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Distribution of Plankton Communities in *Penaeus Monodon* (Fabricius) Culture Systems Of Kerala

Biology

KEYWORDS : Brackishwater ponds; extensive system; modified extensive system; *Penaeus monodon*; shrimp culture; plankton

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ABSTRACT

Quantitative distribution of plankton communities in extensive and modified extensive Penaeus monodon culture systems on the southwest coast of Kerala, was studied during three shrimp culture seasons. Phytoplankton constituted the major component in both systems, 84.9% - 93.5% in extensive and 88.5% - 90.8% in modified extensive system. Among phytoplankton, Bacillariophyceae dominated throughout in both extensive (56.8% - 67.0%) and modified extensive (70.2% - 75%) system. Zooplankton constituted only a small portion of the plankton in both systems. In extensive system densities of Chlorophyceae and Myxophyceae were negatively correlated with salinity ($P < 0.05$). A significant positive relation ($P < 0.05$) between density of Chlorophyceae and DO was observed. In modified extensive system, densities of Myxophyceae ($P < 0.01$) and zooplankton ($P < 0.05$) were negatively correlated with water temperature. Negative correlation was registered between density of Myxophyceae and H_2S, alkalinity ($P < 0.05$) and NH_3 ($P < 0.01$), also between zooplankton density and NH_3 and alkalinity ($P < 0.05$). In extensive and modified extensive system, natural food contributed significantly to the growth of P. monodon and proper assessment of this food in the pond may help reduce the use of supplementary feed

Introduction

Plankton and algae play a major role in shrimp production in extensive culture systems. Knowledge of spatial and temporal distribution of plankton together with data on water characteristics is useful in the assessment of water quality as it provides information on the minute and subtle changes in the environment (Gupta *et al.,* 1988). Fluctuations in phytoplankton densities are due to changes in temperature, salinity, light, turbidity and nutrients (Arfy *et al.,* 2003; Paniadima *et al.,* 2006). Phytoplankton distribution, species composition and dominance are, *according* to Gowda *et al.* (2001), closely associated with the prevailing hydrographic parameters and nutrients. ElHang (1984) reported higher consumption of algae by the juveniles of *P. monodon*. Anderson *et al.* (1987) are of the view that prawns graze more on natural than artificial feed when both are available.

Information pertaining to plankton composition in *brackishwater* culture ponds is rather scanty (Kaliyamurthy *et al*., 1979; Sankaranarayanan *et al.*, 1982; Balasubramanian *et al.*, 1995). Though there are some studies on the occurrence of *plankton* and their succession in freshwater fish and prawn culture ponds, similar information on *Penaeus monodon* culture ponds is limited (Moorthy and Altaff, 2002). The present study envisaged assessing the plankton populations and their *interrelationship* with hydrographical parameters of extensive and modified extensive *P. monodon* culture ponds located in Kollam district, Kerala.

Materials and methods

Six culture ponds growing *P. monodon* were selected from Kollam district, Kerala state (9.28'45º N and 76.28'0º E). In two ponds, (0.7 ha each), located at Munrothuruthu, 30 km *northwest* of Kottiyam town and fed with water from the Ashtamudi lake, extensive type of culture (stocking density = 5 m^{-2}) having neither specific management practices nor supplementary *feeding* was practiced. In four ponds (0.4 to 0.6 ha each), two located at Mayyanadu about 12 km southwest and two at Pathayakkodi 5 km south of Kottiyam town, all fed with water from the *Paravoor* Kayal, modified extensive type of farming (stocking density =10 m^{-2}) was done. In these ponds pellet feed was given, thrice a day.

Plankton samples were collected from all the six ponds during June 2006-May2007 by using plankton net made of bolting silk (standard grade No. 25; mesh size = 60 µm). 100 L of the pond water was filtered through the net by pouring water into the net using a 20 L polythene bucket. The residue left in the plankton net was transferred into a polythene bottle, immediately *preserved* with 4% formalin and brought to the lab for further studies.

Planktons were observed in wet mounts under compound microscopes (TRM, Model BX50 and Inverted phase-contrast microscope, Model CK 2, Olympus, Japan) and identified with the help of standard identification keys (Needham and Needham, 1962; Ward and Whipple 1992; APHA, 1998).

