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# THE DYNAMIC RELATIONSHIP OF N:P RATIO TOWARDS THE GROWTH OF VANAME SHRIMP (*Litopenaeus vannamei*) IN INTENSIVE CULTIVATION PONDS

Hubungan Dinamika Rasio N:P Terhadap Pertumbuhan Udang Vaname (*Litopenaeus vannamei*) di Tambak Budidaya Intensif

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## ABSTRACT

In intensive aquaculture systems, production success is strongly influenced by water quality management, particularly the balance of nitrogen and phosphorus nutrients. An imbalance in the N:P ratio due to high feed input can reduce the environmental carrying capacity and negatively affect shrimp growth. This study aimed to determine the dynamics of the nitrogen to phosphorus (N:P) ratio and its relationship with the growth of vaname shrimp (*Litopenaeus vannamei*) in intensive aquaculture ponds. The research was conducted for approximately one month at intensive shrimp ponds owned by PT. Mitradelta Bahari Pratama, Bima Regency, West Nusa Tenggara, Indonesia. A non-experimental research method with a correlational approach was applied, and data were collected through direct field observation in three culture ponds. The main parameters observed were the N:P ratio of the water, calculated from inorganic nitrogen concentrations ($NH_4^+$, $NO_2^-$, $NO_3^-$) and phosphate ($PO_4^{3-}$), as well as shrimp growth parameters including Mean Body Weight (MBW) and Average Daily Growth (ADG). The results indicated that the N:P ratio fluctuated during the culture period, primarily influenced by ammonium and phosphate concentrations derived from feeding activities and organic matter accumulation. An increase in the N:P ratio beyond optimal conditions tended to be followed by a decrease in shrimp growth rate, as reflected by reduced ADG values and feed consumption. In contrast, relatively stable N:P ratios were associated with better shrimp growth performance. These findings suggest that the dynamics of the N:P ratio are closely related to the growth of vaname shrimp and can serve as an important indicator for water quality management in intensive shrimp farming systems.
Keywords: Growth, Intensive Ponds, N:P Ratio, Vaname Shrimp, Water Quality

## ABSTRAK

Dalam sistem budidaya intensif, keberhasilan produksi sangat dipengaruhi oleh manajemen kualitas air, terutama keseimbangan unsur hara nitrogen dan fosfor. Ketidakseimbangan rasio N:P akibat penggunaan pakan yang tinggi dapat menurunkan daya dukung lingkungan dan berdampak pada pertumbuhan udang. Penelitian ini bertujuan untuk mengetahui dinamika rasio nitrogen terhadap fosfor (N:P) serta hubungannya dengan pertumbuhan udang vaname (*Litopenaeus vannamei*) pada tambak budidaya intensif. Penelitian dilaksanakan selama ±1 bulan di tambak intensif PT. Mitradelta Bahari Pratama, Kabupaten Bima, Nusa Tenggara Barat. Metode penelitian yang digunakan adalah metode deskriptif, dimana pengambilan data dilakukan secara observatif langsung pada tiga petak tambak. Parameter utama yang diamati meliputi rasio N:P perairan yang dihitung berdasarkan konsentrasi nitrogen anorganik ($NH_4^+$, $NO_2^-$, $NO_3^-$) dan fosfat ($PO_4^{3-}$), serta parameter pertumbuhan udang yang meliputi *Mean Body Weight* (MBW) dan *Average Daily Growth* (ADG). Hasil penelitian menunjukkan bahwa dinamika rasio N:P mengalami fluktuasi selama masa pemeliharaan, terutama dipengaruhi oleh konsentrasi amonium dan fosfat yang berasal dari aktivitas pemberian pakan dan akumulasi bahan organik. Peningkatan rasio N:P yang tidak terkendali cenderung diikuti oleh penurunan laju pertumbuhan udang, yang ditandai dengan menurunnya nilai ADG dan konsumsi pakan. Sebaliknya, rasio N:P yang relatif stabil menghasilkan pertumbuhan udang yang lebih optimal. Dengan demikian, dinamika rasio N:P memiliki hubungan erat dengan pertumbuhan udang vaname dan dapat dijadikan salah satu indikator penting dalam pengelolaan kualitas air pada budidaya udang sistem intensif.

Kata Kunci: Rasio N:P, Pertumbuhan, Kualitas Air, Udang Vaname, Tambak Intensif

## INTRODUCTION

Whiteleg shrimp originate from the west coast of Latin America and were officially introduced to Indonesia in 2001 through Decree No. 41 of 2001 of the Minister of Maritime Affairs and Fisheries of the Republic of Indonesia (Pratama et al., 2017). Whiteleg shrimp can be raised at high stocking densities and also have a fairly high appetite. This can affect the feed used. If the stocking density is low, whiteleg shrimp farmers can use feed with a low protein content (Umami et al., 2018). Whiteleg shrimp cultivation productivity can increase with the availability of available land and is influenced by two aspects: technical and non-technical aspects (Alaudin & Putra, 2023). The intensive cultivation system widely implemented can increase production through high stocking densities and the use of artificial feed. However, this system has the potential to degrade water quality due to the accumulation of leftover feed and metabolic waste, which increases the concentration of nitrogen and phosphorus in pond waters. Whiteleg shrimp cultivation faces several obstacles that can disrupt the process and production results. One of the main obstacles experienced is a decrease in water productivity. Aquatic productivity can affect the survival of whiteleg shrimp (Novia et al., 2016). High shrimp stocking results in a high demand for artificial feed, which ultimately leads to high concentrations of nitrogen and phosphate (Dewi et al., 2016). An imbalance in the nitrogen to phosphorus (N:P) ratio can trigger algae blooms and disrupt the stability of the pond ecosystem, thus impacting environmental carrying capacity and shrimp growth. Water quality management, particularly controlling the N:P ratio to maintain optimal water quality, is a crucial factor in the success of intensive cultivation. A balanced N:P ratio is known to play a role in maintaining the dominance of beneficial phytoplankton, such as green algae and diatoms. In addition, research results (Widyo et al., 2022) state that the calculation of a good N/P ratio for stable growth of green algae and diatoms is in the range of 20-30:1. Based on these problems, this study aims to analyze the dynamics of the N:P ratio and its relationship to the growth of whiteleg shrimp in intensive ponds. The research results are expected to form the basis for more effective water quality management to support optimal cultivation productivity.

