Water quality parameters and their relation to Rotifera composition in brackish shrimp ponds

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Abstract. The study was conducted in three black tiger shrimp (*Penaeus monodon* Fabricius, 1798) ponds and three whiteleg shrimp (*Litopenaeus vannamei* Boone, 1931) ponds in the Bac Lieu province, Vietnam. The results showed that the environmental parameters in shrimp ponds, such as temperature, pH, salinity, total ammonia nitrogen (TAN), nitrate (NO_3^-), phosphate (PO_4^{3-}), total nitrogen (TN), total phosphorus (TP), and chlorophyll-a, were relatively high and suitable for the growth of shrimp. A total of seven and six species of Rotifera were recorded in black tiger shrimp and whiteleg shrimp ponds, respectively. The Rotifera species number varied from 6-7 species (27-31%) in shrimp ponds. The *Brachionus plicatilis* species had the highest frequency (100%) during the sampling periods. Rotifera abundance tended to decrease considerably after 1-7 days of shrimp stocking. The mean density of Rotifera in whiteleg shrimp ponds tended to be higher than that in black tiger shrimp ponds. The development of Rotifera was significantly affected by TN concentrations ($p<0.05$), while most densities of Rotifera species showed no significant relation ($p>0.05$) with levels of temperature, pH, salinity, TAN, PO_4^{3-}, TP, and chlorophyll-a in the brackish shrimp ponds. The Rotifera composition included *Brachionus angularis*, *Brachionus plicatilis*, *Hexarthra mira*, *Philodina* sp., *Synchaeta* sp., *Ploesoma* sp., *Synchaeta* sp1, *Trichocerca* sp., and *Colurella adriatica*.

Key Words: abundance, *Brachionus plicatilis*, natural food.

Introduction. In recent years, aquaculture has become one of the key economic sectors in the Mekong Delta, Vietnam. Black tiger shrimp (*Penaeus monodon* Fabricius, 1798) and whiteleg shrimp (*Litopenaeus vannamei* Boone, 1931) are two widely farmed species in coastal provinces and are increasingly being farmed on a large scale. The estimated production of farmed shrimp in the first 5 months of 2021 reached 291.1 thousand tons, of which whiteleg shrimp production reached 174.2 thousand tons, accounting for 60% of farmed shrimp production and 10.3% of aquaculture fishery production (GSO 2021). Water quality is an important element affecting the optimal growth and production of shrimp. Therefore, to increase shrimp production, the processes of water quality management and pond care should be closely monitored, including the management of natural food sources such as algae and aquatic animals. According to Ut and Oanh (2013), zooplankton plays an important role in the food chain of water bodies. In addition, zooplankton contributes significantly to the nutrient availability of shrimp larvae immediately after stocking (Coman et al 2003).

The most common groups of zooplankton found in brackish water aquaculture ponds include Protozoa, Rotifera, Copepods, and larvae of Polychaeta and Mollusca. Among them, Rotifera is often consumed by shrimp at the highest rate because of its slow swimming behavior and high nutritional content. Furthermore, Rotifera are zooplankton that are more sensitive to the environment than other groups and are considered as an indicator of water quality (Gannon & Stremberger 1978). In addition, Rotifera have a small size and a short life cycle but are an important component both qualitatively and quantitatively of zooplankton in aquatic ecosystems (Sharma 2010). Loureiro et al (2012) showed that ciliates and rotifers were found in the shrimp gut mainly in the early and middle stages of culture, indicating that shrimp preferentially utilize these groups of organisms, especially at the early stage in their life cycle. Therefore, the objective of this study was to investigate the species composition and abundance of Rotifera in shrimp ponds and its correlation to water quality factors of shrimp ponds. The results of the present study will help to effectively manage the natural food in shrimp ponds.

