Bangladesh J. Zool. **46**(2): 167-175, 2018 ISSN: 0304-9027 (print)
2408-8455 (online)

NUTRIENT IMPACT ON THE ABUNDANCE OF PLANKTON IN *PENAEUS MONODON* (FABRICIUS, 1798) SHRIMP PONDS AT DUMURIA, BANGLADESH

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Abstract: This study was carried out to understand the effects of addition of supplemental feed nutrients such as high protein (feed 1) and low protein (feed 2) diets on the natural food web in twelve tiger shrimp (*Penaeus monodon*) ponds at Dumuria of Khulna district, Bangladesh. During this study, water temperature ranged from 32.23 - 32.61°C and 32.29 - 32.44°C in case of feed 1 and feed 2 treated ponds respectively. On the other hand, salinity, pH and transparency were more or less stable and similar in both treatment ponds. In high protein supplemented feed 1 ponds, dissolved oxygen (DO) varied from 5.51 - 5.68 mg/l and in low protein feed 2 ponds, DO varied from 5.53 to 5.67 mg/l. During this study period, 13 taxa of phytoplankton under six classes were recorded. Most dominated class was Coscinodicophyceae (42.02% in feed 1 and 42.26% in feed 2 ponds) whereas minimum quantity of phytoplankton belonged to the class Dianophyceae (1.86 and 2.17%). On the other hand, a total of 29 taxa of zooplankton under 3 groups were recorded. In ponds treated with feed 2 phytoplankton abundance was slightly higher than that of ponds treated with feed 1. Whereas, abundance of zooplankton was higher in ponds treated with feed 1 than in ponds fed with low protein feed 2. As phytoplankton is the important factor for the production of zooplankton and also for natural food web, any addition of feed was found to be improving nutrients and enhancing the natural productivity of tiger shrimp ponds.

Key words: Tiger shrimp farms, high & low protein diets, water quality, plankton, Dumuria, Bangladesh

INTRODUCTION

An ecosystem is composed of biotic communities that are structured by biological interactions and abiotic environmental factors. Biotic component is composed of autotrophic and heterotrophic organisms which are interrelated to each other. Heterotrophic organisms consume autotrophic organisms and use the organic compounds in their bodies as energy sources and as raw materials to create their own biomass. Plankton are the important natural food for fishes either throughout the life or at least any one stage of their life cycle. Successful shrimp pond cultures primarily depend on the maintenance of a healthy aquatic

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 DOI: http://dx.doi.org/10.3329/bjz.v46i2.39050

environment and production of sufficient fish food organisms, i.e. Plankton (Chandler 1940). They fix solar energy and convert it to food energy and from the basis of energy transfer through the entire animal kingdom.

The addition of artificial nutrients may affect the natural food web. The availability of plankton greatly depends on water quality. Natural production in a pond provides cultured shrimp with a portion of their food, especially in extensive aquaculture, while with increased stocking densities, supplemental feeds become increasingly important (Tacon 2002). Productivity of pond fishery mainly depends on the skillful management of pond (Bailey 1982). It can be said that the target of fishery sectors can achieve through the balance production of the natural food for the fish in any water body. Therefore, this and other requirements have influenced the researchers to find out the alternative way about the enrichment of food with their natural food. In aquaculture especially in semi-intensive systems, artificial feed have two main functions, these are to be directly eaten by fish, and to supply nutrients to the environment, which in turn increases natural food availability (Tacon 2002).

In the present investigation, the relationships of water quality and natural food availability with the input of two types of artificial feed with the aims are to obtain an integrated view on the effects of the pond ecosystem, to investigate the mechanisms in which different components of the pond food web interacts and strength of the links between different sets of food web variables in pond aquaculture.

MATERIAL AND METHODS

The study was carried out during October to November, 2016 on 12 shrimp ponds at Dumuria in Khulna which is located in South-western Bangladesh at 22°49′0″N 89°33′0″E, on the banks of the Rupsha and Bhairab river. Each pond was 24 feet in Length and 12 feet in width. The water was brackish with salinity varies from 0.5 to 30 ppt. Two types of feed: feed1 (high protein diet) and feed 2 (low protein diet) were tested in pond P2, P4, P6, P7, P9, P11 and ponds P1, P3, P5, P8, P10, P12, respectively. Physico-chemical and biological parameters of water samples were studied after each 10 days of intervals up to 30 days of studied periods with treatments, treated as Round-1, Round-2 and Round-3.