## METHODS

### Time and Location

This research was conducted for approximately one month, from October 11, 2025, to November 15, 2025, at PT. Mitradelta Bahari Pratama, in Sampungu Village, Soromandi District, Bima Regency, West Nusa Tenggara.

### Research Materials

The test animals used in this study were 78-day-old whiteleg shrimp with an average shrimp size of 22 grams per shrimp. The whiteleg shrimp larvae used as test animals were obtained from Hatchery Prima Larvae Bali, Hisenor, and Suri Tani Pemuka.

### Research Tools and Materials

The tools used in this study included sample bottles to collect water samples. A digital scale was used to weigh the shrimp, while a ruler was used to measure their length. A thermometer was used to measure the water temperature at the research site. A refractometer was used to measure the water salinity. A pH meter is used to determine the acidity or alkalinity of water, while a DO meter is used to measure dissolved oxygen levels. A Secchi disk is used to measure the clarity or transparency of water. Additionally, writing instruments are used to record observations and measurements, and a camera or mobile phone is used to document research activities in the field. Materials used in this study included distilled water, which served as a solvent or rinse for the measuring instrument. An ammonia test kit was used to measure ammonia levels in water, a nitrite test kit was used to determine nitrite levels, a nitrate test kit was used to measure nitrate levels, and a phosphate test kit was used to determine phosphate levels in water samples.

### Research Method

This study employed a non-experimental correlation method, with data collection conducted through direct observation. The correlation method in non-experimental research involves collecting data to determine the relationship between two or more variables. This research method was used because, according to Rukminingsih et al. (2020), this research method must address complex variables and cannot be manipulated as in experimental research methods.

Whiteleg shrimp growth can be measured using data obtained from the sampling process, then processed using the following formula according to Foes et al. (2016):

$$\mathrm{ADG} = \frac{\mathrm{Wt} - \mathrm{Wo}}{\mathrm{t}}$$

$$\mathrm{MBW} = \frac{\text{total weight}}{\text{individuals}}$$

Where:
ADG = weight growth rate (grams/day)
t = observation time (days)
Wo = initial weight (grams)
Wt = final weight (grams)

### Data Analysis

After the research was completed, the collected data was analyzed to determine the relationship between the two variables. The data analysis used in this study was descriptive qualitative. Descriptive data analysis describes and explains the data obtained, corroborating it with references or previous research.

## RESULTS

Dynamics in the N:P ratio can affect shrimp growth. Observed shrimp growth included mean body weight (MBW) and average daily growth (ADG). The N:P ratio data obtained was calculated from the concentrations of ammonium, nitrite, nitrate, and phosphate. The impact of this N:P ratio dynamic is a decrease in shrimp growth after unstable water conditions. Data on the N:P ratio and growth monitoring in each pond can be seen in the table below.

Table 1. N:P Ratio Data and Growth Monitoring for Pond 1 (Number of fry 350,000; 140/$m^2$)

| DOC | $NO_2$ | $NO_3$ | $NH_4$ | $PO_4$ | N:P | MBW | ADG | F/D |
|---|---|---|---|---|---|---|---|---|
| 85 | 0.03 | 15 | 0.35 | 1.75 | 8.2 | 18.47 | 0.40 | 203 |
| 92 | 0.03 | 14 | 0.92 | 1.07 | 12.9 | 23.58 | 0.73 | 251 |
| 99 | 0.04 | 16 | 1.54 | 0.75 | 21.4 | 25.96 | 0.34 | 296 |
| 106 | 0.06 | 16 | 1.90 | 1.55 | 10.6 | 30.64 | 0.67 | 211 |
| 113 | 0.23 | 14 | 2.01 | 0.62 | 24.2 | 34.09 | 0.49 | 286 |
| 120 | 0.05 | 14 | 0.09 | 0.81 | 16.3 | 39.93 | 0.83 | 196 |

Table 1 above, in plot 1, shows that an increase in the N:P ratio tends to be followed by a decrease in shrimp growth. Increases in the N:P ratio in weeks 3 and 5 resulted in a decrease in ADG. This decrease in ADG occurs due to a decrease in shrimp appetite due to the high N:P ratio, resulting in reduced feed consumption to avoid overfeeding.

Table 2. N:P Ratio Data and Growth Monitoring for Pond 2 (Number of Fry 350,000;140/$m^2$)

| DOC | $NO_2$ | $NO_3$ | $NH_4$ | $PO_4$ | N:P | MBW | ADG | F/D |
|---|---|---|---|---|---|---|---|---|
| 85 | 0.01 | 11 | 0.82 | 0.75 | 14.5 | 20.05 | 0.52 | 201 |
| 92 | 0.02 | 14 | 1.51 | 1.40 | 10.1 | 24.57 | 0.65 | 233 |
| 99 | 0.02 | 16 | 0.25 | 0.84 | 18.0 | 29.39 | 0.69 | 276 |
| 106 | 0.01 | 15 | 0.09 | 0.92 | 15.3 | 35.36 | 0.85 | 211 |
| 113 | 0.04 | 16 | 1.70 | 0.73 | 22.2 | 40.24 | 0.34 | 286 |
| 120 | 0.28 | 14 | 5.54 | 1.41 | 12.5 | 45.40 | 0.74 | 189 |

Table 2 in plot 2 shows that an increase in the N:P ratio tends to be followed by a decrease in shrimp growth. The increase in the N:P ratio in week 5 resulted in a decrease in ADG values due to decreased shrimp appetite, resulting in reduced feed consumption in the following week. However, compared to plot 1, the increase in the N:P ratio in plot 2 was more controlled because it only occurred once.