The biomass of plankton was determined by the method *suggested* by APHA (1998) and expressed in litre. Abundance of plankton was determined by the classical Sedgwick rafter *counting* method and results expressed as number per litre.

Water temperature (°C), pH and salinity (‰) were recorded at the site itself using a Celsius thermometer of + 0.5ºC accuracy, portable pH meter of ± 0.1 accuracy [Model No. ip (1- 198107) RI, USA], and portable refractometer (Erma Inc., Tokyo), respectively. Water quality parameters were analysed following *standard* procedures: dissolved oxygen (DO) - Winkler's (1888), *dissolved* carbondioxide (CO_2) - APHA (1998), hydrogen sulphide (H_2S) and total suspended solids (TSS) - Trivedy *et al.* (1987), total hardness (TH) - Golterman et al. (1978), ammonia (NH_3) - Koroleff (1983a) and nitrate (NO3, mg l^{-1}), nitrite (NO2, mg l^{-1}), phosphate (PO4, mg l^{-1}), silicate (SiO3, mg ml^{-1}) and sulphate (SO4, mg l^{-1}), respectively by the methods suggested by Morris and Riley (1963), Benschneider and Robinson (1952), Strickland and Parsons (1972), Trivedy *et al.* (1987) and Koroleff (1983b). For spectrophotometric assays, a dual beam spectrophotometer

(Model UV2-100, UNICAM, UK) was used.

Statistical significance of associations (dependence) of *estimated* planktonological variables among themselves and between them and hydrobiological variables were tested using correlation analysis and of variations within extensive and modified *extensive* systems, between them and between seasons, by employing ANOVA. Relevant theoretical inputs for statistical analyses were adopted from Zar (1974) and analyses were done using "statistiXL 1.8" package.

Results and discussion

The mean monthly and seasonal biomass and density of plankton are presented in Table 1; Fig. 1. Mean hydrographical *parameters* of extensive and modified extensive shrimp culture systems during three seasons of shrimp culture operation are given Table 2. The results of statistical analyses are included in Tables 3 and 4.

Table 1 &2..

In extensive system, mean plankton biomass and total plankton density registered from 0.16 to 0.20 l and 2,075 to 2,525, respectively. Phytoplankton mean percentage ranged from 84.9% to 93.5%. Mean percentage of Chlorophyceae, Myxophyceae and Bacillariophyceae ranged from 27.0% to 35.5%, 4.8% to 7.7% and 56.8% to 67.0% respectively. Zooplankton ranged from 6.5% to 15.1 % of total plankton density. Density of Bacillariophyceae was significantly positively correlated with both total plankton density and total phytoplankton density ($P < 0.01$). Plankton biomass was significantly positively correlated with salinity ($P < 0.05$), *total* plankton *density* ($P < 0.01$) and phytoplankton density ($P < 0.05$) as also densities of Chlorophyceae ($P < 0.05$) and Myxophyceae ($P < 0.05$) were negatively correlated with salinity. A significant positive relation ($P < 0.05$) between density of Chlorophyceae and DO was observed. Zooplankton *density* was significantly negatively correlated with H_2S and SiO_3 ($P < 0.05$).

Table 3..

In modified extensive system, mean plankton biomass and total plankton densities ranged from 0.18 to 0.21 l and 2,063 to 2,365 per litre, respectively. Mean percentage of phytoplankton ranged from 88.5% to 90.8%. Percentage of Chlorophyceae, Myxophyceae and Bacillariophyceae ranged from 18.8 to 26.4%, 3.5% to 6.2% and 70.2% to 75.0% respectively. Relative percentage of zooplankton was the highest during premonsoon (11.5%) and the lowest during monsoon (9.2%). Density of Bacillariophyceae was significantly positively correlated with plankton biomass ($P < 0.05$), total plankton density and total phytoplankton density ($P < 0.01$). Densities of Myxophyceae ($P < 0.01$) and *zooplankton* ($P < 0.05$) were *negatively* correlated with water temperature in the modified extensive shrimp culture system. In this system, negative correlation was registered between density of Myxophyceae and H_2S, alkalinity ($P < 0.05$) and NH_3 ($P < 0.01$) and between zooplankton density and NH3 and alkalinity ($P < 0.05$). The *results* of ANOVA showed that there were no significant *quantitative* differences for planktons either between extensive and *modified* extensive culture systems or between seasons.