Material and Method

Sampling time and location. The study was carried out in intensive black tiger shrimp (*Penaeus monodon*) and whiteleg shrimp (*Litopenaeus vannamei*) ponds in Giong Giua A hamlet, Vinh Trach Dong commune, Bac Lieu city, Bac Lieu province, Vietnam. Research took place from December 2020 to June 2021. There are a total of six shrimp ponds which were monitored, including three black tiger shrimp ponds and three whiteleg shrimp ponds. Qualitative and quantitative samples of Rotifera were collected for the first time a day after stocking shrimp. Then, these samples were taken once a week for the first month. From the second month onward, Rotifera samples were collected every 2 weeks until the end of the farming process. Black tiger shrimp ponds had 10 sampling times, and the other ponds had 8 sampling times. Stocking density in the black tiger shrimp ponds was 35 shrimp/m^2, with an area of 1,000 m^2 for each pond. Black tiger shrimp were introduced at post 15. Similarly, the whiteleg shrimp ponds were stocked at post 12 with a density of 60 shrimp/m^2, pond area of 1,200 m^2. Shrimp were fed Grobest feed (proteins of 39-43%, lipids of 4-5%, lysine of 1.6-1.8%), with the amount of feed according to the manufacturer's instructions. Probiotics were periodically applied once a week in the afternoon to stabilize the growth of algae. The farming process did not change the water but only provided about 10% additional water when the shrimp were 2 months old, then periodically supplied water once a week from the treated settling pond.

Sampling and analyzing methods of water quality parameters. Water quality parameters were studied including temperature, pH, salinity, total ammonia nitrogen (TAN), nitrate (NO_3^-), phosphate (PO_4^{3-}), total nitrogen (TN), total phosphorus (TP) and chlorophyll-a. The methods of collection and analysis of water quality parameters were conducted according to APHA (2017).

Collection and analysis of Rotifera

Qualitative and quantitative sampling methods of Rotifera. The filtration method was used to obtain quantitative and qualitative zooplankton samples. A conical (60 µm mesh size) plankton net was used with a 110 mL plastic bottle attached below to collect zooplankton samples. Water was scooped from various points in the shrimp pond with a 20 L plastic bucket and passed through the plankton net with a sample volume of 100 L. After collection, the sample was placed in a 110 mL plastic bottle and fixed with 4% formalin.

Analysis method. The species composition of Rotifera in shrimp ponds was recorded based on morphology and taxonomic documents by Shirota (1966), Thanh et al (1980), Khoi (2001), and Phan et al (2015). Rotifera abundance was identified by Sedgwick-Rafter counting chamber according to the method of Boyd and Tucker (1992) by the following formula:

$$X = \frac{T \times 1000 \times V_{con.}}{A \times N \times V_{sam.}} \times 10^6$$

where X is the density of Rotifera (ind/m^3), T is the number of individuals counted, Vcon. is the volume of the concentrated sample (mL), A is the area of one cell (1 mm^2), N is the number of cells counted, and Vsam. is the volume of the collected sample (mL).

Data analysis. Correlations (Pearson) between abundance of zooplankton and water quality parameters were analyzed using SPSS 22.0 software.

Results

Water quality parameters. The water temperature in shrimp ponds ranged from 26-32.2°C. The average pH value ranged from 7.5-8.5 and 7.6-8.6 in black tiger shrimp (*Penaeus monodon*) and whiteleg shrimp (*Litopenaeus vannamei*) ponds, respectively. The salinity in shrimp ponds varied from 4-11‰, at which salinity in the whiteleg shrimp tended to increase at the end of the farming stage. The salinity in the black tiger shrimp ponds was lower than that in the whiteleg shrimp ponds, ranging from 4-6‰. The concentrations of total ammonia nitrogen (TAN), nitrate (NO_3^-), phosphate (PO_4^{3-}), total nitrogen (TN) and total phosphorus (TP), fluctuated from 0.02-0.21 (mg L^{-1}), 0.02-0.47 (mg L^{-1}), 0.03-0.22 (mg L^{-1}), 0.97-4.98 (mg L^{-1}), and 1.03-2.24 (mg L^{-1}), respectively. TAN level in the black tiger shrimp ponds showed the highest value at the end of the farming period. Similarly, the concentrations of NO_3^- and PO_4^{3-} also increased at periods of 56–70 days. The chlorophyll-a content varied remarkably across the sampling periods, ranging from 1.5–20.5 μg/L in black tiger shrimp ponds and from 14.8-19.4 μg L^{-1} in whiteleg shrimp ponds. The value of chlorophyll-a decreased very low at stages of 21–84 days in the black tiger shrimp, while in the whiteleg shrimp ponds did not change significantly during periods of 0-56 days and obtained the lowest level at the end of the farming period (Table 1).

