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Some aspects of fisheries of the Sylhet basin, North-east Bangladesh

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Abstract
A comprehensive study on the fisheries aspect was done in the Sylhet basin, Bangladesh during 1994 through 1998. Maximum fishing effort was engaged in the period of April to September while the bulk catch came during the September-January, when less effort was exerted. Barbs comprised 19%, catfishes 18% and major carps 16% of the total catch. Chatla *beel*, a three years pile, showed the highest fish production. Nine types of nets, four types of hooks and five types of traps were found in operation in the basin. The highest daily mean catch was recorded in *gher jal* (26.5 kg/day) and the lowest in the *chandi jal* (2.5 kg/day). *Behundi jal* was the most efficient (0.89 kg/man/h) while *chandi jal* was the worst (0.12 kg/man/h) gear. Gill net (*fash jal*) seems to be the best selective gear. Actual catch/effort always remained less than the projected catch/effort. Maximum economic point of effort lies around 7.0 mandays/km^2 and the fishery is gradually moving towards over-fishing. Income of professional fishermen was comparatively high than that of non-professional subsistence groups.

Key words: Openwater fishery, Gears, Species composition, Socio-economics

Introduction

Inland open water resources of Bangladesh provides about 52% (excluding river and the Kaptai lake) of total annual fish production (BFRSS 1993-94). Fish harvests are gradually declining and species composition changing rapidly due to gradual alterations of open water bodies. Among the open water resources rivers haors, *beels* and floodplains hold a remarkable position. Sylhet-Mymensingh basin is the largest natural depression (62,106 ha) in the country occupying approximately 15.6% of the inland open water area and58.28% of the total *beels* (FAP-6 1993). Sylhet basin in the north-east region ha a unique fish species diversity, which is quite different from the other basins. Hills and depressions make an attractive and unique topography. In the rainy season, early flash flood comes from the neighboring Meghalya (hilly) areas of India. Flood period extends from the months of April through September with mean precipitation of 350-450 mm/month.

It is a bowl shaped depression. Almost entire land area in this basin is about 8 m below the high flood level. Depression comprises about 25% of the total land, 55% are seasonal areas and rest 20% is alluvial farms, terraces, upland areas, etc.

Two-monsoon air movement governs the climate of the region. The most important is wet southwest monsoon, which extends from June to September and the other is dry northeast monsoon, which extends from December to March (FAP-6 1993). Fishing patterns are mainly based on the seasonal rainfall. A systematic survey work was done to understand the seasonal fishing patterns, gears, and fish species catch composition and fishermen's socio-economics in this region.

Materials and methods

Data were collected for four years during 1994 to 1998. Fish harvest data were collected from fish landing centers of 12 randomly selected different *beels* covering the entire area of Sylhet division. Pre-tested questionnaires were used to collect data. Data were collected at fortnight intervals. Fishers were interviewed to know their present day's catch and their previous day's fishing activities in this area. Generally, 8-10 of the potential fishers was interviewed from each landing center. As none of the respondents maintained, the records of previous day's fishing, expenses, catch and earnings, data were based on the memory of the respondent fisherman. While the weight of present day's catch was taken in g by a pan balance and grouped according to habitat and closely related species. Since time of the day for the survey varied from six O'clock in the morning to often eight O'clock at night, the selection of fisherman was random. Information were collected for weight of the catch, gear type, time spent for fishing, species composition, number of fishers involved, expenses, income, etc. In general at least two types of gear were used in any given month hence, information about the exploitation of a wide variety of fish were obtained. Fishers of Sylhet basin used a variety of fishing method on any given day. Therefore, fishers selected for interviews were representative to the relative proportion of different types of gear employed.

Fish production was estimated from nine sampled *beels* of different micro-ecological categories. Monthly fish catch was estimated by physically monitoring the daily random catch, while annual catch was estimated by summing the monthly catches. Catch/ha of *beel* was computed by dividing the summation of total annual catch by the dry season area of the *beel*.

Daily incomes (DI) of fishers were calculated by using the following formula (IRBUCD 1994).

$$DI = \frac{C * F * V}{M}$$

Where, DI = daily income in Tk., C = mixed catch in kg/fisher/day, F = number of possible fishing days/month, V = value in Tk./kg of mixed catch, and M = 30 days.

The weight of the catch from each type of gear was taken as a whole without segregation into different species of fish harvested, as fishers were anxious to sell their catch in the closest landing center or market within the shortest possible time.

In this estimation, the changes in fishing effort due to weather condition (bad or good), taxes or toll (high or less) were reflected by the average number (increase or decrease) of fisher engaged in the basin per day rather than the number of possible fishing days/month.

Catch per unit effort (CPUE) estimates measured in kg/fisher/day and were based on the same fortnightly interview used to calculate yield. For comparative purposes, CPUE was estimated from the total catch of different types of net of the particular area (IRBUCD 1994).

$$CPUE = \frac{C * F}{C * P}$$

Where, *CPUE* = daily catch in kg/fisherman, *C* = catch in kg/net/day, *F* = number of possible fishing days/month, *M* = 30 days, and *P* = participant fishermen/net.

Water quality monitoring: Sub-surface (0.2 m) water samples were analyzed at the site once in a month from Beri *beel* of Moulavibazar in 1996 and Medo*l beel* of Horipur, Sylhet region in 1997. Water temperature, dissolved oxygen and free carbondioxide content, pH, nitrite-nitrogen, ammonia-nitrogen, total hardness and alkalinity were analyzed during January through December with a HACH water kit (model FF-2).

Data analyses: Since the primary purpose of this study was to establish a baseline data of Sylhet basin fishery, much of the analysis is descriptive and some inferences were drawn from these. CPUE, monthly and annual fish yields have been calculated to describe the seasonal patterns of the fishery.

Results and discussion

Diverse fishing activities were observed depending on the season (Table 1). Though fishing continued year round in the Sylhet basin yet it has certain and/or definite harvesting period. Based on the volume of fish harvest, fish trading, rainfall, etc. fishing period was classified as monsoon, pre-harvesting, harvesting, post-harvesting and lean periods. Harvesting depended on several criteria, such as, availability of fish, depth of water, rainfall, etc. The period was found flexible. Harvesting time in upland depressions was earlier than the lowland deeper areas. Harvesting and pre-harvesting periods ran simultaneously in different micro-geographical zones. The frequency of flash flood, volume of harvest and the numbers of operating fishing gears were higher during the rainy season. Maximum fishing effort was engaged during that time but catch was not maximum (Table 1).

Table 1. Generalized fishing chart of the *beels* of Sylhet basin, Bangladesh

Description	Periods				
	Flood	Pre-harvesting	Harvesting	Post-harvesting	Lean
Calendar months	April-September	August-November	September-January	December-February	February-April
Flooded area (%)	80-100	40-80	20-40	20-30	10-20
Operating fishing gears (nos.)	High	High	Few	Few	Minimum
Volume of fish harvest	High	High	Highest	Minimum	Few
Engaged fishing effort (%)	100	80	40	30	30
Frequency of flash flood	Very high	Accidental	Nil	Nil	Accidental
Marketing points	Fish ghat	Road side	Near the *beel*	Near the *beel*	Road side
Rain fall (mm)	340-450	5-200	0-90	0-22	50-300

August-November was identified as the pre-harvesting period. In that time the number of fishing gear, engaged effort and the volume of fish harvest were higher. Fish marketing points were found near the roadside. Flash flood comes accidentally in this period (rainfall 0-5 mm/month). The catchment area gradually reduces from 100-80% as of the flood period to 80-40% in the pre-harvesting period (Table 1).

Harvesting period started from September and ended in January. In that time, water area was further reduced than the pre-harvesting period. Few numbers of fishing gears were in operation while the catch per gear as well as the total volume of harvest was highest. Leaseholder of the water body usually makes a temporary fish market nearby the *beel*, where the harvested fish were sold on wholesale basis. Engaged fishing effort was reduced to almost 40% in comparison to that of the flood period. Rainfall and flash flood have rarely been reported during this time (Table 1).

In the post-harvesting period (December-February), few numbers of fishing gear were found in operation. The volume of harvested fish was minimum. The fishing efforts were further reduced to about 30%. The probability of both rainfalls a flash flood was near about zero.

After the formal and informal harvesting, few fishes remained in the water body during the lean period (February-April). Those caught by completely dewatering the *beels*. Minimum number of fishing gears was in operation in this period. The engaged fishing effort was about 30%. Minimum amount of fishes was harvested in this period. Sometimes early rainfall and flash flood were reported.