The mean plankton biomass reported for different estuaries (Patnaik, 1973; Tiwari and Nair, 1998; BijoyNandan and Unnithan, 2004) shows that it is highly variable in these water bodies and that in the backwaters of Kerala, the average biomass *seldom* exceeds 10 mL. The present result is confirmatory with this.

Table 4..

In both extensive and modified extensive system, phytoplankton was the major group contributing to total plankton density, which conforms to the observations by Sankaranarayanan *et al.* (1982) and Gopalakrishnan *et al.* (1988). Plankton count was the lowest during premonsoon in both systems studied, possibly due to low rain fall, low nutrients and high temperature (Paniadima *et al.*, 2006). The higher plankton counts observed during monsoon and postmonsoon tallies with findings of Qasim *et al.* (1972) and Naik *et al.* (2009) in who found blooming of phytoplankters in low salinities, which might be an adaptation to utilize to the maximum advantage the nutrient enrichment brought down by the fresh water (Gouda and Panigrahy, 1996) and also because of intrusion of neritic species of phytoplankton (Gowda *et al.,* 2001).

Fig 1,2, &3...

Comparatively higher plankton population noted during initial months of culture in both systems may be attributed to the *initial* manuring of the ponds, residual nutrients available from the previous culture and the favourable physical and chemical parameters. The decline in plankton population at the end of each culture season might be the consequence of grazing by shrimp (Moorthy and Altaff, 2002).

As reported by Paniadima *et al.* (2006) and Manna *et al.* (2010), during the three seasons of farming, Bacillariophyceae *dominated* in the phytoplankton. Diatoms are known to thrive well in widely changing hydrographical conditions (Gopinathan *et al.*, 2001; Senthilkumar *et al.*, 2002) and salinity positively influences their abundance (Redekar and Wagh, 2000). A similar trend was observed in the modified extensive system.

In both systems of the present study, Chlorophyceae was the second dominant group of phytoplankton as also reported by *Gowda et al.* (2001). Dominance of Chlorophyceae during monsoon period indicates the presence of freshwater algae in the low *saline* waters. In extensive system, Chlorophyceae was negatively correlated with salinity ($P < 0.05$).

The observed poor representation of zooplankton in the shrimp culture system could be because of grazing by shrimp and the high density of zooplankton during premonsoon followed by reduction during monsoon and increase during postmonsoon tallies with the trend reported by Haridevi *et al.* (2004), Bijoy Nandan and Unnithan (2004) and Islam *et al.* (2004).

In both systems, the predominant phytoplankton genera were *Ankistrodesmus, Ulothrix, Spirogyra, Hydrodictyon, Chlorella, Scenedesmus, Clorococcus.* (Chlorophyceae) and *Oscillatoria, Anacystis, Arthrospira, Nostoc* and *Spirulina* (Myxophyceae). In both systems, Bacillariophyceae was represented by the genera *Navicula, Pleurosigma, Gamphonema, Campylodiscus, Cyclotella, Coscinodiscus, Synedra, Asterionella, Tabellaria, Fragillaria,* and *Cymbella.* Rotifers, copepods and mysids were the predominant zooplankton. Rotifers were represented by *Brachionus spp. and Keratella* spp. Copepods were dominated by *Diaptomus spp., Paracalanus* spp. and nauplii. Miscellaneous groups of planktons mostly consisted of foraminiferans, *Cypris*, and plant materials.

Plankton biomass and relative abundance of phytoplankton components and zooplankton agree well with the regime known for brackishwater bodies in the tropics. The results of ANOVA showed that though the densities of Chlorophyceae differed significantly between systems and of Myxophyceae between seasons, these differences were not projected in the multivariat tests implying that, on the whole, there were no significant quantitative differences for planktons either between extensive and modified extensive culture systems or between seasons. The overall result shows that in extensive and modified extensive

system, natural food contributed significantly to the growth of P. monodon and proper assessment of this food in the pond may help reduce the use of supplementary feed.