Table 1

Water environment elements in the shrimp ponds

Day after stocking	*pH*	*Salinity (ppt)*	*Temp (°C)*	*TAN (mg L^{-1})*	*NO_3^- (mg L^{-1})*	*PO_4^{3-} (mg L^{-1})*	*TN (mg L^{-1})*	*TP (mg L^{-1})*	*Chlorophyll-a (μg L^{-1})*
Black tiger shrimp ponds									
1	7.5	4.3	28.8	0.03	0.03	0.07	0.97	1.31	15.6
7	7.7	4.2	26.0	0.03	0.13	0.06	1.21	1.10	20.5
14	7.9	4.2	28.0	0.04	0.20	0.06	1.40	1.03	13.8
21	8.0	4.3	28.5	0.03	0.11	0.05	1.26	1.33	7.8
28	7.8	4.6	28.4	0.02	0.06	0.07	2.17	1.63	8.3
42	7.8	5.0	26.5	0.10	0.05	0.18	2.17	1.71	1.8
56	8.4	5.2	26.2	0.06	0.05	0.13	1.82	1.41	1.5
70	8.3	6.1	26.2	0.08	0.05	0.04	1.87	1.51	2.4
84	8.5	6.3	26.7	0.07	0.05	0.07	2.43	1.62	3.8
96	8.2	6.4	29.7	0.21	0.05	0.14	1.91	1.46	15.2
Whiteleg shrimp ponds									
1	8.4	7.2	27.93	0.08	0.02	0.03	4.98	1.43	19.4
7	8.5	7.3	32.17	0.07	0.05	0.06	2.06	1.36	14.9
14	8.0	9.2	26.60	0.04	0.04	0.06	2.66	1.12	17.1
21	7.6	10.2	29.57	0.05	0.10	0.05	2.66	1.08	16.0
28	8.6	10.3	33.80	0.04	0.06	0.06	1.29	1.10	16.6
42	8.3	10.3	26.43	0.05	0.07	0.05	1.27	2.24	14.8
56	8.4	11.2	26.60	0.06	0.45	0.22	1.17	1.36	15.8
70	8.5	11.4	26.93	0.06	0.47	0.12	1.15	1.17	11.9

Zooplankton in brackish shrimp ponds. The total number of zooplankton species in black tiger shrimp and whiteleg shrimp ponds is shown in Figure 1 and Figure 2. In general, there was no significant difference in the zooplankton structure between shrimp ponds. In black tiger and whiteleg shrimp ponds, the total number of zooplankton species recorded was 23 species and 25 species, respectively. Rotifera species numbers in the black tiger shrimp and whiteleg shrimp ponds were 7 species (accounting for 31%) and 6 species (accounting for 27%), respectively. The remaining groups, including Protozoa, Copepoda, and Cladocera, had a lower number of species. Protozoa were identified as 4 species in black tiger shrimp ponds (17%) and 10 species in whiteleg shrimp ponds (30%) ponds. Similarly, Copepoda had the same number (4 species) in the two shrimp ponds, but Cladocera was not found in whiteleg shrimp ponds. Other groups of zooplankton, including Nematoda, larvae of Gastropoda, Bivalvia, and Polychaeta ranged from 5-7 species.

