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Dynamics and Composition of Plankton in Superintensif Shrimp Ponds *Litopenaeus vannamei*

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ABSTRACT

The problem with superintensive vannamei shrimp cultivation is the increase in N and P concentrations which can cause eutrophication and blooming algae. Therefore, this research aims to obtain data and information regarding plankton dynamics and water quality in super intensive vannamei shrimp cultivation at different densities. The research used 3 pond plots with a shrimp density of 750 individuals/m^2 (A); 1,000 heads/m^2; and 1,250 heads/m^2. Plankton data was collected through observation by filtering pond water at five points using planktonnet no. 25, 20 liters at 5 sampling points or 100 liters of water per plot, and sampling was carried out every 7 days. The results of statistical analysis show **s**pearman correlation analysis showed that shrimp density did not have a significant effect on plankton abundance, phytoplankton abundance, zooplankton abundance, TAN, NO_2, NO_3, PO_4, and TSS because the sig value. 2-tailed $P > 0.05$. however, the abundance of phytoplankton had a significant influence on the abundance of zooplankton ($P < 0.05$). while zooplankton abundance was influenced by NO_2 ($P < 0.05$). The close relationship between shrimp density and the abundance of plankton, phytoplankton, zooplankton, and water quality (TAN, NO_2, NO_3, PO_4, and TSS) is very low (-0.85–2.79). positive and very close correlation between plankton density, phytoplankton density and zooplankton density (0.68–0.956), and negative correlation with water quality (TAN, NO_2, NO_3, PO_4, and TSS). This causes the distribution of low levels of diversity (H) and evenness (E), so that the average dominance index is below 1, which indicates the absence of dominant individuals. Therefore, in the three treatments no dangerous plankton blooming was found.

Keywords: plankton, *Litopenaeus vannamei,* shrimp, pond

INTRODUCTION

Superintensive *Litopenaeus vannamei* cultivation has developed (Pinho et al., 2022; Rakhmanda et al., 2021; Venero et al., 2009; Costa et al., 2018; Rahim et al., 2021) with a density reaching 600 Ind/m^2, and continues to be improved to increase income (Almeida et al., 2022), with various cultivation methods. However, behind the success of increasing production, there is the impact of cultivation waste produced during maintenance.

The waste generated from feed that is not eaten by shrimp reaches 24.32% with an N content of 3.61 tons/year and P of 0.28 tons/year (Paena et al., 2020). where the characteristics of waste water that is discharged every day has a concentration of TAN, N-Total PO_4, BOT, and TSS exceed the waste disposal threshold (Fahrur et al., 2015). However, the concentration of N and P in shrimp cultivation water continues to increase with the age of cultivation (Fahrur et al., 2016). This can cause eutrification and phytoplankton blooms (Fernandes et al., 2019). because phytoplankton effectively utilize NO_3 and PO_4 for growth. (Malerba et al., 2012), so it can grow quickly (Fried et al., 2003).

Observations of plankton abundance at various densities have been carried out. Various studies have been conducted on plankton dynamics in ponds (Musa et al., 2021; Sani et al., 2022; Heri

Ariadi and Fajar 2021), in traditional ponds with low density (Pleto and Cabillon, 2022), higher intensive density (Palupi et al., 2022), and and at a superintensive density of 200 Ind/m^2 (Lien et al., 2022). However, there is no information regarding the plankton composition in ponds with higher superintensive densities. So monitoring the dynamics of plankton abundance in super intensive vannamei shrimp cultivation is very important to know. Therefore, this research aims to obtain data and information on plankton dynamics in super intensive vaname shrimp cultivation and their relationship with different densities, as a basis for evaluating water quality management.

METODS AND MATERIAL

Site of study

The study was conducted installation of the Research Institute for Brackish Water Aquaculture and Fisheries Extension, located in Takalar Regency, South Sulawesi.

Materials

The study was conducted using three concrete ponds with of 1.000 m^2 in size respectevely. The treatment were three different densities of PL-9 *Litopenaeus vannamei.* Namely treatment A was 750 shrimp/m^2, B (1.000 shrimp/m^2), and C (1.250 shrimp/m^2). The shrimp were reared in a 105-day rearing period. Plankton sampling wes executed a plankton net designed for plankton filtration and equipped with a 100 mL polyethylene bottle. Additionally, a 10-L volume bucket served as a water sampler and a 100 mL polyethylene bottle functioned as a container for plankton samples. The obtained plankton samples were then-preserved under in lugol solution. Plankton were observed under Olympus BX40 microscopes using 40× magnification.

