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Growth of juvenile freshwater prawn *Macrobrachium malcolmsonii* fed with various protein diets containing different biowastes

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Abstract

An experiment was conducted with juvenile prawns *Macrobrachium malcolmsonii*, (0.76± 0.01 to 0.94±0.01 g) to evaluate various protein source diets. Six diets containing 20%, 25%, 30%, 35%, 40%,and 45% of crude protein were formulated, and fed to prawns in the form of pellet to evaluate their suitability. The experiment was designed for 60 days and sampling was made at every 15 days interval. At the end of the study period growth, feed conversion ration (FCR) specific growth rate (SGR), feed efficiency and survival were determined for prawns in each dietary treatment. Among the above five feeds poor FCR and higher weight gain observed in 35% protein diet (B-4). Similarly specific growth rate and feed efficiency are also highest with diet containing 35% protein. The dietary protein levels above 35% exerts a decrease in growth of prawn was observed in the present study. The feed efficiency ratio and protein efficiency ratio decreased with the increased dietary protein levels. It is concluded that 35% protein diet could be suitable with optimum protein supply for *Macrobrachium malcolmsonii*. Therefore, above and below this 35% protein level in the formulated feed leads to metabolic stress which lowers the conversion efficiency and wastage of nutrients.

Key words : *M. malcolmsonii*, Formulated feed, FCR, Optimal protein feed

Introduction

The larger growing freshwater prawns are good candidate species for inland aquaculture. They fetch a high price both in domestic as well as export markets. Commercial culture of freshwater prawn is well established in countries like Thailand, Vietnam and Taiwan (New 1990). In India, interest in Penaeid shrimp culture was triggered by the increased market demand coupled with inadequacy of the capture fishery landings. One of the key factors for the ensuring success of shrimp farming is the availability of good quality feeds in sufficient quantity. Therefore, development of a suitable balanced feed is essential for freshwater prawn culture. Basic nutrients required for shrimps to meet out the demand of physiology, growth, and reproduction are protein, lipid, carbohydrates, minerals and vitamins.

However, it is known that the quantum requirements of these vary from species to species, age of development and culture conditions. Protein is the major nutrient needed for growth of shrimps (Sadhana and Neelakantan 1996). The primary focus of shrimp nutrition research has to evaluate diet quality in terms of growth and feed conversion ratio (FCR) of the cultured shrimp (Akiyama 1992). Although this information is essential for proper evaluation of feed formulation, the bio availability of the nutrients in the diet must also be determined (Allen Davis and Arnold 1993). Feed forms one of the major inputs among the operating cost of any aquaculture system. Formulation of efficient and cost effective feed is therefore of prime importance (Jeyalakshmy and Natarajan 1993). Many investigations have been carried out to assess the optimum protein levels for specific shrimps and prawns, both in temperate and in tropical countries. Several researchers have reported that protein is an essential nutrient for prawns but costlier among ingredients (Alava and Lim 1983). Therefore, dietary protein should be optimally utilized for growth rather than for maintenance (Shiau and Yang peng 1992). Research in feed formulation is currently concentrating on the investigations of various low cost protein sources. Ideally, these should be readily available at low cost and have high nutritional quality (D' Abramo and Lovell 1991). Although aquaculture is a rapidly expanding industry, freshwater prawn (*Macrobrachium* spp) farming is of recent origin. The lack of information on the tolerance limits and optimal conditions for better growth (Batlett and Enkerlin 1983) still continues and has motivated their research study. *Macrobrachium malcolmsonii* is a good candidate species for freshwater prawn culture in India and can be cultured either alone or along with other amenable species in polyculture. Although, there exist some informations on the dietary requirements of *M. rosenbergii* (Heimen and Mensi 1991), but comparatively very little is known on the aspects of nutrition and feeding of *M. malcolmsonii*.

Materials and methods

Experimental design

A feeding trial was conducted for 60 days in an indoor laboratory under a photo-period cycle 12h light : 12h dark. The six experimental diets constituting the six treatments were arranged according to completely randomized design with three replications per treatment.

Juveniles of *M. malcolmsonii* were obtained from the lower anicut (110° 15'N; 79° 30'E) of the River Cauvery near Kumbakonam, Tamilnadu and were transported to the laboratory in double polyethylene bags, filled with river water and oxygenated to saturation level. Prawns were acclimated for 5 days before individually weighted and sized for the experiment.

Ten Prawns of mean weight (0.76 ± 0.01g) were stocked in each trough. The prawns were starved for 24 h before starting the experiment in order to empty the gut contents. Aeration was provided continuously but slow aeration to the experimental tanks except during placement of feed and during collection of faeces and wasted feed. One third of the water in each tank was changed daily with fresh dechlorinated tap water. Dead prawns if any were removed and recorded. Prawns were fed at 5% of biomass twice a day at 10 and 18 h. The faeces were siphoned out manually as soon as they appeared in the trough in order to prevent coprophagy and its leaching into the water. The excess feed that remained at the bottom of the trough was also siphoned out onto a bolting cloth within 5 mins after one hour feeding. The collected unconsumed feed were stored in petri plates after drying at 40°C in hot air oven. Ration was adjusted. Animals were weighed every 15 days.

Diet preparation

Six diets of different protein ratios such as 20%, 25%, 30%, 35%, 40%, and 45% protein were formulated according to the proximate composition of protein sources used (Table 1). All raw materials of dry components were finely ground using an electric grinder and passed through a 0.5 mm mesh sieve. The diets were prepared by thoroughly mixing the dry ingredients and then adding water until the texture of the whole mixture reached a stiff dough consistency. The dough was steamed at 60°C for 10 min using an autoclave, pelleted through a 2mm die, and then dried in an oven overnight at 40° C. After drying, pellets were cut in 5mm length, packed in sealed plastic bags and then stored at room temperature (Sudaryona *et al.* 1995).

Table 1. Formulations and proximate composition of five experimental diets containing isonitrogenous percentage of protein

Ingredient g/100g diet	Experimental diets				
(on fed-basis)	SKP	TFM	SQM	SBM	ECM
Silkworm pupae meal	40.0	-	-	-	-
Trash fish meal	-	48.0	-	-	-
Squilla meal	-	-	35.0	-	-
Soybean meal	-	-	-	35.0	-
Eichhornia meal	-	-	-	-	21.0
Prawn waste meal	10.0	10.0	20.0	15.0	7.0
Mangrove leaf meal	15.0	20.0	10.0	0.5	0.5
Groundnut oil cake	10.0	8.0	10.0	23.0	35.0
Gingelly oil cake	10.0	5.0	5.0	22.0	34.0
Rice bran	5.0	5.0	10.0	0.5	0.5
Wheat flour	5.0	2.0	5.0	2.0	0.5
Maida flour	5.0	2.0	5.0	2.0	1.5
Proximate composition (%)					
Crude protein	30.64	30.21	30.0	30.16	30.08
Nitrogen free extract	40.18	23.07	24.11	38.77	36.71
Crude fat	7.15	8.45	10.08	6.96	9.02
Ash	9.25	23.03	22.85	10.96	9.61
Crude fibre	4.52	5.30	4.92	5.73	4.10
Moisture	8.26	9.94	8.04	7.42	10.48

SKP= Silkworm pupae, TFM= Trash fish meal, SQM= Squilla meal, SBM= Soybean meal, ECM= *Eichhornia meal*

Analyses of diets

Diets were analysed for crude protein, fat, ash, fiber and moisture by standard AOAC (1990), methods for drymatter (oven drying at 105°C for 24h), crude protein (Kjeldhal-nitrogen x 6.25), fat (solvent extraction with petroleum ether, boiling point 40-60° C for 10-12h), ash (Muffle furnace incineration at 650°C), and crude fiber (1.25% acid and 1.25% alkali digestion). Nitrogen free extract was calculated by difference (NFE = 100-(% crude protein + % crude lipid + % total ash + % crude fiber +% moisture).

Body composition analysis

At the end of the experiment, a pooled sample of dressed prawn flesh from each treatment was collected, frozen and freeze-dried for final body proximate composition analysis. The analyses were conducted using the same methods previously described.

Data calculation and analysis

The following parameters were calculated for evaluation of prawn performance:
Weight gain (%)=[(final weight - Initial weight) / Initial weight] x 100;
Specific growth rate (SGR) = [(In.Wt-In.Wi)/Tx100,
where Wt is the average individual weight of prawn at time t, wi is the average individual weight of prawn at time O, and T is the culture period in days.

The efficiency of utilization of feed was expressed as feed conversion ratio (FCR) = (dry feed intake/ wet body weight gain). Feed efficiency (FE%) = wet weight gain (g)/dry feed consumed (g)x100; Percentage of survival=Nf /Ni x100, where Nf is the final number of prawn in the experiment, Ni is initial number of prawn in the experiment. Protein efficiency ratio (PER)=(Wf-Wi) TfxCP. Where Wf is the average final weight; Wi is the average initial weight, Tf is the averaged total weight of feed intake (g) for each prawn, Cp is the crude protein (g) fed. The collected prawn were sacrificed and excised for the yield of edible flesh. The remaining part of prawn, after muscles were excised, was weighed to determine the percentage of carcass waste. Edible flesh (%)= (muscle weight/body weight)x 100, Carcass waste (%) =Prawn waste weight/body weight)x100.

Statistical analysis

All data were analysed using analysis of variance. Multiple comparisons among means were made with the Duncan New Multiple Range Test (Puri and Mullen 1980). Statistical significance was determined at 5% for each set of comparisons.

Results and discussion

The proximate composition of the formulated experimental feeds, B-series are given in Table 2. The Prawns fed on feed B-4 with 35% protein showed higher weight gain (1.86 ± 0.12g) and lowest FCR (2.96 ± 0.27). Similarly specific growth rate (3.24 ± 0.64) and Feed efficiency (33.99 ± 2.97) were also highest with the diet containing 35% protein (feed B-4). However, protein efficiency ratio was maximum with feed B-2 (1.08 ± 0.16) and minimum in feed B-6 (0.47 ± 0.06) (Table 3). The proximate analysis of prawn flesh exerts that prawn fed with feed B-4 contain highest amount of protein than those fed with other feeds (Table 4). In this experiment, the diet with 35% protein exhibited better growth, FCR, and PER when compared to diets with 20%, 25%, 30%, 40% and 45% protein levels. The present finding in this prawn are in agreement with the results of Balazs and Ross (1976) who reported maximum growth in *M. rosenbergii* when fed with diets in excess of 35% protein level. Dietary protein requirement is reported to be 30% to 40% for Penaeid species (Alava and Lim, 1983; Shiau *et al*, 1991). In the present study, protein requirement shown by *M. malcolmsonii* also falls within this range.

Table 2. Fatty acid composition of experimental feeds

Fatty acids		(mg/g of fat)				
		SKP	TFM	SQM	SBM	ECM
Saturated fatty acids						
Hepatanoic acid	C7:0	ND	ND	ND	ND	ND
Caprylic acid	C8:0	ND	ND	ND	ND	ND
Nonanoic acid	C9:0	ND	ND	ND	ND	ND
Capric acid	C10:0	2.85	2.35	8.03	ND	ND
Undecanoic acid	C11:0	ND	ND	1.64	0.35	ND
Lauric acid	C12:0	0.66	0.17	1.99	0.02	2.73
Tridecanoic acid	C13:0	3.19	11.69	15.02	2.98	2.17
Myristic acid	C14:0	0.97	3.72	5.07	1.68	0.41
Pentadecanoic acid	C15:0	6.62	24.17	19.23	1.10	13.55
Palmitic acid	C16:0	3.48	0.53	4.87	0.67	2.56
Heptadecanoic acid	C17:0	ND	ND	1.27	0.80	4.95
Stearic acid	C18:0	ND	ND	27.26	5.69	30.21
Nondecanoic acid	C19:0	ND	4.88	2.94	0.14	1.66
Arachidic acid	C20:0	ND	17.85	ND	0.83	2.49
Heneicosanoic acid	C21:0	0.25	2.27	ND	0.61	ND
Behenic acid	C22:0	0.15	ND	0.09	ND	0.05
Tricosanoic acid	C23:0	ND	ND	ND	8.33	ND
Lignoceric acid	C24:0	ND	ND	ND	ND	ND
Unsaturated fatty acid						
Palmitoleic acid	C16:0	ND	ND	ND	ND	ND
Oleic acid	C18:0	0.35	0.43	0.31	0.19	0.38
Cis Linoleic acid	C18:0	43.81	25.01	20.17	19.78	23.97
Linolenic acid	C18:0	0.09	0.08	0.08	0.08	0.09
Arachidonic acid	C20:0	2.38	29.82	ND	0.23	ND
Eicosapentaenoic acid	C20:0	4.84	3.03	4.84	3.97	4.50
Decosahexaenoic acid	C22:0	5.13	5.75	6.11	4.98	6.02

SKP= Silkworm pupae, TFM= Trash fish meal, SQM= Squilla meal, SBM= Soybean meal, ECM= *Eichhornia meal*

Table 3. Growth performance and diet utilization of *M. malcolmsonii* fed isonitrogenous diets

Parameters	SKP	TFM	SQM	SBM	ECM
Initial mean wt. (g)	1.82±0.02	1.82±0.03	1.82±0.02	1.81±0.03	1.82±0.02
Final mean wt. (g)	3.47±0.04	3.02±0.04	3.02±0.03	3.12±0.04	3.30±0.04
Mean wt gain (g)	1.65±0.04^{a}	1.20±0.02^{b}	1.99±0.01^{c}	1.29±0.06^{b}	1.48±0.01^{ab}
Weight gain (%)	90.78±2.99	66.04±0.29	66.06±0.79	71.08±4.12	81.09±0.53
Feed intake	5.41±0.16	5.35±0.21	5.26±0.14	5.48±0.19	5.39±0.18
FCR	3.27±0.16^{d}	4.45±0.22^{a}	4.39±0.09^{ab}	4.24±0.21^{bc}	3.65±0.14^{c}
SGR (%)	2.75±0.07^{d}	2.00±0.03^{cd}	2.00±0.02^{cd}	2.16±0.09^{a}	2.46±0.02^{b}
FE (%)	30.56±1.45^{a}	22.45±1.10^{cd}	22.78±0.49^{cd}	23.58±1.17^{a}	27.38±1.07^{b}
PER (%)	1.02±0.05^{a}	0.75±0.04^{c}	0.76±0.02^{c}	0.79±0.4^{c}	0.91±0.04^{b}
Survival (%)	100^{a}	78.33±7.52^{c}	85.00±8.36^{bc}	86.67±8.16^{bc}	88.33±4.08^{b}

Values are means ±SD of three replication. Letters in the same column having the same superscript are not significantly different (p>0.05)

Table 4. Body proximate composition of *M malcolmsonii* fed with experimental diets for 60 days

On wet weight basis	Feeds				
	SKP	TFM	SQM	SBM	ECM
Waste weight, %	35.05	42.33	43.21	49.11	47.99
Edible flesh, %	39.50	36.79	32.62	32.16	35.64
Body composition (on dry basis)					
Moisture, %	71.23	79.46	81.17	76.58	79.74
Protein, %	57.73	57.13	53.50	50.85	55.23
Lipid, %	3.00	3.51	2.95	3.16	4.20
Ash, %	3.13	2.54	3.53	2.98	2.85

The dietary protein levels above 35% exert a decrease in growth of prawns as observed in the present study. The decreased growth at protein levels greater than the optimum may be attributed to increased energy expenditure on protein catabalism and subsequent increase in ammonia production, which will have a negative impact on growth (Ramnarine 1995). Ahamad Ali (1994) stated that protein contributes towards the major portion of the feed cost, and the determination of nitrogen balance, along with other parameters, might greatly help in keeping protein levels at the minimum, leading to more economical practical feed formulation. Colvin (1975) stated that weight gain declined with increase in the dietary protein in *P. indicus. M. rosenbergii* post larvae may need a minimum dietary protein level of about 35% (Read, 1987). In our experimental feed (B-4) contains 35% protein also recorded a high growth response in *M. malcolmsonii.* The finding of Read, (1987) also supports the finding that a 35% dietary protein level was more than enough to sustain optimal growth in young/ juveniles of *M. malcolmsonii.* In a properly balanced diet the level of protein must be sufficient to support optimum growth and should be minimally utilised for energy production (Shiau *et al.* 1991). Optimal dietary protein levels are also found to influence protein to energy balance, the amino acid composition, digestibility of the dietary protein and the amount of non-protein energy in the test diets (Wilson 1989).

Food consumption rate of prawns did not show much variation at different protein levels. Many experimental studies have shown that food intake and conversion efficiency strongly depend on environmental factors such as temperature, salinity, quality of food, water flow, as well as internal factors, such as age and size of the fish/prawn, heredity and even the environmental history of fish/prawn, especially in early life (Brefi 1979). The best feed conversion ratio (FCR - 2.96) was obtained in the prawn *M. malcolmsonii* fed with 35% protein level in this experiment. FCR was maximum at higher as well as lower dietary protein feed. The feed conversion ratio in penaeid prawns was studied by Royan *et al* (1977). Forster (1970) pointed out that conversion ratio in prawns would be rather less efficient than in fish due to loss incurred during moulting and only a ratio of 2-3 could be anticipated in prawns. The food consumption and wet weight gain play an important role in the increase or decrease of food conversion ratio (Sadhana and Neelakantan 1996). In most of the studies the protein requirement was determined by measuring the growth, FCR and in some cases, PER as a response to the dietary protein level. These studies were summarised by (Kanazawa 1984). Sambasivam *et al.* (1982) concluded that conversion will be low due to high dietary protein.

In this experiment the highest PER was recorded in 25% protein diet (Feed B-2). Protein efficiency ratio decreased almost linearly with increasing dietary protein content up to 36% and then reached a plateau. Generally protein efficiency ratio decreases with increasing dietary protein level and has been noted for many other species also (Akand *et al.* 1989). FCR and PER are known to decrease with increasing dietary protein contents (Jauncey 1982). PER is also influenced by dietary protein level and vary with species (Dabrowski 1979). The findings of PER in the present study are in agreement with these observations.

The survival rate of *M. malcolmsonii* in this experiment was found to be higher at 35% protein diet and low in 45% protein diet. Survival and growth of prawn also depends on stocking density, water quality, type of diet and climate (Kanaujia and Mohanty 1996). In support of this finding Das *et al.*, (1995) indicated that the diet containing about 35% protein are considered for satisfactory survival and growth of juvenile prawn *M. malcolmsonii*. The findings of Felix (1998) also support the belief that a 35% dietary protein level was enough to sustain good growth in juveniles of *M. rosenbergii*. The results in the present study are in agreement with the above findings.

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Effect of high and low cost brood feeds on gonado-somatic index and fecundity of freshwater prawn *Macrobrachium rogenbergii* de Man

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Abstract

Studies were conducted to observe the effects of different types of feeds on the gonado-somatic index (GSI) and fecundity of freshwater prawn *Macrobrachium rogenbergii*. Three different treatments (T_1, T_2 and T_3) were designed with three types of feed as follows: (i) Saudi-Bangla Prawn feed 100% - T_1, (ii) Saudi-Bangla prawn feed 50%+local feed 50% - T_2 and (iii) local feed 100% - T_3. The results showed that the average value of gonado-somatic index (GSI) was 14.39, 14.35 and 14.36 and the average fecundity of *M. rogenbergii* was 99,741, 98,125 and 97,911 in T_1, T_2 and T_3 respectively. No significant difference ($p > 00.5$) was between gonado-somatic indices (GSI) and fecundities of *M. rogenbergii* among different feeding trails. The price of Saudi-Bangla prawn feed was very high (Tk. 23/kg) than the local feed (Tk. 14/kg). So, use of local feed was recommended for *M. rogenbergii* brood rearing.

Key words: Prawn feed, Gonado-somatic index, Fecundit, *M. rogenbergii*

Introduction

Among the wide array of prawn species available in Bangladesh, the long legged giant freshwater prawn, *Macrobrachium rogeabergii* (golda chingri) is the largest, most desirable and contribute a lot to the major share of the exported prawns. *M. rogenbergii* grows fast, tolerate salinity changes and can be cultured in freshwater ponds. While the demand of this prawn has been progressively in home and abroad, the production of the same from natural water is declining in our country day by day due to over fishing and environmental hazards. In the fish culture feed cost accounts about 60-70% of the total cost which is very expensive to poor farmers of Bangladesh. In the market, there are some commercial prawn feeds, which are also expensive. Unsuitable feed, unavailability of fry and lack of technological know-how are the main drawbacks for increasing prawn production in freshwater ponds. Now-a-days Government and private hatcheries are producing large number of post-larvae of *M. rogenbergii* for their culture in ponds throughout the country, but these hatcheries face problems due to high price of artificial feeds for brood rearing. Polyculture of *M. rogenbergii* has been investigated with Chinese and Indian carps (Hoq *et al.* 1996, NFEP 2001, Alam *et al.* 2001) but no scientific study has been conducted to find out the suitable low cost feed for *M. rogenbergii* brood rearing. So, the present experiment was designed to determine the effect of high cost and low cost feed on the gonado-somatic index and fecundity of *M. rogenbergii*.