Fish species and their habitat were divided respectively into eleven and four groups (Table 2). Barbs were most dominant comprising 19% of the total catch, and most common in the floodplains (7.5%), seasonal *beels* (6.5%) and rare in the rivers and perennial *beels* (2.0-3.0%). Catfishes were widely and uniformly available in all habitats and contributed to about 18% of the total catch. Catch contribution of major carps was about 16% and was restricted to mainly in the rivers (8%) and perennial *beels* (6.5%). Minnows contributed 13% of the total catch with highest contribution from the perennial *beels* (5%), identical contribution (3.25-3.5%) from the flood plains and seasonal *beels* and lowest contribution from the rivers (1.25%). Snakeheads contributed about 11% of the total catch of which the bulk came from the seasonal *beels* (6.26%). Contribution of perches and gouramis, prawns, freshwater eels, shads, featherbacks and miscellaneous mixed species were respectively 6%, 5%, 3%, 3%, 2% and 4% to the total catch. Minnows, perches and gouramis were common in the floodplains and seasonal *beels*. Featherbacks were common in the rivers and perennial *beels* but rare in the floodplains and seasonal *beels*. Prawns were widely distributed in the floodplains but rare in the rivers.

Table 2. Group- and habitat-wise percentage of fish harvest from the sampled *beels*

Fish group	Habitats				% of
	Floodplains	Rivers	Perennial *beel*	Seasonal *beel*	total catch
Barbs (*Puntius* spp.)	7.5	2.0	3.0	6.5	19.0
Catfishes (*Heteropneustes*, *Clarias*)	4.0	4.0	5.25	4.75	18.0
Major carps (*Labeo*, *Catla*, *Cirrhina*)	0.25	8.0	6.5	1.25	16.0
Minnows (*Chela*, *Oxygaster*, *Rasbora*)	3.25	1.25	5.0	3.5	13.0
Snakeheads (*Channa* spp.)	1.0	0.13	3.25	6.62	11.0
Perches (*Anabas*, *Nandus*) and gouramis (*Ctenops*, *Colisa*)	3.5	0.13	0.37	2.00	6.0
Prawns (*Macrobrachium* spp.)	2.0	0.12	1.13	1.75	5.0
Shads (*Tenualosa ilisha*)	0.3	0.33	0.87	1.50	3.0
Spiny eels (*Mastacembalus* spp.)	0.25	0.5	0.75	1.50	3.0
Featherbacks (*Notopterus* spp.)	0.25	0.75	0.75	0.25	2.0
Miscellaneous (mixed species)	1.28	0.8	0.92	1.00	4.0
Total	23.58	18.01	27.79	30.62	100.0

Among the nine sampled *beels* best production (507.5 kg/ha/yr) was obtained from the Chatla *beel* (Table 3) and was kept unexploited for the last three years (under pile fishery). Melaghar and Katasingra *beels* are next to Chatla in terms of fish production. These two beels had the fish pass facilities built by the Canadian International Development Agency under the Fish Pass Pilot Project of Khawadighi *haor* and they were also stocked with carp fingerlings (in addition to natural recruitment) by the lease holders. The *beels* those have connections to the nearby rivers but were not stocked with carp fingerlings showed third highest production (*viz*. Mohasingh, Chaptakuri and Aril *beel*). *Beels* those were comparatively shallow and were partially converted to rice lands showed worst fish production, *viz*. Kanglar *haor*.

Table 3. Production performances of different categories of *beels* of Sylhet basin, Bangladesh

Name of the *beel*	Approximate area in (ha)		Production (kg/ha)		Mean production (kg/ha/yr)	Remarks
	Dry season	Flood season	1995	1996		
Chatla	209.0	350.0	Pile	1015.0	507.5	3 years pile fishery
Katasingra	152.0	550.0	446.0	504.0	475.0	Stocked supplementally
Melaghor	30.36	150.0	421.0	602.0	502.5	Stocked supplementally
Medol	810.0	1500.0	79.0	60.0	69.5	Partial harvest in every year
Darail	142.0	250.0	323.0	67.0	195.0	Partial harvest in every year
Aril	78.0	80.0	233.0	234.9	233.95	Stocked supplementally
Chaptakuri	28.3	50.0	241.0	315.0	278.0	Connected with the river
Mohasing	28.3	70.0	423.0	451.0	437.0	Connected with the river
Kanglar *haor*	810.0	1200.0	74.2	86.91	80.55	Continuing encroachment for agricultural purposes

Physical and limnological data of two representative *beels* of Sylhet basin were shown in the Tables 4 and 5. Water temperature fluctuated between 18.5°C and 33.8°C. Highest water temperature was found in the month of August-September and lowest in January. Water transparency was maximum (157.0 cm) in January and minimum (60.0 cm) in July. Turbidity was normally caused mainly by the flush flood and to some extent by fishing action. Water pH ranged between 6.1 and 7.2. Dissolved oxygen content ranged between 6.1 and 8.0 mg/l with maximum in April and minimum in November. Free carbon-dioxide varied between 11.0 and 21.0 mg/l with maximum in June and minimum in February. Nitrite-nitrogen was found very low ranging from 0.03 to 0.06 mg/l, similarly ammonia-nitrogen ranged between 0.1 and 0.22 mg/l (Tables 4 and 5). Total hardness and alkalinity ranged respectively between 43.0 and 92.0 mg/l and between 50.0 and 89.0 mg/l. Water quality criteria were similar to the reported characteristics of unmanaged *beels* of India (Rana *et al.* 1996).

In the floodplains of the Sylhet sub-basin nine types of nets were generally found in operation (Table 6). Those were, *ber jal* (purse sine net), *konaber jal* (small pen), *fash jal* (gill net), *veshal jal* (lift net), *ghori jal* (circular pen), *moi jal* (drag net), *khepla jal* (cast net) and *thela jal* (push net). Four types of hooks and five types of traps were also recorded in that area. All gears were used for fishing but four types of nets such as, *fash jal*, *konaber jal*, *gher jal* and *katha jal* (fine meshed seine nets) were mostly used for commercial fishing. Of these, *fash jal* seems to be the best selective gear. Based on operation and mesh size there were different varieties of *fash jal*. Minimum mesh was found in the case of *katha jal* that is about 1.0 mm and the maximum was 75 mm in the case of *fash jal*.

Table 4. Monthly mean water quality parameters of *Beri beel* of Moulvibazar district, Sylhet basin, Bangladesh

Parameter	Jan.'96	Feb.'96	Mar.'96	Apr.'96	May '96	Jun.'96	Jul.'96	Aug.'96	Sep.'96	Oct.'96	Nov.'96	Dec.'96
Water temperature (°C)	19.1	20.2	23.1	26.4	29.1	30.0	31.3	33.5	33.8	27.9	23.2	19.9
Secchi transparency (cm)	154.0	152.0	143.0	80.0	74.0	72.0	62.0	70.0	80.0	92.0	98.0	122.0
pH	7.0	6.9	6.5	6.3	6.5	6.5	6.8	6.8	7.0	7.1	7.3	6.2
Dissolved oxygen (mg/l)	7.1	7.3	7.5	8.0	7.0	6.4	7.0	6.7	6.5	6.8	6.1	6.7
Carbon dioxide (mg/l)	14.0	11.0	17.0	15.0	18.0	21.0	17.0	14.0	15.0	12.0	14.0	17.0
Nitrite-nitrogen (mg/l)	0.04	0.04	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.04	0.05	0.04
Ammonia-nitrogen (mg/l)	0.20	0.19	0.17	0.15	0.10	0.13	0.14	0.19	0.20	0.21	0.22	0.20
Total hardness (mg/l)	89.0	81.0	54.0	48.0	54.0	59.0	67.0	70.0	86.0	90.0	92.0	90.0
Total alkalinity (mg/l)	76.0	75.0	59.0	53.0	51.0	58.0	61.0	63.0	81.0	86.0	88.0	84.0

Table 5. Monthly mean water quality parameters of *Medal beel* of **Horipur**, Sylhet basin, Bangladesh