Plankton sampling

Plankton samples were collected every 7 days using a composite sampling method. This process included gathering water samples from five distinct sampling points within each pond plot. Furthermore, at each sampling point, a total of 20 L water was filtered using plankton nets sized at no. 25. This process resulted in a cumulative volume of 100 L/pond plot. After filtration, the plankton-rich water was carefully transferred into 100 mL polyethylene bottles and preserved using a 1% concentration of Lugol solution, as described by (Maroulakis and Ege 2014). Subsequently, samples were transported to the laboratory for analysis.

Plankton sampling calculation

Plankton samples were observed under microscope using with 40× magnification, and the Sedwick Rafter Counter (SRC) was used solely for this purpose. Accordingly, various calculations related to plankton were conducted, including abundance, diversity, uniformity, and dominance indices.

Procedure

Abundance of plankton types, these calculations were performed using specific formulas tailored to each index (Baird et al. 2017) as follows:

$$N = Oi/Op \times Vr/Vo \times 1/Vs \times n/p \quad (1)$$

where: *N* - total individuals per liter; *Oi* - area of the preparation cover glass (mm^2); *Op* - area of one field of view (mm^2); *Vr* - volume of filtered water (mL); *Vo* - observed water volume (mL); *Vs* - volume of filtered water (L); *n* - total plankton in the entire field of view; *p* - total field of view observed.

The species diversity index uses a formula (Shannon and Weaver 1964):

$$H' = -\Sigma Pi \cdot ln \cdot Pi; Pi = ni/N \quad (2)$$

where: *H'* - species diversity index; *ni* - total individuals of the ith taxa; *N* - total individuals; *Pi* - proportion of ith species.

Classification of biota community conditions based on *H'* is as follows: *H'* < 2.30 (little diversity and low community stability), 2.30 < *H'*< 6,91 (medium diversity and moderate community stability), *H'* > 6.91 (high diversity and high community stability). The uniformity index is calculated based on the formula (Sournia, 1978):

$$E = H'/Hmax \quad (3)$$

where: *E* - species uniformity index; *H'* - species diversity index; *Hmax* - maximum diversity index.

The classification of the species diversity index is as follows: *E* < 0.4 (low category), 0.4 < *E* < 0,6 (medium category), *E* > 0.6 (high category).

The dominance index uses a formula (Gowen et al., 2011):

$$D = \Sigma_{i=1}^{s}[ni / N]^2 \quad (4)$$

where: D - Simpson's dominance index; ni - total i-th individual; N - total individual; S - total types.

Generally, the D value, which falls within a range of 0 to 1, serves as an indicator of population dominance. When this value nears 0, it indicates a situation where very few individuals display dominance. Meanwhile, when D is close to 1, it suggests the presence of individuals that hold a significant dominance within the population (Scherer et al., 2014).

Statistical analysis

Data analysis of plankton abundance and water quality (TAN, NO_2, NO_3, PO_4, and TSS) was carried out to determine how much water quality is related to plankton abundance using Pearson corellation (Ali and Al-Hameed, 2022). Analysis using tools in SPSS 25.

RESULTS

Plankton abundance

Based on pearson correlation grouping, the degree of relationship is based on the following conditions: 0.00–0.20 = no correlation; 0.21–0.40 = weak correlation; 41–0.60 = moderate correlation; 0.61–0.80 = strong correlation; 0.81–1.00 = very strong correlation, where the decision. The results of statistical analysis show spearman correlation analysis showed that shrimp density did not have a significant effect on plankton abundance, phytoplankton abundance, zooplankton abundance, TAN, NO_2, NO_3, PO_4, and TSS because the sig value. 2-tailed $P > 0.05$. however, the abundance of phytoplankton had a significant influence on the abundance of Zooplankton ($P < 0.05$). while zooplankton abundance was influenced by NO_2 ($P < 0.05$). The close relationship between shrimp density and the abundance of plankton, phytoplankton, zooplankton, and water quality (TAN, NO_2, NO_3, PO_4, and TSS) is very low (-0.85–2.79). positive and very close correlation between plankton density, phytoplankton density and zooplankton density (0.68–0.956), and negative correlation with water quality (TAN, NO_2, NO_3, PO_4, and TSS). However, there is a positive correlation between TAN, NO_2 and NO_3, so that the TAN concentration has a real effect on NO_2, but not on NO_3. real influence of NO_2 concentration on NO_3 and PO_4 with a strong correlation of 0.486 and 0.695 respectively (Table 1).