Materials and methods

Observation of the effects of high and low cost feeds of *Macrobrachium rogenbergii* broods on their gonado-somatic index and fecundity was carried out in the backyard hatchery (Pramanik and Mahmud 1995) of Bangladesh Fisheries Research Institute, Riverine Station, Chandpur. Three Treatments were designed for feeding with three replications as follows: T_1=Saudi-Bangla prawn feed 100%, T_2=Saudi-Bangla prawn feed 50% and Local feed 50% and T_3=Local feed 100%. Local feed was prepared by using local ingredients such as fish meal, mustard oil cake, rice-bran, wheat flower and vitamin-mineral premix by maintaining the protein level 30% (Table 1) which was equal to that of the Saudi-Bangla prawn feed (Table 2). An earthen pond of 135 m^2 area was chosen for the experiment. The water of the pond was completely drained out and remained exposed to the sun for 15 days until the bottom cracked. After complete drying, the pond was tilled to improve the soil quality by exposing sub-soil to the atmosphere there by speeding up the oxidation process and the released of nutrients that were locked in the soil. Lime was applied to the soil at the rate of 1 kg/dm. After liming the pond was divided into nine plots of 15 m^2 size each. These plots were divided by using nylon nets. They were of 4 feet height from ground level so that the prawns, stocked in one plot cannot move towards the other plot. Bamboo poles were used to fix the net vertically. After complete netting the pond was filled with water. The nets were cleaned periodically during the experiment to maintain the water quality of each plot equal. Organic and inorganic fertilizers were applied in the pond. Organic fertilizer of cowdung was broadcasted over the pond at a ratio of 10 kg/dm. After 6-7 days of organic fertilization, the chemical fertilizers were applied at the rate of urea 100g/dm and TSP 75g/dm. The juveniles were stocked at a density of 2/m^2. The average length and weight of the juveniles were 10.3 cm and 20.5 g respectively. Feeds were supplied to the prawns at 5-3% of their body weight. Three types of feeds were supplied to each three replicates of the nine experimental ponds. The physico-chemical parameters of the plots were recorded fortnightly. Temperature was recorded by a Celsius thermometer. The p^H, DO and ammonia were measured by a portable water test kit (HACH Company, love land, Colorado).

Table 1. Percentage composition of local feed

Ingredients	Percentage (%)	Protein (%)
Fish meal	21.0	12.13
Mustard oil cake	45.0	13.65
Rice-bran	28.0	03.33
Wheat flower	05.0	00.89
Vitamin-mineral premix	01.0	-
Total	100.00	30.00

Source: BFRI

Table 2. Feed analysis of Saudi-Bangla prawn feed (finisher pellet)

Food value	Percentage (%)
Moisture	11
Protein	30
Fat	4
Fiber	6
Ash	17
Carbohydrate	32

Source: Saudi-Bangla Fish Feed Ltd.

Determination of Gonado-Somatic Index

Gonado-somatic index (GSI) of prawn is the percentage of gonadal weight in relation to the total weight of prawn. GSI was determined for each prawn by the following formula:

$$GSI = \frac{\text{Weight of gonads (g)}}{\text{Weight of prawn (g)}} \times 100$$

Determination of fecundity

Fecundity was determined using gravimetric method (Lokman Ali 2002). Mother prawns were collected from different experimental plots. The prawns were transpotted to the backyard hatchery with plastic drum. The total weight of individual prawn was taken by an electronic balance. A portion of ovary was sampled from the mother prawn in a clean petridish with the help of forceps. The mother prawns were then released in the aquarium with 6 ppt saline water for hatching of the eggs. The water from sampled eggs was blotted by a blot paper and then dried at room temperature. Number of eggs in the sampled portion was counted. After hatching, the weight of each mother prawn was taken. The weight of total eggs i.e. the weight of the gonad was calculated from the following formula:

Weight of gonad (total eggs) = Weight of mother prawn before hatching - Weight of mother prawn after hatching.

Finally, the total no. of eggs i.e. the fecundity of each individual prawn was calculated with the help of the following formula:

$$\text{Total no. of eggs (fecundity)} = \frac{\text{Weight of total eggs} \times \text{No. of eggs in the sampled portion}}{\text{Weight of the sampled eggs}}$$

Statistical analysis

One way analysis of variance (ANOVA) was performed on the yield data to determine treatment effects. Significant differences between treatments were isolated using Duncan's multiple range test (DMRT) at 5% level of significance.

Results

Water quality parameters

Respective values of water quality parameters during the experimental period were same in all the treatments because one pond was divided into nine plots by fine mesh net. The values *viz.*, water temperature, dissolved oxygen (DO), pH, transparency and ammonia (NH_3) under different treatments are shown in Table 3. Average value of dissolved oxygen was 5.71 mg/L, temperature, 26.8°C, p^H, 7.68 and NH_3, 0.31 mg/L.

Table 3. Average values of water quality parameters in each fortnight during the experimental pe from February to May

Parameters	February		March		April		May	
	1^{st}	15^{th}	1^{st}	15^{th}	1^{st}	15^{th}	1^{st}	15^{th}
Temperature	22.0	24.0	25.3	26.9	27.6	29.1	29.5	30
Dissolved Oxygen (mg/L)	5.5	5.6	6.0	6.9	4.3	6.0	5.8	6.2
p^H	7.3	7.6	8.0	7.2	7.9	8.1	7.8	7.9
Ammonia (NH_3) (mg/L)	0.2	0.3	0.25	0.23	0.33	0.37	0.26	0.3

Gonado-Somatic Index

The gonado-somatic indices (GSI) of *M. rosenbergii* of different treatments are shown in Table 4. The average value of GSI for T_1 was 14.39, for T_2 was 14.35 and for T_3 was 14.36. There were no significant differences (P>0.05) between the gonado-somatic indices of *M. rogenbergii* of different feeding trails.

Table 4. Values of gonado-somatic index and fecundity of *Macrobrachium rosenbergii* of different treatments

Treatments	Gonado-somatic index		Fecundity	
	Range of GSI	Average of GSI	Range of fecundity	Average of fecundity
T_1	13.35 - 15.39	14.39^{a*}	60,525-1,36,502	$99,741^{b*}$
T_2	13.36 - 15.15	14.35^{a}	62,024-1,29,355	$98,125^{b}$
T_3	13.73 - 15.50	14.36^{a}	62,920-1,30,620	$97,911^{b}$

*Values in the same column with same superscripts did not differ significantly ($p>0.05$)

Fecundity

The estimated results of fecundity of *M. rogenbergii* are presented in Table 4. Average fecundity of *M. rogenbergii* in T_1 was 99,741, in T_2 was 98,125 and in T_3 was 97,911. Statistical analysis indicated that there were no significant differences ($P>0.05$) between the fecundity of *M. rogenbergii* of different feeding trails.

Discussion

The water quality parameters were ranging from 4.3 to 6.9 mg/L for dissolved oxygen, 22°C to 30°C for temperature, 7.2 to 8.1 for p^H, and 0.2 to 0.37 mg/L for ammonia. New and Singholka (1985) reported that the temperature below 14°C or above 35°C is lethal for freshwater prawn and maximum growth occured near 31°C. Generally, winter is not the breeding season for *M. rogenbergii* due to some environmental disadvantage (Rao 1965). Wulff (1982) reported that juveniles of freshwater prawn could tolerate dissolved oxygen levels of 1.0 to 1.5 mg/L at early morning and suggested not to allow the prawn at such level for extended period. Cohen *et al.* (1983) observed that dissolved oxygen level should always be maintained above 4.0 mg/L for prawn culture. Michael (1969) described that the best p^H level for culturing fisheries organisms is around 7.5 to 8.5.

The average gonado-somatic index was 14.39, 14.35 and 14.36 for T_1, T_2 and T_3 respectively. The lowest GSI value being 13.35 and highest being 15.50. The differences were not statistically significant ($p>0.05$). Patra (1976) observed the average GSI value of *M. rogenbergii* to be 14.88, ranging from 12.81 to 17.78. Similar results were found in the present experiment.

The fecundity of the freshwater prawn, *M. rogenbergii* was found to be 99,741 in T_1, 98,125 in T_2 and 97,911 in T_3. There were no significant differences between the fecundities of *M. rogenbergii* in different feeding trails at the 5% level of significance. Patra (1976) found mean fecundity of *M. rogenbergii* from natural brood to be 1,30,000. Ling and Merican (1961) found average fecundity of *M. rogenbergii* to be 90,000. Costa and Wanninayake (1986) reported that the fecundity of *M. rogenbergii* ranged from 19,000 to 1,37000. Sureshkumar and Kurup (1998) found that the mean fecundity of *M. rogenbergii* was 95,687 ranging from 30,666 to 2,27,161. The fecundity found during the present study was within the above range of hatchery broods. The deviation in fecundity may be attributed to the differences in size of gravid females. As the average size of the prawn is generally higher in case of wild stock, the fecundity also increases exponentially due to the size of the prawn. The differences in fecundity may also be due to the differences in the habitat of the stock or may be due to their genetic variations. According to Bromage *et al.* (1992) fecundity varies with season, climatic conditions, environment and nutritional status.

Similar gonado-somatic index and fecundity of *M. rogenbergii* larvae at three different feeding trails indicates that gonado-somatic index and fecundity of larvae were not significantly affected by three types of brood feed. Cost of feed is a major factor in the financial management of brood rearing. During the present experiment, a local feed consisting of 21% fish meal, 45% mustard oil cake, 28.0% rice-bran, 5.0% wheat flower and 1.0% vitamin-mineral premix, was prepared the cost of which was Tk. 14/kg. It was apparent that this feed was substantially cheaper than the Saudi-Bangla prawn feed, the cost of which was Tk. 23/kg. Though the difference of price of the feeds was remarkable but there were no significant differences between the gonado-somatic index and fecundity from these two types of feeding trails. Considering all the above facts, the local feed was recommended for the brood rearing of *M. rogenbergii* in ponds.

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Effect of phosphorous supplementation in the formulated fish feed on carcass quality of Nile tilapia *Oreochromis niloticus* L.

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Abstract
A study was conducted to evaluate the effect of phosphorus supplementation in the formulated fish diet on carcass quality of Nile tilapia in net-cages suspended in fertilized earthen ponds. In the experiment 3% di-calcium phosphate (DCP), 3% triple supper phosphate (TSP) and 7% 16:20 inorganic fertilizer were added as phosphorous sources to three diets containing fish meal as main protein ingredient. Feeding tilapia in net-cages with these diets significantly ($p<0.05$) improved the carcass quality and bone phosphorous content of Nile tilapia over fish fed with same diet without phosphorous supplementation and fish given no feed. The final body composition and bone phosphorous content of Nile tilapia fed with DCP, TSP and 16:20 grade fertilizer supplemented diets were comparable.

Key words : Phosphorus, Di-calcium phosphate, Triple super phosphate, Carcass quality, Bone phosphorus

Introduction

Phosphorus is one of the most essential minerals for fish growth and bone mineralization which function primarily as structural component of hard tissues e.g., bone, exoskeleton, scale and teeth. Effects of dietary phosphorous deficiency in fish have been found mainly to be loss of appetite, reduced growth and head and skeletal deformities and under extreme circumstances affect bone formation and lead to death of fish (Lall 1979). In semi-intensive culture system the natural food alone usually may satisfy all phosphorous requirements of fish to support slow growth rate and to avoid gross phosphorous deficiency symptoms. However, in intensive and semi-intensive aquaculture system farmers uses supplementary diets to obtain better fish growth, which may be deficient in phosphorus or contain in an unavailable form to fish. Then addition of phosphorus in supplementary diets may be more appropriate to obtain improve carcass quality and better fish growth.

The aim of the present study was to evaluate the effect of supplementation of di-calcium phosphate (DCP), inorganic fertilizer triple super phosphate (TSP), and inorganic fertilizer 16:20 (16:20 grade fertilizer contains 16 percent N and 20 percent

P_2O_5) as phosphorus sources in the formulated fish feed on carcass quality of Nile tilapia (*Oreochromis niloticus*).

Materials and methods

The study was conducted for a period 60 days in 15 net-cages each measuring 2.0 m x2.0mx1.0m suspended in three fertilized earthen ponds each measuring 200 m^2 at the campus of Asian Institute of Technology, Bangkok, Thailand. Five treatments including one non-feed treatment with three replicates each were tested in a randomized complete block design (RCBD). Four iso-nitrogenous and iso-caloric experimental diets were formulated and prepared. Di-calcium phosphate (DCP), Triple supper phosphate (TSP) and grade 16:20 fertilizer were supplemented at rates 3, 3 and 7% respectively in three diets as phosphorus sources. In treatment 3, 4 and 5 fish were fed with 3% DCP 3% TSP and 7% grade 16:20 fertilizer supplemented diets respectively. In treatment 2 fish were fed with phosphorous non-supplemented diet and in treatment 1 fish were given no feed. All sex reversed male Nile tilapia were used in the experiment and stocked with 25 fish per net-cage. The initial and the final individual length and weight of fishes were measured and recorded. For the analysis of initial carcass proximate composition and bone phosphorus thirty fishes were sacrificed and for the analysis of final carcass proximate composition and bone phosphorus fifteen fishes per replicate were also sacrificed at the end of the experiment. Earthen ponds were fertilized one week before stocking of fish and after that regularly weekly basis with inorganic fertilizer at the rate of 4-kg Urea-N/h/day and 2 kg TSP-P/h/day. Composition, nutrient and energy content of diets used in the experiment are given in Table 1.

Table 1. Composition, nutrient and energy content of experimental diet (g/100g dry weight basis)

Ingredients	DIETS			
	1	2	3	4
Soybean meal	60	60	60	60
Fish meal	5	5	5	5
Cassava starch	29	26	26	22
Corn oil	4	4	4	4
Vitamin premix	2	2	2	2
DCP[1]	0	3	0	0
TSP[2]	0	0	3	0
16:20[3]	0	0	0	7
Total	100	100	100	100
Proximate composition				
% Dry mater	91.01	89.82	90.12	89.63
% Protein	31.52	31.83	32.44	31.66
% Lipid	5.02	4.97	5.11	5.07
% Crude fiber	4.99	7.89	8.53	6.62
% Ash	5.78	8.65	8.03	8.68
% NFE	52.69	46.65	45.89	47.97

% Phosphorus	0.57	1.14	1.18	1.15
Gross energy (kj/g)	18.68	17.65	17.74	17.91
P.E ratio (mg/kj)	16.87	18.01	18.28	17.67

[1] DCP = Di-calcium phosphate [2] TSP = Triple super phosphate [3]16:20= A 16: 20 grade fertilizer contains 16 percent N and 20 percent P_2O_5

In the experiment fish were fed at the rate 3% of body weight (dry feed/wet fish weight) twice in a day (50% in the morning between 9.00 –10.00 a.m. and rest of the 50% in the evening between 5.00- 6.00 p.m.). The feed was given in feeding trays suspended in water column. The ration was adjusted biweekly intervals according to batch weight after every sampling.

Water samples were taken at weekly and biweekly intervals and analyzed for assessing temperature, dissolved oxygen, pH, ammonia, nitrogen, total alkalinity, total phosphate, nitrite, total suspended solid (TSS), chlorophyll-*a*, phaeophytin-*a* and plankton biomes.

Proximate composition of ingredients, diets and fish carcass were analyzed according to the analytical methods of AOAC (1984) and phosphorous were analyzed by molybdate–vandate and spectrophotometric (420nm) method.

To test significance of treatments at 0.05 confidence level ($p<0.05$) on the mean final carcass composition and bone phosphorous, the multi-factor analysis of variance (ANOVA) and paired t-test was used. The Mstatc statistical software package was used for this purpose.

Results

Proximate composition of fish body carcass

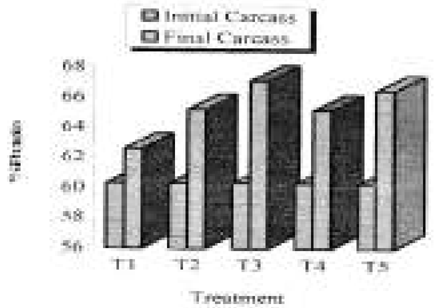
The initial and final proximate composition of fish carcass in different treatments reflected the significance alteration in proximate composition. The initial and final mean proximate compositions of fish carcass are given in Table 2.

Table 2. The initial and final mean proximate composition of fish carcass (± S.E n=3)

Composition	Initial	Final composition in treatment				
		1	2	3	4	5
% Moisture	78.67±1.13	79.39±0.28	75.83±0.46	74.77±1.13	75.56±1.81	76.10±0.83
% protein	60.28±0.55	62.61^{d}±0.22	65.23^{c}±0.33	67.12^{a}±0.49	66.18^{b}±0.59	66.50^{b}±0.56
% Lipid	9.56±0.42	9.60^{c}±0.27	16.12^{a}±0.51	15.48^{b}±0.28	15.22^{b}±0.40	15.51^{b}±0.30
% Ash	17.51±0.62	21.55±0.60	15.45±0.37	16.66±0.58	16.81±0.67	19.26±0.36

** Figures in the same row having the same superscript are not significantly different ($p>0.05$)

Final carcass crude protein content of fish in different treatments ranged from 62.61 to 66.50% with means of 62.61%±0.22, 65.23%±0.33, 67.12%±0.49, 66.18%±0.59 and 66.50%±0.56 in T_1, T_2, T_3, T_4 and T_5 respectively. Carcass protein difference among the treatments were significant ($p<0.05$). The highest carcass protein content was in treatment 3 (DCP) and the lowest was in treatment 1(Non-feed). Final carcass protein content of fish fed with DCP, TSP and 16:20 supplemented diets were comparable. Carcass crude lipid content ranged from 9.60 to 16.12% and the lowest crude lipid content was in fish given no feed. Carcass lipid content differed significantly ($p<0.05$) among the treatments. Ash content in fish carcass ranged from 15.45 to 21.55 % in different treatment the highest ash content was in non fed fish. Comparison between initial and final carcass protein and lipid level in different treatment is shown in Fig. 1



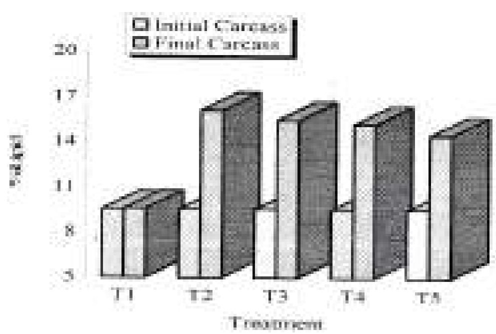


Fig. 1. Comparison between initial and final carcass protein and lipid level in different treatments

Phosphorous level in fish carcass and vertebrae bone

The mean value of phosphorous content in initial and final fish carcass and bone are summarized in Table 3.

Table 3. The initial and final mean phosphorous content of fish carcass and bone (± S.E)

	Initial	Final composition in treatment				
		1	2	3	4	5
Carcass						
% Ash	17.58±0.16	21.55±0.06	15.45±0.37	16.66±0.58	16.81±0.67	19.26±0.36
%Phosphorous	2.34±0.03	2.54^{b} ±0.06	2.69^{ab}±0.06	2.95^{a}±0.06	2.85^{ab}±0.16	2.81^{ab}±0.05
Bone						
% Ash	44.02±0.43	58.77±2.06	46.54±1.19	50.98±0.90	50.71±0.80	50.28±0.51
%Phosphorous	5.78±0.05	6.19^{c}±0.03	7.32^{b}±0.18	7.87^{a}±0.15	7.78^{a}±0.06	7.77^{a}±0.35

** Figures in the same row having the same superscript are not significantly different ($P<0.05$)

Carcass phosphorous content of fishes ranged from 2.54 % to 2.95% in different treatments. The highest phosphorous content was in carcass of fish fed with DCP supplemented diet and the lowest was in fish given no feed. Phosphorous content in vertebra bone of fishes ranged from 6.19% to 7.87 % and meal values of vertebra bone differed significantly ($p<0.05$) among the treatments. The highest phosphorous content was in carcass of fish fed DCP supplemented diet and lowest was in fish given no feed. Carcass phosphorous and vertebrae bone phosphorous content of fishes fed DCP, TSP and 16:20 fertilizer supplemented diet were comparable. Comparison between initial and final carcass and bone phosphorous are shown in Fig.2.