Parameter	Jan.'97	Feb.'97	Mar.'97	Apr.'97	May.'97	Jun.'97	Jul.'97	Aug.'97	Sep.'97	Oct.'97	Nov.'97	Dec.'97
Water temperature (°C)	18.5	19.0	22.1	25.4	29.0	30.1	31.3	33.0	33.0	27.59	22.2	19.5
Secchi transparency (cm)	157.0	151.0	148.0	74.0	72.0	71.0	60.0	68.0	77.0	82.0	82.0	120.0
pH	6.9	6.8	6.5	6.1	6.3	6.5	6.6	6.7	6.9	7.0	7.2	6.5
Dissolved oxygen (mg/l)	7.0	6.8	7.2	7.5	7.3	6.0	7.1	7.7	6.4	7.3	6.5	6.4
Carbon dioxide (mg/l)	13.0	12.0	15.0	17.0	15.0	18.0	15.0	17.0	18.0	16.0	18.0	19.0
Nitrite-nitrogen (mg/l)	0.05	0.06	0.03	0.03	0.03	0.03	0.03	0.03	0.03	0.05	0.05	0.04
Ammonia-nitrogen (mg/l)	0.19	0.18	0.15	0.13	0.12	0.11	0.13	0.16	0.16	0.14	0.20	0.20
Total hardness (mg/l)	80.0	80.0	51.0	43.0	51.0	56.0	61.0	64.0	81.0	87.0	91.0	84.0
Total alkalinity (mg/l)	72.0	72.0	57.0	51.0	50.0	54.0	60.0	62.0	80.0	82.0	89.0	80.0

Table 6. Gear-wise catch per unit effort (kg/net/day) of different beels of Moulavibazar district of Sylhet basin

Name of gear	Jan.'95	Feb.'95	Mar.'95	Apr.'95	May.'95	Jun.'95	Jul.'95	Aug.'95	Sep.'95	Oct.'95	Nov.'95	Dec.'95
Ber jal	50.0	37.0	33.0	50.0	*	*	*	*	*	*	40.0	44.0
Kona ber jal	150.0	75.0	37.0	50.0	*	*	*	*	*	*	200.0	191.0
Fash jal	*	*	*	*	7.0	7.0	6.0	6.0	*	*	*	*
Vesal jal	*	*	*	*	6.0	5.0	5.0	5.0	*	*	*	*
Katha jal	*	*	*	*	5.0	8.0	*	*	*	*	*	*
Ghori jal	6.0	5.0	*	*	*	*	*	*	*	*	*	5.0
Moi jal	2.0	2.0	*	*	*	*	*	*	*	*	*	*
Khepla jal	*	*	*	*	2.0	2.0	2.0	*	*	*	*	*
Thela jal	1.1	0.8	0.8	0.5	*	*	*	*	*	*	1.0	1.0

Indicates no use of that type of gear.

Season-wise intensity of fishing gears was shown in Table 7. Box traps and gill nets were the predominant gears during the flood and pre-harvesting season. Push nets were dominant during pre- through post-harvesting period. Catch per unit of fishing effort in terms of kg/day/net is shown in the Table 6 and was found different in different types of gears. Highest catch was found from *Konaber jal* (200.0 kg/day). *Ber jal* also seems to be a good one. Both gears were operated during November through April, the main harvesting and post-harvesting period. Other gears were comparatively less efficient. *Fash jal* (gill net) and *veshal jal* (lift net) were used during May to August, the flood and pre-harvest period. *Katha jal, ghori jal, moi jal, khepla jal* and *thela jal* were used for two to six months of the year.

Table 7. Intensity of fishing gears/km^2 in different seasons in the floodplain of Sylhet basin

Gear types	Periods				Lean
	Flood	Pre-harvesting	Harvesting	Post-harvesting	
Lift net	0.1	0	0	0	0
Long line*	0.5	0.25	0	0	0
Box trap	23.0	10.0	0	0	0
Push net	4.5	10.0	15.0	10.0	5.0
Lift net	3.0	1.0	0	0	0
Gill net	30.0	10.0	5.0	0	0
Purse sine net	0.25	0.75	1.0	0	0
Cast net	1.0	0.5	0.5	0	0
Drag net	0.5	0	0	0	0.5

*Every long line is comprised of 1000 hooks.

Long line and lift net's catches have got the highest fish species composition (six) while in the catches of gill net, cast net and box trap's four to five species of fish were recorded. Selective species of fish/prawn has been caught by the push net (operated with the help of craft) and purse sine net (locally called as *pai jal/ sondha jal*). Both are active gear and operated in a certain water depth.

Catch efficiency of different gears varied from 0.12 to 0.89 kg/man/h with the highest catch in *behundi jal* and the lowest in *chanda jal* (Table 6). With respect to catch, composition *behundi* was found to be multi-species gear while that of *chandi* was restricted to a few selective species. Catch efficiency of *dhara jal, ghear jal* and *konaber jal* were respectively, 0.69, 0.68 and 0.50 kg/ man/ h. Daily mean catch analysis showed the highest catch in *gher jal* though *behundi* had the highest efficient catch, and the lowest in *chandi jal* (Table 8). The highest number of fishermen was involved in *konaber jal* (48 man/h/day) and lowest in *felun jal* (5.5 man/h/day). Except *felun jal*, all fishing operations were performed by a group of fishermen (Table 8).

Table 8. Catch efficiency of different gears of the Sylhet basin, Bangladesh

Local name of the gear*	Average catch/day (kg)	Person/gear (number)	Engaged manpower (man/h/day)	Catch (kg/man/h)
Behundi jal (Set bag net)[1]	25.0	4.0	28.0	0.89
Ghori jal (Purse seine net)[1]	5.0	3.0	18.0	0.28
Konaber jal (Small purse seine)[1]	22.5	12.0	48.0	0.50
Dhara jal (Large lift net)[1]	9.7	2.0	14.0	0.69
Koti jal (Small lift net)[2]	3.0	2.0	20.0	0.15
Gher jal (Purse seine net)[1]	26.5	6.0	39.0	0.68
Dharma jal (Lift net)[1]	3.0	2.0	13.0	0.23
Felun jal (Push net)[2]	2.4	1.0	5.5	0.43
Chandi jal (Gill net)[2]	2.5	3.0	21.0	0.12

*English name of the gear in the parentheses; [1]Needs a craft to operate, [2]dose not need a craft.

Behundi jal, *dhara jal*, *dharma jal* and *chandi jal* were passive types of gears while *ghori jal*, *kona ber jal*, *koti jal*, *gher jal* and *felun jal* were active gears. *Konaber* and *gher jal* needs two crafts to operate.

Three categories of fishermen have been found in this region such as professional, subsistent and artisanal. Professional fisherman inherited their profession from their ancestors. They never change their profession in either hard time or favorable time. Their income was comparatively higher than other non-professional groups as found in South American region (Christensen *et al.* 1995). The income of professional fishermen varied from Tk. 118 to 200/day depending on the season. Highest average income was found to be Tk. 200/day during harvesting season. Their income was Tk. 155, 165 and 196/day respectively during flood, pre-harvesting and lean period. Fishermen did not give any share of their catch to the leaseholder in the lean period. During that period license holder, professional fishermen pay taxes to the Government or the concern authority for fishing rights in the river of *jalmohal*. They have reasonably higher income than other categories of fishermen during the lean period.

Before the harvesting period professional fishermen completed their fishing agreement with lease holder for certain percentage of catch. The amount varies from 15% up to 35% depending on the availability of fish and status of the water body. In lean period professional fishermen's average income was Tk. 196/day. Subsistence fishermen from other sectors flock to the nearby *haors* and *beels* for fishing due to unemployment in the farm activities and or rickshaw pulling due to flood. Income limits of part-time fishermen varied from Tk. 52 to 63/day and that of the artisanal about Tk. 52/day.

Fish catch from the floodplain came from multi-gears. Though there were differences in the catch rate of different gears, yet when averaged (divided) by the number of manpower involved it revealed that the amount of catch/man/day, originating from different fishing gears were not contrastingly different. Hence, in calculating CPUE, catch/man/day was used as a unit effort. The average fishing days was around 100/yr for all sorts of gears. The engaged man power increased almost at a constant rate in each year (Fig. 1). Consequently, actual catch/effort always remained less than the projected catch/effort.

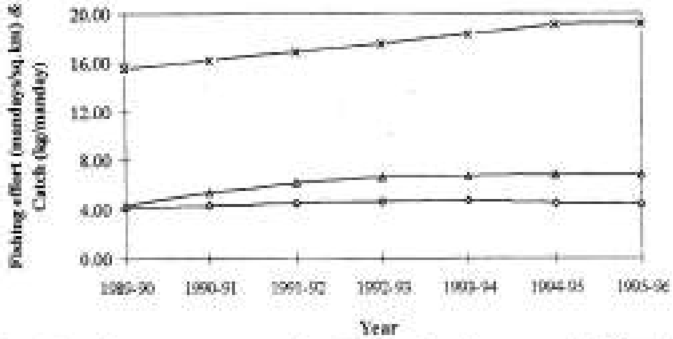

Fig.1. Relationship of yearly average engaged effort and catch per unit effort (considering 100 working days in a year) in the Sylhet basin, Bangladesh (**cross marks** = fishing effort, **rhomboid marks** = catch/effort, and **triangular marks** = projected catch/effort).