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Table 1. Mean plankton biomass (ℓ), total plankton density (No./ℓ) and percentage composition of plankton components of extensive and modified extensive shrimp culture systems during three seasons of shrimp culture operation.

							Months/Seasons								
			Premonsoon									Postmonsoon			
	Parameters	Mar. 07	Apr.	May	Mean	Jun. 06	Jul.	Aug.	Sep.	Mean	Oct.	Nov.	Dec.	Mean	Annu-alMean
						Extensive System									
Plankton biomass		0.20	0.22	0.19	0.20	0.15	0.13	0.19	0.20	0.17	0.16	0.16	0.16	0.16	0.18
Total plankton density		2058	2200	1967	2075	3201	2083	2483	2333	2525	2617	2050	2025	2231	2302
	Phytoplankton	89.9	92.4	98.3	93.5	91.1	83.2	85.9	79.3	84.9	83.4	92.7	82.7	86.3	87.8
	Chlorophyceae	23.9	27.0	33.6	28.2	42.3	31.3	28.9	39.6	35.5	37.0	21.5	22.4	27.0	31.5
%	Myxophyceae	10.8	3.7	0.0	4.8	8.6	9.6	5.5	7.2	7.7	2.3	6.6	10.9	6.6	6.4
	Bacillariophyceae	65.3	69.3	66.4	67.0	49.1	59.1	65.6	53.2	56.8	60.7	71.9	66.7	66.4	62.1
	Zooplankton	10.1	7.6	1.7	6.5	8.9	16.8	14.1	20.7	15.1	16.6	7.3	17.3	13.7	12.2
						Modified Extensive System									
Plankton biomass		0.23	0.20	0.20	0.21	0.22	0.19	0.14	0.18	0.18	0.22	0.20	0.18	0.20	0.19
Total plankton density		2200	2304	1683	2063	2475	2075	1925	1833	2077	2263	2479	2354	2365	2159
	Phytoplankton	87.9	87.2	90.6	88.5	91.6	88.8	90.0	93.0	90.8	91.7	89.1	91.0	90.6	90.0
	Chlorophyceae	23.9	29.5	25.7	26.4	18.8	19.5	18.3	18.6	18.8	31.9	19.4	24.3	25.2	23.0
%	Myxophyceae	3.9	3.3	3.3	3.5	5.1	7.2	7.7	4.9	6.2	3.8	3.6	3.9	3.8	4.6
	Bacillariophyceae	72.2	67.2	71.0	70.2	76.1	73.3	74.0	76.5	75.0	64.3	77.0	71.8	71.0	72.3
	Zooplankton	12.1	12.8	9.4	11.5	8.4	11.2	10.0	7.0	9.2	8.3	10.9	9.0	9.4	10.0

Monthly values for extensive system are the means of two ponds and of modified extensive system, of four ponds.

For the sake of clarity and convenience, the data for monsoon and postmonsoon for the year 2006 are presented after premonsoon data for the year 2007.

Table 2. Mean hydrographical parameters of extensive and modified extensive shrimp culture systems during three seasons of shrimp culture operation.

Parameters		Extensive System			Modified Extensive System			
	Pre- Monsoon	monsoon	Post- monsoon	Mean	Pre- Monsoon	monsoon	Post- monsoon	Mean
Water temp. (°C)	30.5	28.8	29.5	29.5	30.9	28.0	29.6	29.4
pH	6.9	7.1	7.0	7.0	7.4	8.0	7.6	7.7
Salinity (‰)	20.3	7.0	18.8	14.5	25.8	9.1	22.6	18.2
DO (mg ℓ^{-1})	3.0	3.8	2.6	3.2	5.9	4.5	5.5	5.2
CO_2 (mg ℓ^{-1})	11.3	7.8	10.0	9.5	7.9	7.6	6.8	7.4
H_2S (mg ℓ^{-1})	0.07	0.04	0.07	0.06	0.06	0.02	0.07	0.05
NH_3 (mg ℓ-1)	0.22	0.14	0.30	0.21	0.41	0.15	0.31	0.28
Total alkalinity (mg ℓ^{-1})	46.7	27.4	42.7	37.8	67.7	45.8	56.0	55.4
Total hardness (mg ℓ^{-1})	255.8	82.6	208.3	172.3	817.5	100.7	634.2	475.8
TSS (mg ℓ^{-1})	17525	4225	8383	9463	19113	3124	7917	9359