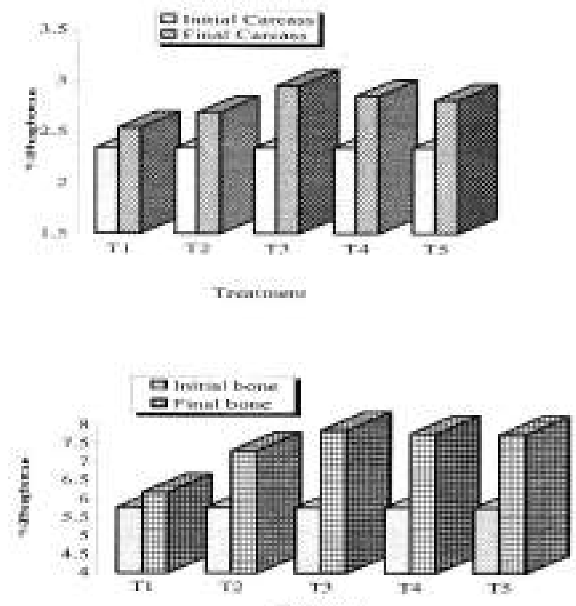


Fig. 2. Comparison between initial and final carcass and bone phosphorous level in different treatments

Water quality parameters

The water quality parameters analyzed at the start of the experiment and during the whole experimental period are summarized in Table 4. Water quality parameters in different ponds was almost uniform and within suitable range for fish culture.

Table 4. Mean value of water quality parameters during whole experimental period

Pond	DO (mg/l)	pH	Temp	NH_4-N (mg/l)	Alkalinity (mg/l)	TSS (mg/l)	Chlo-a (μg/l)
1	2.69 ± 0.3	7.64± 0.3	29.22± 0.45	0.62± 0.02	237± 5.28	43.91± 16.43	64.38± 0.75
2	2.59 ± 0.2	7.31± 0.3	29.16± 0.39	0.60± 0.02	230± 3.12	31.52± 13.23	55.20± 2.67
3	2.79 ± 0.3	7.39± 0.5	29.24± 0.39	0.72± 0.01	239± 13.23	43.46± 16.93	66.30±1.91

Discussion

In the present study Nile tilapia fed diets, supplemented with 3% di-calcium phosphate (DCP), 3% triple super phosphate (TSP), 7% inorganic fertilizer 16:20 as Phosphorus sources. The supplementation of phosphorus in diets reflected the significant alteration in proximate composition of final fish carcass of tilapia. The highest body protein level was in fish fed with DCP supplemented diet and the lowest body protein level was in phosphorus non-supplemented diet. Body protein and lipid content of fish in DCP, TSP and 16:20 supplemented diets were resembling. The highest lipid content was in phosphorus non-supplemented diet. Murakami (1970, cited in Lall 1979), Hung (1989) and Wee and Shu (1989) found that supplementation of phosphorus in the diet causes decrease in the lipid content of the muscle and viscera and increase in muscle protein of fishes. Phosphorus supplementation in diets influenced the carcass and bone ash content and phosphorus level of fishes. The lowest ash content and phosphorus level in body carcass and vertebrae bone was found in fishes fed with phosphorus non-supplemented diet. Higher and coinciding ash content and phosphorus level were found in carcass and bone of fish fed with DCP, TSP and 16:20 supplemented diets respectively. It indicates that there was a positive relationship between dietary phosphorus level and ash content in carcass and bone as well as phosphorus level in carcass and bone. Similar results also found by Robinson et al. (1987) and Haylor *et al.* (1988). Phosphorus supplementation also affected the phosphorus deposition in fish body carcass. The lowest phosphorus deposition was in fish fed with phosphorus non-supplemented diet. Higher and alike body phosphorus deposition observed in fish fed with DCP, TSP and 16:20 supplemented diets. It also indicates that phosphorus availability from DCP, TSP and 16:20 to tilapia were almost same.

Conclusions

In view of the above study it may be concluded that, phosphorus supplementation in the formulated fish feed play significant role on fish carcass quality and bone phosphorous content. Body composition and bone phosphorous content of Nile tilapia fed with di-calcium phosphate (DCP), triple super phosphate (TSP) and a 16:20 grade fertilizer supplemented diets were comparable.

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Food habits of *Oxygaster bacaila* (Ham.) from Kaptai Lake, Bangladesh

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Abstract

Gut contents of 120 *Oxygaster bacaila* from Kaptai Lake were studied. Index of preponderance (IP) indicated that *O. bacaila* consumed highest amount of Insects (35.89%) and thus occupied the first position among the food items. Zooplankton (Rotifera and crustacea 31.79%) and the other food items found in the guts were algae (Chlorophyceae, Bacillariophyceae, Euglenophyceae and Cyanophyceae 24.51%). From the analysis of gut contents, this fish might be considered as omnivore as it consumed both animal and plant foods with higher preference for animal food. The feeding intensity of this fish is fairly high. Total length (TL) versus gut length (GL) relationship and their ratio were found to be GL = 0.57663 $TL^{1.04801}$ (r = 0.9963) and TL: GL = 1: 0.7086 respectively.

Key words : Food habit, *Oxygaster bacaila*, Kaptai Lake

Introduction

There are about 58 fish species in Kaptai Lake (Hafizuddin *et al.* 1989) *Oxygaster bacaila* is one of them. It is a common fresh water indigenous small fish of Bangladesh. It is locally known as chela. This fish is very much popular and less costly. Its found available in the rivers, canals, beels, ponds, lake etc. of Bangladesh (Rahman 1989, Islam and Hossain 1984). Small indigenous fish is not only as a source of animal protein but also as a source of vitamin, iron, calcium, phosphorus etc. (INFS 1977). It also contains 14.60g protein, 4.35g fat, 1.5g carbohydrate, 590mg calcium and 2.0g vitamin per 100 g of fish (Tripathi *et al.* 1997). So, this fish should be considered as a good source of minerals and protein.

Proper knowledge about the food and feeding habits of fish are very important factor for increasing fish production. The food habits of fishes vary with time of the day, size of the fish, season of the year, locality and availability of various foodstuffs. Many workers made studies on the food and feeding habits of different fishes, but so far literature reviewed no published report was found on food and feeding habits of *Oxygaster bacaila* from Kaptai Lake, Bangladesh. So the present work was undertaken to determine the food and feeding habits of *O. bacaila* from Kaptai Lake which might be helpful to the fish management policy for the increase of production of fish in the Kaptai Lake and other water bodies.

Materials and methods

One hundred twenty specimens of *O. bacaila* were collected for examination from Bangladesh Fisheries Development Corporation (BFDC) fish landing center at Rangamati, Chittagong Hill Tracts from July'99 to June'00. The fish samples were preserved in 5% buffered formalin immediately after collection and carried to the laboratory. Upon collection the length and weight of the fishes were recorded to nearest millimeter and 0.01g respectively. The fishes were dissected by a sharp scissors, then the entire alimentary canal of the fishes were taken out immediately. After dissection of fish total gut length were recorded to nearest millimeter. The food items were identified up to generic level following Ward and Whipple (1952), Davis (1955) and Needham and Needham (1962).

For the analysis of gut contents two methods namely occurrence and points methods were used.

Occurrence method : The number of stomach containing one or more food items was recorded (Hyslop 1980). The number was then expressed as a percentage of all stomach (Hunt and Carbine 1951 and Frost 1954).

Points method : In this method, each of the food item was allotted of points on the basis of quantity and all the points gained by different food items were summed up and scaled down to percentage to express them in percentage composition of the gut contents of all the fish examined (Hynes 1950).

The relative importance of various food items was calculated using index of preponderance (IP) with the following formula:

$$IP = \frac{\%\text{ of total occurrence} \times \%\text{ of total points}}{\sum(\%\text{ of total occurrence} \times \%\text{ of total points})} \times 100$$

$$= \frac{O_i \times V_i}{\sum O_i V_i} \times 100 \quad \text{(Natarajan and Jhingran 1961).}$$

Relationship between total length and gut length of the fish was calculated by least square method.

Results

The gut contents were analyzed and categorized into different food groups and so far identified up to generic levels. Following are the food organisms that were recorded under each group.

Insecta	:Red and black ant and small water bugs.
Crustacea	:*Cyclops, Daphnia, Nauplius*
Rotifera	:*Keratella, Brachionus, Trichocerca*

Chlorophyceae	:*Chlorella, Cosmarium, Gonatozygon, Ankistrodesmus, Pediastrum, Staurastrum, Spirogyra*
Bacillariophyceae	:*Actinella, Cyclotella, Naviculla, Fragilaria*
Euglenophyceae	:*Euglena, Phacus, Trachelomonas*
Cyanophyceae	:*Microcystis, Anabaena, Oscillatoria, Aphanocapsa, Gomphospheria, Merismopodia*
Semidigested food	:Phytoplankton, Zooplankton and Plant parts.
Debris and mud	:These are the components of plant matter, sand and clay

particles.

Moreover, abundance of each of the food group present in the gut was analyzed by both the occurrence and points method.

Insecta : This group of food item was most abundant and occurred regularly in the gut of *O. bacaila*. Monthly observation indicated that the highest quantity of this food item was present in June (32.87%) and the lowest in April (15.76%). This food item appeared to be 22.56% of the total percentage of occurrence (Table 1). According to Points method the same food item was also found to be the highest in June (32.25%) but the lowest in April (17.65%). This group formed 22.85% of the total percentage of points (Table 2).

Crustacea : The crustacean food item was appeared 13.65% of the total percentage of occurrence. The highest quantity (18.45%) was found in October and the lowest (8.97%) in June (Table 1). On the other hand according to points method this kind of food item was also found to be the highest in October (17.42%) but the content was lowest (8.35%) in July. This group was formed 13.49% of the total percentage of points (Table 2).

Rotifera : This food item was found to appear 16.61% of the total percentage of occurrence. The amount of this item was found to be the highest in June (23.91%) and the lowest in July (5.98%) (Table1). Points method also indicated that this food item was the highest in June (25.79%) but the lowest in July (6.67%) and comprises 16.41% of the total percentage of points (Table 2).

Chlorophyceae : This group of food item was appeared 13.54% of the total percentage of occurrence and its quantity was found to be the highest in July (22.36%) and the lowest in December (8.27%) (Table 1). On the basis of points method the same food item was appeared 14.34% of the total percentage of points and its availability in the gut of the fish was found to be the highest in July (25.79%) and the lowest in September (8.27%) (Table 2).

Bacillariophyceae : This group of food item was appeared 7.16% of the total percentage of occurrence. The highest quantity of this food was found in July (10.25%) and the lowest in February (5.35%) (Table 1). While the Bacillariophyceae comprises 6.88% of the total percentage of points with a maximum of 9.08% in July and a minimum of 5.12% found in October (Table 2). In the month of November no representative of diatoms was found in the gut of this fish.

Euglenophyceae : This food formed 7.09% of the total percentage of occurrence. The amount of this food item was found to be the highest in April (9.12%) and the lowest (4.55%) in August (Table 1). According to Points method this food item was found to be the highest in April (8.39%) and the lowest in August (3.62%). This group was formed 6.88% of the total percentage of points (Table 2). This food item group was found in all season except February, June and October.

Cyanophyceae : This food group formed 8.16% of the total percentage of occurrence. In this method the highest quantity of food item was found in May (12.72%) and the lowest (4.75%) in March. (Table 1). Points method exhibited the highest content of this food item that prevailed in the gut of the fish in May (11.27%) and the lowest in June (5.09%). It was formed 7.39% of the total percentage of points (Table 2). This blue green algae was found all season except in September.

Semi-digested food : This item was comprised different parts of the phyto and zooplankton. It was appeared 5.3% of the total percentage of occurrence. The highest quantity of semi-digested food was found in December (8.79%) and the lowest in May (3.21%) (Table1). Points method also indicated that the highest amount of this kind of food was present in December (8.17%) and the lowest in May (2.87%). This group occupied 5.37% of the total percentage of points (Table2).

Debris with mud : The highest amount of this item was found in December (15.51%) and the lowest in May (2.20%). It was comprised of plant matter, sands and clay particles. It was appeared 8.95% of the total percentage of occurrence (Table 1). But points method estimated this item 9.28% of the total percentage of points. The highest amount was found in September (11.68%) and the lowest in May (4.94%) (Table 2).

Index of preponderance (IP)

Preference for food item by the fish was evaluated by calculating its preponderance index. The index of preponderance for Insecta was 35.89%, Rotifera 18.97%, Chlorophyceae 13.51% and Crustacea 12.82% thus occupied the first, second, third and fourth position in the gut contents of *O. bacaila*. (Table 3).

Relationship between total length (TL) and gut length (GL)

Relationship between total length (TL) and gut length (GL) of the fish was statistically analyzed by least square and was found to be significantly correlated ($r=0.9963$, $t=32.87$) at 0.01 level. Ratio between average total length and gut length was 1: 0.7086.

The relationship between total length and gut length can be expressed by the following equation:

$GL = 0.57663\ TL^{1.04801}$ or $\text{Log}\ GL = 0.2391 + 1.04801\ \text{Log}\ TL$ (Table-4).

Table 1. *Monthly variation in percentage of occurrence of various groups of food items in the gut of O. bacaila*

Months	No. of fish	Phytoplankton				Zooplankton			Semidigested food	Debris with mud
		Bacillariophyceae	Chlorophyceae	Cyanophyceae	Euglenophyceae	Crustacea	Rotifera	Insecta		
July.	10	10.25	22.36	11.21	6.19	9.65	5.98	15.85	6.64	11.87
Aug.	10	7.68	12.85	8.79	4.55	13.93	16.25	25.37	5.61	4.97
Sept.	10	6.12	9.25	Not found	8.07	15.65	20.37	22.71	4.86	12.97
Oct.	10	5.98	15.93	6.15	Not found	18.45	17.27	23.87	4.35	8.00
Nov.	10	Not found	13.21	8.75	7.29	14.35	18.12	25.34	4.21	8.73
Dec.	10	6.95	8.27	8.35	7.25	13.57	10.74	20.57	8.79	15.51
Jan.	10	7.32	10.78	9.29	7.95	12.78	12.21	21.86	6.25	11.56
Feb.	10	5.35	12.45	7.61	Not found	15.12	18.65	20.98	7.5	12.34
Mar.	10	8.15	14.32	4.75	6.71	15.89	16.77	24.07	4.09	5.25
Apr.	10	6.75	16.92	6.23	9.12	13.87	20.52	15.76	4.55	6.28
May.	10	8.52	14.98	12.72	6.75	11.59	18.58	21.45	3.21	2.2
Jun.	10	5.75	11.24	5.92	Not found	8.97	23.91	32.87	3.54	7.8
Average		7.16	13.54	8.16	7.09	13.65	16.61	22.56	5.3	8.95

Table 2. The percentage of total points of various groups of food items in the gut of *O. bacaila*

Months	No. of fish	Phytoplankton				Zooplankton			Semidigested food	Debris with mud
		Bacillariophyceae	Chlorophyceae	Cyanophyceae	Euglenophyceae	Crustacea	Rotifera	Insecta		
July.	10	9.08	25.79	9.76	5.89	8.35	6.67	19.48	4.74	10.24
Aug.	10	8.12	16.23	5.86	3.62	12.67	15.53	20.89	7.31	9.77
Sept.	10	5.85	8.27	Not found	6.24	16.75	19.8	25.29	6.12	11.68
Oct.	10	5.12	17.39	5.73	Not found	17.42	15.21	22.35	5.83	10.95
Nov.	10	Not found	12.85	9.32	7.88	13.86	17.37	24.65	6.02	8.05
Dec.	10	7.42	10.99	8.98	6.73	15.48	11.21	19.89	8.17	11.13
Jan.	10	6.77	9.35	7.82	8.25	12.65	13.46	25.96	5.9	9.84
Feb.	10	5.71	11.96	6.12	Not found	14.72	20.15	23.98	5.83	11.53
Mar.	10	7.35	13.16	5.97	7.85	16.12	15.48	21.25	4.92	7.9
Apr.	10	6.44	19.78	5.45	8.39	12.98	18.5	17.65	3.68	7.13
May.	10	8.65	15.89	11.27	7.12	10.95	17.77	20.54	2.87	4.94
Jun.	10	5.23	10.42	5.09	Not found	9.87	25.79	32.25	3.12	8.23
Average		6.88	14.34	7.39	6.88	13.49	16.41	22.85	5.37	9.28

Table 3. Index of preponderance (IP) of various groups of food items of *O. bacaila*

No.	Food groups	% of total points	% of Occurrence	% of occ. × % of points	IP	Grade
1	Insecta	22.85	22.56	515.49	35.89	i
2	Rotifera	16.41	16.61	272.57	18.97	ii
3	Chlorophyceae	14.34	13.54	194.16	13.51	iii
4	Crustacea	13.49	13.65	184.13	12.82	iv
5	Debris with mud	9.28	8.95	83.05	5.78	v
6	Cyanophyceae	7.39	8.16	60.30	4.19	vi
7	Bacillariophyceae	6.88	7.16	49.26	3.42	vii
8	Euglenophyceae	6.88	7.09	48.77	3.39	viii
9	Semidigested food	5.37	5.3	28.46	1.98	ix

Table 4. Relationship between total length (TL) and gut length (GL) and their ratio

Sl. No	Length group (mm)	Mid length (TL)	No. of fishes	Average total gut length (GL) (mm)	Log TL (X)	Log GL (Y)	Expected gut length	Ratio of TL: TGL
1	50-55	52.5	5	35.67	1.72	1.55	36.61	1:0.679
2	55-60	57.5	16	39.82	1.75	1.6	40.27	1:0.692
3	60-65	62.5	25	45.26	1.79	1.66	43.95	1:0.724
4	65-70	67.5	21	48.35	1.82	1.68	47.64	1:0.716
5	70-75	72.5	25	51.96	1.86	1.71	51.35	1:0.716
6	75-80	77.5	10	54.12	1.88	1.73	55.06	1:0.698
7	80-85	82.5	5	59.50	1.91	1.77	58.79	1:0.721
8	85-90	87.5	7	63.42	1.94	1.80	62.53	1:0.724
9	90-95	92.5	4	65.98	1.96	1.81	66.29	1:0.713
10	95-100	97.5	2	68.55	1.98	1.84	70.04	1:0.703
			$\Sigma f = 120$				Average	1:0.7086

Discussion

Index of preponderance (IP) indicated that *O. bacaila* consumed the highest amount of insects (35.89%) thus occupied the first position among the food items while Rotifers (18.97%), Chlorophyceae (13.51%), Crustaceans (12.82%) respectively occupied the second, third and fourth position. The fish fed mainly on aquatic insects (mostly coleopterans and dipteran larvae and small water bugs) and Zooplankton (Rotifera and Crustacea). The other items found in the guts were algae (Chlorophyceae, Euglenophyceae, Cyanophceae and Bacillariophyceae) and some debris with mud.

Alikunhi and Chaudhuri (1954.) have stated that *O. phulo* generally subsists on a predominately Zoo-plankton diet but also feeds on non-planktonic bottom living forms like *Spirogyra*, aquatic insects etc, in the absence or paucity of Zooplankton. Parameswaran *et al.* (1969) have stated that *O. bacaila* subsists predominantly on Zooplankton in all stages of its life. Dewan (1973) reported that the food of *Chela phulo* of a lake of Bangladesh Agricultural University consisted of green algae, higher aquatic plants, Rotifera, Crustacea and organic debris. Natarajan *et al.* (1975) found that the food of *Chela laubuca* (Ham.) appeared to be insect feeder and the insect were mainly coleopterans and dipteran larvae. These results partially agree with the present observation.

Considering Nikolosky's (1963) assumtion and according to our index of preponderance insects (35.89%) and Zooplankton (31.79%) (Rotifera and Crustacea) should be treated as the basic food. Phytoplan kton (24.51%) which composed of Chlorophyceae, Euglenophyceae, Cyanophceae and Bacillariophyceae should be considered as secondary food. Debris with mud and Semi digested food (7.76%) should be considered as an incidental food.

The relationship between total length (TL) and total gut length was $GL = 0.57663\ TL^{1.04801}$, ($r = 0.9963$, $t = 32.872$) which was highly significant at 0.01 level. The ratio of TL: GL was 1: 0.7086. As per total length versus gut length, *O. bacaila* should be grouped under the carnivorous type of fish (Das and Moitra 1956, 1963). They stated that the gut length of carnivorous fish is shorter or of equal to the body length. This result fully agreed with the present findings. Because in the present study although the gut length was shorter then the body length. About 68% of the gut contents of the fish occupied by animal foods which indicated the carnivorous nature of the fish.

From the present study it should be claimed that *O. bacaila* mainly depend on insects (Red and black ant and small water bugs), Zooplankton (Rotifers and Crustaceans) and Phytoplankton (Chlorophyceae, Bacillariophyceae, Euglenophyceae and Cyanophyceae) which rightly indicated that the fish is a planktivore omnivorous with preference for animal nature plankton like insects and Zooplankton.