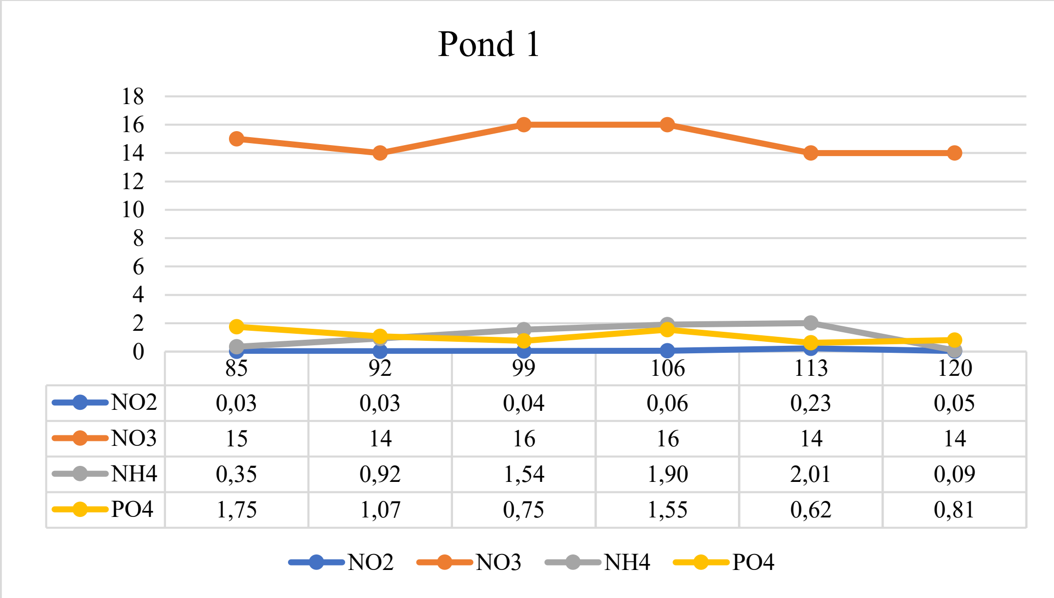
Table 3. N:P Ratio Data and Growth Monitoring for Pond 3 (Number of Fry 350,000;140/$m^2$)

| DOC | $NO_2$ | $NO_3$ | $NH_4$ | $PO_4$ | N:P | MBW | ADG | F/D |
|---|---|---|---|---|---|---|---|---|
| 85 | 0.01 | 2 | 0.02 | 0.10 | 19.0 | 14.33 | 0.19 | 144 |
| 92 | 0.01 | 7 | 0.01 | 0.40 | 16.4 | 17.72 | 0.48 | 210 |
| 99 | 0.01 | 15 | 0.67 | 0.73 | 19.8 | 20.79 | 0.44 | 222 |
| 106 | 0.01 | 14 | 0.01 | 0.87 | 15.0 | 25.86 | 0.73 | 201 |
| 113 | 0.05 | 13 | 2.42 | 1.20 | 11.6 | 29.96 | 0.59 | 271 |
| 120 | 0.02 | 14 | 1.83 | 0.84 | 17.1 | 33.76 | 0.54 | 179 |

The N:P ratio and growth data in pond 3 tended to be more stable, as the N:P ratio in this pond could still be controlled according to existing standards. However, the first week showed relatively low ADG gains. This was not due to a high N:P ratio, but rather to the fact that the feeding program tended to slightly adjust to the given growth target.

**N:P Ratio Dynamics**

N:P ratio data was obtained by calculating total nitrogen from ammonium ($NH_4$-N), nitrite ($NO_2$-N), and nitrate ($NO_3$-N) and compared with total phosphorus data to obtain the N:P ratio dynamics. The results of the N:P ratio dynamics test are described for each pond, along with fluctuations in its elements. Three ponds were observed: ponds 1, 2, and 3, which will be presented separately. The dynamics of the N:P ratio in each pond can be seen in the following figure:




| | 85 | 92 | 99 | 106 | 113 | 120 |
|---|---|---|---|---|---|---|
| NO2 | 0,03 | 0,03 | 0,04 | 0,06 | 0,23 | 0,05 |
| NO3 | 15 | 14 | 16 | 16 | 14 | 14 |
| NH4 | 0,35 | 0,92 | 1,54 | 1,90 | 2,01 | 0,09 |
| PO4 | 1,75 | 1,07 | 0,75 | 1,55 | 0,62 | 0,81 |

