliance, enhancing pond productivity [11]. Optimal water quality supports both growth and survival rates. The average results of water quality observations in ten research ponds with HDPE and concrete pond types and optimal cultivation standards can be seen in Table 1.

Temperature

The average temperature parameter measurement results in HDPE ponds in the morning and daytime range from 28.1-30.4°C and concrete ponds range from 28.1-29.9°C, the average value of dissolved oxygen in HDPE ponds ranges from 4.01-4.92 ppm, and concrete ponds range between 4.47-4.92 ppm, and the average value of morning and daytime pH parameters in HDPE ponds ranges between 7.98-8.34 and concrete ponds range between 8.16-8.44. The average value of these parameters follows the optimal standards in Regulation of the Minister of Marine Affairs and Fisheries of the Republic of Indonesia (RMMAFRI) No. 75 of the year 2016, which states that the optimal temperature value for vannamei shrimp cultivation is 28–32 °C, the optimal dissolved oxygen value for cultivation is ≥4 ppm, and the optimal pH value is 7.5–8.5.

The water temperature in both types of ponds shows different fluctuations at each measurement. The average temperature of the HDPE ponds in the morning ranges from 27.3-28.7℃; in the daytime, it ranges from 28.9 to 31˚C. Meanwhile, the average concrete pond temperature in the morning ranges from 27.3 to 29 °C and during the day ranges between 29.3 to 30 °C. The research results show that the average water temperature of shrimp cultivation in a HDPE pond in the daytime has an average value of 28.1 °C and an average daytime value of 30.12 °C. In contrast, the average water temperature of a concrete pond in the morning daylight is 28.17 °C. The mean value is 29.9 °C in the evening, which is the optimum value for cultivating a van of udame. The optimal value aligns with the statement of [12] that the water temperature range is good for the growth of shrimps in an intensive system is 26-32 ° C. The fluctuation of water temperature in both types of ponds can be seen in figure 3.

Table 1. Observation data and optimal standards for temperature, dissolved oxygen, and pH

Pond Type	Pond	Temperature Morning	Temperature daytime	Dissolved Oxygen	PH Morning	PH daytime
		Result				
HDPE	H1	28.1	30	4.70	8.00	8.34
	H2	28.1	30	4.65	7.99	8.25
	H3	28.1	30	4.56	7.98	8.25
	H4	28.1	30	4.69	7.99	8.30
	H5	28.1	30	4.78	7.99	8.30
	H6	28.1	30	4.65	7.99	8.34
	H7	28.1	30	4.92	8.00	8.31
	H8	28.1	30.4	4.10	7.95	8.09
	H9	28.1	30.4	4.01	7.98	8.09
	H10	28.1	30.4	4.15	7.93	8.06
Concrete	B1	28.3	29.9	4.47	8.18	8.43
	B2	28.1	29.9	4.85	8.16	8.43
	B3	28.1	29.9	4.92	8.21	8.44
		Optimal Standard				
Temperature		28-32 (°C)		RMMAFRI No. 75(2016)		
Dissolved Oxygen		≥4 ppm		RMMAFRI No. 75(2016)		
pH		7.5-8.5		RMMAFRI No. 75(2016)		

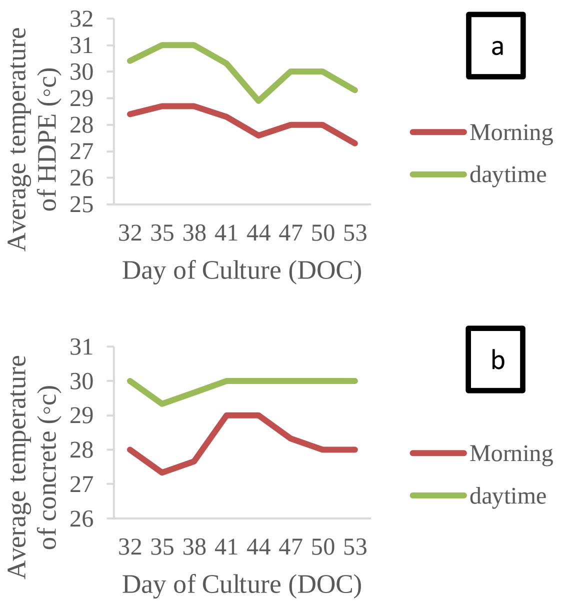


Figure 3. The fluctuation of water temperature of HDPE Ponds(a), Concrete ponds (b)