In terms of observations, plot A contained a total of 19 plankton genera, comprising 11 phytoplankton and 8 zooplankton while plot B featured 16 plankton genera, consisting of 7 phytoplankton and 9 zooplankton. On the other hand, plot C was observed to exhibit a total of 19 genera, with 8 phytoplankton and 11 zooplankton. Among the three plots, Oscillatoria was the most abundant phytoplankton genus. In plot A, the highest zooplankton abundance was observed in Branchionus, while plots B and C had Oithona. It is also crucial to acknowledge that plot B exhibited the highest total abundance. With 1616 individuals/L of phytoplankton and 3105 individuals/L of zooplankton. This was followed by plots C and A, as indicated in Table 2.

Plankton dynamics in super-intensive vannamei shrimp cultivation showed fluctuations in abundance in the cultivation period. These fluctuations began with an initial increase but were followed by a decrease towards the end of the research. Accordingly, the primary reason for the observed fluctuations was predation by shrimp. In this ecological chain, phytoplankton, as primary producers, are consumed by zooplankton, and in turn, zooplankton are preyed upon by shrimp. This pattern can be observed in (Figure 1), where during the 5th week of observation, no phytoplankton species were detected in any of the plots. This same pattern repeated in the 7th, 9th, 10th, 12th, 13th, 14th, and 15th weeks, with plot B consistently lacking phytoplankton species, while plots A and C maintained arelatively abundant presence.

Zooplankton abudance

As opposed to the stability in phytoplankton abundance, zooplankton exhibited dynamic changes across all plots. For instance, during the 11th week of observations, no zooplankton species were observed in plots B and C, and a similar phenomenon occurred in plot A during the 15th observation. In the research period, *Branchionus*

Table 1. Correlation between phytoplankton, zooplankton and water quality TAN, NO_2, NO_3, PO_4 and TSS during the study

Correlations										
Specification		Treatment	Abundance F	Abundance Z	Abundance plankton	TAN	NO_2	NO_3	PO_4	TSS
Treatment	Pearson correlation	1	.149	.161	.169	.147	.230	.104	.279	-.085
	Sig. (2-tailed)		.330	.291	.266	.337	.128	.497	.064	.578
	N	45	45	45	45	45	45	45	45	45
Abundance F	Pearson correlation	.149	1	.683**	.867**	-.064	-.253	-.180	-.225	-.029
	Sig. (2-tailed)	.330		.000	.000	.674	.094	.236	.137	.848
	N	45	45	45	45	45	45	45	45	45
Abundance Z	Pearson correlation	.161	.683**	1	.956**	-.131	-.358*	-.307*	-.216	-.059
	Sig. (2-tailed)	.291	.000		.000	.392	.016	.040	.153	.701
	N	45	45	45	45	45	45	45	45	45
Abundance plankton	Pearson correlation	.169	.867**	.956**	1	-.115	-.346*	-.282	-.238	-.052
	Sig. (2-tailed)	.266	.000	.000		.451	.020	.060	.116	.735
	N	45	45	45	45	45	45	45	45	45
TAN	Pearson correlation	.147	-.064	-.131	-.115	1	.007	.152	.346*	.079
	Sig. (2-tailed)	.337	.674	.392	.451		.964	.319	.020	.607
	N	45	45	45	45	45	45	45	45	45
NO_2	Pearson correlation	.230	-.253	-.358*	-.346*	.007	1	.486**	.695**	-.006
	Sig. (2-tailed)	.128	.094	.016	.020	.964		.001	.000	.967
	N	45	45	45	45	45	45	45	45	45
NO_3	Pearson correlation	.104	-.180	-.307*	-.282	.152	.486**	1	.314*	-.041
	Sig. (2-tailed)	.497	.236	.040	.060	.319	.001		.036	.791
	N	45	45	45	45	45	45	45	45	45
PO4	Pearson correlation	.279	-.225	-.216	-.238	.346*	.695**	.314*	1	.243
	Sig. (2-tailed)	.064	.137	.153	.116	.020	.000	.036		.107
	N	45	45	45	45	45	45	45	45	45
TSS	Pearson correlation	-.085	-.029	-.059	-.052	.079	-.006	-.041	.243	1
	Sig. (2-tailed)	.578	.848	.701	.735	.607	.967	.791	.107	
	N	45	45	45	45	45	45	45	45	45

Note: **Correlation is significant at the 0.01 level (2-tailed), *Correlation is significant at the 0.05 level (2-tailed).