Figure 1. Graph of $NO_2$, $NO_3$, $NH_4$, and $PO_4$ Values in Pond 1

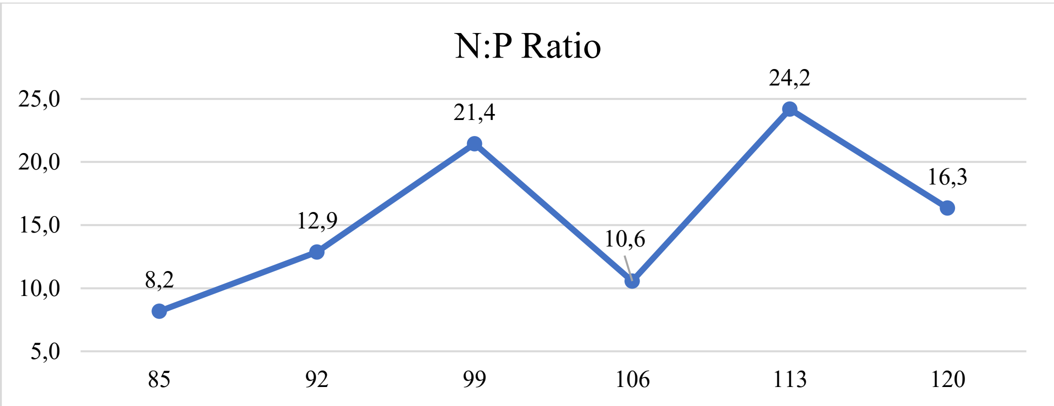
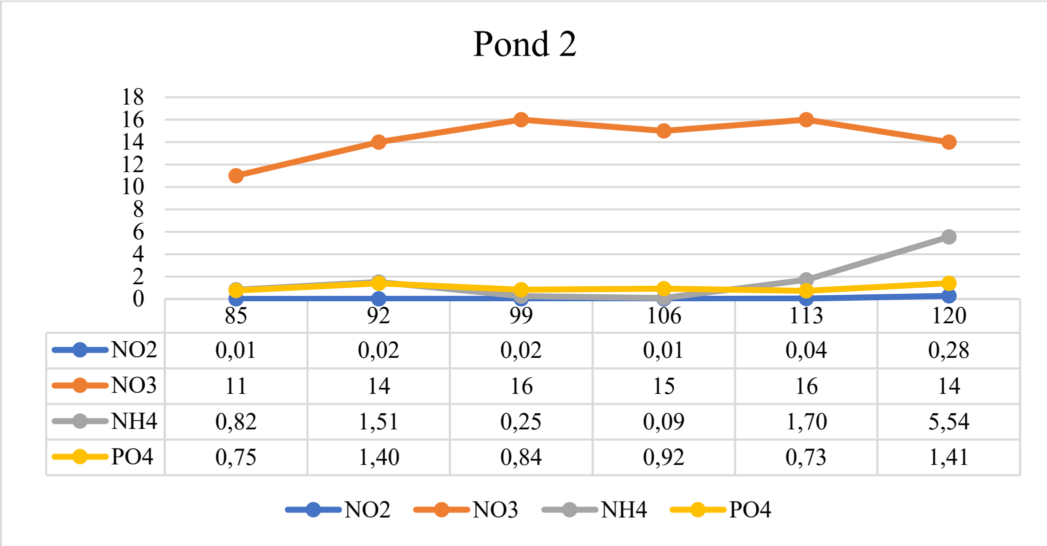



Figure 2. Graph of N:P Ratio Dynamics in Pond 1

The nitrogen to phosphorus (N:P) ratio in each pond showed variation throughout the rearing period. The most prominent changes occurred in pond 1, particularly in weeks 3 to 5, marked by an increase in the N:P ratio due to rising ammonium concentrations. This increase was related to overfeeding and the accumulation of organic matter, causing a temporary imbalance in the water's nutrients. After week 6, the N:P ratio tended to stabilize again. This change in the N:P ratio is an important indicator in assessing water quality and the dynamics of the N:P ratio, which influences shrimp growth.




| | 85 | 92 | 99 | 106 | 113 | 120 |
|---|---|---|---|---|---|---|
| NO2 | 0,01 | 0,02 | 0,02 | 0,01 | 0,04 | 0,28 |
| NO3 | 11 | 14 | 16 | 15 | 16 | 14 |
| NH4 | 0,82 | 1,51 | 0,25 | 0,09 | 1,70 | 5,54 |
| PO4 | 0,75 | 1,40 | 0,84 | 0,92 | 0,73 | 1,41 |

