Plankton Diversity in *Litopenaeus vannamei* Cultured Ponds

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Abstract

The culture of animals in ponds is vital in the context of increasing demand for seafood and declining trend of marine production. Aquaculture makes significant contribution to export earnings and employment in India. The annual production of shrimps from aquaculture in India is approximately 0.126 million metric tons. The production of *P. monodon* was stagnant over the last few years due to WSSV disease outbreaks and drastic fall in export prices. The growth rate of *P. monodon* was only 44%, whereas *L. vannamei* registered a growth rate of 1067% globally during the past decade. Considering the disease outbreaks in *P. monodon* and success of *L. vannamei* in other countries, it has been introduced in India recently. There is a lot of variation in plankton species under different systems of shrimp culture. To understand the diversity of plankton and its variation due to seasonal changes, *L. vannamei* ponds were monitored monthly for the occurrence of phytoplankton, zooplankton and benthos. In addition to this, other physico-chemical parameters of water were analyzed. During summer, a total of 29 different species of phytoplankton belonging to six different classes were observed. There were 15 different species of zooplankton belonging to two different classes namely Rotifera and Copepoda. The major groups of macro-benthos comprising of gastropoda, foraminifera, polychaeta, bivalvia and insecta were recorded during culture. During winter crop, Cladocera group was observed in addition to the summer crop zooplankton diversity. In summer crop, phytoplankton, zooplankton and benthos densities varied from 225-337x10^4cells ml^{-1}, 72-342 cells l^{-1} and 47-79 numbers m^{-2} respectively, whereas in winter crop, phytoplankton, zooplankton and benthos densities varied from 74-105x10^4 cells ml^{-1}, 64-189 cells l^{-1} and 13-26 numbers m^{-2} respectively. It is concluded that there is a significant variation in plankton population due to seasonal changes. Plankton abundance is higher in summer crop whereas diversity is more in winter crop.

1. Introduction

Aquaculture has developed rapidly over the last three decades worldwide to become an important global economic activity. Shrimp continues to be the main fish commodity trade in value terms. *Penaeus monodon* used to be the major cultivated shrimp species in India till *Litpenaeus vannamei* has been introduced in 2009/2010 and its culture is growing extensively. Water qua,lity plays a significant role in plankton productivity as well as the growth rate and development of animal (Jhingran, 1991). The qualitative and quantitative abundance of plankton in a shrimp pond are of great importance in managing the successful and sustainable aquaculture. The phytoplankton population represents the biological wealth of a water body whereas the zooplankton forms the principal source of food for shrimp within the water body (Prasad and Singh, 2003). The plankton diversity varies from location to location and from pond to pond within the same location even within similar ecological conditions (Boyd, 1982). Climate has a major influence on water quality and consequently, the biodiversity within the water bodies (Boyd and Tucker, 1998). There are little or no studies on plankton diversity under *L.vannamei* culture in India, though similar studies have been reported under *P.monodon* (Tookwinas and Songasangjinda, 1999; Moorty and Altaff, 2002; Cremen et al., 2007). Hence, the present study reports on preliminary details of water quality, plankton abundance its diversity and their seasonal variation during the culture period of *L. vannamei*.

2. Materials and Methods

2.1. Shrimp culture details

The study was carried out in *L. vannamei* ponds located in Kancheepuram District of Tamil Nadu, India with a stocking density of 60-70 no. m^{-2} during summer (April 2011 to August 2011) and winter season (September to December 2011). During winter season, the area received rainfall from North East monsoon. At the start of the culture, liming was done with lime stone powder (Ca_2CO_3) in all the ponds at the rate of 750-800 kg ha^{-1}. No water exchange and fertilization were done during the culture period in both the crops. Aeration and probiotics were provided in both the crops. The shrimps were fed with commercial feed throughout the crop period. Survival rate was around 90% in both the crops. Physico-chemical parameters and nutrient levels of water, plankton abundance and diversity were estimated at monthly intervals.