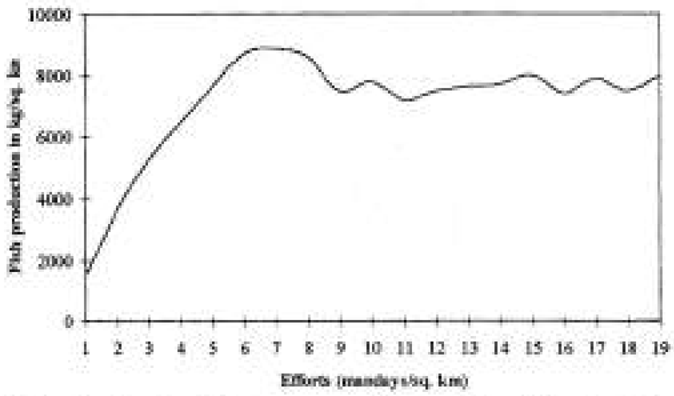

Fig. 2. Fish production in relation to engaged effort in the Sylhet basin, Bangladesh.

Fish production in relation to the engaged effort in the Sylhet floodplain basin were put into Pauly's (1984) model to understand the trend of catch and fishing effort (Fig. 2). It revealed that the maximum economic point of effort lies around seven mandays/km^2, the asymptotic point of the curve and the fishery is moving towards over-fishing. If the efforts are further, increased total production will dwindle. Larkin (1992) pointed out that contrary to expectations there is a little evidence that total catches have fallen in tropical fisheries due to over fishing. Hence fishing effort should be reduced to seven mandays/km^2, to get both sustained production and minimize fishing cost.

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Optimisation of stocking density of Thai silver barb (*Barbodes gonionotus* Bleeker) in the duckweed-fed four species polyculture system

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Abstract
The optimisation of stocking density of Thai silver barb (*Barbodes gonionotus*) in the polyculture with *Labeo rohita*, *Catla catla* and *Cyprinus carpio* was investigated in seasonal ponds. Three different stocking densities of Thai silver barb i.e., 5,000, 6,000 and 7,000 fingerlings ha^{-1} were tested with stocking density of carps fixed at the rate of 10,000 fingerlings ha^{-1}. Duckweed was applied to all ponds supplemented with rice bran and oil cake. There were no significant variations on either water quality parameters or abundance of planktonic organisms due to the different stocking densities of silver barb. A significantly higher fish production ($p<0.05$) was recorded in the ponds in which medium stocking density of Thai silver barb was maintained.

Key words: *Barbodes gonionotus*, Stocking density, Polyculture, Duckweed

Introduction

Polyculture of fish has been practised with the aim that different species stocked in the ponds occupy different niches with their complementary feeding habits, utilising all the natural food available in the ponds and thus increasing the total fish production of the ponds (Sinha and Gupta 1975). Species composition and stocking density are important factors for the maximum fish production in polyculture. Several species compositions, usually with 6-7 species of carps, are practised in the polyculture systems of Bangladesh. These polyculture systems based on large number of species have developed without true scientific basis. It is rather an outcome of trial and error. Both native and exotic species are stocked together, many of them have been found antagonistic to each other (Wahab and Ahmed 1991, Wahab *et al.* 1994), and exert dietary overlap (Dewan *et al.* 1991). Moreover, farmers are often disappointed following complex nature of the technology, and find it difficult to obtain fingerlings of all species at their time of stocking. To overcome this situation, efforts have been made to develop a four species polyculture technique for Bangladesh with fast growing and compatible species of carps and Thai silver barb (Haque *et al.* 1998, Azim *et al.* 1998), which may exert synergistic effects (Milstein 1990) in the polyculture and thus enhance fish production.

Several experiments carried out under this project have revealed that two Indian major carps, rohu and catla, and two exotic species, common carp and Thai silver barb are highly compatible for semi-intensive polyculture system (Haque *et al.* 1998, Azim *et al.* 1998). It was observed that an addition of 2,500 fingerlings ha^{-1} of silver barb in polyculture has slightly decreased the growth of Indian major carps while increased that of common carp and overall fish production in the polyculture (Haque *et al.* 1998). In a recent study, Azim and Wahab (1998) reported that application of duckweed as pond input enhanced not only the growth of Thai silver barb but also that of rohu, catla and common carp in the polyculture where an equal stocking density for each species was maintained. Further, Azim *et al.* (1998) reported that duckweed can be used as an effective supplementary feed in the four species polyculture of carps with an addition of phytophagus Thai silver barb stocked at the rate of 5,000 fingerlings ha^{-1} and fed with duckweed. From the above findings, it is clear that inclusion of Thai silver barb could enhance the total fish production in polyculture provided duckweed is used as supplementary feed. Duckweed has been found helpful to compensate the adverse impacts of Thai silver barb in the carp polyculture. However, it remains uncertain about the optimum stocking density of Thai silver barb for a four species polyculture system which would ensure the optimum utilisation of duckweed as well as maximise the production of fish from this newly proposed species combination. The objective of present experiment was to optimise the stocking density of Thai silver barb by comparing three stocking densities in the duckweed-fed carp polyculture system.

Materials and methods

Experimental ponds and their preparation

The experiment was carried out for a period of 120 days between July and October '97 in six earthen fish ponds adjacent to the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh. Ponds were all equal in size and depth with pond area of 100 m^2 and average depth of 1.5 m. Ponds were initially cleaned and limed at the rate of 250 kg/ha. Then ponds got filled up with underground water. Before one week of fish stocking, ponds were fertilised with cattle dung, urea and TSP at the rate of 5,500, 125 and 100 kg /ha, respectively.

Stocking of fish and pond management

The ponds were randomly divided into three treatment groups: ponds 1 and 4 in treatment 1 (T_1), ponds 2 and 6 in treatment 2 (T_2), and ponds 3 and 5 in treatment 3 (T_3). Fingerlings of fish of different species were collected from local supplier and stocked in the ponds. Rohu (*Labeo rohita*), catla (*Catla catla*), common carp (*Cyprinus carpio*) and Thai silver barb (*Barbodes gonionotus*) were stocked at the number of 33, 33, 34 and 50, respectively in each pond of T_1; T_1 plus additional 10 fingerlings of Thai silver barb (T_2); T_2 plus additional 10 fingerlings of Thai silver barb (T_3).

Fish were fed at a rate of 3% body weight per day with rice bran and soaked mustard oil cake (2:1). Quantity of feed was adjusted fortnightly on the basis of sampled fish weights. Duckweed was supplied to the ponds in 1 m^2 floating bamboo enclosures and made available for 24 hours per day. Duckweed was established in a pond adjacent to the experimental site, harvested and added to the bamboo enclosures when needed. Ponds were fertilised fortnightly with cattle dung, urea and TSP at the rate of 5,500, 125 and 100 kg/ha, respectively.

Limnological parameters

A series of physico-chemical parameters, viz., temperature, transparency, dissolved oxygen (DO), total hardness, pH, total ammonia, nitrate nitrogen (NO_3-N), phosphate phosphorus (PO_4-P) and chlorophyll-*a* of pond water were determined fortnightly between 0900 and 1000 hrs on each sampling day. Temperature, and DO were measured by a digital DO meter (YSI model 58). Transparency and pH of water were measured by a secchi disc and a pH meter (Jenway model 3020), respectively. Total hardness was determined by titrimetric method (Stirling 1985). Water samples were filtered for nutrient analysis except total ammonia which was determined on unfiltered sample. Nutrients were analysed by a Spectrophotometer ((Milton Roy Spectronic model 1001 plus) following Stirling (1985). Chlorophyll-*a* was also analysed spectrophotometrically after acetone extraction (Stirling 1985)

Quantitative and qualitative analyses of phytoplankton and zooplankton were made fortnightly. Sampling for plankton collection was performed after every one week of fertilisation. Samples were collected by passing 5 litre of water from three locations of each pond at different depths (surface, middle and bottom) through a plankton net (mesh size 45μm). The concentrated plankton samples were preserved in small plastic bottles with 3% formalin. The number of plankton was estimated using a Sedgewick-Rafter counting cell (S-R cell). One ml concentrated sample was placed on to the counting chamber of the S-R cell (providing 1000 fields) and was left to stand for 15 minutes to allow the plankton to settle. Then the plankton on randomly selected 10 fields of the chamber were counted under a binocular microscope (Swift M-4000). The number of plankton was calculated using the following formula:

$$N = \frac{P \times C \times 100}{L}$$

where, N is the number of plankton cells or units per litre of original water; P is the total number of plankton counted in 10 fields; C is the volume of final concentrate of the sample in ml; and L is the volume of the original water in litre. Identifications of plankton up to genus level were done according to Bellinger (1992).