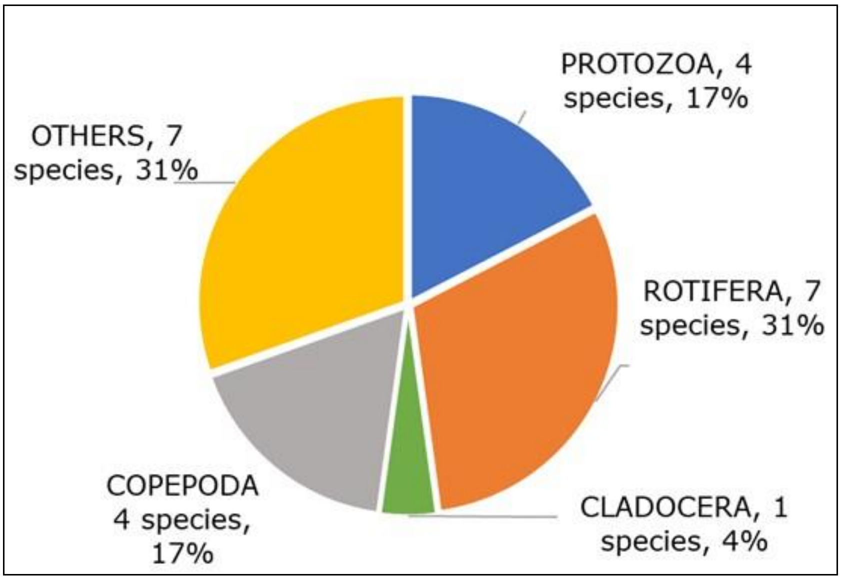

Figure 1. Structure of zooplankton species composition in black tiger shrimp ponds.

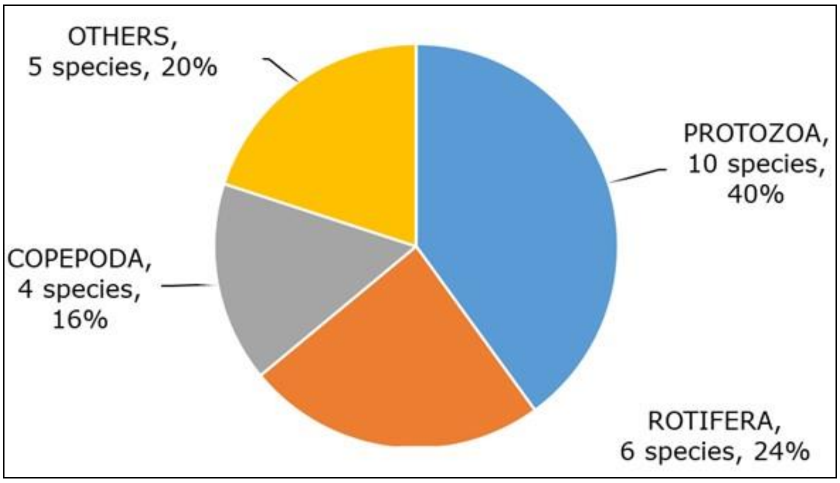

Figure 2. Structure of zooplankton species composition in whiteleg shrimp ponds.

Species composition and abundance of Rotifera in black tiger shrimp ponds. The number of Rotifera species recorded in black tiger shrimp ponds was quite low, with only 7 species found in total (Table 2). The species number of Rotifera had the lowest value after 7 days of stocking with only one species. Rotifera species identified are *Brachionus angularis*, *Brachionus plicatilis*, *Philodina* sp., *Colurella adriatica*, *Trichocerca longiseta*, *Hexarthra mira*, and *Synchaeta* sp. The number of Rotifera species varied from 1–5, of which *Brachionus plicatilis* was presented regularly through the sampling stages with 100% frequency. In addition, *Hexarthra mira* species was also found in most of the samples at a rate of 90%. The remaining species had a lower frequency (10-60%). The abundance of Rotifera fluctuated relatively high through the survey periods (1,767-601,261 ind. m^{-3}) with the predominance of *Trichocerca longiseta*, *Hexarthra mira*, and *Brachionus plicatilis* species at 1 day after stocking. In black tiger shrimp ponds, *B. plicatilis* rotifers had densities ranging from 1,757-91,381 ind.m^{-3}, with the highest abundance at 86 days and the lowest value at 7 days. The abundance of *Hexarthra mira* fluctuated from 16,750-135,439 ind. m^{-3}, highest abundance after 1 day and its lowest at 14 days. The density of *Philodina* sp. ranged from 1,810-172,252 ind. m^{-3} and reached a peak in the 28-day period. *B. angularis* density ranged from 892-1,9361 ind. m^{-3} in the period from 28-56 days. The remaining species, including *Trichocerca* sp. and *Synchaeta* sp1, were found only in the 1-day stage with densities of 369,056 ind. m^{-3} and 27,617 ind. m^{-3}, respectively (Figure 3b).