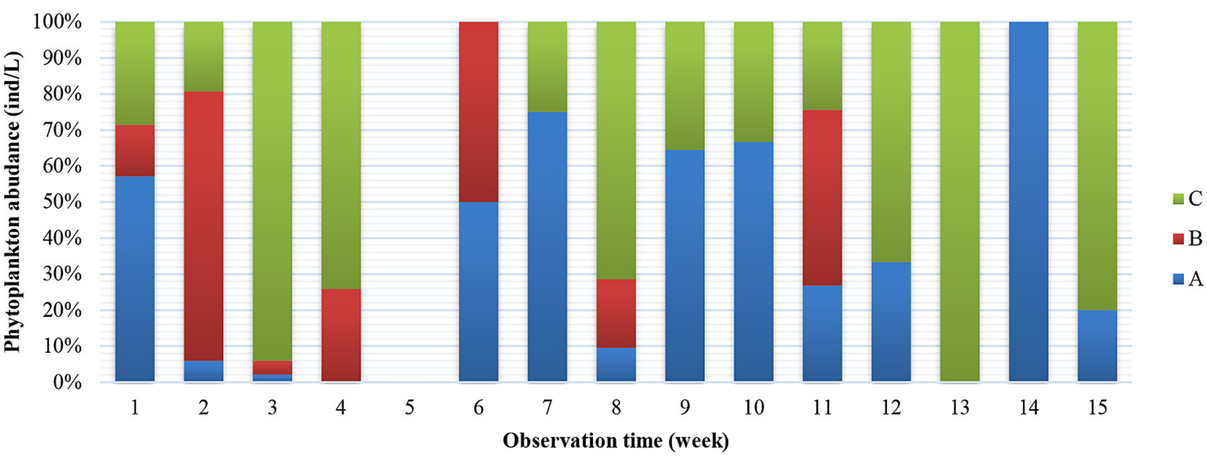

Figure 1. Phytoplankton abundance during the research

Table 2. Abundance of plankton species during the research phytoplankton abudance

No	Abundance of plankton genera	Treatment					
	Fitoplankton	A (ind/L)	%	B (ind/L)	%	C (ind/L)	%
1	Bacteriastrum sp.	24	7.8	–	–	–	–
2	Bidulphia sp.	10	3.2	–	–	–	-
3	Chaetoceros sp.	–	–	–	–	70	5.8
4	Ceratium sp.	–	–	–	–	90	7.4
5	Coscinodiscus sp.	11	3.6	20	1.2	16	1.3
6	Gyrosigma sp.	20	6.5	–	–	–	–
7	Gleotricia sp.	20	6.5	20	1.2	–	–
8	Navicula sp.	35	11.3	10	0.6	42	3.5
9	Nitzschia sp.	10	3.2	–	–	–	–
10	Oscillatoria sp.	119	38.5	1476	91.3	870	71.6
11	Pleurosigma sp.	–	–	10	0.6	10	0.8
12	Prorocentrumsp	30	9.7	60	3.7	42	6.2
13	Protoperidinium sp.	20	6.5	20	1.2	75	3.5
14	Thallassiorira sp.	10	3.2	–	–	–	–
	Total	309	100	1616	100	1215	100
	Average	28.09	9.1	230.86	14.3	151.88	12.5
Zooplankton							
1	Acartia sp.	30	3.1	419	13.5	141	6.3
2	Apocyclops sp.	42	4.3	340	11.0	61	2.7
3	Branchionus sp.	266	27.3	188	6.1	383	17.1
4	Copepoda sp.	26	2.7	89	2.9	42	1.9
5	Microsetella sp.	16	1.6	37	1.2	106	4.7
6	Nauplii copepoda	187	19.2	121	3.9	204	9.1
7	Nitocra sp.	–	–	–	–	6	0.3
8	Oithona sp.	238	24.4	1461	47.1	848	37.8
9	Polychaeta sp.	-	-	20	0.6	31	1.4
10	Temora sp.	171	17.5	430	13.8	417	18.6
11	Tortanus sp.	–	–	–	–	6	0.3
	Total	976	100	3105	100	2245	100
	Average	122	12.5	345	11.1	204.0	9.1