The temperature parameter values in HDPE ponds fluctuate more than in concrete ponds. This is influenced by the fact that HDPE absorbs heat more rapidly, as stated by [13], which indicates that HDPE plastic has a higher heat absorption capacity, leading to quicker temperature changes. Consequently, variations in external temperature may affect the water temperature in HDPE ponds to a greater extent than in concrete ponds. HDPE ponds tend to have more exposed surfaces and are susceptible to direct sunlight exposure. This can result in excessive heat entering the water of the HDPE pond, causing greater temperature fluctuations. In contrast, concrete ponds maintain a more stable temperature because concrete can retain heat, as noted by [14], who assert that ponds made from concrete can stabilize temperature, resulting in more consistent thermal conditions. Concrete can store heat for longer periods, slowing down temperature changes caused by weather or environmental conditions fluctuations. The temperature in concrete ponds tends to rise or fall gradually, contributing to greater stability. In addition to pond type, environmental factors affect temperature, including air temperature, sunlight exposure, water clarity, plankton density, and aquaculture management practices, which can also influence temperature stability in concrete and HDPE ponds [15].

Dissolved Oxygen

Dissolved oxygen (DO) parameter measurements show differences in the average water temperature values in HDPE and concrete ponds used to cultivate vannamei shrimp (L. vannamei). Dissolved oxygen levels in HDPE ponds are typically lower than in concrete ponds. The average dissolved oxygen values in HDPE ponds range from 4.37-4.66 ppm, while the average dissolved oxygen values in concrete ponds range from 4.52-4.96 ppm. The research findings reveal that the average dissolved oxygen solubility in shrimp aquaculture water in HDPE ponds is 4.52 ppm. It is 4.75 ppm in concrete ponds, which falls within the optimal range for vannamei shrimp cultivation. These optimal values are aligned with RMMAFRI No.75 2016, which states that the dissolved oxygen range in good-quality water for shrimp growth in intensive systems is ≥4 ppm. The fluctuation of dissolved oxygen in both ponds can be seen in Figure 4.

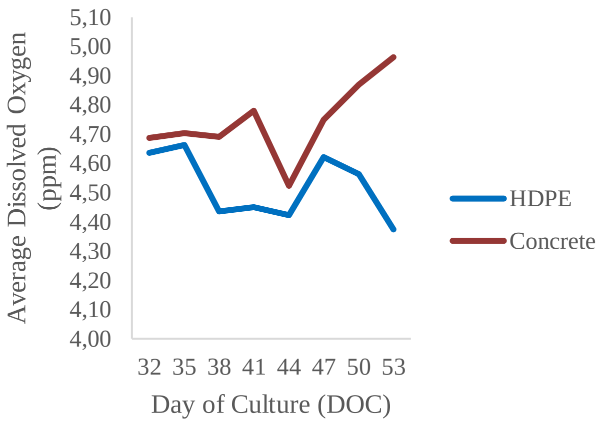


Figure 4. The fluctuation of dissolved oxygen in HDPE and Concrete ponds

The solubility of oxygen in vannamei shrimp ponds depends on the presence of aerators and the population density of the shrimp in the pond. According to [16], aerators should be adjusted based on stocking density and pond surface area, where a 1 HP aerator can accommodate biomass up to 500 kg of shrimp. Aerators serve not only to supply oxygen through air diffusion but also to create water flow across the pond surface. The current generated by the aerators can influence the homogenization of temperature and stabilization of parameters, leading to uniformity of conditions throughout the pond and minimizing temperature stratification and other water quality parameters. Inconsistencies in water quality can cause stress in shrimp, making them more susceptible to diseases, which can adversely affect the growth rates and survival of vannamei shrimp [6]. Environmental factors such as temperature, sunlight, and weather can also influence the dissolved oxygen content in the pond. Ponds with different environmental conditions may exhibit variations in oxygen absorption. Elevated temperatures in HDPE ponds can increase shrimp metabolism, resulting in higher oxygen consumption than concrete ponds and leading to lower dissolved oxygen levels in HDPE ponds.