Physico-chemical parameters: The temperature of surface water of different sampling ponds was taken with the help of a centigrade thermometer, graduated from 10 - 110^{o}C. Water transparency was recorded with the help of a 'Secchi disc' with a diameter of 20 cm following the technique of Almazan and Boyd (1978).

The pH of water sample was determined by using a glass electrode pH meter (Hanna instrument pH 300 series Bench-top pH meter). Dissolved oxygen was determined with the use of Winkler's reagent and titrating with sodium thio-sulphet solution. Salinity was measured by using a refractometer (NewS-100, TANAKA, Japan).

For plankton identification samples were gently shaken to resuspend all materials and allowed to settle for one minute. Then 2 - 3 drops were removed from the middle of the sample and placed on a glass slide. Taxonomic identification of phytoplankton was performed with a phase-contrast microscope (Olympus, Japan) at × 100 to 400 with bright field and phase contrast illumination on living materials and on samples preserved with formaldehyde. Quantitative estimation of phytoplankton was done on Sedgewick-Rafter (S-R cell) counting chamber (Stirling 1985). Counting results were summarized as cells per milliliter.

Finally, the average number of phytoplankton and zooplankton individuals was expressed as the number per liter of original water sample by using the following formula:

$$N = \frac{A \times C}{L}$$

N = No. of plankton per liter original water

C = Volume of the concentrated sample in ml

L = Volume of the original water expressed in liter

A = Average no. of plankton observe in 20 sub-cells of the Sedgewick - Rafter cell

RESULTS AND DISCUSSION

Physico-chemical factors of water: The temperature fluctuated between 32.23 and 32.61°C during the 30 days of study (Table 1). Highest temperature was recorded in case of feed 1 treated pond in round 1 whereas, lowest temperature was recorded in round 3 in case of feed 1 treated pond. The range of temperature was found 22 - 30°C in semi-intensive prawn farm of Bagherhat (P6) and 30 ± 1.3°C in a modified extensive shrimp pond of Tamil Naidu, India (Moorthy and Altaff 2002) which were lower than the present findings. During the study period, water transparency varied between 26.55 to 26.80 cm and this transparency decreased with increased of days means increased plankton production (Table 1). Fluctuation of the limit of visibility is inversely related with turbidity. Transparency depends on zooplankton abundance and other organic particles. Present findings is more or less similar to the findings of Shil *et al*. (2013).

During the study period the pH ranged from 7.9 to 8.1 (Table 1) and which remained more or less similar in case of feed 1 and feed 2. This record coincides with the findings of Shil *et al.* (2013), Moorthy and Altaff (2002) and Umamaheswara-Rao *et al*. (2015). On the other hand, dissolved oxygen fluctuated in between 5.5 and 5.8 mg/l (Table 1). Both feed showed the acceptable dissolved oxygen (DO) in each round. The present observation is more or less similar with the findings of Moorthy and Altaff (2002). However, this finding is higher than the findings observed by Umamaheswara-Rao *et al*. (2015) and Veronica *et al*. (2014) in shrimp ponds.

Table 1. Mean variation of some water qualities of tiger shrimp ponds during the study period

Physico-chemical factors	Round 1		Round 2		Round 3	
	Feed 1	Feed 2	Feed 1	Feed 2	Feed 1	Feed 2
Water temperature (°C)	32.61	32.43	32.46	32.44	32.23	32.29
Water transparency (cm)	26.80	26.80	26.60	26.60	26.55	26.55
pH	7.9	7.9	8.1	8.1	7.9	8.1
Dissolved oxygen (mg/l)	5.5	5.4	5.7	5.8	5.6	5.7
Salinity (ppt)	5	5	4.3	4.3	2.6	2.6

Salinity fluctuated greatly ranging from 2.6 to 5 ppt (Table 1). In round, the salinity was 5 ppt in both feeds and thereafter the salinity decreased gradually and at round 3 showed the 2.6 ppt in both feed treated pond. These findings were slightly higher than the findings reported by Shil *et al.* (2013). However, they were much lower than the observed values of Moorthy and Altaff (2002) and Umamaheswara-Rao *et al*. (2015) in case of modified extensive shrimp ponds.