Figure 3. Graph of $NO_2$, $NO_3$, $NH_4$, and $PO_4$ Values in Pond 2

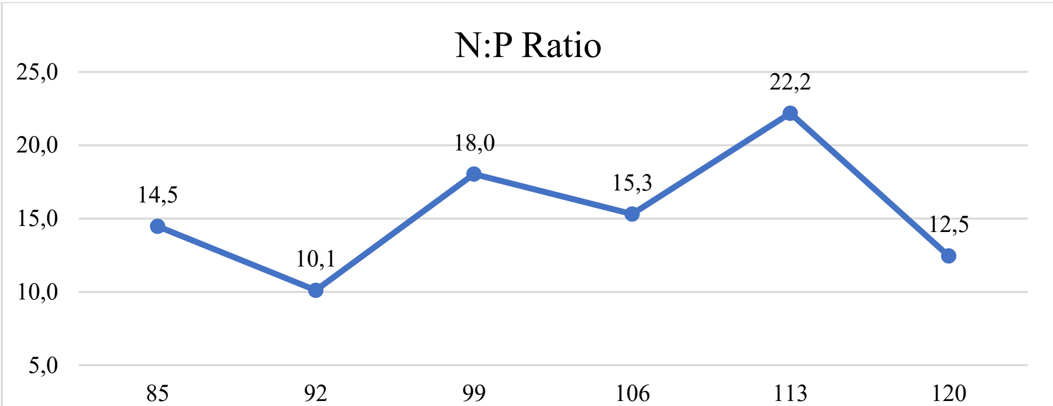
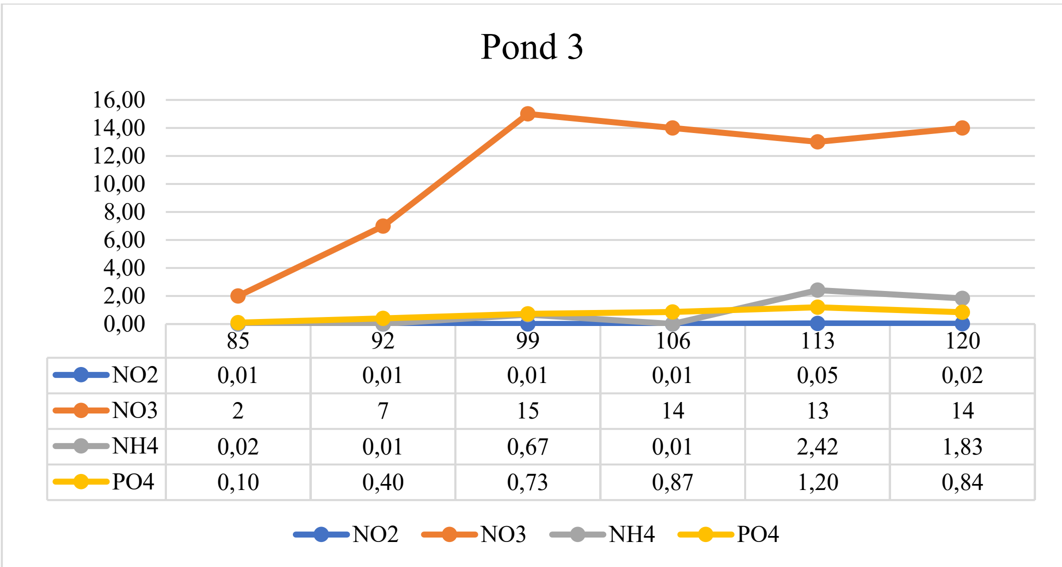



Figure 4. Graph of N:P Ratio Dynamics in Pond 2




| | 85 | 92 | 99 | 106 | 113 | 120 |
|---|---|---|---|---|---|---|
| NO2 | 0,01 | 0,01 | 0,01 | 0,01 | 0,05 | 0,02 |
| NO3 | 2 | 7 | 15 | 14 | 13 | 14 |
| NH4 | 0,02 | 0,01 | 0,67 | 0,01 | 2,42 | 1,83 |
| PO4 | 0,10 | 0,40 | 0,73 | 0,87 | 1,20 | 0,84 |

Figure 5. Graph of $NO_2$, $NO_3$, $NH_4$, and $PO_4$ Values in Pond 3

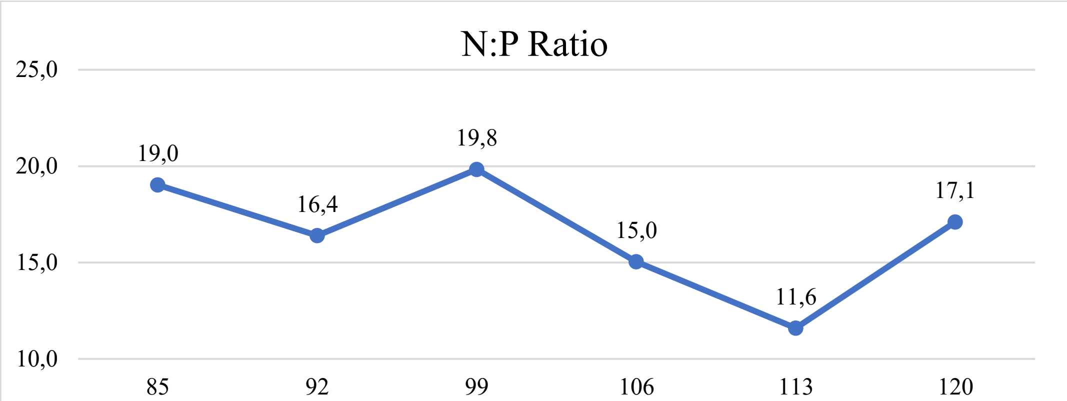



Figure 6. Graph of N:P Ratio Dynamics in Pond 3

The N:P ratio in ponds 2 and 3 showed lower and more stable changes than in pond 1. Inorganic nitrogen concentrations in both ponds tended to be lower, although nitrogen and phosphorus levels increased in weeks 4 and 5. The increase in the N:P ratio was primarily influenced by the high concentration of ammonium, the primary nitrogen contributor, while nitrite had the lowest contribution. Overall, fluctuations in the N:P ratio in ponds 2 and 3 were relatively stable. The increase in phosphate in all ponds is suspected to be caused by the organic load in the water, necessitating water quality management, such as using a bottom siphon to prevent the accumulation of organic matter.

**Feed Consumption**

Feed consumption data was recorded daily based on the total feed provided in each pond. The amount of feed was adjusted based on weekly targets and shrimp conditions, such as activity and appetite. Feeding was controlled using a fish feeder to monitor remaining feed after each feed. The presence of remaining feed is an indicator of decreased appetite and a basis for subsequent feed adjustments, while depleted feed indicates that feeding can be maintained. Controlled feed management aims to reduce the accumulation of remaining feed, which can affect water quality. Feed consumption data during the study are presented in the following figure.