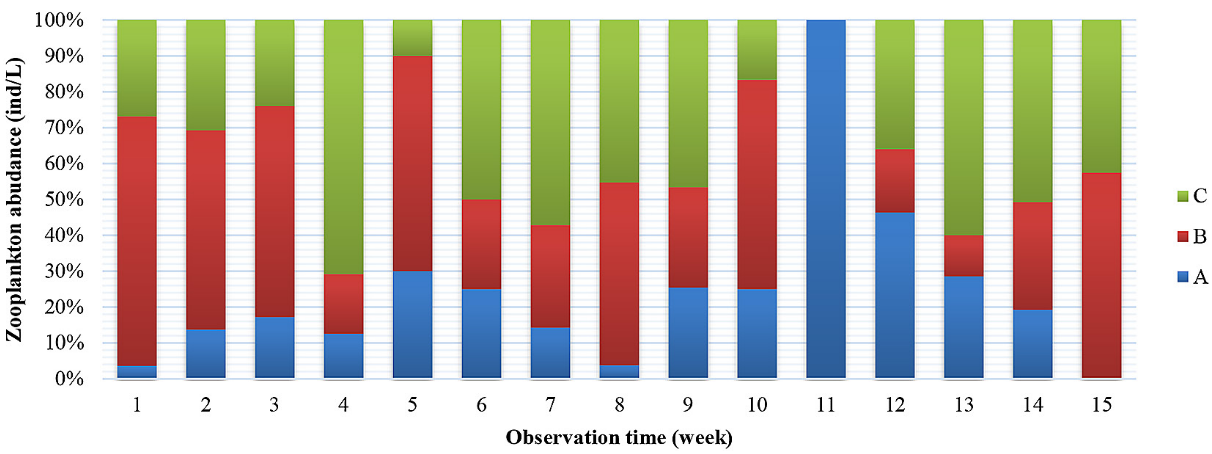

Figure 2. Abundance of zooplankton during the research

sp and *Oscillatoria* sp. consistently yielded the highest levels of abundance in all plots.

Plankton class

In this research, the obtained species of plankton can be categorized into six distinct groups. These include four classes of phytoplankton, namely Bacillarophyceae, Cyanophyceae, Chlorophyceae, and Cromonadea, as well as two classes from zooplankton, specifically Crustacea and Rotatoria. Accordingly, plots A and B comprised a total of five classes and among these groups, plot A exhibited the highest diversity. It is also crucial to establish that Bacillarophyceae was found to be the most prevalent class, comprising eight species of phytoplankton, while the less dominant class Crustacea accounted the for seven species of zooplankton. As a result, both distinct and less dominant classes existed within the dataset (Table 3).

Diversity

This research demonstrated a consistent increase in diversity indices, as shown in (Figure 3), especially during the shrimp maintenance period in plots A, B, and C. In this situation, plots A and B experienced an initial increase up to the 13th week, followed by a subsequent decline towards the conclusion of the research. On the other hand, plot C showed significant fluctuations in its duration. Initially, there was an increase until the 7th week, which was followed by a decline in the 8th week, then another increase up to the 10th week, and finally, a decrease extending to the 15th week.

Uniformity index

The uniformity index exhibited fluctuations in the maintenance period, signifying varying levels of uniformity among the different plots. In this situation, plot A showed a consistent increase in uniformity from week 4 onwards, reaching its peak at week 11 and maintaining this high level until the conclusion of the research. This plot was observed to consistently outperform plots B and C in terms of uniformity. However, it is worth acknowledging that at weeks 6, 7, 13, and 14, plot B surpassed plots A and C in terms of uniformity for a short while. Plot C, on the other hand,