Growth of fish

Fish samples were collected with a seine net fortnightly to estimate the growth in length (cm) and weight (g) for adjusting the quantity of feed application and to check up the health condition of fish. At the end of the experiment, all fish were harvested by de-watering the ponds.

Statistical analysis

For statistical analyses of data, a one-way ANOVA, and Duncan's multiple range test (DMRT) were applied using the statistical package, STATGRAPHICS version 7.

Results

Water quality parameters

Water quality parameters in all culture ponds throughout the experimental period are shown in Table 1. Temperature difference among the treatments was not significant (F=0.057) Secchi values varied significantly (F=3.55; $p<0.05$) among the treatments with the higher mean value in T_3 followed by T_2 and T_1. Further analysis of secchi data using Duncan's multiple range test showed that significant differences were confined between T_1 and T_3.

Table 1. Average (±SE) water quality parameters of different treatments

Treatments/density	T_1 (Lower)	T_2 (Medium)	T_3 (Higher)
Temperature (°C)	29.97±0.38	29.78±0.39	29.96±0.39
Transparency (cm)	29.22±1.13	31.38±1.24	33.66±1.16
Total hardness (mgl^{-1})	124.77±6.37	119.77±3.93	114.44±4.24
pH	7.20	7.46	7.47
Dissolved oxygen (mgl^{-1})	5.37±0.10	5.31±0.10	5.42±0.12
NO_3-N (mgl^{-1})	1.12±0.05	1.12±0.04	1.16±0.03
Total ammonia (mgl^{-1})	0.21±0.049	0.20±0.045	0.18±0.054
PO_4-P (mgl^{-1})	0.18±0.006	0.18±0.004	0.18±0.005
Chlorophyll-*a* (μgl^{-1})	122.43±15.89	95.13±17.34	95.06±13.48

There was no significant variation (F=1.080) in the total hardness of the ponds water among different treatments. pH of water was around neutral and these values were not significantly different when compared using ANOVA (F=0.519). Dissolved oxygen (DO) did not vary significantly (F=0.268) among the treatments.

Mean values of total ammonia were not significantly different (F=0.084) among the treatments. Nitrate nitrogen did not vary significantly (F=0.319) among the treatments Ortho-phosphate of pond waters were almost similar among the treatments during the study period. Mean values of chlorophyll-*a* in different treatments were not significantly different (F=0.347).

Plankton

Mean (±SE) abundance of plankton in different treatments are presented in Table 2. The phytoplankton population of the fish ponds comprised of four major groups: Bacillariophyceae (6), Chlorophyceae (31), Cyanophyceae (10) and Euglenophyceae (2). Mean abundance of Bacillariophyceae did not vary significantly (F=0.850) when compared using ANOVA. Mean abundance of Chlorophyceae varied significantly

($F=3.806$; $p<0.03$) with the higher mean value in T_1 followed by T_3 and T_2. Cyanophyceae was the most dominant group in all treatments in terms of abundance. These values were not significantly different when analysed statistically ($F=2.397$). When compared using ANOVA, Euglenophyceae showed no variation among the treatments ($F=1.159$). However, mean abundance of total phytoplankton was slightly higher in T_2 followed by T_1 and T_3 but these values were not statistically significant ($F=0.819$).

Table 2. Mean abundance ($\pm$SE cells l^{-1}) of plankton of different treatments

Treatments/density	T_1 (Lower)	T_2 (Medium)	T_3 (Higher)
Phytoplankton			
Bacillariophyceae	9468.75$\pm$1111.93	14206.25$\pm$4826.62	9375.00$\pm$1549.52
Chlorophyceae	30406$\pm$3453.32	17781.25$\pm$2419.09	23718.75$\pm$3696.55
Cyanophyceae	54781.25$\pm$13637.56	29656.25$\pm$7331.39	27843.75$\pm$6629.43
Euglenophyceae	20656.25$\pm$10108.75	8500.00$\pm$1396.42	10968.75$\pm$1655.46
Total phytoplankton	115531.25$\pm$17498.48	125406.25$\pm$50499.07	71906.25$\pm$10683.05
Zooplankton			
Crustacea	2575.00$\pm$265.75	3312.50$\pm$410.47	3500.00$\pm$442.53
Rotifera	8625.00$\pm$1345.90	7875.00$\pm$1108.20	10781.25$\pm$1519.98
Total Zooplankton	11312.50$\pm$1498.52	11187.50$\pm$1341.54	14281.25$\pm$1767.74

The zooplankton only comprised of Crustacea and Rotifera. Rotifera dominated in all the three treatments. There was always lower zoo-planktonic abundance in the fish ponds. Total zooplankton from different treatments were compared and no significant difference ($F=1.283$) was observed.

Growth and yield of fish

Yield parameters of different fish species under the three treatments are shown in Table 3. Based on the number of fish harvested at the end of the experiment, survival ranged from 66.17 to 90.90%. Rohu and catla showed more or less similar and higher survival among the treatments with the mean values of 90.90, 90.90 and 87.84% for rohu and 87.87, 90.90 and 86.35% for catla in lower (T_1), medium (T_2) and higher (T_3) stocking density, respectively. Common carp had lower survival in all treatments with the mean values of 67.64, 72.05 and 66.17% in T_1, T_2 and T_3, respectively. All fish species except Thai silver barb did not vary significantly in respect of survival rate among the treatments. The mean survival of Thai silver barb varied significantly ($p<0.05$) with a higher mean value of 87.50% in T_2 followed by 85.00% in T_1 and 78.57% in T_3. Further analysis of survival data of silver barb using Duncan's multiple range test showed no significant difference between T_1 and T_2.

Table 3. Yield parameters of various fish species under different treatments

Treatment/ Density	T_1 (Lower)				T_2 (Medium)				T_3 (Higher)			
Species	Rohu	Catla	C. carp	Silver barb	Rohu	Catla	C. carp	Silver barb	Rohu	Catla	C. carp	Silver barb
No. at stocking	33	33	34	50	33	33	34	60	33	33	34	70
No. at harvest	30	29	23	42.5	30	30	23.5	52.5	29	28.5	22.5	55
%Survival	90.90	87.87	67.64	85.00	90.90	90.90	72.05	87.50	87.84	86.35	66.17	78.57
Wt. at stocking (g)	1.87	4.86	3.49	1.61	1.85	4.83	3.51	1.63	1.84	4.91	3.52	1.66
Wt. at harvest (g)	135.37	222.07	159.84	122.02	140.16	221.38	152.59	118.26	111.53	183.93	140.91	96.31
Wt. gain/fish (g)	133.50	217.21	156.35	120.41	138.31	216.55	149.08	116.63	109.69	179.02	137.39	94.65
Net yield (kg/pond)	4.005	6.300	3.600	5.117	4.150	6.500	3.507	6.123	3.181	5.102	3.091	5.206
Net yield (Kg/ha)	400.5	630.0	360.0	511.7	415.0	650.0	350.7	612.3	318.1	510.2	309.1	520.6
Total (kg/ha/ 120 days)	1902.2				2028.0				1658.0			

A significant difference in weight was observed in mean increase in biomass of all fish species. Rohu was found to show distinct variation in weight gain, with a higher mean value of 138.31 g in T_2 followed by 133.50 g in T_1 and 109.69 g in T_3. Catla showed the best growth performance in all treatments when species-wise comparison was made. Weight gain per fish in T_1, T_2 and T_3 were 217.71, 216.55 and 179.02 g, respectively. There was no significant difference between T_1 and T_2. The growth of common carp varied to a small extent with the mean values of 156.35, 149.02 and 137.39 g in T_1, T_2 and T_3, respectively. Thai silver barb was found to show significant variation ($p<0.05$) with a higher mean value of 120.41 g in T_1 followed by 116.63 g in T_2 and 94.65 g in T_3. However, there was no significant difference between T_1 and T_2.

The relative contributions of different fish species in different treatments are illustrated in Fig. 1. Net yield of fish per hectare was extrapolated from the data of the 100 m^2 pond over a period of 120 days, and found that there was a wide difference in net yield of fish among three treatments, with 1,902, 2,028 and 1,658 kg/ha in T_1, T_2 and T_3, respectively. The relative contribution of each species of fish as shown in Table 3, showed that catla in T_1 and T_2, and Thai silver barb in T_3 were the highest, Thai silver barb in T_1 and T_2, and catla in T_3 were the second highest contributors to the pond production in this experiment. Rohu ranked third and common carp ranked the last in all treatments in respect of the relative contribution to the total production of fish. Rohu varied significantly ($F=129.673$; $p<0.001$) among the treatments with the higher mean value of 415 kg ha^{-1} in T_2 followed by 401 kg ha^{-1} in T_1 and 318 kg ha^{-1} in T_3. However, there was no significant variation between T_1 and T_2. Similar results were observed in case of catla and common carp.