Power of Hydrogen (pH)

The measurement results indicate that the average pH values of HDPE and concrete ponds in the morning and afternoon are not significantly different in each research pond. This is consistent with [17] that water pH in ponds tends to be constant and stable. The stability of pH in intensive system ponds is influenced by alkalinity as a buffering compound and oxygen from aerators, in line with [15] that ponds with high total alkalinity have lower pH fluctuations compared to those with low alkalinity due to the buffering capacity of alkalinity. pH changes directly affect photosynthesis, which utilizes CO2, lowering the H+ concentration and raising water pH.

The average pH parameter values during the shrimp aquaculture research in HDPE ponds in the morning were 7.98 and in the afternoon were 8.23, while the average pH values in concrete ponds in the morning were 8.18 and in the afternoon were 8.43. During that time, pH fluctuations tend to increase in the afternoon due to increased phytoplankton activity. The average pH in both types of ponds can be seen in figure 5.

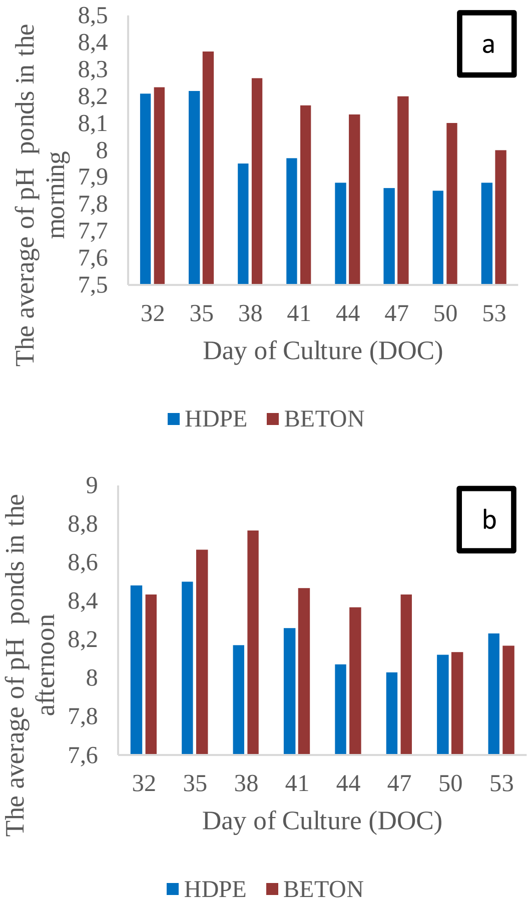


Figure 5. The fluctuation of pH in HDPE and Concrete ponds in the morning (a) and Afternoon (b)

The acidity degree, or pH, can influence the presence or concentration of several compounds in water, such as carbon dioxide (CO_2) and bicarbonate (HCO_3^-) [18]. The presence of these compounds can affect the water's ability to retain or conduct heat, thereby impacting water temperature. However, this influence is more related to the physical properties of water rather than a direct effect of pH on temperature. Environmental conditions such as sunlight intensity, air temperature, and water quality can affect pH and temperature in vannamei shrimp ponds.

The pH level in vannamei shrimp ponds (L. vannamei) can influence the solubility of oxygen in the water. At high pH levels, the concentration of hydroxide ions (OH^-) in the water increases, which can bind with metal ions such as iron (Fe) and manganese (Mn), forming sediments that reduce oxygen solubility in the water [19]. As a result, ponds with high pH tend to have low dissolved oxygen levels, which can negatively impact shrimp survival. This is consistent with the statement by [20] that dissolved oxygen variables are negatively correlated; as pH, salinity, and sediment thickness increase, dissolved oxygen in the water may decrease. Elevated pH can also enhance decomposer activity.

Concrete tends to have the capacity to raise the water pH due to chemical reactions between the materials in concrete and water. This can lead to the release of alkaline compounds into the pond water, increasing the pH value. Environmental factors such as water source, sunlight exposure, and surrounding environmental influences can affect the pH of pond water. Different water exchange systems or water management practices in concrete and HDPE ponds can influence pH changes. Replacement or additional water sources used in concrete ponds may have different pH values. High pH can be mitigated by increasing alkalinity through liming to enhance the water's buffering capacity. Additionally, reducing plankton density can help lower pH levels [15].