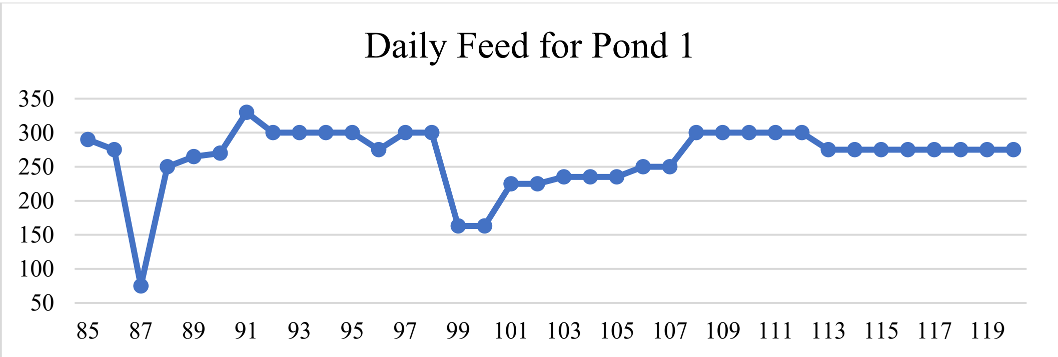



Figure 7. Daily Feeding Graph for Pond 1

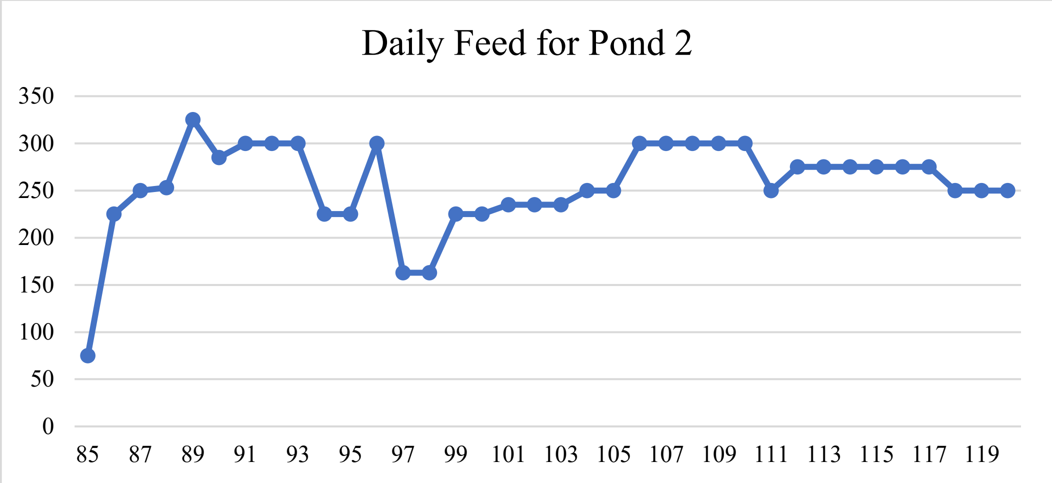



Figure 8. Daily Feeding Graph for Pond 2

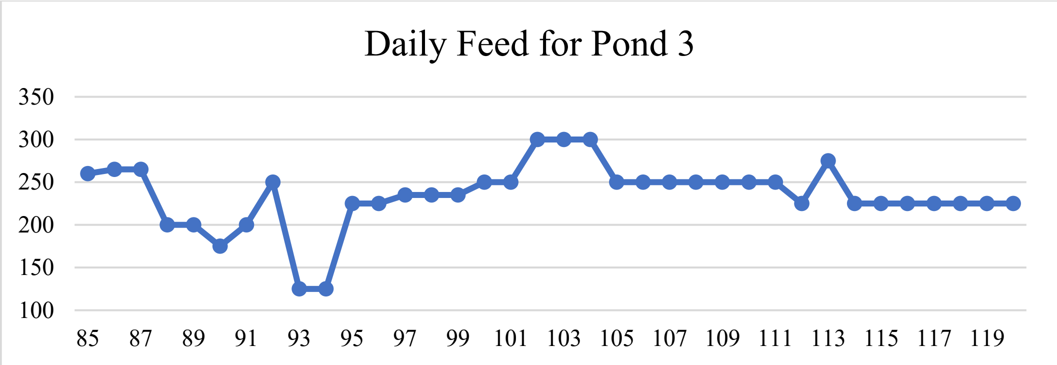



Figure 9. Daily Feeding Graph for Pond 3

In the initial rearing phase (DOC 1–30), the blend feeding program was used. After that phase, the feeding strategy was adjusted to the ADG target. At DOC ages ≥80, the feed size was adjusted based on shrimp weight gain. Feed requirements increased as long as appetite and water quality remained optimal, although there were fluctuations in feed amounts at certain periods. These fluctuations are thought to be influenced by decreased appetite due to an imbalance in the N:P ratio.

**Shrimp Growth**

Shrimp growth was assessed based on body weight gain, measured through weekly sampling. The first sampling was conducted on DOC 30 after the blend feeding program concluded to obtain baseline growth data. Sampling was carried out using a net. The captured shrimp were collected, the water removed, and the total weight was calculated, and the number of individuals was calculated to obtain the weight per shrimp. The average shrimp weight, or Mean Body Weight (MBW), was calculated by dividing the total weight by the number of shrimp sampled. A graph of shrimp growth during the study is presented in the following figure.