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Effects of iso-nitrogenous fertilizers as nutrient sources on carp polyculture in Bangladesh

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Abstract
A 120-day long experiment was conducted to find out the effects of urea *plus* triple super phosphate (UT), cow manure (CM) and poultry manure (PM) having iso-nitrogen content on pond productivity and fish yield. Three fertilizer treatments, with three replicates each, were randomly assigned into nine earthen ponds of 100 m^2 each. The stocking fish were rohu (*Labeo rohita*), catla (*Catla catla*) and mrigal (*Cirrhinus mrigala*) in each treatment pond at the rate of 10000/ha with the ratio of 1:1:1. All ponds were fertilized fortnightly at the rate of 125 kg/ha urea *plus* 100 kg TSP/ha, 7000 kg/ha cow manure and 3500 kg/ha poultry manure for the treatment of UT, CM and PM, respectively, having an iso-nitrogen content of 56 kg in each. Though the physico-chemical water quality parameters were more or less similar in all treatment ponds, the chlorophyll-*a* content and abundance of total plankton were significantly higher ($P < 0.05$) in the ponds receiving the treatment PM. Final growth as well as per unit production of fish was significantly higher ($p<0.05$) with the treatment of PM (2067 kg/ha/4 months) followed by UT (1639 kg/ha/4 months) and CM (1246 kg/ha/4 months). The over all results showed that the poultry manure proved to be superior to urea *plus* TSP and cow manure, even when nitrogen content is similar, in carp polyculture system under prevailing conditions.

Key words : Iso-nitrogenous fertilizer, Water quality, Fish production

Introduction

Fertilization is the cheapest and simplest means of increasing aquatic productivity. The natural productivity of a pond can be greatly enhanced by the use of fertilizer, which may make up or provide the essentially needed nutrients for the production of aquatic biota serving as, either directly or indirectly, the food of fishes. Several workers have observed direct correlation between plankton and fish yield (Olah 1986). While fertilization is considered for increasing the pond productivity, nitrogen and phosphorus are the major key factors playing the most dominant role to this regards (Hepher 1962 and Saha *et al.* 1968).

In terms of nitrogen, urea is considered more economical than other nitrogenous fertilizers, because it is a bicomponent physiologically neutral fertilizer, containing approximately 46% of pure nitrogen, as aquatic plants assimilate both ammonia and carbon dioxide being released out by urease hydrolysis (Wolny 1967). Pond fertilization practices using animal wastes are also widely used in many countries to sustain pond productivity at low cost (Perker and Olah 1990). Cow and poultry manure are the best among the commonly used organic manures in Bangladesh. However, cow manure contains less amount of nitrogen over that of poultry manure. The differences in nitrogen content in cow and poultry manure could be an important factor in case of manure standardization for maintaining optimum level of pond productivity.

Although a number of studies have been conducted on effects of fertilization on plankton production and growth of fish (Wahab *et. al.* 1994, Ahmed *et. al.* 1997, Wahid *et al.* 1997), studies on the effect of cow and poultry manure having a similar quantity of nitrogen are still very limited or scanty. Thus, the present study was undertaken to determine the effect of three iso-nitrogenous fertilizers *viz.*, urea *plus* triple super phosphate, cow manure and poultry manure on water quality, pond productivity and fish production.

Material and methods

The experiment was conducted for a period of 4 months from July to October'99 at the Field Laboratory of the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh. Nine earthen ponds with an area of 100 m^2 each and average maximum depth of 1.5 m were used for this study. Ponds were rain fed and well exposed to sunlight.

Experimental design

The experimental ponds were randomly divided into three treatment groups for three levels of iso-nitrogenous fertilizers, *viz.*, urea plus triple super phosphate (UT), cow manure (CM) and poultry-manure (PM) with three replications for each. The rate of urea and triple super phosphate for the treatment UT was fixed to the standard inorganic fertilization rate of 125 kg and 100 kg/ha per application, respectively, in Bangladesh aquaculture conditions. As the UT, i.e., 125 kg urea plus 100 kg triple super phosphate contains 56 kg N, the loading rates of CM and PM were calculated equivalent to 56 kg N as 7000 kg and 3500 kg/ha, respectively. The iso-nitrogenous fertilization rates were calculated on the basis of nitrogen content in respective fertilizers and manures. The total nitrogen content in poultry manure, cow manure and urea, used during the course of experiment, was analyzed (on oven dry basis) as 1.6%, 0.8% and 45%, respectively according to the methods given by APHA (1992).

Pond preparation, stocking and fertilization

Before starting the experiment, ponds were drained out, renovated and made free of any unwanted aquatic organisms. Lime (Ca0) was applied at the rate of 250 kg/ha and left over for 5 days to sundry. After 5 days of liming, the ponds were filled up with underground water and fertilized with respective fertilizer at selective dosages.

Seven days after fertilization, each pond was stocked with rohu (*Labeo rohita*), catla (*Catla catla*) and mrigal (*Cirrhinus mrigala*) at the rate of 10000 fingerlings/ha with the ratio of 1:1:1. The stocking size of fish is given in Table 3. During the entire period of the experiment, fertilizers were applied twice in a month, while both CM and PM were applied into the ponds as slurry on wet basis and UT was diluted with water and sprayed over the pond water.

Monitoring of water quality

Physicochemical parameters, *viz.*, temperature, transparency, dissolved oxygen (DO), pH, ammonia-nitrogen (NH_4-N), nitrite-nitrogen (NO_2-N), nitrate-nitrogen (NO_3-N), phosphate-phosphorus (PO_4-P) and chlorophyll-*a* of each pond water were monitored at ten days interval between 09.00-10.00 hours. Temperature was measured by digital thermometer (precision = $\pm 0.1^{\circ}C$) and DO by a digital DO meter (YSI model 58). Transparency was measured by a Secchi disc and pH by a digital pH meter (Jenway model 3020). Analyses of NH_4-N, NO_2-N, NO_3-N was done by using a HACH kit (model DREL 2000). Phosphate-phosphorus concentrations were determined by a spectrophotometer (Milton Roy Spectronic, model 1001 plus) according to methods of Stirling (1985). Chlorophyll-a was determined spectrophotometrically at 664 nm and 750 nm of absorbance after acetone extraction (Boyd, 1979).

Plankton enumeration

Quantitative and qualitative samples of phytoplankton and zooplankton were taken fortnightly throughout the experimental period. To enumerate plankton population, 10 samples (5 liters of water in each sample) of water were collected from different areas and depths from each pond and were filtered through a fine mesh (25μ) plankton net. Then the filtered samples were taken in a measuring cylinder carefully and made up to a standard volume of 100 ml with distilled water. Samples were then preserved in small sealed plastic bottles containing 5% buffered formalin. Plankton were enumerated using a Sedgewick-Rafter counting cell (S-R cell). A 1ml sample was transferred to the counting chamber of the S-R cell (providing 10000 fields) and left to stand for 15 minutes to allow the plankton to settle. Using a binocular microscope (Swift M-4000), all cells/colony-forming units occurring in randomly selected 10 fields of the S-R cell were counted. Plankton density was estimated using the following formula:

$$N = (P \times C \times 100)/L$$

Where, N is the number of plankton cells or units per litre of original water
P is the number of plankton counted in 10 fields
C is the volume of final concentrate of the sample (ml)
L is the volume (litres) of the pond water sample.

Identification of plankton to genus level was carried out using keys from Ward & Whipple (1959), Prescott (1962), Belcher & Swale (1976), Palmer (1980) and Bellinger (1992).

Fish sampling and harvesting

Fish of each species (n>10) from each pond were caught at each fortnight sampling day using a cast net. To determine growth gain, total length (cm) and weight (g) of each fish were measured using a centimeter scale and an electronic balance (Ohaus model CT1 200). At the end of the experiment, the pond water was pumped out and all fish were harvested, measured and weighed. Weight gain per fish was calculated by deducting the average initial weight from the average final weight. Specific growth rate (SGR; % body weight/day) was estimated using the formula:

$$\frac{\text{Log}_e\text{(final weight)} - \text{Log}_e\text{(initial weight)}}{\text{Culture period (days)}} \times 100$$

Data analysis

For statistical analyses of data, a one-way ANOVA was carried out using *STATGRAPHICS Version-7* statistical package for the PC.

Results and discussion

The mean values of water quality parameters monitored during the period of experiment are given in Table 1. The values of water temperature, transparency, pH, DO, total alkalinity, PO_4-P, NO_2-N, NO_3-N, NH_4-N and chlorophyll-*a* ranges from 28.0 to 33°C, 18 to 46 cm, 6.35 to 8.90, 4.15 to 6.10 mg/l, 74.41 to 96.55 mg/l, 0.23 to 2.45 mg/l, 0.035 to 0.063 mg/l, 1.94 to 2.64 mg/l, 0.35 to 0.63 mg/l and 102.74 to 299.76 μg/l respectively. Variations in water temperature, transparency, DO, pH, NO_2-N, NO_3-N and NH_4-N among treatment ponds were found similar. However, significant differences ($P < 0.05$) in total alkalinity, phosphate-phosphorus and chlorophyll-*a* values were observed among the treatments (Table 1). The water quality parameters measured in different treatments throughout the experimental period were found to be within the acceptable ranges for fish culture (Lakshmanan *et al.* 1971, Dewan *et al.* 1985, Dewan *et al.* 1991, Ahmed 1993, Wahid *et al.* 1997).

Table 1. Mean value (± SD) of water quality parameters in different treatments

Water quality parameters	Treatments		
	UT	CM	PM
Water Temperature (°C)	30.56 ± 0.22	30.63 ± 0.27	30.95 ± 0.24
Transparency (cm)	27.54 ± 1.13	27.93 ± 1.45	25.67 ± 1.40
Dissolved oxygen (mg/l)	5.01 ± 0.09^{ab}	4.89 ± 0.08^{b}	5.24 ± 0.01^{a}
pH	6.70 - 8.70	6.65 - 8.45	6.35 - 8.90
Total alkalinity (mg/l)	79.38 ± 2.91^{a}	77.61 ± 3.19^{a}	92.32 ± 4.23^{b}
PO_4-P (mg/l)	1.69 ± 0.09^{a}	1.22 ± 0.12^{b}	0.73 ± 0.09^{c}
NO_2-N (mg/l)	0.061 ± 0.02	0.036 ± 0.00	0.035 ± 0.00
NO_3-N (mg/l)	2.50 ± 0.14	2.18 ± 0.16	2.06 ± 0.12
NH_4-N (mg/l)	0.48 ± 0.01	0.43 ± 0.08	0.52 ± 0.11
Chlorophyll-*a* (μg/l)	116.11 ± 13.37^{b}	122.52 ± 17.16^{b}	253.16 ± 46.51^{a}

*Values in the same row having no or the same superscript are not significantly different.

Though the nitrogenous nutrient content in treatment ponds were similar, it is interesting to note that the phosphorus content was significantly higher ($P < 0.05$) in the pond water receiving UT (1.69 ± 0.09 mg/l) compared to 1.22 ± 0.12 mg/l and 0.73 ± 0.09 mg/l in pond receiving CM and PM, respectively (Table 1). The lowest levels of phosphorus in the pond receiving CM and PM might be due to that the primary producers utilized the phosphorus in organic form more efficiently than that in inorganic form for their luxurious growth. This is being supported by the significantly highest ($P < 0.05$) chlorophyll-a content of 253 ± 51 μg/l in the ponds received poultry manure (PM) followed by that of 122.52 ±17.16 μg/l (Table 1) in the ponds received cow manure (CM). It has further been observed that the chlorophyll-*a* content had an inverse relationship with the phosphorus concentration. The absence of direct relationship between phosphorus and chlorophyll-*a* concentration was also evident in the fertilization studies of Metzger and Boyd (1980).

Plankton population indicates the productive status of a water body, because these are the direct and basic source of food for most of the animals in aquatic habitat. The abundance of plankton with their different groups has been shown in Table 2.

Table 2. Mean abundance of plankton (x 10^4 cells/l) in pond water under different treatments

Plankton groups	Treatments		
	UT	CM	PM
Bacillariophyceae	13.07±2.11^{b}	20.50±3.14^{ab}	48.29±19.51^{a}
Chlorophyceae	32.36±6.53^{b}	45.39±5.97^{b}	100.93±29.07^{a}
Cyanophyceae	24.36±6.57^{b}	31.71±4.26^{b}	79.64±19.93^{a}
Euglenophyceae	6.07±2.21^{b}	13.14±3.05^{ab}	23.50±6.68^{a}
Total phytoplankton	76.71±11.35^{b}	105.79±12.80^{b}	244.93±54.24^{a}
Crustacea	80.93±14.53^{a}	49.71±6.11^{a}	53.21±12.38^{a}
Rotifera	37.00±4.97^{a}	31.14±3.21^{a}	29.14±6.39^{a}
Total zooplankton	111.36±13.36^{a}	80.93±7.78^{a}	82.36±18.24^{a}
Total plankton	197.57±24.62^{b}	191.93±17.92^{b}	341.29±69.73^{a}

Values with similar or no superscript in the same row are not significantly different ($p < 0.05\%$)

Phytoplankton population was mainly composed of Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae. Chlorophyceae showed the quantitative dominance over other groups and Euglenophyceae was the least abundant phytoplankton group in all treatments. Zooplankton population consisted of only two plankton groups *viz.*, Crustaceans and Rotifers. The mean abundance of total phytoplankton of 244.93x10^4 cells/l was significantly higher ($p<0.05$) with the treatment PM followed by that of 105.79x10^4 cells/l with CM and 76.71×10^4 cells/l with UT. However, though the concentration of total zooplankton in all treatment ponds was similar ($p<0.05$), the total plankton was significantly abundant with the mean concentration of 341.29x10^4/l in the ponds fertilized with poultry manure (Table 2). Dhawan (1986), Dhawan and Toor (1989) reported a higher total phytoplankton and zooplankton concentration in ponds treated with poultry droppings alone and in combination with cow dung, mainly due to the content of phosphates and nitrates. As the fertilizers used in the present experiment had a similar content of nitrogen, the highest concentration of chlorophyll-*a* (Table1) and total plankton (Table 2) with poultry manure suggests that the phosphate along with the organic carbon in manure has a significant regulatory role over the nitrate in primary production. Besides 40% of total nitrogen, the poultry manure releases 50% of its total carbon and 20% of total phosphorus through leaching and decomposition (Knud-Hansen *et al.* 1993).

The growth performance of fish in terms of initial weight, final weight, weight gain, specific growth rate (SGR), survival rates and total production are shown in Table 3. The growth of different fish in three treatments was significantly different when increase in biomass was taken into consideration. Growth and production data were extrapolated in order to express net yields on a per hectare basis over the 120-day culture period. A significantly higher ($p<0.05$) net fish yield of 2067 kg/ha was obtained with the treatment PM followed by 1630 kg/ha with UT and 1246 kg/ha with CM. The survival rates of different species in three treatments at harvest time were fairly high and ranged from 92% to 98%. There were regular increase in weight of fish in all treatments; however, the weight gain was much higher in the poultry manure received ponds followed by urea plus TSP and cow manure received ponds (Fig. 1).

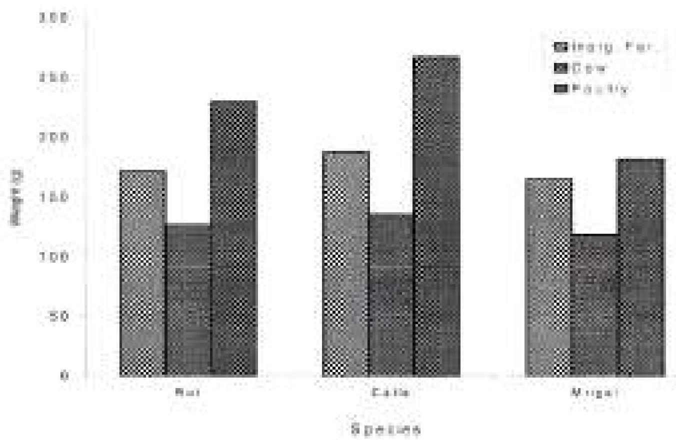

Fig. 1. Treatment wise production of rohu, catla and mrigal under different treatments.

Table 3. Details of growth and production of fish under different test treatments of iso-nitrogenous fertilizers in a 120-day culture period

Treatments	Fish species	At stocking		At harvest		Survival rate (%)	SGR (%)	Total weight (kg)	Total production (kg/ha/4 months)	
		No.	Initial wt. (g)	No.	Final wt. (g)				Species wise	Total
UT (urea+TSP)	Rohu	33	7.73	31	172.49±31.3	93.94	2.64	5.35	535	1630^{b}
	Catla	33	7.21	31	188.15±27.7	93.94	2.66	5.83	583	
	Mrigal	34	5.63	31	165.19±31.0	93.94	2.82	5.12	512	
CM (cow-manure)	Rohu	33	7.70	33	126.86±24.6	100	2.33	4.19	419	1246^{c}
	Catla	33	8.59	32	135.75±35.2	96.97	2.30	4.34	434	
	Mrigal	34	5.59	33	119.15±20.6	97.06	2.55	3.93	393	
PM (poultry manure)	Rohu	33	7.52	31	229.83±44.6	93.94	2.91	7.12	712	2067^{a}
	Catla	33	7.45	31	267.05±27.3	96.87	2.74	8.28	828	
	Mrigal	34	5.71	29	181.83±39.5	85.29	2.97	5.27	527	

*Values with similar superscript in the same row are not significantly different at 5% level.

This shows the superiority of poultry manure over cow manure due to the fact that poultry manure create more favourable limits of physico-chemical factors and nutrients which in turn increase the plankton production (Sandhu 1982, Dhawan 1986). Functionally, manure might also have acted as a direct food source, but Schroeder (1978) reported that fish fed directly on manure showed poor growth and that the major contribution of the manure is to increase the population of microorganisms. Laha and Mitra (1987) evaluated the effect of poultry manure and cow dung slurry at the rate of 5,000 kg/ha and 8,000 kg/ha, respectively, on the growth of three Indian major carps, *viz.*, rohu, catla and mrigal and observed the significant growth of fish in ponds fertilized with chicken manure than the cow dung slurry. While Mitra *et al.* (1987) evaluated the effect of poultry manure alone and in combination with pig or cow dung on the growth of production of catla, rohu and mrigal in four ponds, they found that the poultry manure alone or in combination with pig manure showed potentially in boosting up the productivity at comparatively cheaper rate.

Enhancement of fish yields by applying manure and fertilizers in composite fish culture ponds is an established phenomenon in many countries. However, studies on how water qualities and fish yield is related to the various iso-nitrogenous fertilizers and manures are very limited and there is none in Bangladesh. The present study on effects of different iso-nitrgenous fertilization on water quality and growth of fishes in composite carp culture is a part of series of experiments on the development of fertilization techniques for the composite carp culture in Bangladesh. Based on the results discussed above it could be concluded that even the nitrogen content in inorganic fertilizer and organic manure is similar, poultry manure seems to be superior than the commonly used urea plus TSP and cow manure for better yield under the prevailing carp polyculture system.

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A mixed culture trail of mud crab (*Scylla serrata* Forskal) with tilapia (*Oreocromis niloticus* L.)

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Abstract

A ten-month study on mixed culture of mud crab *Scylla serrata* with tilapia (*Oreochromis niloticus*) was performed in brackishwater earthen ponds using live tilapia fry as the only feed for crab. The monthly growth rate varied from 9.07-19.11g among four treatments. Treatment T_1, cw: 0.68cm (±0.72) and bw: 19.11 gm (±12.97) showed highest performance which was followed by T_3, cw: 0.62cm (±0.60) and bw: 13.42 gm (±10.51), T_4 cw: 0.65cm (±0.64) and bw: 13.20 gm (±9.89) and T_2 cw: 0.36cm (± 0.25) and bw: 9.07 gm (±8.05). Highest survivability of crabs was also recorded in T_1 (21.5%) which was followed by T_2 (15.65%), T_4 (14.95%) and T_3 (14.15%). In terms of survivability, significant differences ($p<0.05$) were observed among the treatments whereas these were recorded as insignificant difference ($p<0.05$) in final weight, weight gain and production of crabs and tilapia. Mixed culture of mud crab with tilapia could make more rewarding than crab monoculture but the study suggests that only tilapia fry can not fulfill the feed requirement of crabs in respects of survivability, final body weight and weight gain. Besides, existed salinity level of 4-12 ppt during experimental period might be the another key factor for low survivability and weight gain.