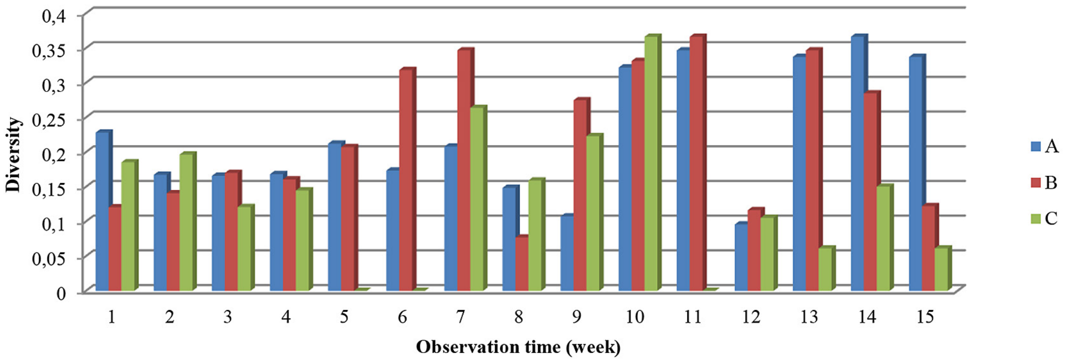

Figure 3. Diversity index during shrimp rearing period

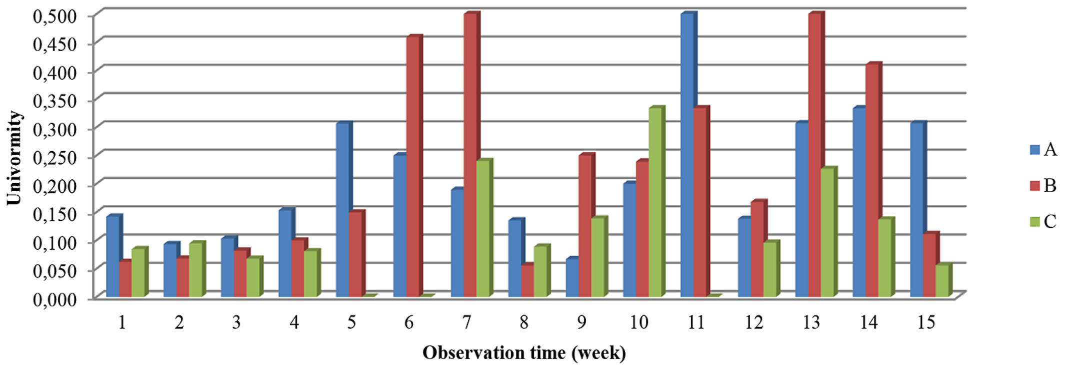

Figure 4. Uniformity index during the maintenance period

Table 3. Grouping of plankton classes during research

No	Phytoplankton class	Genus	Treatment		
			Plot A	Plot B	Plot C
1.	Diatom (Bacillarophyceace)	Bacteriastrum sp.	24	–	–
		Biddulphia sp.	10	–	–
		Chaetoceros sp.	–	–	70
		Coscinodiscus sp.	11	20	16
		Navicula sp.	35	10	42
		Nitzschia sp.	10	–	–
		Pleurosigma sp.	–	10	10
		Thallassiorira sp.	10	–	–
		Total	100.0	40.0	138.0
		Average	16.7	13.3	34.5
2.	Cyanophyceae (Bluegreen algae)	Gleotrichia sp.	20	20	–
		Oscillatoria sp.	119	1476	870
		Total	139.0	1,496.0	870.0
		Average	69.5	748.0	870.0
3.	Chlorophyceae (Chlorophyta)	Ceratium sp.	–	–	90
		Total	–	–	90
		Average	–	–	90
4.	Dinoflagellata (Cromonadea)	Prorocentrum sp.	30	60	42
		Protoperidinium sp.	20	20	75
		Total	50.0	80.0	117.0
		Average	25.0	40.0	58.5
	Zooplankton class				
1.	Crustacea	Acartia sp.	30	419	141
		Copepoda	26	89	42
		Microsetella sp.	16	37	106
		Nauplii copepoda	187	121	204
		Oithona sp.	238	1461	848
		Temora sp.	171	430	417
		Polychaeta sp.	–	20	31
		Total	668.0	2577.0	1789.0
		Average	111.3	368.1	255.6
2.	Rotatoria	Brachionus sp.	266	188	383
		Apocyclops	–	–	61
		Gyrosigma	20	–	–
		Total	289.0	188.0	444.0
		Average	143.0	188.0	222.0

experienced an increase in uniformity until the 10th week, before exhibiting a declining trend until the end of the research period (Fig. 4).

Dominance index

The D value, which, in accordance with predefined standards, should fall within the range of 0 to 1, serves as an indicator of dominance in a population. The D value close to 0 suggests minimal dominance, with individuals evenly distributed, while a value close to 1 indicates a significant presence of dominating individuals within the population. The plankton dominance dynamics within plots A, B, and C are shown in (Figure 5). In this research, the dominance index values for plot A ranged from 0.04 to 0.45, with an average of 0.15, and B from 0.06 to 0.50 (with an average