Abundance of plankton: In present study 13 taxa of phytoplankton was identified during the study period (Table 2). Among these identified taxa 11 and 13 taxa were recorded from feed 1 and feed 2 treated ponds, respectively. It was observed that *Nitzschia* sp. and *Phacus* sp. were observed in feed 2 treated pond which were absent in feed 1 treated pond. It was well known that higher concentration of dissolved oxygen were favorable for the development of phytoplankton (Zafar *et al*. 1964). In the present study, the dissolved oxygen in two treated ponds was approximately equal so, there was not much qualitative variation in phytoplankton.

The most dominating class was Coscinodiscophyceae (42.02% in feed 1 and 42.26% in feed 2) which was followed by Chlorophyceae (34.30 and 25.92%), Cyanophyceae (15.42 and 16.12%), Euglenophyceae (5.31 and 9.58%), Bacillariophyceae (1.06 and 3.92%) and Dianophyceae (1.86 and 2.17%) (Table 2). These results disagree with the findings reported by (Umamaheswara-Rao

2015) who stated diatoms and dinoflagellates as dominating group in case of tiger shrimp culture pond under natural condition.

Table 2. Abundance of phytoplankton in tiger shrimp ponds treated with two different feeds

Class	Feed 1		Feed 2	
	Taxa	Ind/l	Taxa	Ind/l
Chlorophyceae	*Eudorina* sp.	55	*Eudorina* sp.	75
	Monoraphidium sp.	17	*Monoraphidium* sp.	15
	Rhophalodia sp.	57	*Rhophalodia* sp.	30
		129		**119**
Bacillariophyceae	*Surirella* sp.	4	*Surirella* sp.	14
			Nitzschia sp.	4
		4		**18**
Euglenophyceae	*Trachelomonas* sp.	20	*Trachelomonas* sp.	40
			Phacus sp.	4
		20		**44**
Cyanophyceae	*Merismopedia* sp.	7	*Merismopedia* sp.	10
	Anabaena sp.	4	*Anabaena* sp.	4
	Oscillatoria sp.	47	*Oscillatoria* sp.	60
		58		**74**
Dianophyceae	*Synedra* sp.	**7**	*Synedra* sp.	**10**
Coscinodiscophyceae	*Melosira* sp.	144	*Melosira* sp.	164
	Cyclotella sp.	14	*Cyclotella* sp.	30
		158		**194**
Total		**376**		**460**

*Data are average of 6 replications and 3 rounds.

Regarding the quantitative status of phytoplankton a total of 418 ind/l were recorded during the study period in which feed 2 treated ponds contained higher number of phytoplankton (460 ind/l) whereas, feed 1 treated ponds showed 376ind/l indicating that feed 2 has good effect on to grow phytoplankton (Table 2). Again, the maximum (194ind/l) and minimum (4ind/l) phytoplankton was recorded belonged to Coscinodiscophyceae and Bacillariophyceae in feed 2 and feed 1 treated ponds, respectively.

However, a total of 29 taxa of zooplankton under 3 groups was recorded (Table 3). In total, 4 taxa - *Colurella* sp., *Cephalodella* sp., *Asplanchna* sp. and *Filinia sp.*were found only feed 1 treated ponds whereas, another 4 taxa- *Gammarus* sp., *Gastropus* sp., *Lecane* sp. and *Myersinella* sp. were recorded only feed 2 treated ponds. Among the recorded 3 groups, Arthopoda comprising 45.58 and 60.41% taxa in feed 1 and feed 2 treated ponds, respectively. Again, next to arthropoda, rotifer (42.40 and 33.75%) and Protozoa (12.01 and 5.83%) were recorded during the study period. The present findings supported by (Shil *et al.* 2013, Moorthy and Altaff 2002, Ghosh *et al*. 2014, Fatema and Omar 2016).