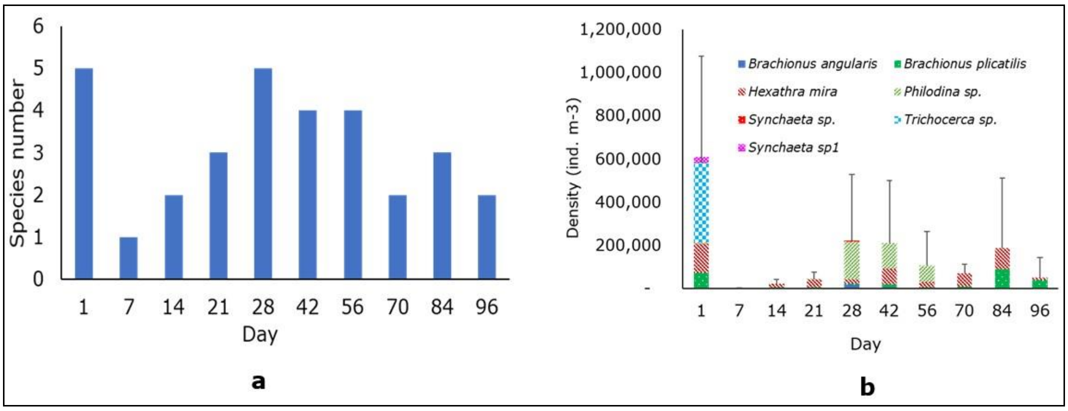

Figure 3. (a) Species composition and (b) density of Rotifera species in black tiger shrimp ponds.

Species composition and density of Rotifera in whiteleg shrimp ponds. In whiteleg shrimp ponds, Rotifera species numbers varied from 1–5 species through the sampling periods. The number of species of Rotifera declined noticeably after stocking shrimp until the end of the farming cycle and ranged from 1–3 species (Figure 4a). The abundance of Rotifera tended to decrease significantly after 14 days of stocking (Figure 4b). Rotifer *B. plicatilis* dominated with high percentages of 87% and 98% after 1 day and 7 days of stocking shrimp with densities of 1,948,722 and 2,352,733 ind. m^{-3}, respectively. The Rotifera abundance decreased significantly at stages of 14–70 days. The mean densities of *Colurella adriatica, Ploesoma* sp., and *Trichocerca* sp. species were 2,415 ind. m^{-3}, 1,813 ind. m^{-3}, and 3,177 ind. m^{-3}, respectively. In addition, *Philodina* sp. species had the lowest abundance, with a mean density of 16 ind. m^{-3}.

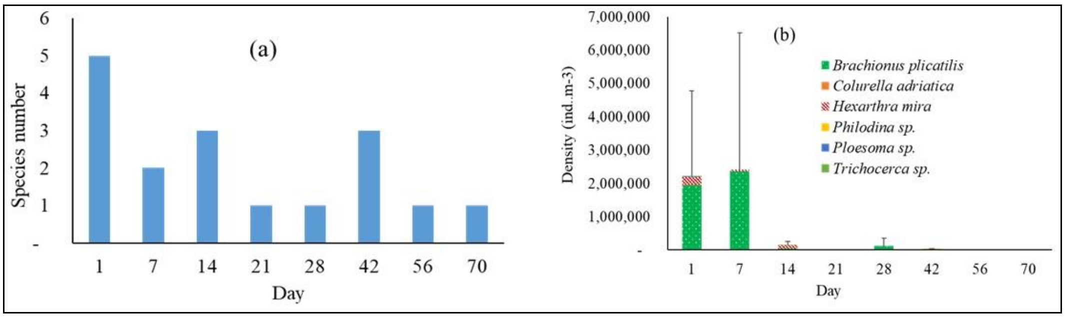

Figure 4. (a) Species composition and (b) density of Rotifera in the whiteleg shrimp ponds.