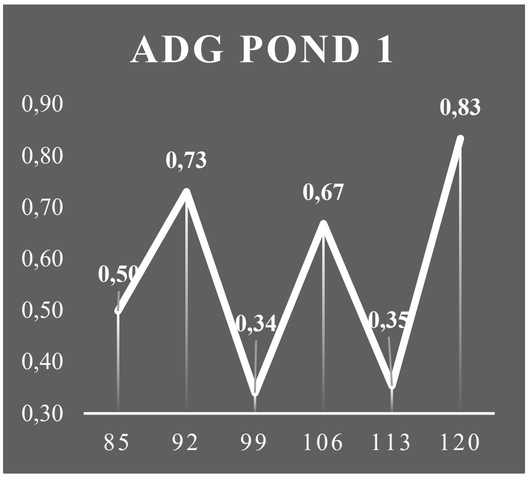



Figure 10. Average Daily Growth (ADG) Value Graph for Pond 1

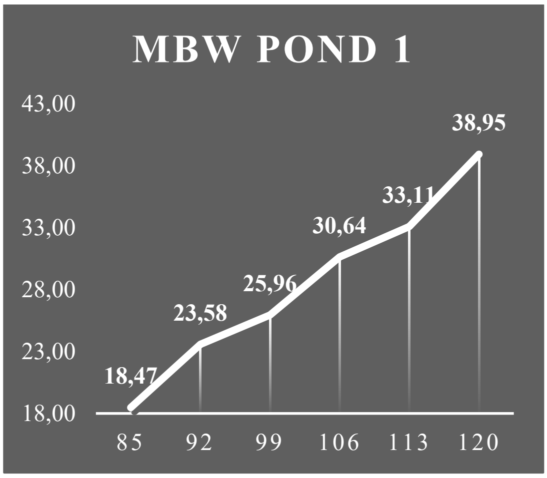



Figure 11. Shrimp Weight Growth Graph for Pond 1

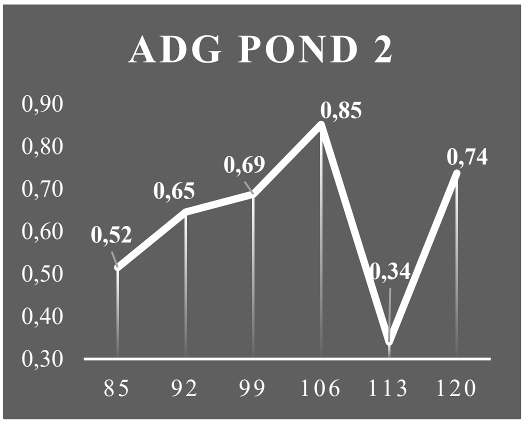



Figure 12. Average Daily Growth (ADG) Value Graph for Pond 2

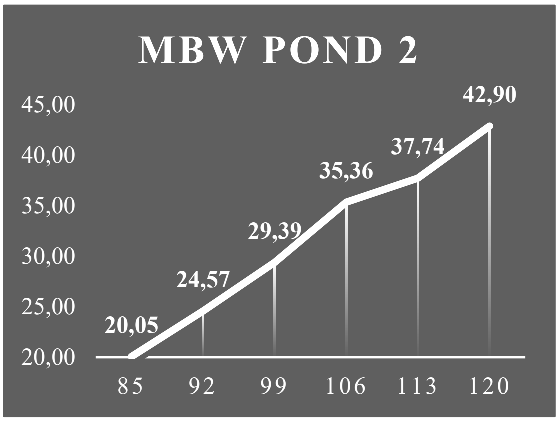



Figure 13. Shrimp Weight Growth Graph for Pond 2

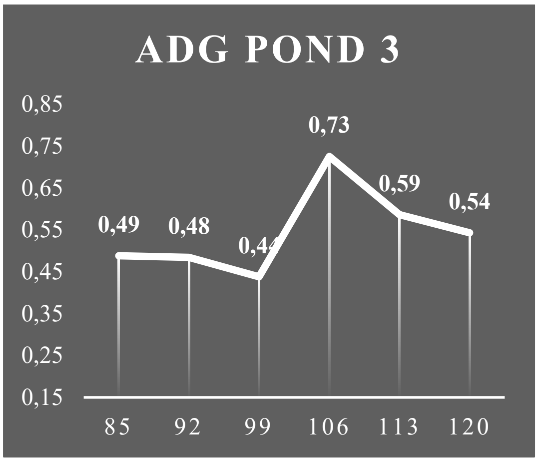



Figure 14. Average Daily Growth (ADG) Value Graph for Pond 3

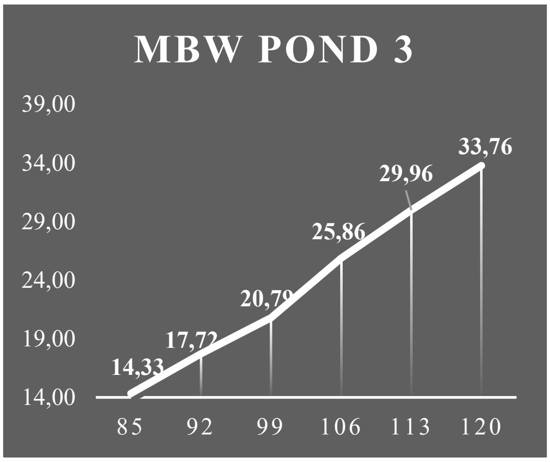



Figure 15. Shrimp Weight Growth Graph for Pond 3

In the first week of the study, shrimp growth rates showed differences between ponds. Pond 3 had a more stable ADG value, while ponds 1 and 2 experienced significant fluctuations. These differences are thought to be related to variations in rearing conditions and shrimp responses to the treatments applied. Growth measurements were conducted through weekly sampling until harvest to monitor growth patterns and the effectiveness of rearing management. During the study, ponds 1 and 2 more frequently failed to achieve ADG targets than pond 3, indicating the importance of feed management for shrimp growth. In pond 1, growth fluctuations primarily occurred in weeks 3 and 4, when ADG values were below standard. This condition occurred simultaneously with an increase in the N:P ratio, which is thought to decrease water quality and shrimp appetite, thus inhibiting growth.