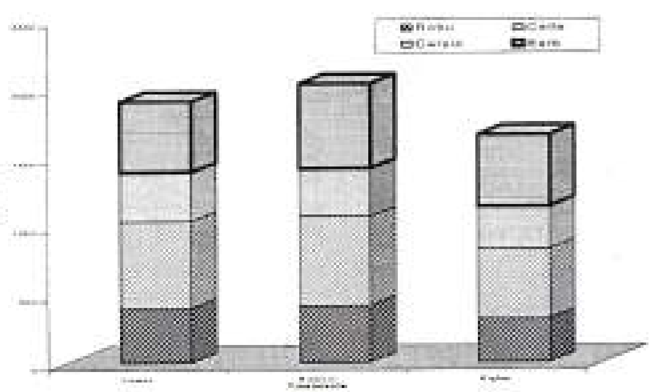

Fig. 1. Relative contributions of different fish species to the total fish production in different treatments

Net yield of catla was significantly lower ($F=47.977$; $p<0.005$) in T_3 than either T_1 or T_2. Catla contributed 630, 650 and 510 kg ha^{-1} in T_1, T_2 and T_3, respectively. Net yield of common carp was significantly higher ($F=10.161$; $p<0.05$) in T_1 with the mean value of 360 kg ha^{-1} followed by 351 kg ha^{-1} in T_2 and 309 kg ha^{-1} in T_3. Further analysis using DMRT revealed that there was no significant variation between T_1 and T_2. Thai silver barb was found to contribute significantly higher production ($F=42.36$, $p<0.01$) in T_2 with the mean value of 612 kg ha^{-1} followed by 521 kg ha^{-1} in T_3 and 512 kg ha^{-1} in T_1. However, there was no significant variation between T_1 and T_3.

Discussion

During the experimental period, it was observed that there was a little variation among the physico-chemical factors except transparency in respect of different stocking density of Thai silver barb but these were within the acceptable range for fish culture. The causes of higher secchi depth reading in T_3 might be due to the lower abundance of phytoplankton in the ponds where increased number of silver barb was stocked.

Phytoplankton was composed of four groups, Bacillariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae. Mean abundance of Chlorophyceae was significantly higher in T_1 but the causes were uncertain. In the present study, phytoplankton population showed inverse relationship with zooplankton population.

The survival rates of all fish species in all three treatments were from 66.17 to 90.90%. Survival rate of Thai silver barb was significantly lower in T_3 where the highest number of fish were stocked. The lowest survival was observed in case of common carp in all treatments.

Weight gain per fish of catla, common carp and Thai silver barb were higher in T_1, in which the lowest stocking density was maintained. However, these values were significantly different from T_3 but not from T_2. Individual weight gain of rohu was almost similar in T_1 and T_2 but different from that of T_3. This might be due to the additional numbers of silver barb which may have decreased the availability of food materials and space for other species and this species itself.

Among the four fish species, rohu, catla and Thai silver barb showed the highest net yield in T_2 and common carp showed the highest yield in T_1. The overall increase in total fish production in T_2 may have been due to the synergistic interaction resulted from faecal input of silver barb and the confounding effects of additional numbers of silver barb. This statement may not be extended in case of T_3 in which additional 7,000 silver barb were stocked. Inter-specific and intra-specific competition for food and space may have reduced the growth and production of all fish species. Duckweed was provided in order to mitigate any possible impacts resulting from addition of silver barb, since they are known to feed on both filamentous algae and higher aquatic plants (Hickling 1971; Journey *et al.* 1990). In addition, supplemental feed at the rate of 3% of total biomass was also applied to the ponds with a view that if there is any antagonistic effects of Thai silver barb (Haque *et al.* 1998) on other carps would be minimised.

From the present study, it may be concluded that the addition of duckweed and supplemental feed (rice bran and oil-cake) may compensate any inter-specific and intra-specific dietary competition and enhance the overall fish production within certain limits of stocking of Thai silver barb in the proposed four species polyculture system. The overall highest production was obtained from an additional stocking of Thai silver barb at the rate of 6,000 fingerlings ha^{-1} rather than 5,000 fingerlings ha^{-1} and 7,000 fingerlings ha^{-1} with a stocking density of carps at 10,000 fingerlings ha^{-1} in the polyculture system.

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Effects of organic manuring (chicken droppings) on growth of *Labeo rohita* Ham. spawn

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Abstract
An experiment was conducted in six nursery ponds to determine the effect of different doses of organic fertilizer (chicken droppings) on growth and survival of *Labeo rohita* spawn. Ponds were stocked with four-days old *L. rohita* spawn at a density of 25 g/decimal and reared for 25 days. Three doses of organic fertilizer *viz.* 20kg, 10 kg and 5kg per decimal were tried in treatments T_1, T_2 and T_3 respectively with two replication each. Fry were fed twice a day with a mixture of fine mustard oil cake and rice bran at the ratio of 1:1. The highest growth (6.33 cm and 3.33 g) and survival rate (72.30%) were observed for the treatment T_2. Physico-chemical and biological parameters were found within the productive range for all the treatments.

Key words: Chicken manure, Spawn, *L. rohita*

Introduction

Shortage of major carp seeds has been identified by various agencies as one of the constraints for aquaculture development in Bangladesh. This indicates that mere increase in hatchling production (over 12 billion hatchlings) will not solve the problem of shortage of fry/fingerlings unless efforts are made at the same time to increase their survival rate in nursery ponds. But due to improper nursing practice a considerable portion of those seeds become mortal, which requires to develop suitable techniques for nursing and rearing of larvae to ensure reliable supply of cultural fish fingerlings. In nursery management, proper care and understanding about the biotic and abiotic conditions of particular water body is important, when a undesirable condition may lead to mass mortality of fingerlings (Jhingran and Pullin 1985). Application of organic manure in nursery and rearing ponds can play vital role to ensure the production of planktonic feed for fingerlings. Among the organic manure poultry dropping is the best one for most of the fish species because it contain more nitrogen and phosphorus which play a vital role for primary production (David *et al.* 1969) and promoting fish growth with high profit Rappaport *et al.* (1977). Therefore, the present study was undertaken to understand the effect of different doses of organic fertilizer (chicken droppings) on the growth and survival of Indian major carp, rohu (*L. rohita*).

Materials and methods

The experiment was undertaken in 6 nursery ponds of the Fisheries Faculty, Bangladesh Agricultural University Campus, Mymensingh. The size of ponds were equal having 1.67 decimal (0.004 ha) each. The average depths of the ponds were 1.25 meter. The experiment was conducted during the month of July 1996. Three doses of fertilizer, like 20 kg, 10 kg and 5 kg chicken droppings/decimal in treatment T_1, T_2 and T_3 respectively, each with two replicates were applied.

The ponds were prepared by cleaning them properly and then poisoned by phostoxin (aluminum phosphate) at a rate of 4 tablets/decimal. Three days after the use of phostoxin, lime ($CaCO_3$) was applied at a dose of 1 kg per decimal and then after 3 days, the ponds were fertilized properly by chicken droppings using proper dose in the respective three treatment groups. After 5 days of fertilization, the ponds were stocked with carp spawns (*L. rohita*) at a density of 25 g per decimal to the ponds of all the treatments.

From the second day of stocking fry were fed twice daily with a mixture of finely powdered dried mustard oil cake and rice bran at the ratio of 1:1. Supplemental feed was applied on the following days maintaining 3 times of the initial stock of the spawn and was continued up to 5 days. On the consequent 5 days, the amounts of feed were increased 5 times, 7 times and 9 times respectively.

Sampling was done every 5 days interval by dragging a hapa in the pond to check the growth. Survival rate was calculated after the final harvest. Weight and length of 30 fry/pond were recorded randomly during each sampling.

Water quality parameters such as temperature, dissolved oxygen and pH were recorded at an interval of 5 days throughout the experimental period.

Plankton samples were collected by filtering 15 litres of water through No. 55 bolting silk value of plankton net with a mesh size of 100 µm. Collected samples were preserved in 5% formalin. The Sedgwick Refter (S-R) cell was used to calculate the plankton population. The procedure was repeated 5 times for each sample and the average number of organisms was determined for one litre of water by applying the following formula:

$$N = \frac{A \times 1000 \times C}{V \times L \times F}$$

Where, N = No. of plankton cells or units per litre of original water

A = Total No. of plankton counted C = Vol. of final conc. of the sample in ml.