Growth of Cultivated Shrimp

The growth of vaname shrimp (L. vannamei) is influenced by various factors. Factors that influence the growth of vaname shrimp are water quality, including temperature parameters, dissolved oxygen and pH in aquaculture pond waters [21]. Vaname shrimp growth is one of the performances of vaname shrimp cultivation, which can be seen by calculating the average shrimp weight (ABW) and specific shrimp growth rate (SGR) [22].

Average Shrimp Weight (ABW)

The results of the average growth weight of vaname shrimp (L. vannamei) during four sampling times are presented in the ABW graph and can be seen in Figure 6.

The results of the research showed that the growth of a name shrimp based on the average value of shrimp weight or Average Body Growth (ABW) in High-Density Polyethylene (HDPE) ponds and concrete ponds for cultivating name shrimp (L. vannamei) had results with different average values at each sampling. The average weight value of HDPE pond shrimp (H1 = 2.31-8.49 g/head; H2 = 2.30-8.71 g/head; and H3 = 2.76-9.01 g/head, H4 = 2.70-9.39 g/head, H5 = 2.63-9.39 g/head, H6 = 2.31-7.84 g/head, H7 = 2.30-7.32 g/head , H8 = 2.31-8.49 g/head, H9 = 2.30-7.84 g/head, and H10 = 2.76-9.01 g/fish), while the average value of pond shrimp weight concrete (B1 = 2.34-9.71 g/head; B2 = 2.22-9.53 g/head; and B3 = 2.48-9.73 g/head) for 4 sampling times.

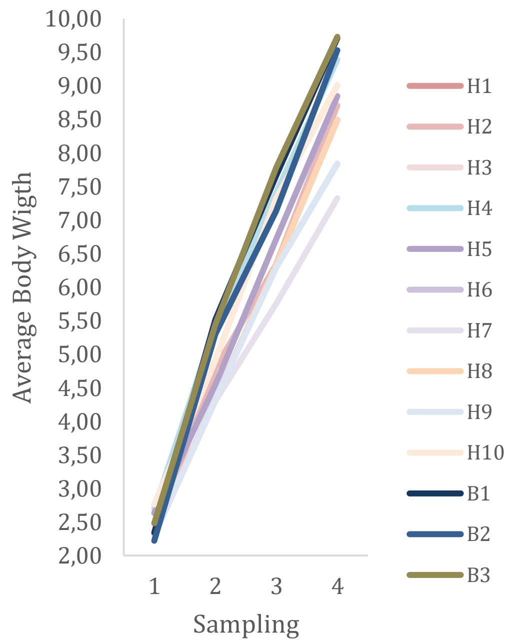


Figure 6. Average Body Weight (ABW) of vaname shrimp

Specific Growth Rate (SGR)

The results of the Specific Growth Rate (SGR) of vaname shrimp (L. vannamei) during four sampling times are presented in the SGR graph can be seen in Figure 7 as follows:

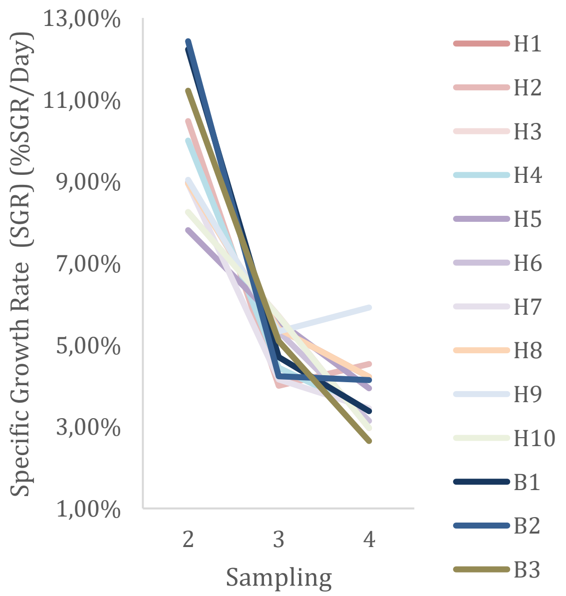


Figure 7. Specific Growth Rate (SGR) of vaname shrimp.