Key words : Mud crab, Tlapia, Mixed culture, Salinity

Introduction

Mud crab (*Scylla serrata*) can soon be attained the level of aquaculture of the important cultivable aquatic organisms (Fortes 1999). Culture of the species has been tried in India (Marichamy *et al.* 1986, Srinivasagam *et al.* 1988), the Philippines (Baliao *et al.* 1981), Sri Lanka (Raphael 1973), Taiwan (Chen 1990), Thailand (Varikul *et al.* 1973) and Malaysia (Subramaniam and Liong 1994). In Bangladesh, techniques for the culture of mud crab are yet to be developed though mud crab is being harvested from shrimp gher where the larvae enter the pond along with the tidal waters, but the farmers do not take any special care of them. In 1987, a group of fisherman tried to culture juvenile mud crab (2-4 cm) to marketable size in the Matamuhury estuary at Chokoria, Cox's Bazar. But due to lack of previous experience, technical know how and financial constraints they could not continue the experiment (Ahmed 1992). Considering the crab as a potential aquatic resource, the government of Bangladesh introduced crab fishing in Sundarban during 1987-88.

Usually feed cost of mud crab constitutes more than 40% of production (Utama and Othman 1994). As crabs is carnivore and prefers live organism, so its culture is very expensive. To develop an appropriate economically viable culture technology of mud crab the present study seems to be essential. Though no research work is available on mud crab, but mixed culture of tilapia with *Lates calcarifer* was studied (Mazid 1994). Tilapia is also found to be used for mix culture with other predatory fish such as snakehead *Channa striata* (Little *et al.* 1994). Polyculture of mud crab with shrimp, milkfish, and sea grass is being practiced in different county of Southeast Asia. The aim of the study was to identify the efficiency of live tilapia fry as feed for mud crab culture.

Methodology

The study was conducted in brackishwater earthen ponds of Bangladesh Fisheries Research Institute, Brackishwater Station at Paikgacha, Khulna from May'00 to March'01. The experiment was designed with four treatments having two replications for each treatment *viz.* 10,000 crabs/ha (T_1-control), 6,000 tilapia+10,000 crabs/ha (T_2), 8,000 tilapia+10,000 crabs/ha (T_3) and 10,000 tilapia+10,000 crabs/ha (T_4) (Table 1).

Pond preparation

Among eight selected ponds, six were of 0.1 ha and two of 0.05 ha each. First ponds were repaired and then fertilized urea and TSP at a rate of 40 kg/ha (urea:TSP=2:1). Bamboo fences were fixed on the embankment of the experimental ponds one meter away from the edge of water. It was done to prevent the crabs from burrowing and escaping and to provide shelter to them.

Stocking, feeding and management

After three days of pond fertilization tilapia, (30.5-35.2g, @ 2 male:3 female ratio) were stocked prior to at least one month of crabling stocking to ensure tilapia fry as feed for the crablings. But due to nonavailability of desired number of crablings a wide range of 5-70g was stocked at different time. Rice bran was given to tilapia as supplementary feed @ 6-3 % bw of tilapia in treatments T_2-T_4. Slaughterhouse waste, as a feed for crabling, @ 10-5% bw was given to treatment T_1. Water was exchanged at a rate of 40-45% during every new and full moon.

Growth was recorded by taking the carapace width and body weight of crab and body weight of tilapia in every fortnight. The presence of tilapia was also recorded fortnightly by using push net. Physico-chemical parameters of water such as water temperature, water transparency, pH and salinity were monitored fortnightly.

Crabs and tilapia were harvested by completely draining out the pond water. Comparison of the treatments was carried out using one way analysis of variance (ANOVA)

Table 1. Salient features of the mixed culture of mud crab, *Scylla serrata* with tilapia, *Orieochromis niloticus*

Conditions	Recorded data
Water source	Kapotakhya (Shibsa) river
Initial average weight of male and female crab (g)	11.59-49.35
Initial average weight of male tilapia (g)	30.5
Initial average weight of female tilapia (g)	35.2
Feeding rate for tilapia	6-3%/ kg body weight/per day
Feeding rate for crab	10-5%/ kg body weight/per day
Feeding frequency	Twice daily
Salinity range	2-11.5 ppt
pH	7.7-9.0
Range of water temperature	19-34°C
Water depth	0.6-1.1 m
Water transparency (cm)	19.5-36cm

Results

The monthly growth responses, initial and final carapace width of crablings , initial and final weight, weight gain, survival rate, and production of both crab and tilapia are presented in Tables 1 & 2.

Differences in the initial and final weight (g) of crabs in four treatments were found insignificant ($p<0.05$) (Table 2). Initial carapace width was found significant difference ($p<0.05$), but final carapace width was insignificant ($p<0.05$) (Table 2). An irregular growth trend of crabs was observed during the experimental period. Monthly growth rate varied from 9.07-19.11 g among the treatments (Table 2).Best growth performance was found in T_1 (cw: 0.68cm±0.72 and bw: 19.11 g±12.97) which was followed by T_3 (cw: 0.62cm± 0.60 and bw: 13.42 g± 10.51, T_4 (cw: 0.65cm± 0.64 and bw: 13.20 g± 9.89) and T_2 (cw: 0.36cm± 0. 25 and bw: 9.07 g± 8.05).

The highest survivability of crabs was also recorded in T_1 (21.5%) followed by T_2 (15.6%), T_4 (14.75% and T_3 (14.15%). Significant difference ($p< 0.05$) was found among the four treatments (Table 2).

For tilapia, mean of the initial mean weight for all the treatments was same, but during on-going experiment, the difference in the final weight was observed to be insignificant ($p<0.05$) both for male and female (Table 2). The percentage of male tilapia at harvest was higher than stocking in treatments T_2 (152%) and T_3 (117.21%) but it was reduced to 90.54% in T_4. The survival rate of female was recorded as 98.75% (T_2) and 93.7 % (T_4) and 78.14% (T_3) (Table 2).

Among the four treatments, production was highest in T_1 (344.77kg/ha) followed by T_2 (187.09kg/ha), T_4 (175.42kg/ha) and T_3 (155.16kg/ha). Besides, tilapia production was also recorded as 1056.9kg/ha, 893.92kg/ha and 1156.70kg/ha in T_2, T_3 and T_4 treatments, respectively. Individually male tilapia production was higher (583.5-744.85kg/ha) than that of female (310.42-537.88kg/ha) in all the treatments though the stocking ratio of

Table 2. Details of mixed culture of mud crab (*Scylla serrata*) with tilapia (*Orieochromis niloticus*)

Treat-ments	Species	Stocking rate no /ha	Av. size at stocking		Av. final size of harvesting		Weight gain (g)	Av. monthly growth		Survival (%)	Production kg/ha
			size (cw in cm)	weight (g)	Size (cw in cm)	weight (g)		size (cw in cm)	weight (g)		
T_1	*S. serrata*	10,000/ha	4.75	26.5	9.5	160	133.5	0.68±0.72	19.11±12.97	21.5[a]	344.77
T_2	*S. serrata*	10,000/ha	6.06	49.35	8.38	122	72.65	0.36±0.25	9.07±8.05	15.65[b]	187.09
	O. niloticus	6,000/ha		M: 30.5 F: 35.2		M: 232.85 F: 79.7	M: 202.35 F: 44.5			M: 152 F: 98.75	1056.9 (M:744.85+F:312.05)
T_3	*S. serrata*	10,000/ha	3.58	14.75	8.51	109.5	97.75	0.620±0.6	13.42±10.51	14.15[b]	155.16
	O. niloticus	8,000/ha		do		M: 193.34 F: 74.84	M: 162.84 F: 39.64			M: 117.21 F: 78.14	893.92 (M:583.5+F:310.42)
T_4	*S. serrata*	10,000/ha	3.56	11.59	8.77	116.5	104.91	0.65±0.64	13.20±9.89	14.75[b]	175.42
	O. niloticus	10,000/ha		do		M: 214.44 F: 86.62	M: 183.94 F: 51.42			M: 90.54 F: 93.7	1156.70 (M:618.8+F:537.88)

male and female was 2:3 (Table 2). The weight gain of male tilapia (162.84-202.35g) was almost 3-4 times higher than females (39.64-51.42g) (Table 2).

The abundance of tilapia fry was recorded as 1.65 g in T_2, 1.65g in T_3 and 1.31 g in T_4. Besides tilapia fry, other weed fishes such as *Oryzias melastigma, Glosogobius giuris,* some caridian hrimps and macrozooplankton were also caught as 8.35, 11.73 and 13.40g/m^2 during checking of tilapia fry in T_2, T_3 and T_4 respectively. The abundance of tilapia fry showed a strong negative relationship (r=0.98879) with the abundance of other organisms.

Among the water parameters (Table 1), water temperature was found from 19-34°C without any significant difference in all treatments. A suitable pH ranges of 7.7-9.0 was noted during the experimental period. The average water transparency for found in between 19.5-36cm. The variation of salinity noted as 2-11.5 ppt, with highest as 7.0-11.5 ppt in June-July and lowest of 2-5 ppt in remaining period. The average water depth recorded as 0.6 - 1.1m in the experimental ponds during the study period.

Discussion

In experimental earthen pond culture of mud crab with milkfish (*Chanos chanos*) and mullet (*Liza macrolepis*), Srinivasagam and Kathirvel (1991) recorded a survival rate of 26-30% and monthly growth rate of 10-23 mm and 48-62g. In the present study, survival rate of 21.5%, T_1 was almost similar to the above findings. However, lower survival rate (14.15-15.65%) and very low monthly growth rate (0.36-0.68mm, 9.07-19.11g) were recorded for other treatments. Apparently, T_1 showed a higher monthly growth rate, final weight gain, as well as crab production than other treatments. These might be due to application of slaughter housewaste as feed in the control treatment (T_1). In case of other treatments only rice bran was applied as a supplementary feed for tilapia to keep the tilapia breeding performance. Food items in the wild *S. serrata* included the remains of crustacean (44.3%), fish (22.3%), mollusk (14.3%) and others (19.1%) (Kathirvel 1981, Parasad *et al.* 1985). Crabs are omnivorous and like fleshy feed (Shah *et al.* 1999) .

The total biomass/density in specific volume of water might have an effect on survivability, final weight gain and production. Aldon (1997) obtained crab production of 600kg/ha/crop cultured with milk fish (5,000 crablings+2,500 fingerlings/ha). In the present study, stocking density of both crabs and tilapia were higher. Besides, female tilapia can breed within every 40- 90 days which could increase the total biomass in a specific area of water body. During the experimental period of 10 months tilapia should have spawned 2-6 times and observation also indicated tilapia breed normally but not sufficiently. Guerrero and Gracica (1983) mentioned potential outputs of tilapia ranged from 186 to 614/m^2 /month, with an average of 414 for a period of four month. In an another study, Sipe (1981) found 400/m^2 /per month in 10 breeders, with a ratio of one male for two females tilapia. In the present study, estimated weight and number of tilapia fry were almost lower than their studies (T_2 1.65g, 4.13 nos.; T_3, 65g, 5.84nos. and T_4, 1.31gm, 4.33 nos.). Perhaps, a major portion of tilapia was taken by crabs and some might have been preyed by male tilapia due to size variation. Gilbert (1996) expressed that if the age distribution is above 1.5 month, than larger males of tilapia can become cannibals. Besides, a portion should recruited but it is seemed to be that maximum were male tilapia. Females were also recruited in experimental ponds otherwise it would not be possible to get around 100% survival rate of female tilapia.

Survival rate of crab in present study was low. Highly stressed condition during stocking due to poor handling aand transportation could be the one of the reasons for low survival rate of crab. Due to nonavailability of required size crabling in natural environment at a time, a wide range variation in weight during stocking was occurred which led to natural mortality and cannibalism. Besides, stocking of required number of crabling in each pond of the experiment had taken much time resulting in increased mortality rate due to size variation of crabs. Samarasinghe *et al.* (1992) had similar observation.

A significant differences ($p<0.05$) was recorded only in survival rate of crabs among different treatments. On the other hand, in the case of monthly growth rate, final body weight and production no significance differences was observed in T_1, T_2, T_3 and T_4 ($p<0.05$). Mud crabs are likely to be habituated in euryhaline nature. Lower salinity existed during experimental periods might be the another factor for lower survival rate, growth, final body weight and production. Utama and Faazaz (1994) obtained significantly higher ($p>0.05$) differences in final body weight and weight gain of mud crabs reared in 20 ppt than those reared in 10ppt, but no significant differences recorded between reared in 20-30ppt. In the similar environment, Shah *et al.* (1995) and (1996) found better monthly growth (24.46 g and 30.22g), survival rate (28-31% and 58-69%)) and production (158.4-338kg/ha and 669.19-720.35kg/ha) than present study.

Crab juveniles could not survive at a salinity of 6-48ppt without acclimation and at 4ppt even with acclimation (Srinivaasagam and Kathirvel 1991). Shaha *et al.* (1995 and 1996) had acclimatized the crablings in laboratory conditions for 7 days prior to stocking and they also stated that the fluctuation of salinity hampered the growth of mud crabs. In the present study it was not possible to acclimatize crablings prior to stocking due to the nonavailability of crablings at a time.

Artificial substrates/shelters to be effective in reducing cannibalism. Subramaniam and Liong 1994 mentioned that providing plastic pipes as shelter can prevent cannibalism during molting. Rock islands along the edge of the pond can prevent the natural tendency of the crab to fight and to burrow. Mangrove trees and shrubs within the periphery of the pond were retained to provide hiding grounds for the susceptible soft peelers. In the present study, only bamboo fences were constructed on the embankment of the experimental ponds one-meter far from the edge of water in order to prevent escaping and burrowing of crabs.

To evaluate the growth and survival of crabling, further study on mixed culture of crab with tilapia may be carried out during higher salinity period of March-June/July, at the brackishwater enviroment in south-east-west coastal region of Bangladesh with providing supplementary feed. And also polyculture of crab with other brackishwater finfish may be tried to further asses mono and poly culture of mud crab.

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Water quality parameters of coastal shrimp farms from southwest and southeast regions of Bangladesh

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Abstract

The impacts of shrimp farming on water quality and effluent loading of shrimp farms in southwest (Khulna) and southeast (Cox's Bazar) regions of Bangladesh was investigated during March-August and August-October season, respectively. Water salinity fluctuated from 3.0 to 15.0 ppt in the southwest, whereas it was between 2.5 to 20.0 ppt. in southeast region. Total ammonia nitrogen as recorded in most farms of Cox's Bazar region was higher (0. 1160.438 mg/L) than the recommended level of shrimp farming. Mean values of total ammonia nitrogen and total nitrogen at the outlet of shrimp farms were higher than those of inlet in both regions. Mean values of phosphate phosphorus and total phosphorus at outlet were lower than inlet except in harvest time of *Penaeus monodon*. Total suspended solids were deposited on the bottom of shrimp farms in both regions, which resulted in higher concentration in inlets than outlets in both regions.

Key words : *Penaeus monodon*, Shrimp farm, TSS, Total nitrogen, Total phosphorus

Introduction

Shrimp farming in Bangladesh has rapidly developed due to an increase in demand of cultured marine shrimp in the international markets. Shrimp alone earned about US$350 million foreign exchange from its export of more than 29,713 mt processed products in 2001 and ranked second export item contributing 5.77% to the total export earning (DoF 2002).

Despite the apparent economic success of shrimp farming, the question of sustainability has a great issue in recent years. Shrimp farming does not only generate significant benefits, but also contributes to degradation of coastal environment and may threaten sustainability of shrimp production. Water quality problems resulting from high stocking, increased feeding rates and intake of polluted water are increasingly common in shrimp farming. Good water quality directly influences shrimp growth, survival and overall production. Poor water quality causes disease, mortality, slow growth and low production of shrimp. The discharge of pond water effluent is another activity associated with environmental degradation in the receiving waters.

Effluent from shrimp pond is a source of nutrient enrichment and eutrophication of natural water bodies and its impacts on coastal environment has caused greater concern (Phillips *et al.* 1993). An increasing eutrophication in natural water can lead to ecologically undesirable consequence. The water quality issues of the aquaculture systems as well as environmental impacts associated with shrimp farms have to be carefully evaluated in this country for future policy formulation. Very little works have so far been done on environmental variables of shrimp farms in Bangladesh. There is no detailed study on the water quality parameters and extent of effluent loading from shrimp farms in the environment. In view of the above, the present study has been undertaken to determine the water quality variables of some shrimp ponds and quantify the effluent discharge from the shrimp ponds in both Southeast and Southwest regions to understand the nature of changes take place in water quality over time and the quantity of effluent discharge especially total N, total P and TSS into the environment.

Materials and methods

Study area

Five shrimp farms such as Saral, Alamdanga, Roadanga, Charmulai and Soladana in Southwest Khulna and farm nos. 1, 2, 3, 4 and Beximco in Southeast Cox's Bazar areas were selected for this study. All shrimp farms in Khulna area are fed by the Shibsa river and in Cox's Bazar areas by the Bakkhali river. The farms were all different in areas and most of these have only one channel for both intake and drainage.

Water quality parameters analysis

Water samples were collected monthly from 4 selected *ghers* (impoundment) of each region to estimate the water quality parameters. Four *ghers* were used to conduct routine sampling. The routine sampling involved collection of water samples from three spots inside each farm along with those taken from inlet. The water quality parameters recorded and methods used for this study are shown in the following Table.

Parameters	Methods used
Temperature (°C)	Graduated Celsius thermometer
Salinity (ppt)	Refractometer, mod. 4200/REV A/05-95
pH	pH meter, Hach EC 10 portable pH meter,
Dissolved oxygen (mg/L)	DO meter- YSI mod. 58
Alkalinity (mg/L)	Titrimetric
TSS (mg/L)	Standard procedure and method
NO_2-N (mg/L)	Diazotization method
NO_3-N (mg/L)	Cadmium reduction
TAN (mg/L)	Nessler
PO_4-P (mg/L)	PhosVer 3 (Ascorbic acid)
Total-N (mg/L)	Persulfate digestion
Total-P (mg/L)	PhosVer 3 with acid persulfate digestion

Results

Water quality parameters of shrimp farms

Southwest region

The results of water quality parameters of the shrimp farms are shown in Table 1. Mean values of water temperature at inlet and within farms varied from 31.5-33.33 and 32.5-33.5°C, respectively. Salinity ranged from 9.83-10.83 and 9.83-10.67 ppt, and pH varied from 7.3-7.4 and 7.4-7.5, respectively. Dissolved oxygen contents were found to vary from 4.50-5.3 and 4.46-5.42 mg/L, respectively. Total alkalinity values at inlet and within were between 120.67-132.33 and 127.5-131.33 mg/L, respectively.

Table 1. Mean values of water quality parameters of shrimp farms in Paikgacha

Parameters	Sampling spot	Name of ghers			
		Saral	Alamdanga	Roadanga	Charmuli
Temperature (°C)	Inlet	33.33±3.33	32.67±4.13	31.5±2.25	32.33±3.72
	Within	33.0±4.05	33.5±3.39	32.5±3.02	32.5±3.08
	Inlet	10.5±4.59	10.67±3.56	9.83±2.86	10.0±2.53
Salinity (ppt)	Within	10.33±4.63	10.83±3.76	9.83±3.06	10.67±3.26
	Inlet	7.32	7.3	7.4	7.3
pH	Within	7.5	7.4	7.4	7.5
Dissolved oxygen	Inlet	4.60±0.52	4.50±0.30	5.30±0.12	4.98±0.12
(mg/L)	Within	5.42±0.31	4.46±0.20	5.11±0.08	5.21±0.10
	Inlet	120.67±10.61	127.83±14.13	132.33±13.4	128.33±19.38
Alkalinity (mg/L)	Within	129.0±10.58	128.83±6.31	127.5±11.5	131.33±11.09
	Inlet	213.17±73.84	205.17±73.16	147.5±59.48	157.67±84.57
TSS (mg/L)	Within	128.17±60.04	148.5±43.7	149.83±76.97	138.33±59.3
	Inlet	0.004±0.002	0.003±0.002	0.003±0.001	0.003±0.001
NO_2-N (mg/L)	Within	0.004±0.004	0.004±0.004	0.002±0.001	0.005±0.008
	Inlet	0.10±0.04	0.08±0.02	0.08±0.02	0.07±0.02
NO_3-N (mg/L)	Within	0.08±0.01	0.09±0.03	0.06±0.02	0.08±0.02
	Inlet	0.04±0.02	0.03±0.01	0.04±0.01	0.05±0.02
TAN(mg/L)	Within	0.05±0.02	0.06±0.02	0.03±0.01	0.05±0.03
	Inlet	1.85±0.59	1.53±0.61	1.2±0.45	1.23±0.29
Total N (mg/L)	Within	1.33±0.54	1.52±0.84	1.02±0.45	1.3±0.22
	Inlet	0.049±0.02	0.058±0.02	0.035±0.01	0.053±0.02
PO_4-P (mg/L)	Within	0.041±0.02	0.057±0.01	0.039±0.01	0.048±0.02
	Inlet	0.81±0.52	0.68±0.09	0.44±0.08	0.56±0.14
Total-P (mg/L)	Within	0.77±0.48	0.58±0.06	0.39±0.08	0.52±0.12

Mean values of TSS at inlet and within farms varied between 147.5-213.17 and 128.17-149.83 mg/L, respectively. Nitrite nitrogen concentrations varied from 0.003-0.004 and 0.002-0.005 mg/L, respectively, and nitrate nitrogen (NO_3-N) was found to range between 0.07-0.10 and 0.06-0.09 mg/L, respectively. Significant variations in nitrate nitrogen were not found at inlet and within the different *ghers*. TAN was found to range from 0.03-0.05 and 0.03-0.06 mg/L, respectively.