2.2. Sampling and analysis

2.2.1. Physico-chemical analysis

Water samples were collected at monthly intervals between 07:00 and 08:00 hrs in 250 ml polyethylene bottles and at the same time in-situ measurements were done for pH and salinity using pH meter and hand refractometer. The collected samples were transported in ice-container to the laboratory and were analyzed immediately for alkalinity, hardness (titrimetry as per APHA, 1998), nitrate-N and soluble reactive phosphorus (Strickland and Parsons, 1972).

2.2.2. Plankton analysis

Water samples were collected and preserved in 4% buffered formalin for plankton abundance and identification. Identification of plankton was done under a compound light microscope using keys and illustrations by Prescott (1962), Patrick and Reimer (1966), Round et al. (1990), Tomas (1997), and other taxonomic literature. A Van veen grab was used for collecting bottom fauna. Benthic fauna was separated by passing the sediment through a 0.5 mm mesh sieve and the fauna was preserved for identification using 5% formalin-Rose Bengal solution.

3. Results and Discussion

3.1. Water quality parameters

The pH values ranged from 7.83 to 8.29 during summer crop and 7.01 and 8.05 during winter crop. There was no seasonal influence on pH. The mean value of salinity of pond water was 35.6 ppt and 18.3 ppt in summer and winter crop, respectively. The low salinity was primarily due to the dilution of pond water by rains during the culture period. Total alkalinity and total hardness values in the pond water were higher in summer crop than winter crop. Nitrate-N and phosphate concentration increased as the crop progressed and there was a significant difference between the months in both the crops. The mean value of nitrate concentration during the crop was 0.162 ppm which was higher than that of the winter crop and similar trend was observed in phosphate concentration as well. The physico-chemical and nutrient concentration of pond water in both the crops were optimal for plankton production (Table 1 and 2).

3.2. Plankton

The phyto and zooplankton population was identified up to

Table 1: Variation in water quality parameters during summer crop (Mean±SD)

Parameters	Months			
	April	May	June	July
pH	8.04±0.0707	7.83±0.2545	8.29±0.0212	8.1±0.0636
Salinity (ppt)	35±0	34±1.4142	34.5±0.7071	39±1.4142
Nitrate (ppm)	0.128±0.0009	0.1473±0.0022	0.1668±0.0046	0.2051±0.0030
Phosphate (ppm)	0.19±0.0003	0.215±0.0011	0.2385±0.0010	0.3834±0.0015
Total alkalinity (ppm as $CaCO_3$)	232±5.6568	198±2.8284	159±1.4142	153±2.1213
Total hardness (ppm as $CaCO_3$)	5800±42.4	2950±70.71	6300±28.2	6650±49.4

Table 2: Variation in water quality parameters during winter crop (Mean±SD)

Parameters	Months			
	Sep	Oct	Nov	Dec
pH	7.01±0.1202	8.05±0.1909	7.85±0.0707	7.78±0.2404
Salinity (ppt)	24±0	18±0	18.5±0.7071	12.5±0.7071
Nitrate (ppm)	0.095±0.0070	0.125±0.0063	0.145±0.0056	0.194±0.0035
Phosphate (ppm)	0.134±0.0049	0.183±0.0035	0.224±0.0056	0.3125±0.0035
Total alkalinity (ppm as $CaCO_3$)	113±3.5355	126±3.5355	132±4.9497	81±5.6568
Total hardness (ppm as $CaCO_3$)	3500±70.7	3629±4.24	3430±28.28	2102±7.07

species level as shown in Table 3. The plankton diversity showed that water quality parameters in optimum range and nutrient rich water influenced the growth of both phyto and zoo plankton groups. Similar observation was reported by Hossain et al. (2007). Margalef (1964) also reported that the phytoplankton population in nutrient rich waters is more diverse than those in nutrient deficient waters. Verma and Shukla (1970) recorded 30 genera of phytoplankton from Kamala Nehru tank, Muzaffarnagar, whereas Hossain et al. (2006) recorded 38 genera of phytoplankton and 13 genera of zooplankton during a three month study period in earthen fish ponds in the Mymensingh region, Bangaladesh. During 2007, Hossain and Co-workers studied the earthen fish pond in Rajshahi and recorded 17 genera of phytoplankton and 10 genera of zooplankton (Hossain et al., 2007).