	NO3 (µg ℓ^{-1})	65.4	68	88.5	73.4	67.8	72.2	84.1	75.3
Nutrients	NO_2 (µg ℓ^{-1})	3.1	4.6	4.0	4.0	3.5	3.4	4.5	3.8
	PO_4 (µg ℓ^{-1})	1.5	1.4	2.1	1.6	1.3	1.1	2.0	1.4
	SiO_3 (µg $m\ell^{-1}$)	7.8	3.1	5.4	5.2	3.3	3.9	5.6	4.2
	SO_4 (mg ℓ^{-1})	22.6	10.2	20.4	17.0	24.7	11.7	20.3	18.2

Since surface and bottom water parameters did not differ significantly, pooled means are presented for all parameters.

Table 3. Results of correlation analysis showing *r* values comparing plankton variables of extensive and modified extensive shrimp culture system (N = 20).

Extensive system						
Biomass		Plank_T	Phyto_T	Chloro.	Myxo.	Bacil.
Plank_T	-0.273					
Phyto_T	-0.222	0.932#				
Chloro.	-0.106	0.825#	0.863#			
Myxo.	-0.367	0.482*	0.411	0.302		
Bacil.	-0.18	0.673#	0.769#	0.378	0.121	
Zoo_T	-0.177	0.077	-0.274	-0.204	0.283	-0.344
Modified extensive system						
Plank_T	0.384*					
Phyto_T	0.315*	0.975#				
Chloro.	0.092	0.471	0.513#			
Myxo.	-0.144	-0.135	-0.218	-0.273		
Bacil.	0.320*	0.926#	0.952#	0.259	-0.272	
Zoo_T	0.153	-0.231	-0.423#	-0.311	0.577#	-0.426#

*** P < 0.05; # P < 0.01**

Plank_T - Total plankton density; **Phyto_T** - Total phytoplankton density; **Chloro.** - Chlorophyceae; **Myxo.** - Myxophyceae; **Bacil.** - Bacillariophyceae; **Zoo_T** - Total zooplankton

Table 4. Results of correlation analysis showing *r* values comparing various plankton variables with hydrographical variables of extensive (N = 20) and modified extensive (N = 40) shrimp culture system.

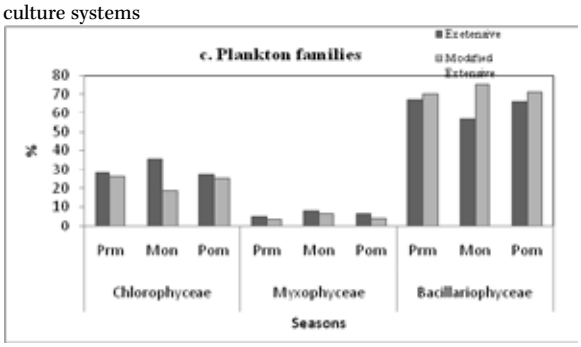
Extensive system							
Biomass		Plank_T	Phyto_T	Chloro	Myxo.	Bacil.	Zoo_T
Temp_W	0.049	-0.292	-0.295	-0.325	-0.332	-0.062	0.026
pH	-0.345	0.215	0.196	0.412	0.275	-0.207	0.027
Sal.	0.435*	-0.584#	-0.450*	-0.556*	-0.507*	-0.064	-0.330
DO	-0.276	0.334	0.341	0.458*	0.406	-0.041	0.027
CO_2	0.33	-0.277	-0.194	-0.307	-0.272	0.074	-0.247
H_2S	0.031	-0.361	-0.177	-0.219	-0.203	-0.058	-0.492*
NH_3	0.189	-0.243	-0.296	-0.279	-0.312	-0.121	0.038
Alk.	0.146	0.039	0.11	0.16	-0.01	0.006	-0.244
Har_T	0.395	-0.467*	-0.262	-0.435	-0.395	0.109	-0.496*
TSS	0.491*	-0.162	0.034	0.000	-0.341	0.15	-0.589#
NO_3	0.208	-0.549*	-0.594#	-0.624#	-0.394	-0.286	0.146
NO_2	-0.059	0.466*	0.444*	0.415	0.268	0.244	0.031
PO_4	-0.339	0.337	0.334	0.439	0.364	-0.029	0.037
SiO_3	0.36	0.198	0.362	0.349	-0.018	0.258	-0.485*
SO_4	0.4	-0.618#	-0.449*	-0.616#	-0.353	-0.048	-0.35
Modified extensive system							
Biomass		Plank_T	Phyto_T	Chloro.	Myxo.	Bacil.	Zoo_T