Table 2

Mean density (ind. m^{-3}) of Rotifera species in shrimp farming ponds

No.	*Species name*	*Black tiger shrimp*			*Whiteleg shrimp*		
		Min	*Max*	*Mean*	*Min*	*Max*	*Mean*
1	*Brachionus angularis*	-	17,205	2,379			
2	*Brachionus plicatilis*	1,767	91,381	25,588	341	2,352,733	560,044
3	*Colurella adriatica*				-	12,568	2,415
4	*Hexarthra mira*	-	135,439	47,399	-	238,250	48,689
5	*Philodina* sp.	-	172,252	37,248	-	126	16
6	*Synchaeta* sp.	-	7,605	761			
7	*Ploesoma* sp.				-	14,500	1,813
8	*Synchaeta* sp1	-	27,617	2,762			
9	*Trichocerca* sp.	-	369,056	36,906	-	16,333	3,177
	Total			153,042			616,154

Relationship between water environmental parameters and Rotifera species density in shrimp ponds. Based on the output of Pearson correlation coefficients between mean Rotifera species density and water quality parameters in the brackish shrimp ponds, the results from Table 3 showed that temperature, salinity, and nutrient contents in shrimp ponds, including TAN, NO_3^-, PO_4^{3-}, and chlorophyll-a, did not show a statistically significant correlation ($p<0.05$) with abundance of most Rotifera species. However, pH was negatively correlated ($p<0.05$) with *Trichocerca* sp. density. The abundance of *B. plicatilis, H. mira, Ploesoma* sp., and *Synchaeta* sp. significantly increased ($p<0.05$) when TN concentration increased, while *C. adriatica* density was positively correlated ($p<0.01$) with TP value.

Table 3

Relationship between water environmental parameters and Rotifera species density in shrimp ponds (n = 54)

Species	Temp	pH	Salinity	TAN	NO_3^-	PO_4^{3-}	TN	TP	Chlorophyll-a
B. angrularis	-0.031	-0.103	-0.164	-0.026	-0.077	-0.015	-0.036	0.019	-0.194
B. plicatilis	0.189	0.095	0.014	0.050	-0.082	-0.086	0.274*	0.034	0.191
C. adriatica	-0.074	0.152	0.194	0.059	-0.100	-0.120	0.131	0.359**	-0.066
H. mira	-0.100	-0.042	-0.131	0.129	-0.164	-0.136	0.321*	0.061	0.057
Ploesoma sp.	-0.084	0.067	0.009	0.204	-0.081	-0.095	0.421**	0.064	0.170
Philodina sp.	-0.084	-0.098	-0.213	0.030	-0.112	0.051	0.000	0.036	-0.256
Synchaeta sp1	0.136	-0.247	-0.183	-0.094	-0.092	-0.006	-0.167	-0.028	0.020
Synchaeta sp.	0.131	-0.131	-0.109	-0.160	-0.126	-0.113	0.404*	0.078	0.135
Trichocerca sp.	0.137	-0.307*	-0.212	-0.116	-0.106	-0.032	-0.160	-0.020	0.074
Rotifera	0.176	0.050	-0.035	0.051	-0.112	-0.094	0.275*	0.040	0.174

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

The mean shrimp production in the black tiger shrimp ponds was 2,153 ± 211 kg/ha, lower than that in the whiteleg shrimp ponds with 2,694 ± 188 kg/ha (Table 4).

Table 4

Shrimp production

No.	*Pond*	*Stocking density (ind. m^{-3})*	*Mean production (kg ha^{-1})*
1	Black tiger shrimp	35	2,153 ± 211
2	Whiteleg shrimp	60	2,694 ± 188