Table 3: Composition of plankton and benthos in *L. vannameii* culture ponds

Phytoplankton	Zooplankton	Benthos
Actinoptychus splendens	*Bdelloidea* sp.	Polychaete worm larvae
Chaetoceros sp.	*Adineta Oculata*	Stages
Nannochloropsis sp.	*Lecane stichaea*	*Veliger Larvae*
Nitzschia sigma	*Gastropus hyptopus*	*Barnacle nauplius*
Striatella unipunctata	*Brachionus plicatilis*	
Pleurosigma elongatum	*Oithona brevicornis*	
Nitzschia closterium	*Nannocalanus minor*	
Epithemia adnata	*Oithona rigida*	
Mastogloia minuta	*Pseudodiaptomus Annandalei*	
Pleurosigma directum	*Paracalanus parvus*	
Oscillatoria sp.	*Pseudodiaptomus Aurivilli*	
Anabaena sp.	*Acartia erythraea*	
Nostoc sp.		
Coscinodiscus concinnus		
Rhizosolenia Castracanei		
Cyclotella meneghiniana		
Tintinnopsis cylindrica		

Monthly variations in total phytoplankton, zooplankton and benthos in shrimp ponds under summer and winter crop are shown in Figures 1, 2 and 3 respectively. The peaks of plankton abundance occur at different months in a year. Similar observation was recorded by Hossain et al. (2007). It showed that variation in plankton densities is influenced not only by temperature and other factors such as pH, alkalinity and nutrients are responsible for the organic production (Pulle and Khan, 2003). Correlation analysis of data showed that the phytoplankton abundance had a positive correlation with nitrate and phosphate. This is similar with the finding of Saraswathy

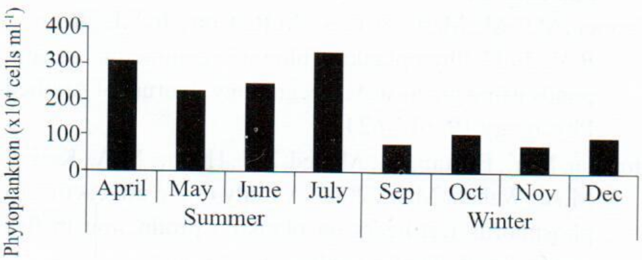

Figure 1: Mean abundance of phytoplankton under summer and winter crop

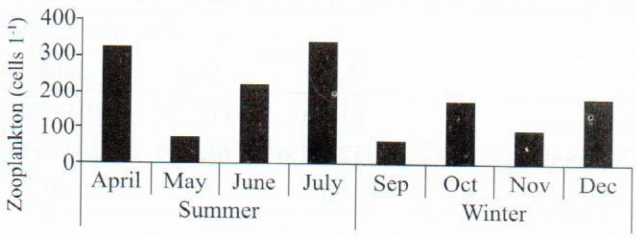

Figure 2: Mean abundance of zooplankton under summer and winter crop

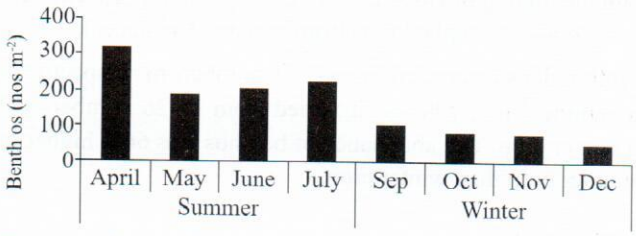

Figure 3: Mean abundance of benthos under summer and winter crop

et al. (2012). During summer crop the correlation with nitrate and phosphate was 0.4184 and 0.6058 respectively, whereas during winter, the correlation was less with nitrate (0.249) and phosphate (0.221). The dominance of plankton species observed during various months of the study period is due to the variations in the optimal conditions for the particular species.