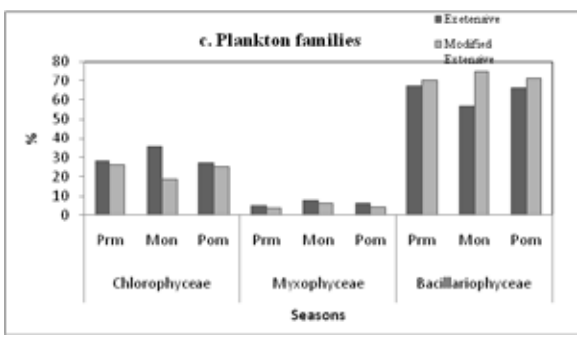
Temp_W	-0.036	0.019	0.075	0.123	-0.425#	0.086	-0.387*
pH	-0.139	-0.245	-0.117	-0.055	0.028	-0.082	-0.345*
Sal.	0.095	0.008	-0.001	0.11	-0.577#	0.006	-0.155
DO	0.189	0.228	0.162	-0.073	-0.107	0.196	0.031
CO_2	-0.234	-0.241	-0.186	-0.037	-0.129	-0.185	-0.17
H_2S	-0.026	0.087	0.05	0.164	-0.366*	0.019	0.035
NH_3	-0.089	-0.01	0.047	0.192	-0.467#	0.03	-0.326*
Alk.	-0.108	-0.239	-0.164	0.008	-0.400*	-0.131	-0.320*
Har_T	0.142	0.065	0.047	0.248	-0.544#	0.006	-0.123
TSS	-0.067	-0.122	-0.113	0.212	-0.505#	-0.151	-0.146
NO_3	-0.098	0.108	0.109	0.21	0.219	0.023	0.018
NO_2	-0.028	0.131	0.104	-0.054	0.108	0.095	0.061
PO_4	-0.1	-0.058	-0.003	0.046	-0.255	0.019	-0.305
SiO_3	0.06	0.208	0.181	0.089	0.01	0.161	0.03
SO_4	0.235	0.219	0.212	0.172	-0.474#	0.211	-0.146

*** P < 0.05; # P < 0.01**

Alk., alkalinity; **Har_T**, total hardness; **Sal.**, salinity; **Temp_W**, water temperature; **Plank_T** - Total plankton density; **Phyto_T** - Total phytoplankton density; **Chloro.** - Chlorophyceae; **Myxo.** - Myxophyceae; **Bacil.** - Bacillariophyceae; **Zoo_T** - Total zooplankton

Fig. 1. Seasonal variation in mean planktonological features of extensive (■)and modified extensive ( ) *Penaeus monodon* culture systems

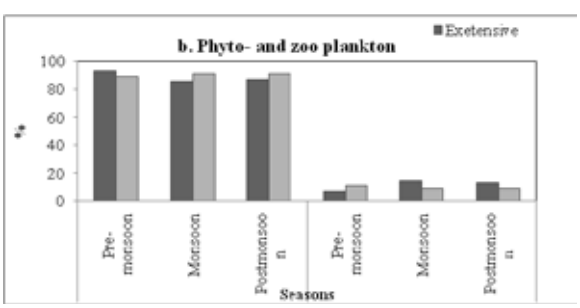




Prm - Premonsoon; **Pom** - Postmonsoon; **Mon** – Monsoon

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