L = Volume of original water expressed in litre F = No. of field counted.

V = Volume of a field = 1 cu mm.

After 25 days of rearing fry were harvested, first by repeated netting, finally by complete draining of ponds.

Results

Water quality

During the period of experiment the water temperature of the ponds were found to varied from 28.30°C to 31.80°C. The average water temperature recorded were 30.30°C, 30.27°C and 30.64°C, for treatment T_1, T_2 and T_3 respectively (Table1).

Table 1. Average temperature (°C), dissolved oxygen (DO mg/L) content and p^H value of pond water under different treatments

Treatments	Parameters	Samplings						Average
		1st	2nd	3rd	4th	5th	6th	
T_1	Temperature	31.4	29.4	28.3	31.1	31.2	30.4	30.3
	DO	7.3	5.6	5.9	5.4	5.4	5.8	5.79
	pH	8.29	7.27	7.10	7.25	7.15	7.93	7.50
T_2	Temperature	31.5	29.8	28.7	31.1	31.1	29.5	30.3
	DO	8.2	7.5	5.9	6.5	7.5	5.5	6.6
	pH	8.14	7.36	7.82	7.08	7.74	8.03	7.70
T_3	Temperature	31.8	29.8	29.1	31.5	31.4	30.3	30.6
	DO	6.5	5.8	5.9	5.1	5.9	5.9	5.8
	pH	8.49	7.32	7.83	7.18	7.48	8.02	7.70

The dissolved oxygen content ranged from 5.05 to 8.20 mg/L. The maximum and minimum values were recorded for the treatments T_2 and T_3 during 1st and 4th sampling respectively. The average dissolved oxygen content recorded with the treatments T_1, T_2 and T_3 were 5.79, 6.55 and 5.81 mg/L, respectively (Table 1).

The pH values of the ponds were found to vary from 7.10 to 8.49 with the treatment T_3 and treatment T_1 at 1st sampling and 3rd sampling respectively. The average value recorded for the treatments T_2, T_3 and T_1 were 7.50, 7.70 and 7.70 respectively (Table 1).

Plankton population

Plankton populations were calculated from all the ponds and the results obtained are shown in Table 2. Sample wise average variation in plankton populations were found to range from 35900 to 47200 organisms/litre, 46700 to 59500 organisms/litre and 42700 to 50500 organisms/litre, in treatments T_1, T_2 and T_3 respectively.

Sample wise average variations in phytoplankton population were found to range from 15700 to 22700 organisms/litre, 22500 to 28700 organisms/litre and 20200 to 24200 organisms/litre in treatments T_2, T_3 and T_1 respectively (Table 2). Sample wise average variations in zooplankton population were found to range from 20200 to 24500 organisms/litre, 24200 to 30700 organisms/litre and 22500 to 26200 organisms per litre in the treatments T_2, T_3 and T_1 respectively (Table 2).

Table 2. Average variation in the abundance of phytoplankton and zooplankton and total plankton populations (× 10^3) among the treatments during the study period

Types of plankton	Treatments	Samplings 1st	2nd	3rd	4th	5th	6th
Phytoplankton	T_1	15.7	18.7	20.5	22.7	21.2	20.5
(Bacillariophyceae, Chlorophyceae,	T_2	22.5	24.5	25.9	28.7	25.5	24.2
Cyanophyceae, Euglenophyceae)	T_3	20.2	22.7	23.9	24.2	22.9	21.7
Zooplankton	T_1	20.2	22.5	23.2	24.5	22.2	23.2
(Crastacea, Rotifera, Hydrozoa)	T_2	24.2	27.2	28.9	30.7	28.2	27.7
	T_3	22.5	23.2	24.7	26.2	27.7	24.9
Total plankton	T_1	25.9	41.2	43.7	47.2	44.5	43.7
	T_2	46.7	51.7	54.9	59.5	53.7	52.0
	T_3	47.7	46.0	48.7	50.5	48.7	46.7

Growth of fish

The growth rate of fishes under different treatments were found to vary from 0.014 to 3.33 g in weight. In case of average gain weight significant variation was observed among different treatments and within the sampling. Significantly higher growth was found in treatment T_2 when compared with other treatments. However, no significant variation was observed between treatments T_2 and T_3 in the 6th samplings. The average maximum (3.33 g) and minimum (1.45 g) growth were observed in treatments T_2 and T_1 respectively. The highest average survival rate was recorded for treatment T_2 (72.30%) followed by treatment T_1 (61.95%) and treatment T_3 (52.50%).

Discussion

During the study period the average temperature of pond water under different treatments were found in a suitable range favorable for carp fry nursing. Goolish *et al.* (1984) recorded maximum growth rate at 30°C temperature for juvenile of common carp and Rahman *et al.* (1982) mentioned that 26.06 to 31.97°C temperatures is the best for fish culture. The temperature ranges recorded in the present study are almost similar to the ranges reported by the authors.

During the experimental period the highest and lowest value of dissolved oxygen content were recorded for the treatments T_2 and T_3 at 1st sampling and 4th sampling respectively. The dissolved oxygen content of the investigated ponds were ranging from 5.05 to 8.20 mg/L which was within productive ranges as reported by Ali *et al.* (1982). DOF (1996) reported that the range of dissolved oxygen content of a suitable water body for fish culture would be 5.0-8.0 mg/L. From the above findings it can be stated that dissolved oxygen contents of water of the ponds under different treatments are found within the productive range.

The maximum and minimum values of pH were recorded for the treatments T_3 and T_1 during 1st and 3rd sampling respectively. No significant variation was observed among the pH values of the treatments. The pH values as recorded from different ponds (7.18 to 8.5) indicated good productivity of the pond water.

During the period of investigation, a wide variation in quantity and type (genera) of phytoplankton in terms of number and genera were observed. The major phytoplankton groups as identified composed of Bacilllariophyceae, Chlorophyceae, Cyanophyceae and Euglenophyceae. Mumtazuddin *et al.* (1982) studied plankton in the ponds of AES, Mymensingh and identified 33 genera of phytoplankton belonging to Chlorophyceae, Xanthophyceae, Chrysophyceae, Bacillariophycea, Euglenophyceae and Myxophyceae. In an identical study, Dewan *et al.* (1991) identified genera of phytoplankton belonging to Chlorophyceae, Bacillariophyceae, Euglenophyceae and Cyanophyceae. It is observed that Cyanophyceae dominated quantitatively in all the ponds during different stages of rearing. Wahab and Ahmed (1992) also found that cyanophytes dominated in the ponds containing Indian major carps. Bhimachar (1971) also reported the highest performance for phytolplankton production by the application of poultry manure. The presence of which was ensured in the present study by the presence of brown- green water color throughout the entire fry-rearing period. In the present study similar observation was noted in case of physico-chemical parameters of the water body and the presence and abundance of phytoplankton type as were reported by Mumtazuddin *et al.* (1982) and Dewan *et al.* (1991).

A wide variation of zooplankton population in term of quantity and type (genera) also observed. The zooplankton groups as identified are Crustacea, Hydrozoa and Rotifers. Zooplankton population in number and genera were found that almost similar to those listed in the earlier studies carried out by several workers in fish ponds. Mumtazuddin *et al.* (1982) studied plankton population of the ponds of AES, Mymensingh and identified 15 genera of zooplankton comprising Crustacea and Rotifers. Dewan *et al.* (1991) also identified 9 genera of zooplankton belonging to Hydrozoa, Crustacea and Rotifers in an identical study. Average higher amount of zooplankton were recorded for the ponds of treatments T_2 those treated with at a rate of chicken droppings 10 kg/decimal to enhance the production of zooplankton. Dhawan and Toor (1989) also discussed the role of poultry droppings alone and in combination with cowdung for higher production of zooplankton compare to application of cowdung alone.

The growth pattern of the fish shows rapid increase at the initial part of the experiment with a significant variation in the average gain in weight, and treatments T_2 showed significantly higher growth compare to other treatments. The cause of such high growth might due to the higher production of plankton food in the ponds under treatment T_2. The role of poultry droppings for production of plankton food in a water body and promoting fish growth was also reported by several authors (Mitra *et al.* 1987., Varghese *et al.* 1981., Rappaport *et al.* 1977).

In the present study, the average survival rate was 61.95%, 72.3% and 52.5% in the treatments T_1 and T_2 and T_3 respectively. The highest (72.30%) survival rate was recorded with the treatment T_2 and the lowest (52.50%) of the same was recorded with the treatment T_1 From the facts stated above, it is clearly indicated that the chicken manuring (10 kg/decimal) in treatment T_2 is the best among all the treatments in case of fish growth. This might be due to the better ability of chicken manuring to enhance the production of plankton as the natural fish food organisms.