Disscusion. Water quality plays an important role in the shrimp ponds. Temperature can be considered normal when it reports values of 26–33°C (Hai et al 2017). A sudden change in temperature may affect the shrimp's immune system. However, Chanratchakool et al (1995) suggested that at temperatures higher than 33°C or lower than 25°C, shrimp's ability to catch prey will decrease by 30-50%. Temperature variations can halt growth, interfere with feeding and swimming, and even cause mortality (Xu et al 2018). The swimming and respiratory activities of the Rotifera were almost unchanged when the pH was between 6.5 and 8.5 (Epp & Winston 1978). According to Chanratchakool et al (1995), suitable pH in shrimp farming ponds was from 7.5 to 8.35 and the daily fluctuation range did not exceed 0.5 pH units. Salinity is considered to be the most vital factor in propelling many functional responses of the shrimp biological system, such as metabolism, growth, migration, osmotic behavior, and reproduction (Edward et al 2016). According to Hai et al (2017), whiteleg shrimp can grow in the range of salinity of 0.5-45‰ and the most suitable salinity for shrimp to grow and develop was from 7-34‰. Most shrimp species grow well at salinities of 15-25 ‰. In general, nutrient levels in shrimp ponds were quite high, especially nitrate (NO_3^-) and phosphate (PO_4^{3-}) concentrations, which tended to increase at the crop end due to the accumulation of nutrients from the shrimp farming process. Nutrients such as nitrogen and phosphorus in the shrimp ponds originated mainly from prepared feed

(Cremen et al 2007). The chlorophyll-a content in black tiger shrimp ponds fluctuated higher than that in whiteleg shrimp ponds and tended to decrease over a period of 42-84 days of culture (1.5-3.8 mg L^{-1}) when the density of Rotifera reached its lowest value at this stage. This result showed that low algae density limited Rotifera growth in general.

In the black tiger shrimp ponds, seven Rotifera species were found during sampling periods. Most of the identified Rotifera species were good food sources for shrimp and fish larvae. The Rotifera composition in this study was higher than in the research from Nguyen et al (2022), but the results showed that only three species of Rotifera were identified in the super intensive whiteleg shrimp tanks, including *Brachionus plicatilis*, *Synchaeta* sp., and *Colurella adriatica*. In addition, Suatoni et al (2006) revealed that the only Rotifera species found at one of the aquaculture sites was *Brachionus plicatilis*, a typical indicator of saline waters. In this study, Figure 2a shows that only 1 species of Rotifera was recorded after 7 days of culture. This is because at this time there was a dominant growth of *Tintinnopsis uruguayensis* (Protozoa), which accounted for 87% of all organisms, overwhelming the development of other groups of organisms and thereby reducing the diversity of the Rotifera species. In general, at salinities of 4-6‰, it limited the diversity of species composition of Rotifera.

The abundance of Rotifera decreased very strongly in the period from 7-21 days, which coincided with the time when the water environment had lower concentrations of total nitrogen (TN) and total phosphorus (TP) compared to other periods. After stocking the shrimp for 7 days, the Rotifera could be consumed by shrimp, which made their density significantly lower. Then, the density of Rotifera tended to increase in the remaining stages, in which *Philodina* sp. predominated in the period from 28-56 days. *Hexarthra mira* species had a higher density in the 70-84 day period, while *B. plicatilis* was more abundant in the 84-96 day period. *B. plicatilis* species is now widely mass cultured and used in aquaculture seed production. The rotifer *B. plicatilis* is a euryhaline species, and in nature, density peaks of these species are associated with high eutrophication (Fenggi 1996). The *B. angularis* individual number obtained the highest value in the period from 28-56 days, coinciding with the time when the water environment had high nutrient content as shown by the contents of TN and TP, which were recorded quite high (1.82-2.17 mg L^{-1} and 1.41-1.71 mg L^{-1}, respectively). According to Kim et al (2006), *B. angularis* has a very small size with a length and width of 102.3 μm and 76.6 μm, respectively, which cannot survive when the water has a salinity higher than 10‰. Moreover, *Trichocerca* sp. and *Synchaeta* sp. species were only identified at the stage of 1 day stocking and disappeared during other periods when salinity increased in the shrimp ponds.