Mean values of total nitrogen (TN) at inlet and within varied between 1.2-1.85 and 1.02-1.33 mg/L, respectively, and phosphate-phosphorus (P04-P) concentrations ranged between 0.035-0.058 and 0.039-0.057 mg/L, respectively. The range of total phosphorus (TP) as recorded was 0.44-0.81 and 0.39-0.77 mg/L, respectively. Comparatively high concentration of total phosphorus was recorded at inlet than those of inside the *ghers*. Variations in total phosphorus between inlet and inside the *ghers* as well as monthly variations did not follow any definite pattern.

Southeast region

The results of water quality parameters of the shrimp ponds are presented in Table 2. In Cox's Bazar region, mean values of water temperature at inlet and within shrimp ponds varied from 29.17-30.83 and 29.67-30.67°C, and salinity ranged from 1.83-10.50 and 2.0-10.30 ppt, respectively among the shrimp ponds. pH values were alkaline and almost similar in both inlet (7.3-8.0) and within (7.5-7.8). Dissolved oxygen concentration varied from 4.85-5.10 and 4.74-5.22 mg/L, respectively. Alkalinity at inlet and inside the farms varied from 62.33-122.0 and 60.5-127.7 mg/L, respectively.

Table 2. Mean values) of water quality parameters of Gher 2, 3, 4 and Beximco ponds, Cox's Bazar

Parameters	Sampling spot	Name of *ghers*			
		Gher 2	Gher 3	Gher 4	Beximco
Temperature (°C)	Inlet	29.33±0.76	29.17±0.76	29.17±1.04	30.83±1.04
	Within	30.0±1.0	30.0±1.0	29.67±0.58	30.67±1.15
Salinity (ppt)	Inlet	9.83±7.78	10.5±8.85	8.0±5.27	1.83±0.28
	Within	10.0±7.54	10.3±8.74	10.3±8.74	2.0±0.5
pH	Inlet	7.46	7.58	7.3	8.0
	Within	7.64	7.61	7.5	7.8
Dissolved oxygen (mg/L)	Inlet	4.85±0.47	5.10±0.20	4.55±0.09	4.48±0.13
	Within	5.00±0.33	4.74±0.13	5.22±0.18	5.21±0.20
Alkalinity (mg/L)	Inlet	64.23±10.84	65.0±14.0	62.33±22.85	122.0±50.40
	Within	69.33±9.71	71.5±9.5	60.5±22.15	127.7±51.02
TSS (mg/L)	Inlet	75.0±25.0	88.33±34.03	66.67±28.87	83.33±28.87
	Within	86.67±32.15	83.33±28.87	83.33±57.74	116.67±76.38
NO_2-N (mg/L)	Inlet	0.002±0.00	0.004±0.001	0.003±0.001	0.003±0.001
	Within	0.003±0.00	0.004±0.0001	0.003±0.000	0.003±0.001
NO_3-N (mg/L)	Inlet	0.05±0.03	0.07±0.04	0.06±0.05	0.12±0.17
	Within	0.3±0.40	0.05±0.04	0.05±0.04	0.14±0.20
TAN(mg/L)	Inlet	0.08±0.02	0.11±0.05	0.08±0.02	0.05±0.04
	Within	0.09±0.04	0.08±0.02	0.09±0.01	0.18±0.22
Total N (mg/L)	Inlet	1.27±0.47	1.13±0.35	1.53±0.25	2.43±0.68
	Within	1.77±0.65	1.37±0.47	1.73±0.45	2.73±0.86
PO_4-P (mg/L)	Inlet	0.122±0.110	0.071±0.008	0.102±0.094	0.520±0.150
	Within	0.168±0.212	0.065±0.015	0.086±0.051	0.598±0.335
Total-P (mg/L)	Inlet	0.70±0.13	0.91±0.44	0.30±0.16	1.62±0.44
	Within	0.56±0.17	0.58±0.05	0.45±0.16	1.61±0.74

Mean values of TSS ranged from 66.67-88.33 and 83.33-116.67 mg/L, respectively. Nitrite nitrogen ranged from 0.002-0.004 and 0.003-0.004 mg/L among the farms, and nitrate nitrogen varied from 0.05-0.12 and 0.05-0.30 mg/L, respectively. The range of TAN recorded was 0.05-0.11 and 0.08-0.18 mg/L at inlet and inside different shrimp ponds.

Mean values of total nitrogen were found to range from 1.13-2.43 and 1.37-2.73 mg/L, respectively. Phosphate-phosphorus concentrations varied from 0.071-0.520 and 0.056-0.598 mg/L, respectively at inlet and inside different *ghers*. Total phosphorus varied between 0.50-1.62 and 0.45-1.61 mg/L, respectively.

Discussion

Discernible variation in water temperature among the *ghers* within the region was not observed. Stress inducing temperature levels up to 33.0-39.0°C during the study period was found in all 5 shrimp farms in Khulna region, which might be due to lower water depth. But this alarming level was not found in Cox's Bazar region. Inlet water temperature was lower than that of within the farms might be due to evaporation of water from the shallow farms. The optimal level of water temperature for *P. monodon* culture is 25-30°C as suggested by Boyd and Fast (1992).

Tiger shrimp can tolerate freshwater for about one month (Chakraborti *et al.* 1986). Predalumpaburt and Chaiyakam (1994) reported that the salinity should be in the range of 5-32 ppt for shrimp production. Salinity dropped to 3-9 ppt after June in Khulna region and it was 2.5-9 ppt before October in Cox's Bazar area, exceptional salinity range of 1.5-2.5 ppt over the study period was recorded in Beximco farm. Higher salinity was found in Cox's Bazar compared to Khulna region. In this regard, the salinity of farms was found unfavourable for shrimp culture, which might have resulted in poor production. The pH values did not show any definite monthly variations among the farms in both regions. Boyd and Fast (1992) and Chanratchakool *et al.* (1995) reported that the optimum pH range for *P. monodon* is 8.0-8.5 and 7.5-8.5, respectively. The obtained pH values 7.3-7.5 in Khulna and 7.3-8.0 in Cox's Bazar were, therefore in optimum level for shrimp growth.

Dissolved oxygen content did not follow any definite pattern during the study period. Chin and Ong (1994) pointed out a DO concentration of 3.8 to >5.0 mg/L is generally found favourable for shrimp culture, which supports the present findings (4.5- and 4.46-5.42 mg/L in Khulna and 4.48-5.10 and 4.74-5.22 mg/L in Cox's Bazar). Islam *et al.* (1998) reported the ranges of DO in Mongla and Paikgacha area of Bagerhat and Khulna districts were 5.1-8.7 and 5.7-8.1 mg/L, respectively. Dissolved oxygen content as recorded from the investigated farms is therefore suitable for shrimp culture.

Natural fertility of pond water increases with increase in total alkalinity up to at least 150 mg/L (Boyd 1998). Ahmed *et al.* (1997) found the range of alkalinity in semiintensive farms of Cox's Bazar district was 44.0-195 mg/L, and Islam *et al.* (1998) also found 130.0-217.5 and 118.0-187.5 mg/L total alkalinity in Mongla and Paikgacha area of Bagerhat and Khulna district, respectively. These are more or less similar with the present findings (120.67-132.33 and 127.5-131.33 mg/L in Khulna and 62.33-122.0

and 60.5-127.7 mg/L in Cox's Bazar region). Noticeable variations in alkalinity were not found in either region. The lower values of total alkalinity might be due to rainfall and cloudy weather. Larkins (1995) suggested that the alkalinity range from 60-140 mg/L is suitable for shrimp culture.

The higher values of TSS were found in Khulna farms compared to Cox's Bazar farms. No definite pattern of TSS concentrations between inlet and inside the *ghers* and within the months was observed. Lin *et al.* (1991) stated that 30-190 mg/L TSS was found in intensive shrimp ponds, and Deb (1998) reported 119.0-225.0 mg/L TSS in effluent water of semi-intensive shrimp farm in Cox's Bazar area. The findings reported by Deb (1998) are more or less similar with the findings from Khulna (147-213 and 128.17-149.83 mg/L) and higher than those of findings of Cox's Bazar (66.67-88.33 and 83.33-116.67 mg/L).

Remarkable variations in NO_2-N were not found in any *gher* in any region. The ranges of nitrite nitrogen concentration 0.004-0.01 and 0.002-0.01 mg/L recorded by Warisara (2000) in two shrimp ponds in Thailand, respectively are quite similar to the present findings (0.003-0.004 and 0.002-0.005 mg/L in Khulna and 0.002-0.004 and 0.003-0.004 mg/L in Cox's Bazar). According to Chien (1992), the favourable level of nitrite concentration for penaeid shrimp is 1.3 mg/L, 0.25 mg/L and 1.0 mg/L, respectively.

The ranges of nitrate concentration obtained in the present study were more or less similar to the ranges 0.00-0.30 and 0.00-0.21 mg/L with mean value 0.03 mg/L reported by Warisara (2000) in Thailand. The ranges of nitrate 0.010-0.040 and 0.010-0.020 mg/L reported by Islam *et al.* (1998) were also more or similar to the findings of present study (0.07-0. 10 and 0.06-0.09 mg/L in Khulna and 0.05-0.12 and 0.05-0.3 mg/L in Cox's Bazar). Boyd (1998) stated that the acceptable concentration of nitrate nitrogen in pond waters is 0.2-10.0 mg/L.

TAN concentration at inlet and inside the *ghers* did not show any significant difference in both regions. Higher concentration of TAN was found in Cox's Bazar area compared to Khulna area. Concentrations of unionized ammonia above 1 mg/L are potentially lethal, concentrations greater than 0.1 mg/L may adversely affect the growth of marine shrimp (Boyd and Fast 1992). The optimal level of ammonia for *P. monodon* culture is <0.1 mg/L (Chien 1992, Boyd 1998). According to them the ranges of ammonia nitrogen (0.03-0.05 and 0.03-0.06 mg/L in Khulna and 0.05-0.11 and 0.08-0.18 mg/L in Cox's Bazar) obtained in the present study were within acceptable range.

Total nitrogen (TN) content between inlet and inside the *ghers* did not show any significant difference in both regions. Lin *et al.* (1991) reported the range of TN in shrimp ponds in Thailand was 0.5-5.0 mg/L, which is more or less similar with the present findings (1.2-1.85 and 1.02-1.52 mg/L in Khulna and 1.13-2.43 and 1.37-2.73 mg/L in Cox's Bazar). According to Boyd and Green (2002) the TN concentrations of 0. 1 to 0.75 mg/L in coastal waters can cause plankton blooms and they suggested that the level of TN should exceed 10 mg/L in effluents of shrimp farms.

Variations in the phosphate content between inlet and inside the *ghers* as well as monthly variations did not follow any well-defined pattern in both regions. The ranges of phosphate for lower and higher stocking densities reported by NACA (1995) were 0.0- and 0.0-0. 18 mg/L, respectively, and Islam *et al.* (1998) found 0.04-0.12 and 0.030- 12 mg/L phosphate-phosphorus, respectively, which support the present findings from Khulna region (0.035-0.058 and 0.039-0.057 mg/L), but higher than the findings from Cox's Bazar (0.071-0.520 and 0.056-0.598 mg/L). According to Boyd (1998) the suitable range of phosphate phosphorus in pond waters is 0.005-0.2 mg/L.

Total phosphorus in discharged water of intensively managed shrimp ponds with stocking density of 30 PL/m2 and 60 PL/m2 was 0. 18 mg/L and 0.49 mg/L, respectively (Tunvilai *et al.* 1993a), and Lin *et al.* (1991) found 0.05-0.40 mg/L TP in intensive shrimp ponds. These are comparatively lower than the present findings (0.44-0.81 and 0.39-0.77 mg/L in Khulna, and 0.50-1.62 and 0.45-1.61 mg/L in Cox's Bazar), which might be attributed to the agricultural farm runoff, as source of phosphorus. A high concentration was observed in the last harvest time when sludge and sediments were released into the outlet for catching the last shrimp by draining the *ghers*. The higher values of TSS were found in Khulna farms compared to Cox's Bazar farms. No definite pattern of TSS concentrations between inlet and inside the *ghers* and among the months was observed. TN content between inlet and inside the *ghers* did not show any significant difference in both regions. Comparatively high concentration of total phosphorus was recorded at inlet than that of inside the *ghers*. Variations in total phosphorus between inlet and inside the *ghers* as well as monthly variations did not follow any definite pattern in both regions. The effluent loading is strongly affected by the water exchange rate throughout the growth cycle. Low or no water exchange rate from stocking to harvest reduces the potential for environmental impacts (Hopkins *et al.* 1993).

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Cephalopod fishery at Kakinada along the east coast of India : Resource characteristics and stock assessment of *Loligo duvauceli*

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Abstract

At Kakinada along the east coast of India, cephalopods were exploited by trawls. Fishery occurred round the year with peak during August-October. Peak abundance and fishery of cuttlefishes coincides with this period, whereas for squids it is during March-May. Cephalopod production continued to increase initially with fishing effort, until 1995, but declined thereafter despite increased fishing effort and expansion of fishing to deeper waters. Fishery, growth, mortality, recruitment pattern and exploitation rates of *Loligo duvauceli* were studied. Nearly 97% of their catch was by zero year groups. They attain sexual maturity and spawn during the first year itself. Spawning occurred round the year with peak during December-February. Exploitation rate of the species is large, 0.741 compared to E_{max} (0.44). This indicated that their stock is under heavy fishing pressure and subjected to over-exploitation. Stock also exhibited declining trend over the years during 1995-'99. These necessitate immediate attention to avoid collapse of the stock and fishery.

Key words : Cephalopods, *Loligo duvauceli*, Stock assessment

Introduction

Cephalopods are the highly developed group of invertebrates and occupy a leading place among the exploited marine fishery resource of the world because of their abundance and high nutritional quality. They constitute 4-5% of the total marine fish production from Indian waters (Meiyappan *et al.* 2000). Their report suggested that the resource in general is either under exploited or optimally exploited from Indian waters. Cephalopods, though share common environment with other marine fishes, they often adopt different life history strategies. In recent years several studies were conducted aimed at understanding the biology and behaviour of commercially important species and their response to exploitation. However, knowledge on many crucial aspects of several species remains limited.

Cephalopod fishery at Kakinada was supported by squids (Order: Teuthoidea) and cuttlefishes (Order: Sepioidea). Increased fishing effort and introduction of large deep going multi-day trawlers along the coast though initially improved the catch, it started declining after 1994-'95. These necessitated proper understanding on the population characteristics of species supporting fishery for developing management strategies. Present study was aimed to update such information on *Loligo duvauceli* along the east coast.

Materials and methods

Fishing effort, catch and catch composition of cephalopods in fishery were monitored at weekly intervals during 1995-1999. Biology of *Loligo duvauceli* was also studied simultaneously. Random samples of the species were collected and analyzed for sex ratio, gonadal maturity *etc.* Catch and effort data documented by the institute for the period 1985-'95 were also used to analyse behaviour of the fishery to increasing fishing pressure over the years.

Monthly length frequency data of the species in the catch was used to estimate growth parameters, mortality rates, exploitation rates and recruitment pattern. Growth parameters, L_∞ and K were estimated through surface response analysis of restructured length frequency histogram by ICLARM's FiSAT software (Gayanilo *et. al.* 1995). Size at first capture (L_{c50}) was estimated following Pauly (1984) and age at zero length (t_0) from von Bertalanffy plot (Bertalanffy 1934)

Natural mortality (*M*) was estimated from the empirical formula proposed by Pauly (1980), by taking mean sea surface temperature as 29°C and total mortality (Z) and exploitation ratios from catch curve as per Pauly (1983). Exploitation rate (E) was estimated from the equation; $E = F/Z$; where, $F = Z\text{-}M$ is the fishing mortality rate. Total stock (P) was computed from the relation; $P = Y/U$; where, Y is the yield and U exploitation ratio $U=F/Z \times (1- e^{-Z})$. Maximum sustainable yield (MSY) was estimated graphically as per Corten (1974).

Results

Fishery

Cephalopods were exploited almost exclusively by trawls. Annual effort increased gradually and steadily from 45,002 units during 1985-'86 to 63,989 units by 1998-'99. During the same period, duration of active fishing also increased from 317,284 hours to 990,110 hours. Active fishing time was increased sharply during nineties after the introduction of voyage fishing. With increase in effort, fishing activity was further extended to far deep seas.

Cephalopod landings increased during this period, with wide annual fluctuation (Fig. 1). Catch increased from 289 tons during 1985-'86 to 1,029 tons during 1994-'95. It declined steadily thereafter to 515 tons by 1997-'98. Catch was the lowest during 1990-'91. Catch rate also registered similar fluctuation between 3.6 kg/unit effort during 1990-'91 and 20.1 kg during 1994-'95 (Fig. 2). Catch/hour of trawling fluctuated between 0.4 kg during 1990-'91 and 1.26 kg during 1986-'87.

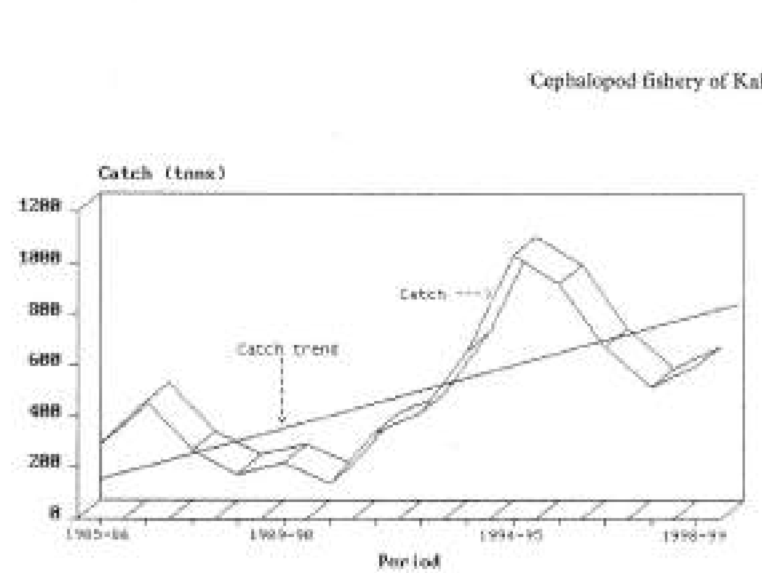

Fig. 1. Growth in cephalopod fishery at Kakinada by trawls during 1985-'99.

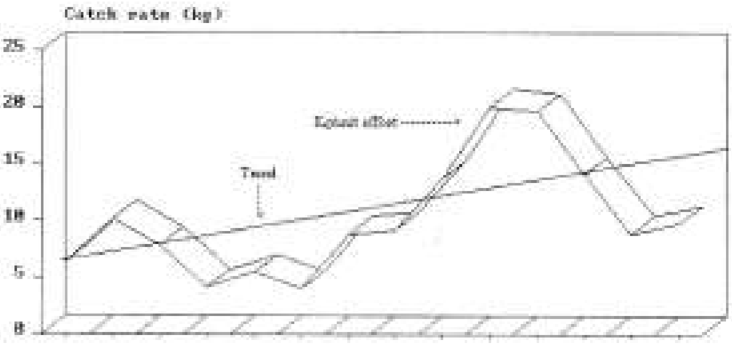

Fig. 2. Fluctuation in the catch rate of cephalopods by trawls during 1985-'99.

Catch composition and seasonal abundance

Fishery was supported by four species each of squids (25.9%) and cuttlefishes (74.1%) (Fig. 3). Among squids, *Loligo duvauceli* dominated (78.1%) the catch. Other species supporting fishery are *L. uyii, Doryteuthes spp.* and *Loliolus spp. Sepia pharaonis* (41.6%), *S. aculeata* (22.6%) and *S. brevimana* and *Sepiella inermis* (31.4%) supported cuttlefish fishery. Fishery occurred round the year, with nearly 50% of the catches during August-October (Fig 4). Peak fishery and abundance of cuttlefishes occurred during this period, whereas that of squids during March-May (Table 1). Peak abundance and fishery of *L. duvauceli* followed their peak period of spawning.