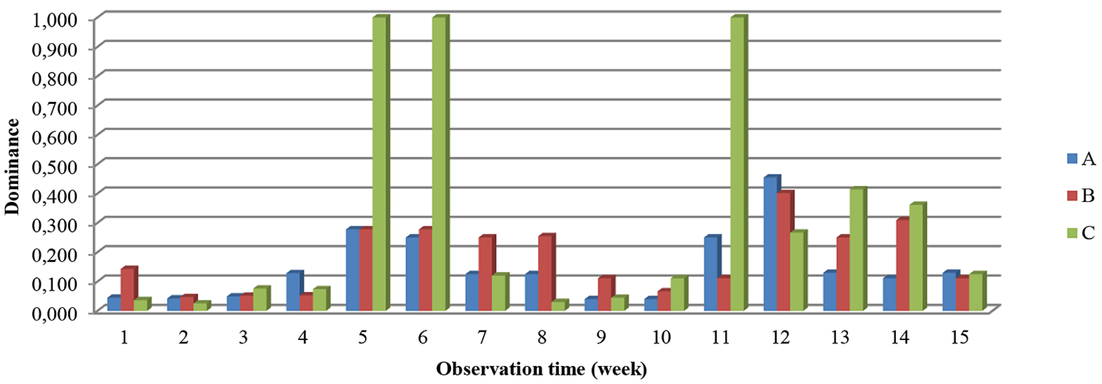

Figure 5. Dominance index during the rearing period

of 0.18). Following this, plot C exhibited a wider range of dominance values, with a minimum of 0.03 and a maximum of 1.00. In this regard, the average dominance index value over the cultivation period in plot C was 0.31, indicating a lack of significant dominance by any one type of plankton. However, it is essential to comprehend that instances of dominance were observed with this plot during observations 5, 6, and 7, as presented in Figure 5.

DISCUSSION

In super intensive shrimp cultivation, large amounts of total ammonium nitrogen (TAN) input are obtained because shrimp consume high protein substances which function as an energy source. In this situation, when the nitrogen + N excreted through feces is combined with the remaining feed, about 75% of the N is released, while only about 25% is retained in the shrimp body (Syah et al. 2014), which causes the NO3 concentration to increase between 10, 3469 to 13.3997 mg/L and PO_4 of 3.6390 mg/L to 6.3580 mg/L (Table 4). At high concentrations it can cause phytoplankton blooms (Fried et al., 2003), so there was a real relationship between the abundance of phytoplankton, NO_3 and PO_4, where the genus Oscillatoria which is in the *Cyanophyceae* or *Bluegreen* algae class had a high abundance in the three treatments. As observed in previous research, these factors can stimulate the growth of blue-green algae, also known as the genus *Oscillatoria* sp. (Ariadi et al. 2022; Quang and Giao 2023). This organism was discovered in relatively high quantities across all plots. Following this, diatom genera were found to be significantly sensitive to fluctuations in water quality, resulting in their lower abundance (Ferdoushi et al. 2023), but they had the most genera compared to *Clorophyceae* and *Dinoflagellates*. The loss of phytoplankton in the 5th week of observation in all treatments was a very real finding, that the superintensive vannamei shrimp cultivation system greatly affected N and P concentrations, but did not cause phytoplankton blooming. it is possible that the loss of phytoplankton occurred due to predation by zooplankton (Gerasimova et al. 2020). Apart from that, high shrimp density was the main factor, where in treatments B and C no zooplankton were found.

The number of phytoplankton whose predation by zooplankton causes their numbers to decrease significantly (Daewel et al. 2014; Shurin 2001), and this condition affects the diversity, uniformity and dominance indices. It can be seen that the uniformity and diversity index in treatment C was very low in the 5th, 6th, 7th and 11th observation weeks, this shows that the very high density of shrimp resulted in a decrease in water quality which had an impact on phytoplankton. growth. so the dominaci index shows very dominant (Figure 5). Fluctuating plankton abundance affects diversity, uniformity and dominance indices. It can be seen that the uniformity and diversity index in treatment C was very low in the 5th, 6th, 7th and 11th observation weeks. The dominaci index showed that it was very dominant. Based on these observations, the average dominance index is still below 1, which indicates that there are no dominating individuals in plots A and B. In research assessing species diversity, a maximum score of 30 (100%) was obtained, which indicates plankton species diversity based on the Shannon-Wiener index. (H'), the Margalef index (E), and the Pielou index (D) are still in good condition, species diversity is stable, and no one species dominates (Akbarurrasyid et al. 2023). However,