During summer and winter crop, a total of 29 different species of phytoplankton belonging to six different classes (Chlorophyceae, Bacillariophyceae, Cyanophyceae, Coscinodiscophyceae, Mediophyceae and Ciliata) (Table 4) were observed. Though all the six classes were present in both the crops, plankton abundance was higher in summer (68.7%) than winter crop. It might be due to algal crash caused by rainfall during winter crop. The most dominant group of phytoplankton was Chlorophyceae contributing 65.1% and 33.3% of total phyto plankton in summer and winter crops respectively. The second dominant group of phytoplankton was Bacillariophyceae (15.9% in summer and 29.1% in winter) followed by Cyanophyceae (10.5%) in summer and Ciliata (15.7%) in winter. Cyanophyceae is 12% of total phytoplankton in winter and Ciliata is prominent during low temperature. All other groups contribute less than 9%.

The zooplankton population (Table 5) consisted of 12 species, with 5 belonging to Rotifera (16.2%) and 7 belonging to Copepoda (83.8%) in summer whereas in winter one more group Cladocera was observed. The reverse trend was observed in winter crop and the most dominant group was Rotifera contributing 43.4% of total zooplankton and followed by Copepoda (39.4%) and Cladocera (17.2%). The results are corroborated with the finding of Hossain et al. (2007) who reported mainly two groups of zooplankton (Rotiferea and Crustacea).

Table 4: Variation in Phytoplankton densities ($\times10^4$ cells mL^{-1}) during *L. vannamei* culture (Mean±SD)

	Summer				Winter			
	April	May	June	July	Sep	Oct	Nov	Dec
Chlorophyceae	225±11.2	134±6.7	176±8.8	194±9.7	14±0.7	51±2.5	18±0.9	34±1.7
Bacillariophyceae	44±2.2	44±2.2	46±2.3	44±2.2	24±1.2	29±1.4	10±0.5	39±1.9
Cyanophyceae	26±1.3	27±1.3	16±0.8	49±2.4	19±0.9	10±0.5	9±0.4	4±0.2
Coscinodiscophyceae	12±0.6	18±0.9	10±0.5	34±1.7	8±0.4	3±0.1	12±0.6	7±0.3
Mediophyceae	2±0.1	2±2.3	1±0.05	5±0.2	Nil	1±0.05	3±0.1	1±0.05
Ciliata	51±2.55	16±0.8	49±2.4	11±0.5	13±0.6	11±0.5	22±1.1	9±0.4

Table 5: Variation in Zooplankton densities (cells L^{-1}) during *L. vannamei* culture (Mean±SD)

	Summer				Winter			
	April	May	June	July	Sep	Oct	Nov	Dec
Rotifera	20±1.0	11±0.5	103±5.1	23±1.1	16±0.8	98±4.9	40±2	76±3.8
Copepoda	312±11.6	61±3.0	121±0.6	319±15.9	41±2.0	72±3.6	12±0.6	84±4.2
Cladocera	NP	NP	NP	NP	7±0.3	11±0.5	44±2.2	29±1.4

Benthos densities varied from 47-79 numbers m^{-2} respectively in summer crop, whereas it varied from 13-26 numbers m^{-2} in winter crop. The abundance of benthos was 66% higher in summer crop than winter crop.

4. Conclusion

From the study of *L. vannamei* crop in two seasons, significant variation is observed in plankton population due to seasonal changes. Plankton abundance is higher in summer crop whereas it is more diverse in winter crop.

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