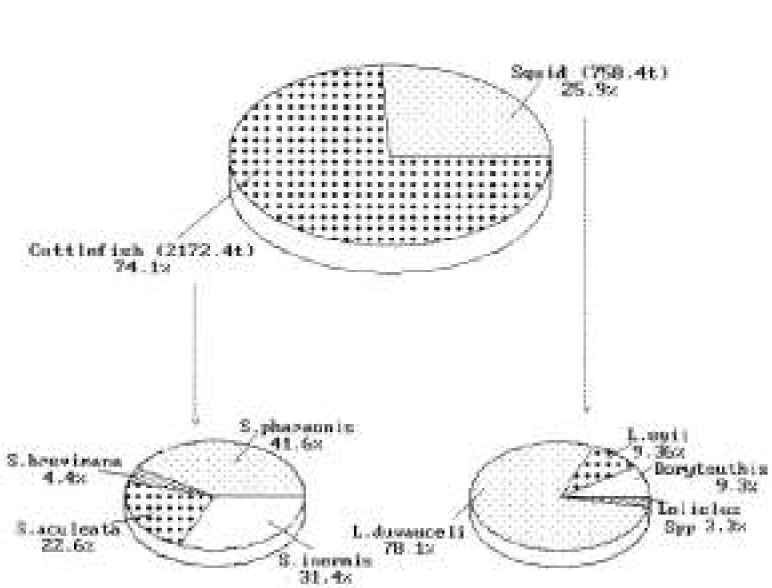

Fig 3. Average annual species composition of cephalopods landed by trawls during1995-'99.

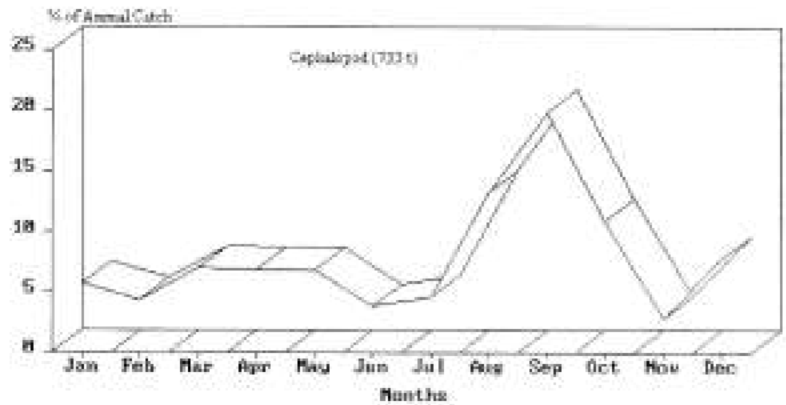

Fig. 4. Seasonal pattern of cephalopod fishery at Kakinada during 1995-'99.

Table 1. Seasonal fluctuation in catch rate (kg/hour) of different species of cephalopods in trawls during 1995-'99

Species	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar
L. duvauceli	0.81	0.73	0.41	0.24	0.20	0.65	0.27	0.17	0.45	0.44	0.53	1.05
L. uyii	0.09	0.73	0.04	0.04	0.03	0.08	0.02	0.01	0.06	0.05	0.10	0.13
Doryteuthis	0.08	0.22	0.07	0	0.004	0.004	0.03	0.01	0.04	0.04	0.07	0.12
Loliolus spp	0.01	0.005	0.01	0.05	0.007	0.04	0.02	0.04	0.04	0.01	0.03	0.04
S. pharaonis	0.19	0.28	0.05	0.12	1.76	2.52	1.27	1.08	0.84	0.40	0.15	0.11
S. aculeata	0.31	0.24	0.10	0.22	0.85	1.19	0.54	0.54	0.36	0.24	0.18	0.20
S. brevimana	0.06	0.06	0.04	0.05	0.10	0.15	0.09	0.06	0.11	0.07	0.10	0.06
S. inermis	0.68	0.04	1.32	0.84	0.52	0.91	1.05	0.67	0.72	0.63	0.36	0.30

Population characteristics of L. duvauceli

Growth : Growth parameters, L_∞ and K were estimated as 211mm and 1.68/year respectively and 't_0' as 0.0083 years. Their growth against time can be described by von-Bertalanffy growth equation as;

$$Lt = 211\ [1 - e^{-1.68(t - 0.0083)}]$$

Length at age data obtained from the above relation shows that they grow to 70.4, 118.6, 150.3 and 171.1 mm respectively by 3, 6, 9 and 12 months. They attain 203.6 and 209.6 mm by the end of 2nd and 3rd year respectively.

Size composition : Their fishery in trawl was supported by 10-170 mm animals with 71.0 mm as mean (Table 2). Zero-year group formed more than 97% of the catch. Juveniles entered trawl fishery at 10-20 mm size almost round the year with peak during January-March. They were caught in large numbers along with *Acetes* and other prawns. Their age at this stage was between 0.45 and 0.8 months. Size and age of the species at first capture was estimated as 38.9 mm and 1.6 months respectively.

Sexual maturity : Species show sexual maturity from 65 mm size onwards. However, their size at first maturity was estimated from probability curve as 86.5 mm for males and 94.5 mm for females and age as 3.9 and 4.3 months. These estimates indicate that they spawn during the first year itself.

Spawning and recruitment pattern : Recruitment pattern showing time of origin of the stock representing fishery (Fig. 5) and presence of animals with matured and spent gonads and small juveniles in the catch indicates that they spawn round the year with peak activity during December-February.

Table 2. Annual size range, modal classes, mean size and commercial size of *L. duvauceli* in the trawl catch at Kakinada during 1995-'99

Period	Size range (cm)	Modes	Mean size (cm)	Commercial size (cm)
1995-'96	20-160	70-80, 130-140	71.2	40-110
1996-'97	20-150	50-60, 80-90,	76.3	50-100
1997-'98	10-150	110-120, 60-70	68.6	50-100
1998-'99	20-170	40-50, 70-80	66.0	60-110
1995-'99	10-170	70-80	70.9	50-110

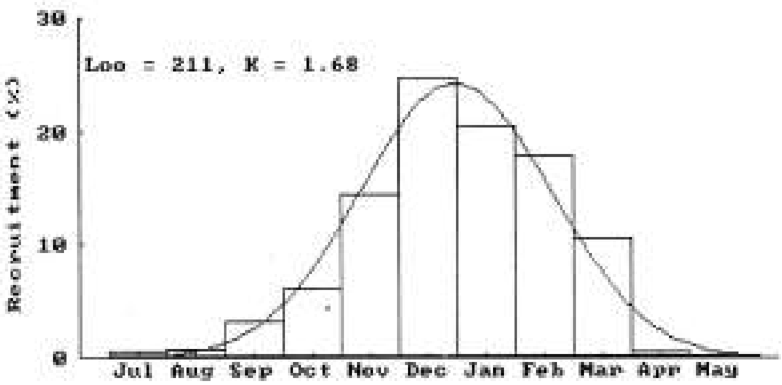

Fig. 5. Recruitment pattern of *L. duvauceli.*

Mortality rates : Estimates of total mortality rates ranged between 10.26 and 13.37 during 1995-'99 with 11.05 as mean (Table 3). Natural mortality was 2.86. Fishing mortality during the period was 8.19 and it varied between 7.4 and 10.5.

Table 3. Types and extent of mortalities operating in the exploited population of *L. duvauceli* during 1995-'99

Period	Total mortality (Z)	Natural mortality (M)	Fishing mortality (F)
1995-'96	13.37	2.86	10.51
1996-'97	10.26	2.86	7.40
1997-'98	12.32	2.86	9.46
1998-'99	11.65	2.86	8.79
Mean	11.05	2.86	8.19

Exploitation rates and maximum sustainable yield : Exploitation rate (E) varied between 0.72 and 0.79, with 0.74 as mean during 1995-'99 (Table 4). E_{max} is small, 0.441, when compared to present levels of exploitation indicating excessive fishing pressure over the stock (Fig. 6). Maximum sustainable yield (MSY) of the species from the present fishing ground is 279 tons/year.

Table 4. Catch, exploitation rate and stock of *L. duvauceli* during 1995- '99.

Period	Catch (tons)	Exploitation rate (E)	Stock (tons)
1995-'96	216	0.786	275
1996-'97	95	0.721	132
1997-'98	126	0.768	164
1998-'99	156	0.755	207
Average	184	0.741	248

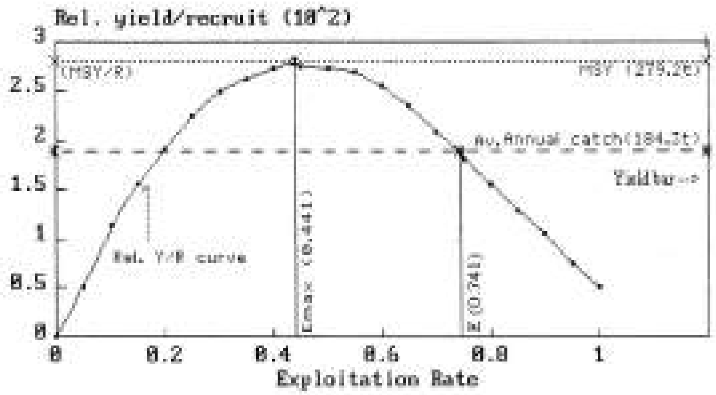

Fig. 6. Relative yield/recruit of *L. duvauceli* at different levels of exploitation, super imposed with yield bar showing MSY.

Stock : Total stock of *L. duvauceli* in the present fishing grounds fluctuated during 1995-'99 (Table 4). Average stock during the period was 248 tons. Stock was 275 tons during 1995-'96. It declined sharply to the lowest level of 132 tons during 1996-'97. It showed signs of recovery during the subsequent years.

Discussion

Catch and catch rate of cephalopods continued to increase, with increased fishing effort over the years during 1985-'95 and thereafter it declined sharply. Catch and stock of the major species also showed similar fluctuations with declining trend after 1995. Growth in catch and catch rate was more pronounced during mid-nineties, after the introduction of voyage fishing, which resulted in the extension of fishing activity to deeper waters beyond 50 m depth.

Estimates of L∞ and growth co-efficient (K) of *L. duvauceli* were comparable to the earlier estimates from east coast (Silas *et.al.* 1985, Meiyappan *et.al.* 1993), whereas L∞ was very small and K was large compared to that from west coast (Kasim 1985, Rao 1988, Meiyappan and Srinath 1989, Vidyasagar and Deshmukh 1992, Meiyappan *et.al.* 1993, Mohamed 1996, Mohamed and Rao 1997). The relatively small size of the species in catch along the east coast and the above variations observed on their estimated growth parameters between east and west coast, suggested either size over-fishing of the resource along the east coast or existence two separate stocks on east and west coast.

Mainly zero year groups supported the fishery and their size and age at first capture was very small. Moreover, present level of exploitation is at a higher side compared to Emax. These suggested heavy fishing pressure on the stock. Species being spawning in shallow inshore waters and young ones feed on shrimps and small fishes in the shelf area, they are vulnerable to trawls from their early juvenile stage onwards. This issue will be more severe for the stocks along the east coast where extent of shallow shelf area is limited compared to west coast, thus forcing the young ones to concentrate on relatively narrow belt. Trawls being aimed primarily for resources like shrimps, mesh size of the gear is expected to be very small. So mesh size regulation to conserve this resource alone is not a practically viable proposal. The only alternative is regulating the effort to reduce fishing pressure in coastal waters especially during peak period of their abundance. Fishing pressure on the stock can also be reduced by diverting large trawlers to deeper waters, for exploitation of other under-exploited resources.

Since they attain full sexual maturity at an age of around 4 months and spawn round the year, large proportion of the stock may get at-least a chance to spawn before being caught. So the present level of exploitation, though high, may not have immediate adverse effect on recruitment. This assumption is further supported by the rapid improvement in the stock after a sharp decline during 1996-'97. However, care must be taken to regulate the fishery to avoid further increase in effort.

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Population dynamics and the management of the goat fish *Upenaeus sulphureus* from the Bay of Bengal

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Abstract

FiSAT program was used to estimate population parameters of *Upenaeus sulphureus* from length frequency data. L∞ and K were found to be 22.7 cm and 0.98 $year^{-1}$ respectively. The Wetherall plot provided an estimate of L∞ and Z/K were 21.585 cm and 4.759 respectively. The annual rate of natural and fishing mortality were estimated as 1.91 and 3.86 respectively. The exploitation rate was 0.668. The selection pattern Lc was 10.824 cm. Recruitment pattern suggest of two uneve.: seasonal pulses in March-April and August-October. Peaks appeared in August-October. Maximum yield could be achieved simultaneously increasing length at first capture to 10.0 cm. The length weight relationship was found to be $W=0.03065\ L^{2.8729}$. Highest yield and price could be achieved by decreasing the fishing mortality to 0.9 coefficient rate.

Key words : Population dynamics, *Upenaeus sulphureus*, Bay of Bengal

Introduction

Upenaeus sulphureus is the most abundant among the goat fish species available in the northern Bay of Bengal of Bangladesh. This species usually moves in school. It forms a considerable part of the demersal fishery and accounts for 3% of the total biomass. Significance of this fish in the fishery of Bangladesh coast has been indicated by several authors (Chowdhury *et al.* 1979, Khan *et al.* 1989, Lamboeuf 1987, Mohiuddin *et al.* 1980, Mustafa *et al.* 1987, Mustafa and Khan 1993, Quddus and Shafi 1983, Saetre 1981). They contributed 2.4% in 10-20m. 47.8% in 20-50m, 35.7% in 50-80m and 14.2% in 80-100m depth zone (Lamboeuf 1987). This study deals with the growth parameters (L∞, K) of the von Bertalanffy equation, instantaneous mortality rates (Z, M and F), selection pattern (Lc), recruitment patterns and the application of the yield-per-recruit, biomass-per recruit, yield-per-recruit-isopleths, length cohort analysis and yield-stock prediction with a view to identifying appropriate management policy.

Materials and methods

The study was conducted from April'95 to March'97. Length-frequency and length-weight data were collected for present study from commercial fishing trawlers immediately after return from trips and research vessels R/V Anusandhani within the continental shelf of Bangladesh. Sampling were done monthly and all length-frequency data for each month were pooled and pooled data were entered in computer through FiSAT program. The gear used was a fish trawl. The mesh size of cod end was 32.0 mm. Trawling depth varying from 20m to 90m. Total length from the tip of the notch to the tip of the tail at two centimeter intervals for a total of 16,888 specimen were measured on board immediately after the catch as well as in the landing center. Length frequency data used for population dynamics analysis are given in Table1.

FiSAT (FAO-ICLARM Stock Assessment Tools) as explained in detail by Gayanilo *et al.* (1994) is the software resulted from the merging of its predecessors, the complete ELEFAN package developed at ICLARM and LFSA developed by FAO were used to analyzed the length frequency data. FiSAT was developed mainly for the detailed analysis of length frequency data. Length-frequency based computer programs ELEFAN I and ELEFAN II were used to estimate population parameters. $L\infty$ and K values were estimated by ELEFAN I (Pauly and David 1981, Saeger and Gayanilo 1986). Additional estimate of $L\infty$ and Z/K value was obtained by plotting L - L' on L (Wetherall 1986 as modified by Pauly 1986).

The growth performance of *U. sulphureus* population in terms of length growth was performed based on the ϕ' index of Pauly and Munro (1984).

$$\phi' = \text{Log}_{10}K + 2\log_{10}L\infty \qquad \text{(1)}$$

where K and $L\infty$ (von Bertalanffy growth parameters) were used.

The ELEFAN II estimate Z from catch curve based on equation as :

$$Z = \frac{K\,(L\infty - L)}{L - L'} \qquad \text{(2)}$$

where L is the mean length in the sample, computed from L' (upper) and L' (lower) limit of the smallest length class used in the computation of L (Beverton and Holt 1956). The parameter Z of equation 2 estimated using the routine ELEFAN II (Pauly 1983, Saeger and Gayanilo 1986) which based on the methods of catch curve analysis (Robson and Chapman 1961) and an extract solution found using the recursive model, i.e.

$$\ln\,(Ni/(-e^{zi\,dti})) = a - zj + 1 * ti \qquad \text{(3)}$$

where dti is the time needed to grow through class i, ti the relative age corresponding to the lower limit of class i, zj is an initial value of Z and Ni is the number of fishes (Pauly 1984). The parameter *M* was estimated using the empirical relationship derived by Pauly (1980), i.e.

$$\text{Log10M} = 0.0066 - 0.279\text{Log10}L\infty + 0.6543\text{Log10} + 0.463\text{Log10T} \qquad \text{(4)}$$

where $L\infty$ is expressed in cm, T(°C) is the mean annual environment temperature (here it was taken as 28°C). The estimate of F was taken by subtraction of *M* from Z. An additional estimate of Z value was obtained by ELEFAN II (Jones and van Zalinge 1981). The exploitation ratio E was then computed from expression:

$E = F/Z = F/(F+M)$.

"Selection pattern" was determined using the routine ELEFAN II i.e., plots of probability of capture by length (Pauly 1984) by extrapolating the catch curve and calculating the number of fish that would have been caught. Recruitment pattern is obtained by backward projection of the length axis of a set of length frequency data (seasonally growth curve) according to the routine ELEFAN II. The separation of normal distribution (NORMSEP) program for the separation of mixture of normal distributions into their components have been accessed within ELEFAN II.

Relative yield-per-recruit (Y′/R′) and relative biomass-per-recruit (B′/R′) was obtained from the estimated growth parameter and probabilities of capture by length (Pauly and Soriano 1986). Here, yield (Y) per recruit (R) was calculated as relative yield-per-recruit (Y′/R′) and relative biomass-per-recruit (B′/R′).

The analysis provide estimates of Y′/R′ and B′/R′ for specified values of the exploitation ratio (E=F/Z) and size at entry to the fishery (Lc) in % of B′/R′ in the unfished population; thus a value of (B′/R′) = 100% implies that the population is unfished. Values of B′/R′ < 100% imply that the biomass-per-recruit has decreased because of fishing.

Yield-per-recruit analysis provide a series of biomass-per-recruit for specified values of the natural mortality (M). Yield-per-recruit isopleths were studied using this biomass-per-recruit of same value against exploitation rate and selectivity (Lc/L_∞) to get isopleths line of maximum yield-per-recruit.

Length-weight relationship

Total length in centimeter and total weight in gram were recorded. The relationship between length-weight was calculated by a computer program followed after Sparre (1985). The intercept (a) and slope (b) of regression line were calculated by using the following formula:

Log weight = log a + b log length,

$W = a \cdot L^b$.

Virtual population analysis (VPA)

The total landing were distributed over length groups. The predictive counter part of VPA and cohort analysis published by Thompson and Bell (1934) and applied by Gulland (1965). It is reviewed by Jones (1984) and Pauly (1984). An estimated length structured Virtual Population Analysis of *U. sulphureus* was carried out.

Yield and stock prediction

Thompson and Bell (1934) routine were used to analyzed yield and stock prediction for *U. sulphureus*. This model combines features of Beverton and Holt's (1957) Y/R model with those of VPA, and used to analyzed single or several species for single or several fleet.

Results and discussion

Growth parameters

Extreme value theory was applied to predict L∞ from extreme values. Predicted extreme length was found 22.64 cm. At 95% confidence interval predicted extreme length lies between 20.74 cm and 24.53 cm. Scan of K value was performed to predict growth constant K ($year^{-1}$). Predicted growth constant K ($year^{-1}$) was found to be 0.98.

The growth parameters, L∞ and K of the *U.sulphureus* have been estimated for 1995-97. L∞ and K were found to be 22.7 cm and 0.98 per year respectively. For these estimates through FiSAT the response surface (ESP/ASP) was 0.199 for main line (solid line) and 0.14 for secondary line (dotted line). The growth curves with those parameters are shown over its restructured length distribution in Fig.1. The t_0 value was taken as 0. L∞ and K ($year^{-1}$) has been reported for *U.sulphureus* were 22.0 cm and 1.1 ($year^{-1}$) respectively by Mustafa (1993).