Table 4. Water quality during the research

Variable	Plot	Minimum	Maximum	Average	Standar deviation
TAN (mg/L)	A	0.0817	12.9380	4.8500	3.2006
	B	0.0788	11.5527	4.3546	3.2970
	C	0.0657	18.9200	5.4907	5.2388
NO_2 (mg/L)	A	0.0062	27.4000	10.0571	9.9853
	B	0.0075	27.2200	13.4171	10.1293
	C	0.0188	40.3000	16.8249	12.0994
NO_3 (mg/L)	A	0.1033	55.3000	10.3469	15.2157
	B	0.0936	50.5200	13.3253	16.7260
	C	0.0794	49.9150	13.3997	17.0225
N Total (mg/L)	A	0.7814	25.2563	8.7998	6.8571
	B	1.1036	25.2866	10.5798	6.4877
	C	1.0957	35.4253	12.7211	8.7203
PO_4 (mg/L)	A	0.1515	10.1400	3.6390	2.5028
	B	0.0500	9.4000	4.9758	2.9276
	C	0.1878	15.0800	6.3580	4.4993
TSS (mg/L)	A	13	640	187	168
	B	18	400	193	125
	C	24	540	193	125
C/N	A	2	48	9	11
	B	2	28	7	8
	C	1	32	7	8
N/P	A	2	242	45	58
	B	4	295	52	66
	C	8	286	68	82

plot C shows dominance because only one genus is widely distributed.

The initial C/N ratio at the beginning of the cultivation period was relatively high at 25. However, as cultivation progressed, it decreased and exhibited fluctuations within the range from 1 to 48 (with an average of 8 ± 6), as shown in (Table 4). It was important to acknowledge that molasses was introduced during the cultivation process. This endeavor was aimed at adjusting the C/N ratio to approach a value of 10, which allowed for controlled growth of flocculants, resulting in a semi-biofloc system. As a result, in the research, the C/N ratio generally remained below 10, underscoring the ongoing need for the addition of molasses to regulate N element concentration in the pond water (Ghonimy et al., 2023; Xu et al., 2022) It is also crucial to recognize that probiotics were applied during the process by adding carbon. This aided in the formation of flocculants, which led to the attraction of plankton into the flocculant colonies and disrupted their growth. As established by previous research, flocculant formation primarily occurs when the C/N ratio exceeds 10 (Gunarto et al., 2012).

In this study the N/P ratio was between 45–68. The N/P ratio influences the abundance of phytoplankton (Sidabutar and Srimariana 2020). In the cultivation process, the N/P ratio varied within the range of 2 to 295, with an average of 55 ± 69. The fluctuations were observed from the outset of shrimp rearing. It is important to acknowledge that by the end of the cultivation period, prior to the harvest period, there was a significant increase in the total N/P ratio (Figure 4). According to (Daruti et al., 2018), the N/P ratio exceeding 30 creates favorable conditions for the growth of blue green algae (BGA). However, it has also been established that bacteria require an N/P ratio above 30 for their enzymatic processes. Probiotics, stimulated by this elevated N/P ratio, produced protease enzymes that were capable of neutralizing toxins produced by BGA and dinoflagellates (Nasution et al. 2021). On the other hand, if the N/P ratio is low (N/P ≤ 5) then the abundance will increase phytoplankton tends to be low (Glibert et al., 2005). Lastly, in this research, a semi-biofloc system was implemented primarily because daily water exchange prevented the formation of large bacterial flocs in terms of both volume and size.

CONCLUSIONS

The higher density of vannamei shrimp in the superintensive system causes fluctuating dynamics of plankton abundance, and causes in some observations no plankton genus to be found. this is caused by high NO_3 and PO_4. The results of statistical analysis show **s**pearman correlation analysis showed that shrimp density did not have a significant effect on plankton abundance, phytoplankton abundance, zooplankton abundance, TAN, NO_2, NO_3, PO_4, and TSS because the sig value. 2-tailed $P > 0.05$. however, the abundance of phytoplankton had a significant influence on the abundance of zooplankton ($P < 0.05$). while zooplankton abundance was influenced by NO_2 ($P < 0.05$). The close relationship between shrimp density and the abundance of plankton, phytoplankton, zooplankton, and water quality (TAN, NO_2, NO_3, PO_4, and TSS) is very low (-0.85–2.79). positive and very close correlation between plankton density, phytoplankton density and zooplankton density (0.68–0.956), and negative correlation with water quality (TAN, NO_2, NO_3, PO_4, and TSS). This causes the distribution of low levels of diversity (H) and evenness (E), so that the average dominance index is below 1, which indicates the absence of dominant individuals.

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