The research results indicate that the growth of white shrimp (Litopenaeus vannamei), based on the Specific Growth Rate (SGR) in HDPE and concrete ponds, shows different values at each sampling. The SGR value at sampling 2 (DOC 40) in concrete ponds tends to be higher than in some HDPE ponds. The variability in SGR is influenced by the Average Body Weight (ABW), which is affected by temperature dynamics during each measurement and morning-afternoon fluctuations. Besides temperature, the SGR variability is also influenced by dissolved oxygen levels, where HDPE ponds have lower dissolved oxygen levels than concrete ponds, impacting white shrimp's metabolism and growth rate. The SGR values at samplings 3 and 4 (DOC 46 and 53) in concrete ponds tend to be lower than those in HDPE ponds. The SGR of shrimp is affected by high stocking densities, which reduce the specific growth rate of white shrimp. The SGR values across the 13 research ponds from sampling 1 to 4 tend to show a decline.

The Effects of Pond Type and Water Quality Dynamics on Vannamei Shrimp Growth

The influence of pond type and water quality dynamics on the growth of vannamei shrimp can be determined through dummy regression analysis. Based on the analysis results using IBM SPSS Statistics 26 software, the output for analysing the influence of pond type and water quality dynamics on AWB can be seen in table 2.

Table 2. Dummy regression analysis of ABW

Coefficients[a]						
		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
Model		B	Std. Error	Beta		
1	(Constant)	121.939	15.737		7.749	0.000
	Type of pond	-3.039	0.536	-0.741	-5.674	0.000
	Ph	-3.600	1.214	-0.368	-2.965	0.006
	Temperature	-2.741	0.367	-0.838	-7.476	0.000
	Do	-0.961	0.585	-0.203	-1.643	0.110

a. Dependent Variable: ABW

Table 3. Dummy Regression Analysis of SGR

Coefficients[a]						
		Unstandardized Coefficients		Standardized Coefficients		
Model		B	Std. Error	Beta	t	Sig.
1	(Constant)	-151.741	31.064		-4.885	0.000
	Type of pond	2.026	1.057	0.312	1.916	0.064
	Ph	6.114	2.397	0.395	2.550	0.015
	Temperature	3.633	0.724	0.702	5.020	0.000
	Do	0.390	1.154	0.052	0.338	0.737

a. Dependent Variable: SGR

Based on table 2, the pond type, pH, and temperature have significance values greater than 0.05, indicating that these three variables significantly impact AWB. In contrast, DO (Dissolved Oxygen) does not have a significant effect on AWB (significance value > 0.05).

The results of ABW measurements in HDPE and concrete ponds from Sampling 1 (DOC 32) to Sampling 4 (DOC 53) indicate that the ABW in concrete ponds tends to be higher than in HDPE ponds. This is because the temperature in concrete ponds is more stable than in HDPE ponds, which exhibit greater fluctuations that affect the feeding behaviour of vannamei shrimp, influencing the ABW values. The ABW values across all 13 research ponds continuously increased from Sampling 1 to Sampling 4. The impact of temperature on ABW depends on the cultivation conditions and the shrimp's developmental stage. An appropriate and optimal temperature can enhance the metabolic rate and feed efficiency in vannamei shrimp, leading to faster growth and higher ABW compared to conditions where the temperature is not ideal for shrimp growth [23]. This is consistent with (RMMAFRI) No. 75 of the year (2016), which states that the optimal temperature range for good shrimp farming is between 26-32°C, as it supports efficient metabolism and digestion. Non-optimal water temperatures can lead to a decrease in appetite, accompanied by a slowdown in the shrimp's metabolic system, thereby slowing the growth rate of the shrimp.

The pH levels in aquaculture ponds can indirectly affect the growth of vannamei shrimp (L. vannamei) through their impact on the balance of the aquatic environment. Water pH that is too low or too high can disrupt the chemical balance in the water, such as nutrient solutions and ions essential for shrimp growth. Inappropriate pH levels or extreme pH fluctuations can cause stress in shrimp. Stress can disrupt the shrimp's feeding patterns, activity, and metabolism, ultimately affecting their growth rate. This is supported by [24], who stated that unstable water quality parameters, particularly pH, can cause stress in shrimp, leading to disease outbreaks and even shrimp mortality.