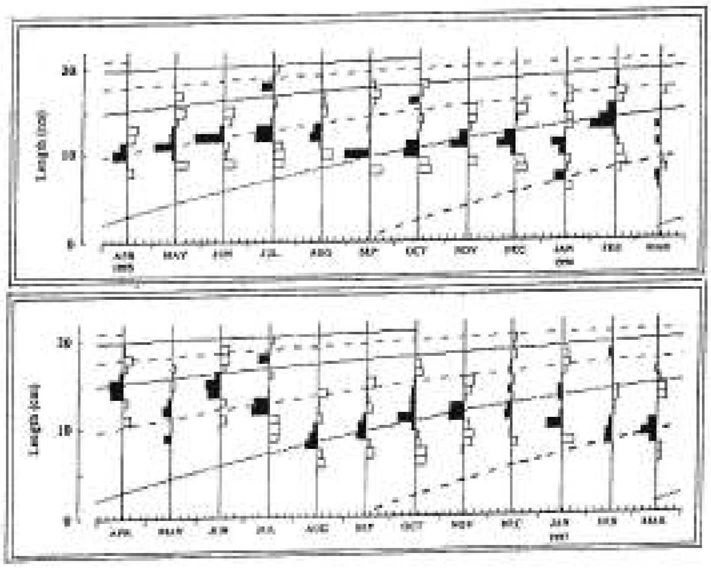

Fig 1. Growth curve superimposed over the restructured length-frequency data of *Upeneus sulphureus* from the Bay of Bengal

Estimation of L∞ and Z/K

The modified Wetherall plot (1986) analysis yielded the regression line Y = 3.75 + (- 0.174)*X and r = 0.975. Based on these points from 11.5 cm show a good linear relationship and that points of lengths below 20.5 cm smoothly approach the extended line from which L∞ = 21.585 cm and Z/K = 4.759 were obtained (Fig. 2).

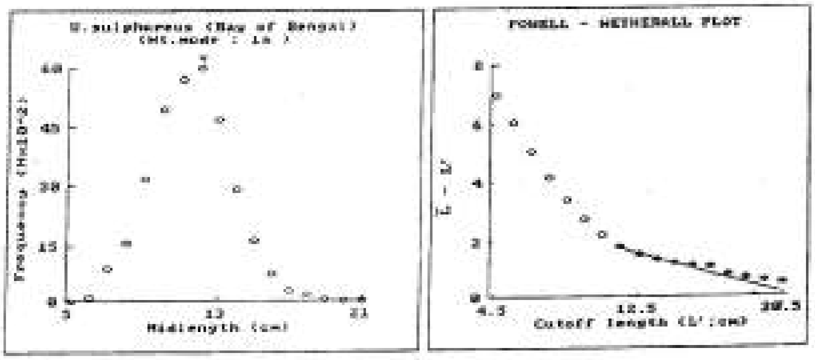

Fig. 2. Estimation of L and Z/K using methods of Wetherall for *U. sulphureus*.

Growth performance

Growth performance index obtained here are L∞ = 22.7 cm and K = .98 year $^{-1}$ giving ϕ' = log10 0.98+2*log10 22.7 = 2.70. The nine other pairs of growth parameters in Table-2 give a mean ϕ' value of 2.571 is well within a 95% confidence interval of ϕ' based on literature data. The results obtained here are therefore not in disagreement with other growth studies of *U. sulphureus*.

Mortality

The mortality rates M, F and Z computed for the *U. sulphureus* were 1.91, 3.86 and 5.77 respectively. Fig. 3 presents the catch curve utilized in the estimation of Z. The darkened circle represent the points used in calculation Z via least squares linear regression. The correlation co-efficient for the regression was 0.999 (a = 15.63 and b = - 5.72). Right hand limb of the catch curve was considered. The fishing mortality rates taken by subtraction of M from Z and was found to be 3.86. These estimates generally agree with what little information is available in the literature (Kh *vittatus* (Zeiglar 1979). The Jones and van Zalinge plot (1981) yielded the regression line Y = -4.13 + (5.741) * X and r = 0.999. Based on these points from 12.25 cm show a good linear relationship and that points of lengths below 18.25 cm smoothing approach the extended line from which Z = 5.741 was obtained.

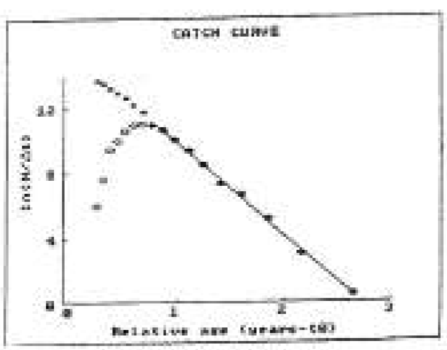

Fig. 3. Length-converted catch curve of *U. sulphureus*.

Exploitation rate

The exploitation rate E has been estimated from the Gulland's (1971) equation E=F/F+M. Thus from the range of values F and F+M it can be shown that the rate of exploitation, E is 0.67. Mustafa (1993) have stated that the rate of exploitation for the stock of *U. sulphureus* in Bangladesh marine water was found to be 0.82 on the basis of length frequency data. From these value, the stock of *U. sulphureus* of Bangladesh coast appears to be over fishing.

Selection pattern

The length at first capture (Lc) from "Selection curve" were found to be 9.85, 10.824 and 11.798 for escapement factor L_{25}, L_{50} and L_{75} respectively. Mustafa (1993) reported that the selection (L_{50}) was 11.073 cm on the basis of the net used by the research vessel (Anusandhani) from the Bay of Bengal, Bangladesh.

Recruitment pattern

Recruitment pattern suggestive of two uneven seasonal pulses in March-April and August-October. Peaks appeared in August-October. It appears from original pattern of recruitment with superimposed normal distribution that 47.01% this species is recruited during March-April and 52.99% recruited during August-September.

Yield-per-recruit and biomass-per-recruit

The yield-per-recruit and biomass-per-recruit were determined as a function of the exploitation rate assuming $Lc/L\infty = 0.4768$ and $M/K = 1.9489$. The present exploitation rate 0.67 which was exceeded the optimum exploitation (E_{max}) 0.57. Fig. 4 shows the yield-per-recruit isopleths diagrams of the various length at entry for *U. sulphureus* species into the fishery based on different values of E and a constant value of M = 1.91. The discontinued curves indicate the range which produced the maximum yield-per-recruit. The maximum value of relative-yield-per-recruit at the meeting point of the eumetric yield curve with the maximum sustainable yield (MSY) curve at E = 0.56 and Lc = 10.0 cm in the yield-per-recruit diagram was so called potential yield-per-recruit. Hence, the value of Lc = 10.0 cm for 0.75 year should be considered as the optimum age of exploitation at which the biomass (standing stock) attains its maximum size. The curve suggests that the maximum yield-per-recruit could be achieved simultaneously decreasing both Lc and F. However this might cause a significant depletion of spawning stock. Hence, about 17.37% of the species entered in to the fishery less then sustainable length (TL<10.0 cm). Present length at first entry was 5.0 cm. It is therefore recommended that maximum yield could be attended by simultaneously increasing the length at first capture to length at MSY 10.0 cm.

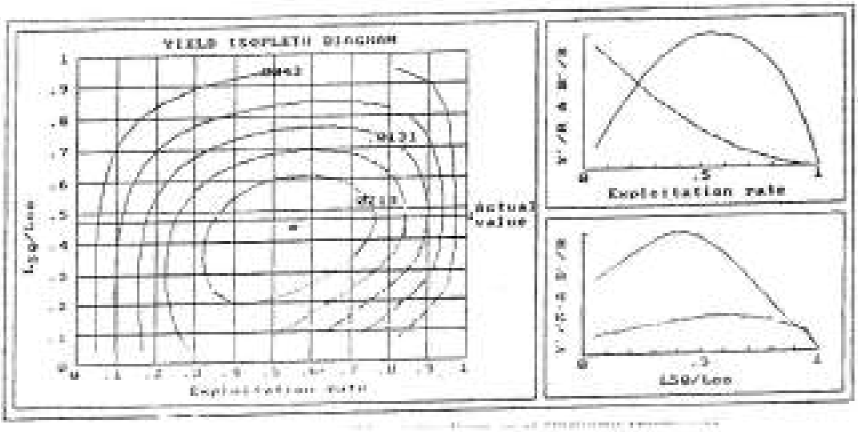

Fig. 4. Yeild per recruit isopleths diagram of *U. sulphureus*.

Length-weight relationship

From the regression analysis of the length and weight the relationship was found to be $W = 0.03065\ L^{2.8328}$.

Virtual population analysis

An average value of F(L > 5.0 cm) and E was obtained 0.969 and 0.337 respectively. L∞ = 22.7, K = 0.98, M = 1.91, F = 3.86, a = 0.03065 and b = 2.8328 were used as inputs to a VPA. The t_0 value was taken a 0. The virtual population analysis produced for *U. sulphureus* with those parameters are shown in Fig. 5. Highest exploitation was observed between 10.0 and 19.0 cm length class.

Yield and stock prediction

Yield, Biomass and Value were determined as a function of the growth parameters (L∞ and K), mortality rates (M and F), recruited size, length-weight relationship (intercept and slope) and price (class length) respectively. Yield and Stock Prediction analysis showed that highest yield and price could be attended by simultaneously decreasing the fishing mortality to 0.9 coefficient rate (Fig. 6).

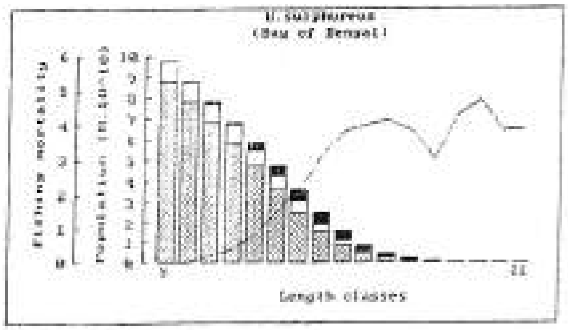

Fig. 5. Length-cohort analysis of polled data of *U. sulphureus.*

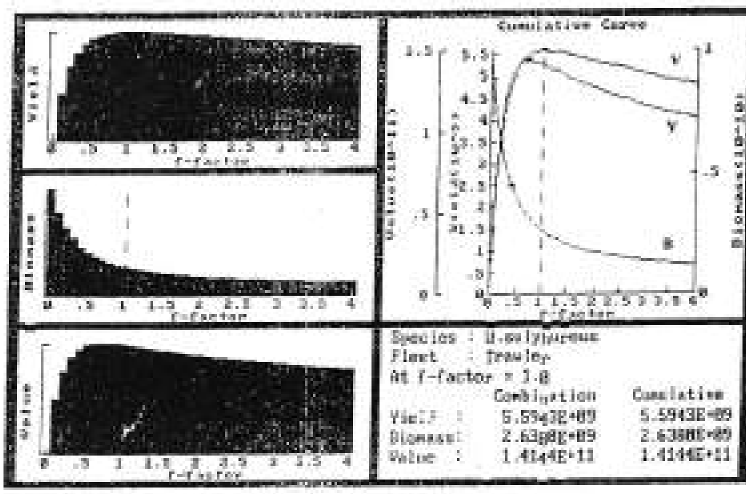

Fig. 6. Thompson and Bell yield stock predicition analysis of *U. sulphurerus.*

Table 1. Length-frequency data used for estimating population parameters in goat fish (*Upenaeus sulphureus*) caught in the Bangladesh EEZ (April'95 - March'97)

Length (cm)	Apr'95	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan'96	Feb	Mar
5												
6										33		9
7										478		15
8	35					1	6		3	195	1	3
9	132	12	2	1		127	50	8	37	208	1	15
10	252	121	50	5	3	442	542	100	260	548	13	30
11	177	29	50	50	330	172	529	230	537	702	88	58

12	34	132	260	542	592	144	288	168	426	313	201	42
13	4	102	88	579	562	91	165	58	183	31	640	75
14		33	20	288	264	48	63	15	88	13	489	48
15		10	7	165	92	24	55	3	1	14	301	42
16		0		63	58	7	60			2	38	24
17		1		55	22	1	18			1	10	3
18				60		1	3			1	5	
19				18							2	
20				3							1	
21												

Length (cm)	Apr'96	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan'97	Feb	Mar
5					24							
6					26	24	1					33
7				1	70	22	2	6			210	66
8				2	250	65	32	6	16	2	688	262
9		840		3	230	234	81	5	78	231	490	387
10	6	271	16	8	180	237	213	124	99	756	387	293
11	3	389	8	50	50	181	447	558	174	488	98	123
12	24	574	64	510	42	52	278	569	171	445	60	67
13	18	333	48	515	18	42	260	208	99	518	5	5
14	90	161	240	256	2	12	80	57	124	424	3	2
15	93	46	250	155		2	15	8	53	223	2	1
16	54	39	160	62			8		60	103	1	1
17	15	2	40	55					29	25	1	
18	3		8	60					12	15	1	
19	3		2	18					8			
20				3					1			
21									1			

Table 2. Growth parameters of *Upenaeus sulphureus* in various areas of the Indo Pacific region

Area	L∞ (cm)	K	ϕ'	Reference
San Miguel Bay	15.3	1.05	2.39	Ingeles and Pauly (1984)
Samar Sea	19.5	1.20	2.66	Ingeles and Pauly (1984)
Samar Sea	19.5	1.30	2.69	Corpuz *et al.* (1985)
Burias Pass	23.5	1.30	2.86	Corpuz *et al.* (1985)
Ragay Gulf	17.0	1.32	2.58	Corpuz *et al.* (1985)
North Java Coast	15.8	1.74	2.64	Beck and Sudrajat (1978)
North Java Coast	17.5	0.90	2.44	Dwiponggo *et al.* (1986)
North Java Coast	16.5	0.78	2.34	Dwiponggo *et al.* (1986)
Java Sea	19.9	0.875	2.54	Suhendro, B. (1986)
Bay of Bengal	22.7	0.98	2.70	This study.

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Short Note

Prevalence of ectoparasites in farmed *Pangasius hypothalamus*

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Abstract

Of the total 240 *Pangasius hypothalamus* (5 - 8.7cm) fry examined during September'01 to February'02, 80 (33.33%) were found to be infested with one or more ectoparasites irrespective of genera or groups. Seven parasitic groups were identified with the highest average prevalence of Trichodinids (55%) followed by *Dactylogyrus* spp. (42%), *Epistylis* spp. (8%), *Apiosoma* spp. (7%) *Argulus* spp. (5%), *Gyrodactylus* spp. (4%) and *Piscicola* spp. (2%) the lowest prevalent group irrespective of months. Trichodinid and *Dactylogyrus* spp. were recorded to be the dominating parasitic groups among the seven both in terms of monthly prevalence and severity of infestation throughout the period of investigation. The highest prevalence (60%) of ectoparasite was recorded in December and the lowest (10%) in February irrespective of groups.

Key words : Ectoparasites, *Pangasius hypothalamus*

Introduction

Intensified fish culture and ectoparasitic prevalence are known to be closely related to each other. Fish mortality due to parasitic infestations was reported by several authors in various fish culture systems in different countries (Banu *et al.* 1993). Physical presence of ectoparasite might damage fin, skin and gill, and thus open portal of entry for secondary invaders (Kabata 1985). During the epidemiological studies in Bangladesh, Khan (2001) and Khan *et al.* (2002) identified the ectoparasitic infestation as a significant risk factor for epizootic ulcerative syndrome (EUS). Therefore, present study attempted the preliminary investigation of ectoparasites in Pangasius hypothalamus at high density farms in order to predict the possible risk of ulcer type disease facilitated by ectoparasitic infestation.

Materials and methods

The investigation was carried out from September'01 to February'02 in and around Freshwater Station, Bangladesh Fisheries Research Institute (BFRI), Mymensingh, Bangladesh. Twelve monoculture based Pangasius ponds were selected for the investigation without any bias. Twenty live *P. hypothalamus* were captured once from each of the ponds during the sampling period using a cast net. Fish were captured randomly during each sampling period irrespective of clinical signs or symptoms and carried to BFRI fish disease laboratory using plastic buckets as soon as possible in order to prevent the ecoparasitic deformity due to death Kabata 1985. Macroscopic ecoparasites were detected with naked eye but scrapings of skin slime and gills were thoroughly examined under compound microscope in order to identify the macroscopic ones. Fish size were recorded as well during fish examination. Parasitic identification was accomplished using the keys of Kabata (1985). Parasitic loadings for each type was categorised as low, medium and high based on visual examination and estimation.

Results

Total 240 P. hypothalamus (5-8.7cm) fry were examined during the investigation. Of the total fish, 80 (33.33%) were found to be infested with one or more parasites irrespective of genera or groups during the sampling period. Seven parasitic groups were identified with the highest prevalence of Trichodinids (55%) followed by Dactylogyrus spp. (42%), Epistylis spp. (8%), Apiosoma spp. (7%) Argulus spp. (5%), Gyrodactylus spp. (4%) and Piscicola spp. (2%) the lowest prevalent group (Fig. 1).

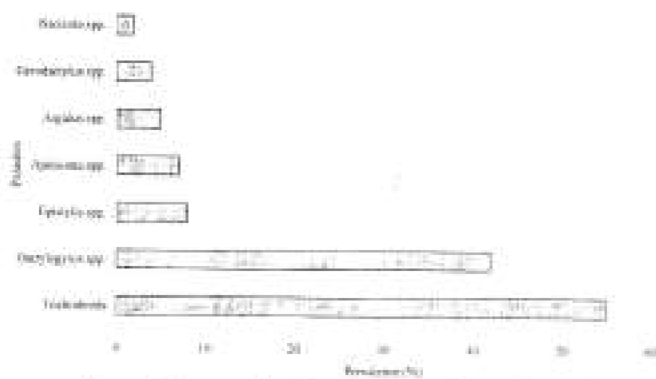

Fig. 1. Average prevalence of ectoparasites in respect to the total number of fish examined.

During the investigation period started from September to February, the highest prevalence (60%) of ectoparasite was recorded in December and the lowest (10%) in February irrespective of groups (Table 1).

Table 1. Average monthly prevalence of ectoparasites irrespective of species in *Pangasius hypothalamus*

Sampling month	Total no. of fish examined	No. of fish infested with any ectoparasite	Prevalence of ectoparasites (%)
September	40	11	27.5
October	40	19	47.5
November	40	9	22.5

December	40	24	60.0
January	40	13	32.5
February	40	4	10.0
Total	240	80	33.33

Trichodinid was found as the most dominating ectoparasitic group among the seven throughout the investigated months except the total absence of parasites in February, with the highest prevalence (40%) in December and followed by (35%) in October, (22.5%) November and (17.5%) September respectively. Second dominating parasitic group, Dactylogyrus spp. showed the highest prevalence (47.5%) in December and followed by (30%) October, (15%) January and (12.5%) September. Epistylis spp. Apiosoma spp. Argulus spp. Gyrodactylus spp. and Piscicola spp. were the least dominant parasitic groups. Gill was identified as the main site of parasitic attachment for most of the parasites. High parasitic loading was shown by Trichodinids only in December and medium in October and November. Dactylogyrus spp. exhibited medium loading in December. Remaining ectoparasitic infestations were found as low level loadings (Table 2).

Table 2. Prevalence of ectoparasites in *Pangasius hypothalamus* during sampling months along with location of attachment and loadings

Sampling month	Size of fish (cm)	No. of fish examined	No. of fish infested	Prevalence of infestation	Parasites observed	Location of infestation	Parasitic load
Sep.	5.0-7.3	40	7	17.5%	Trichodinids	Gill	Low
			5	12.5%	*Dactylogyrus spp.*	Gill	Low
			4	10%	*Argulus spp.*	Skin	Low
Oct.	7.3-8.3	40	14	35%	Trichodinids	Gill/Skin	Medium
			12	30%	*Dactylogyrus spp.*	Gill	Low
			4	10%	*Gyrodactylus* spp.	Skin	Low
			7	17.5%	*Apiosoma spp.*	Skin	Low
Nov.	7.1 -7.8	40	9	22.5%	Trichodinids	Gill	Low
			2	5%	*Piscicola spp.*	Skin	Low
Dec.	5.7 - 7.7	40	16	40%	*Trichodinids*	Gill	High
			19	47.5%	*Dactylogyrus spp.*	Gill	Medium
			4	10%	*Epistylis* spp.	Skin	Low
			1	2.5%	*Argulus* spp.	Skin	Low
Jan.	6.6-8.4	40	9	22.5%	*Trichodinids*	Gill	Low
			6	15%	*Dactylogyrus* spp.	Gill	Low
Feb.	8.0-8.7	40	4	10%	*Epistylis* spp.	Skin	Low

Discussion

Present investigation clearly indicates an association between parasitic infestation and colder months due to decreased aquatic space, high stocking density and deteriorated water quality (Hossain *et al.* 1994). The study also identified a remarkable parasitic infestation in catfish *(P. hypothalamus)* both in terms of loadings and diversity, which might increase the chances of ulcer type disease to some extent. The highest infestation of Trichodinids followed by monogenetic trematodes were found similar to previous investigations conducted by Banu *et al.* (1993) and Hossain *et al.* (1994). Chandra *et al.* (2000) and Chandra and Yasmin (2003) identified fourteen species of monogenetic trematodes in five freshwater catfish and air breathing species of Bangladesh. Gill had been found as the most vulnerable site for ectoparasitic infestation due to its thin epithelial layer and physical protection by the operculum. Exposure of fish skin by external parasites might be one of the sufficient causes for the invasion of secondary invaders to develop ulcer type disease.

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Bangladesh J. Fish. Res., 8(1), 2004

Contents