## DISCUSSION

The nitrogen-to-phosphorus (N:P) ratio acts as a major limiting factor because nitrogen and phosphorus significantly influence each other, so changes in the levels of either element will affect the overall condition of the aquatic environment. This ratio, known as the Redfield ratio, is an important water quality parameter in aquaculture because it reflects the level of water fertility and the dominant types of nutrients or pollutants (Prastowo et al., 2022). After passing through an initial fluctuating phase, the amount of feed provided remained relatively stable until the end of the rearing period, and shrimp growth was able to achieve the predetermined target. This is consistent with research by Rahmi et al. (2023), which showed that stable water quality plays a crucial role in maintaining shrimp appetite and feed utilization efficiency, thus supporting optimal growth. The results of this study align with the findings of Inayah et al. (2023), who stated that increasing concentrations of inorganic nitrogen, particularly ammonia and nitrite, can reduce the feeding response of whiteleg shrimp due to disrupted physiological and metabolic functions. The reduction in feeding during this period is generally in response to the presence of leftover feed in the shrimp cages, indicating a decrease in shrimp appetite (Alfionita et al., 2025). The rather extreme increase in the N:P ratio in pond 1 was accompanied by a decrease in Average Daily Growth (ADG), particularly in DOC 99 (ADG 0.34 g/day) and DOC 113 (ADG 0.49 g/day). This pattern indicates that the nutrient imbalance, reflected in the high N:P ratio, has the potential to degrade the quality of the aquatic environment, resulting in decreased shrimp appetite and growth rate (Akbarurrasyid et al., 2024). These findings align with research by Ariadi et al. (2021), which states that the accumulation of inorganic nitrogen in intensive culture systems can trigger physiological stress in shrimp, inhibit feeding activity, and reduce feed utilization efficiency.

Shrimp growth, as measured by Mean Body Weight (MBW) and Average Daily Growth (ADG), showed different responses in each pond, as the stability of the N:P ratio varied throughout the culture period. In the whiteleg shrimp cultivation system, phytoplankton plays a dual role: as a contributor of oxygen through photosynthesis and as an indicator of water fertility (Pravasuci, 2021). Feeding management in this study was also supported by the implementation of a water exchange pattern according to standard operating procedures (SOP), namely 4 $m^3$ per kg of feed provided. This water exchange serves to reduce nutrient accumulation in the water, maintain water quality stability, and prevent excessive increases in the N:P ratio. However, if nutrients, especially nitrogen and phosphorus, accumulate excessively, phytoplankton can grow massively and cause water quality disturbances (Yang et al., 2025). According to Shilman et al. (2025), the combination of appropriate feeding management and effective water exchange management is a crucial strategy in intensive cultivation systems to maintain nutrient balance and support sustainable shrimp growth.

Algal blooms have the potential to cause fluctuations in dissolved oxygen (DO), particularly during nighttime declines, as well as increase toxic compounds such as ammonia ($NH_3$) and nitrite ($NO_2^-$), which reduce shrimp appetite, disrupt the moulting process, and inhibit absolute growth rates (ADG 0.11-0.14 g/day) (Aprilia et al., 2024). The dominance of Cyanophyceae is also often associated with increased ammonium ($NH_4^+$) concentrations, as this group utilizes ammonium as a nitrogen source, which at certain concentrations can be toxic to other cultured organisms (Zulian, 2018).

The dynamics of the N:P ratio serve as a crucial link between feed management, water stability, and whiteleg shrimp growth performance. These findings align with those of Supono et al. (2021), who stated that the accumulation of inorganic nitrogen due to excess feed is a major factor in the decline of water quality in intensive ponds, impacting shrimp growth and feed efficiency. Research by Al Mubarok & Farikhah (2024) shows that the optimal N:P ratio of 20-30 supports ecosystem balance and best growth (ADG 0.14-0.148 g/day), referring to the Redfield concept (16:1) with adjustments for organic load and stocking density of intensive ponds.

## CONCLUSION

Based on the results of research and discussion on the dynamics of the nitrogen to phosphorus (N:P) ratio in the cultivation of whiteleg shrimp (Litopenaeus vannamei) in intensive ponds, it can be concluded that the N:P ratio during the maintenance period fluctuated with a fairly wide range of values, ranging from 8.2 to 24.2 in all research ponds. The highest N:P ratio values generally occurred in the DOC 99–113 period, along with the increasing accumulation of inorganic nitrogen (especially $NH_4^+$ and $NO_3^-$) originating from leftover feed and shrimp feces. The results showed that a high N:P ratio (≥20) tends to be associated with declining water quality and the appearance of algae bloom indications, which impacts on decreased shrimp appetite and low Average Daily Growth (ADG) values. This is clearly seen in ponds 1 and 2, where an increase in the N:P ratio to 21.4–24.2 is followed by a decrease in ADG and adjustments in feed consumption. In contrast, pond 3, which had a more stable N:P ratio ranging from 11.6 to 19.8, showed a more consistent shrimp growth pattern and approached the target cultivation.

Thus, it can be concluded that the dynamics of the N:P ratio have a significant relationship with the growth of whiteleg shrimp in intensive ponds, where a stable and controlled N:P ratio contributes to more optimal water conditions and supports shrimp growth. Therefore, the results of this study reject the null hypothesis ($H_0$) and accept the alternative hypothesis ($H_1$), namely that the N:P ratio affects the productivity and growth of whiteleg shrimp. Controlling the N:P ratio through feed management, organic waste management, and water quality management is a crucial factor in increasing the success of sustainable whiteleg shrimp cultivation.

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