Quantitative analysis of zooplankton showed that average 261.5ind/l zooplankton was counted during the study period. Contrary to the phytoplankton count, feed1 treated ponds showed maximum number (283ind/l) of zooplankton compare to feed 2 treated ponds which showed 240ind/l zooplankton (Table 3). Total zooplankton biomass is strongly correlated with dissolved oxygen. The negative correlations between DO concentration and zooplankton density are most probably caused by, (i) the respiration of zooplankton and (ii) decomposition of organic matter produced by the zooplankton. This negative correlation between zooplankton availability and DO concentration was documented by Aka *et al*. (2000) and Dresiligm (2003). As there was no significant difference in dissolved oxygen in ponds treated with feed 1 and feed 2, there was not significant variation of arthropods content in case of feed 1 and feed 2. Protozoa were more abundant in ponds treated with feed 1 than in ponds treated with feed 2. Organic fertilizer was especially efficient in increasing the abundance of protozoa and other zooplankton (Hickling 1962). As feed 1 was high protein diet, it was more efficient for the growth of protozoa.

The artificial diets used in these experiments were high and low protein diet. In aquaculture especially in semi-intensive systems, artificial feed has two main functions, to be directly eaten by fish, and to supply nutrients to the environment, which in turn increases natural food availability. The major portion (≈ 80%) of artificial feed is lost in the system as uneaten feed and feces (Daniels and Boyd 1989, Siddiqui and Al-Harbi 1999). Artificial feed, which is lost in the system, has a great effect on water quality through decomposition (Horner *et al.* 1987, Poton and Allouse 1987, Poton and Lloyd 1989). This increases bio-available nitrogenous and phosphorus compounds and CO_2 concentration and decreases the dissolved oxygen (DO) concentration and pH, resulting in lower alkalinity values of the water. Bio-available nitrogenous and phosphorus compounds along with CO_2 enhance photosynthesis and in turn the production of natural food. The availability of natural food may change the food habits, grazing, behavior and growth of fish.

Application of different types of nutrients is an effective way of accelerating productivity of ponds and ultimately enhancing the fish yield. In present study, in both cases such as for feed 1 and feed 2, natural productivity was increased than that at the time of no nutrient was given. But, two different types of diet increase different types of plankton. Overall phytoplankton production was higher in ponds which were treated with feed 2 than in those treated with feed 1. Overall zooplankton production was higher in ponds which were treated with feed 1 than with feed 2. As phytoplankton is the important factor for the production of zooplankton and also for natural food web, any addition of feed was found to be improving nutrients and enhancing the natural productivity of tiger shrimp ponds.

Table 3. Abundance of zooplankton in tiger shrimp ponds treated with two different feeds

Groups	Feed 1		Feed 2	
	Taxa	Ind/l	Taxa	Ind/l
Arthropod	*Cyclops* sp.	20	*Cyclops* sp.	20
	Diaptomus sp.	24	*Diaptomus* sp.	30
	Nebalia sp.	20	*Nebalia* sp.	4
	Nepa sp.	4	*Gammarus* sp.	4
	Velia sp.	4	*Mysis* sp.	34
	Daphnia sp.	4	*Daphnia* sp.	17
	Zoaea larvae	4	*Velia* sp.	4
	Mysis sp.	37	*Zoaea* larvae	4
	Naucoris sp.	4	*Nauplius larvae*	7
	Harpacticoidera sp.	4	*Naucoris* sp.	10
	Larva of Anopheles	4	*Harpacticoidera* sp.	7
			Larva of Anopheles	4
		129		**145**
Rotifer	*Limnais* sp.	4	*Limnais* sp.	4
	Colurella sp.	4	*Gastropus* sp.	4
	Chaetonotus sp.	4	*Keratella cochlerais*	4
	Testudinalle sp.	4	*Notholca* sp.	40
	Lindia sp.	7	*Dicranophorus* sp.	17
	Notholca sp.	40	*Chaetonus* sp.	4
	Keratella cochlerais	17	*Lecane* sp.	4
	Cephalodella sp.	4	*Myersinella* sp.	4
	Chaetonus sp.	4		
	Dicranophorus sp.	24		
	Asplanchna sp.	4		
	Filinia sp.	4		
		120		**81**
Protozoan	*Noctiluca* sp.	24	*Noctiluca* sp.	4
	Balantidium coli	10	*Balantidium coli*	10
		34		**14**
Total		**283**		**240**

*Data are average of 6 replications and 3 rounds.

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(Manuscript received on 20 January, 2018; revised on 24 November, 2018)