Six Rotifera species were found in the whiteleg shrimp ponds in total. This result is similar to the findings of Porto Neto et al (2009), who also identified six species of Rotifera in shrimp ponds in Northeastern Brazil. The abundance of Rotifera fluctuated greatly over the sampling periods, declining noticeably from 21 days until the end of the culturing process. Quantaties of Rotifera changed from 341-2,406,178 ind. m^{-3}, much higher than that in black tiger shrimp ponds. Rotifera indicates a water environment with high nutrients. In this study, the average values of NO_3^- and TN contents in black tiger shrimp ponds were determined to be 0.08 mg L^{-1} and 1.72 mg L^{-1}, respectively. These values were lower than those in whiteleg shrimp ponds**,** with concentrations of NO_3^- and TN of 1.72 mg L^{-1} and 2.16 mg L^{-1}, respectively. Therefore, Rotifera communication in whiteleg shrimp ponds developed stronger than that in black tiger shrimp ponds.

Rotifers presented high quantities of *Brachionus plicatilis* in the whiteleg shrimp ponds, mainly 1–7 days after stocking. This was also the stage when the water environment had very high concentrations of TN and TP, providing nutrients for algal growth as shown by the high chlorophyll-a content (19.4 μg L^{-1}). For these reasons, the Rotifera also obtained the highest abundance. According to Park & Marshal (2000), the contribution of Rotifera to water bodies increased with increasing nutrient levels. The density of Rotifera decreased markedly in the remaining times; this result showed that shrimp consumed Rotifera as feed, thereby reducing the density of Rotifera in shrimp ponds. While rotifer *B. plicatilis* was present in all the research stages with 100% frequency, the other species had a very low frequency (13–38%), showing the adaptive characteristics of *B. plicatilis* in brackish water environments. The remaining Rotifera species, including *C. adriatica, H. mira, Philodina sp., Ploesoma sp., and Trichocerca sp.*, had lower densities, ranging from 219-362,953 ind. m^{-3}. Although they had a lower density than *B. plicatilis*, they were still a useful natural food source for shrimp. The findings of this study revealed that four Rotifera species, including *B. plicatilis*, *Hexarthra mira*, *Philodina* sp., and *Trichocerca* sp., were found in both black tiger shrimp and whiteleg shrimp ponds. The study also discovered three species that were only found in black tiger shrimp ponds, including *B. angularis*, *Synchaeta* sp., and *Synchaeta* sp1, as well as two species found only in whiteleg shrimp ponds, *Colurella adriatica and Ploesoma* sp. Except for *B. plicatilis* species, Rotifera species found in shrimp ponds are mostly distributed in freshwater bodies, where salinity ranges from 4 to 11‰, limiting their development. The mean density of Rotifera in the black tiger shrimp ponds was lower than that in the whiteleg shrimp ponds.

According to Primo et al (2015), zooplankton communities often vary in composition as certain species are highly sensitive to changes in nutrient cycling, temperature, and variable environmental conditions. In the present study, Rotifera abundance was significantly influenced by TN content ($p<0.05$). *B. plicatilis*, *H. mira*, *Ploesoma* sp., and *Synchaeta* sp. species developed as dominants in water environments with high TN levels. The findings from Nguyen et al (2022) showed that the rotifer *Brachionus plicatilis* had a strong relationship with TP content. However, the quantity of Rotifera did not correlate significantly with chlorophyll-a concentration, and the same results were also found in the current study. A significantly positive relation was not found ($p>0.05$) between Rotifera abundance and shrimp production. However, the growth of Rotifera helped to balance shrimp pond ecology as well as the supply of natural food for shrimp. Hence, the shrimp farming model had brought high economic efficiency, improving income for shrimp farmers.

Conclusions. A total of nine Rotifera species were found in the brackish shrimp ponds. The Rotifera species composition in black tiger shrimp (*Penaeus monodon*) ponds tended to be higher than that in whiteleg shrimp (*Litopenaeus vannamei*) ponds. However, the average density of Rotifera in whiteleg shrimp ponds was much higher than in black tiger shrimp ponds. Nutrient contents in water, including total ammonia nitrogen (TAN), nitrate (NO_3^-), and phosphate (PO_4^{3-}), were not strongly correlated with the density of Rotifera species, but total nitrogen (TN) content was significantly correlated with Rotifera abundance. The development of Rotifera made an important contribution to shrimp survival and growth, especially in the initial stages after stocking.

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Conflict of interest. The authors declare that there is no conflict of interest.

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