The average ABW in concrete ponds is higher than in HDPE ponds. This difference is attributed to the varying abilities of concrete and HDPE ponds to maintain water quality. Unstable water quality can lead to a decrease in shrimp appetite. A decline in shrimp appetite affects nutrient absorption, resulting in lower shrimp weights. This is supported by [25], who stated that poor water quality, particularly in terms of temperature, can reduce shrimp appetite, leading to slower growth, as indicated by lower shrimp weight.

The regression model for AWB is as follows:

$$\mathrm{ABW_i} = 121.939 - 3.600\mathrm{X_1} - 2.741\mathrm{X_2} - 0.961\mathrm{X_3} - 3.039\ \mathrm{D_i}$$

The regression model for the HDPE pond is as follows:

$$\mathrm{AWB_i} = 121.939 - 3.600\mathrm{X_1} - 2.741\mathrm{X_2} - 0.961\mathrm{X_3} - 3.039\ (1)$$

$$\mathrm{AWB_i} = 118.9 - 3.600\mathrm{X_1} - 2.741\mathrm{X_2} - 0.961\mathrm{X_3}$$

Meanwhile, the regression model for the concrete pond is as follows:

$$\mathrm{AWB_i} = 121.939 - 3.600\mathrm{X_1} - 2.741\mathrm{X_2} - 0.961\mathrm{X_3} - 3.039\ (0)$$
$$\mathrm{AWB_i} = 121.939 - 3.600\mathrm{X_1} - 2.741\mathrm{X_2} - 0.961\mathrm{X_3}$$

The results of the dummy regression analysis for the influence of pond type and water quality dynamics on SGR can be seen in table 3.

Based on Table 3, pH and temperature have significant values greater than 0.05, indicating that these variables significantly impact SGR. In contrast, pond type and DO do not significantly affect SGR (significance values > 0.05).

The average SGR value in concrete ponds is higher than in HDPE ponds. This can be attributed to the differing abilities of concrete and HDPE ponds to maintain water quality. HDPE ponds absorb heat more quickly, leading to less stable temperatures. This is supported by [26], who noted that HDPE plastic absorbs heat more rapidly. Additionally, the pH levels in concrete ponds are more stable compared to HDPE ponds. [27] Explained that the pH levels in concrete ponds are more stable than in HDPE ponds.

Instability in pH levels can lead to anomalies in shrimp growth. [28] supported this by stating that unstable pH levels can affect shrimp's appetite, disrupting their growth. The low pH values in HDPE ponds are also due to high organic material levels caused by the uneven pond base. An uneven HDPE pond base can accumulate organic material due to sludge centralization and leftover feed difficulties. High organic content can lower pH due to the decomposition process releasing CO2. CO2 is acidic and can reduce pH. Lower pH levels can decrease shrimp appetite, leading to reduced growth rates. [29] Supported this by stating that low pH can cause physiological disturbances in shrimp, leading to stress and reduced appetite. A decrease in shrimp appetite will affect their daily growth rate.
The regression model for AWB is as follows:

$$\mathrm{SGR_i} = -151.741 + 6.114\mathrm{X_1} + 3.633\mathrm{X_2} + 0.390\mathrm{X_3} + 2.026\ \mathrm{D_i}$$

The regression model for the HDPE pond is as follows:

$$\mathrm{SGR_i} = -151.741 + 6.114\mathrm{X_1} + 3.633\mathrm{X_2} + 0.390\mathrm{X_3} + 2.026\ (1)$$
$$\mathrm{SGR_i} = -149.715 + 6.114\mathrm{X_1} + 3.633\mathrm{X_2} + 0.390\mathrm{X_3}$$

Meanwhile, the regression model for the concrete pond is as follows:

$$\mathrm{SGR_i} = -151.741 + 6.114\mathrm{X_1} + 3.633\mathrm{X_2} + 0.390\mathrm{X_3} + 2.026\ (0)$$
$$\mathrm{SGR_i} = -151.741 + 6.114\mathrm{X_1} + 3.633\mathrm{X_2} + 0.390\mathrm{X_3}$$

Conclusion

Based on the analysis results, it can be concluded that different pond types and water quality dynamics, specifically pH and temperature, affect shrimp growth based on ABW. However, when considering SGR values, the type of pond does not have a significant impact. The water quality parameters that affect SGR are pH and temperature.

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