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Growth and yield of GIFT (*Oreochromis niloticus*) and Thai silver barb (*Barbodes gonionotus* Bleeker) in rice fields and their effects on the yield of rice

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Abstract

An investigation into the growth and yield of Genetically Improved Farmed Tilapia (GIFT) (*Oreochromis niloticus*) and Silver barb (*Barbodes gonionotus*) in rice fields and their effects on the yield of rice was carried out in nine experimental rice plots. Three treatments viz., treatment-1 with *O. niloticus* (T_1), treatment-2 with *B. gonionotus* (T_2) and treatment - 3 was kept as control (T_3, without fish) were used in this study. Fertilizers such as, Urea (178 kg ha^{-1}), T.S.P (125 kg ha^{-1}) and M.P. (67 kg ha^{-1}) were applied in each treatment. The fishes were stocked @ 6250 ha^{-1} and the experiment was continued for a period of 107 days.

The values of water quality parameters such as, water temperature, dissolved oxygen, pH and chlorophyll-a were found within suitable level. Between the two species, higher specific growth rate was recorded in *O. niloticus* than that of *B. gonionotus*. But *B. gonionotus* showed much higher survival (72%) than that of *O. niloticus* (35%). Similar to survival, higher production (244 kg ha^{-1}) and income (Tk. 6399 ha^{-1}) were recorded in *B. gonionotus* than those of *O. niloticus* (142.8 kg ha^{-1} and Tk. 2137 ha^{-1}). Significant differences ($p<0.01$) in the yield of rice grain and straw were observed between the treatments with fish and without fish.

Key words: GIFT, Thai silver barb, Integrated farming, Rice field

Introduction

Integration of fish with other animals and crops is the most efficient way of increasing production from per unit area of land. The most common forms of integration are those where there is a direct and simple link between activities, such as the use of chemicals and crop waste as fish feed and fertilizer. Rice-fish farming is a common practice of integrated farming system. Integration of aquaculture with rice farming improves sustainability, productivity and profitability of the farm (Lightfoot *et al.* 1990).

Bangladesh is fortunate enough to have its vast water resources. It has 2.83 million ha of seasonal paddy fields where water stands for four to six months (Department of Fisheries 1993) providing great scope for rice-fish culture. Fish harvested from these areas is about 37 kg ha^{-1} (Master Plan Organization 1985). The fish production from these water bodies can be increased to a great extent by introducing rice-fish culture. If 5 % of the rice field in Bangladesh can be brought under rice-fish culture, about 76 thousand tones of fish will be produced per year assuming a conservative fish production of 150 kg $ha^{-1}yr^{-1}$. In the above context, the present experiment was undertaken with the following objectives:

- Compare the water quality parameters *viz.*, water temperature, dissolved oxygen, pH and chlorophyll-a in rice fields with and without fish.
- Compare the growth and yield of *O. niloticus* and *B. gonionotus* in rice fields.
- Determine the suitable species for rice fish culture.
- Determine the impact of fish culture in rice fields and the yield of rice.

Materials and methods

Preparation and management of plot

The experiment was carried out at the Agronomy Field Laboratory of Bangladesh Agricultural University during July-December'97 in aman season. The facility consisted of nine experimental rice plots each comprising an area of 140 m^2. The experimental plots were laid out in Randomized Complete Block Design (RCBD) with three treatments viz., T_1, T_2 and T_3 each with three replications. In T_1 the plots were stocked with fingerlings of *O. niloticus*, in T_2 the plots were stocked with fingerlings of *B. gonionotus* and T_3 was kept as control without fish. Dykes separating the plots were raised about 50 cm from the land. Small water channels (0.5 m width and 0.3 m depth) were made between the plots to supply water to them. A common inlet and outlet was provided on the dykes of each plot to regulate water depth. Metal screens were placed at the outlet and inlet to prevent entrance of wild fish as wells as escapement of stocked fish. A small ditch (1.5 x 1.5 x 0.5 m) was constructed at the low-lying area of each plot to provide refuge for fish during low water level and high water temperature. All the plots were fertilized with Urea, T. S. P. and M. P. @ 178 kg ha^{-1} 125 kg $ha^{-1}$and 67 kg ha^{-1} respectively. Forty five days old BR-10 rice seedlings were transplanted on 19 August'97 in alternate row spacing of 35 cm + 15 cm.

The fingerlings of *O. niloticus* were released in three replications of T_1 at a stocking density of 6250 ha^{-1} 15 days after rice transplantation. The fingerlings of *B. gonionotus* were released in three replications of T_2 at the same stocking density at the same date. T_3 was kept as control without fish to compare the variations of rice grain and straw yield with those stocked with fish. During the period of fish culture water level was maintained between 12-25 cm. Top dressing of Urea fertilizer was done in three occasions at equal amount on 12, 35 and 65 days after transplantation of rice seedlings. Only bird perches (3-4/plot) were placed in the plots aiming to reduce pest infestation.

Harvesting of rice and fish

Rice was harvested after 107 days of transplanting. The representative samples of rice were taken from each plot from an area of 1 m^2 randomly. After threshing and sun drying, the weight of grain and straw of rice were taken plot-wise. Water was drained out slowly from the plots and the fishes were collected by hand picking. The fishes collected from each plot were counted and the number was recorded plot-wise. The total length and weight of individual fish was measured for 30 fishes from each plot.

Estimation of growth of fish

To estimate the growth of fish, 10 fishes were sampled fortnightly with the help of a cast net from each plot. This was done at the time of minimum water level, when most of the fishes took shelter in the trench, then the cast net was spread manually to cover it. Then the length (cm) and weight (g) of individual fish were recorded separately with the help of a measuring scale and a electronic balance. Growth grained by the fishes was expressed in Specific Growth Rate (SGR) by the following ways:

a) Specific Growth Rate (SGR % day) in length $= \dfrac{\log_e L_2 - \log_e L_1}{T_2 - T_1} \times 100$

b) Specific Growth Rate (SGR % day) in weight $= \dfrac{\log_e W_2 - \log_e W_1}{T_2 - T_1} \times 100$

Where, L_1 = Initial length of live fish (cm) L_2 = Final length of live fish (cm)
W_1 = Initial weight of live fish (g) W_2 = Final weight of live fish (g)
$T_2 - T_1$ = Duration of the experiment (day)

Estimation of survival and yield of fish

The survival of fishes for each treatment and replication were estimated on the basis of number of fish harvested at the end of the experiment. The gross and net yield of fish for each treatment were determined by multiplying the average gain in weight of fish both in gross and net by the total number of fish survived in each treatment at the end of the experiment. Yield per plot were then converted to yields per ha.

Yield of rice grain and straw

The total weight of dried grain and straw of rice per plot were calculated by multiplying the weight of the grain and straw obtained in per square meter of a particular plot with the total area of each plot. These yields of grain and straw data were then converted to yield per ha.

Measurement of water quality parameters

Water quality parameters in rice fields such as, water temperature, dissolved oxygen, pH and chlorophyll-a were measured once fortnightly. Water temperature (°C) and dissolved oxygen (mg l^{-1}) were measured with the help of a portable DO meter (YSI Model 58) and pH of water was determined with the help of a portable pH meter (Jenway, Model 3020). Chlorophyll-a was determined by using a spectrophotometer (Milton Roy Spectronic, Model 1001 Plus) after filtering water sample through Whatman filter paper (46 cm).

Results

Water quality parameters

Water quality parameters of rice fields such as, temperature, dissolved oxygen, pH and chlorophyll-a were measured and the values so far recorded have been shown in Table 1. The average values of water temperature, dissolved oxygen, pH and chlorophyll-a varied from 29.4±1.78°C-29.5±1.77°C, 4.8±0.42 mg/l – 4.9±0.46 mg/l, 7.3±0.10-7.4±0.14 and 29.04±2.74 µg/l-39.5±4.52 µg/l respectively among the different treatments. A more or less decreasing trend in the values of dissolved oxygen was recorded from the start of the experiment towards the end of it. Chlorophyll-a concentration was recorded higher in treatment T_3 where no fish was stocked than the rest of the treatments.

Growth of fish

During the period of study the SGR by length and weight recorded in *O. niloticus* were 1.07 ± 0.03 % and 2.82 ± 0.49 % and that in *B. gonionotus* were 0.80 ± 0.01 % and 2.30 ± 0.01% respectively (Table 2). However, between the two species *O. niloticus* showed higher SGR than that of *B. gonionotus*.

Survival and yield of fish

Between the two species *B. gnionotus* showed much higher survival (72%) than that of *O. niloticus* (35%).The gross and net yield recorded were 244.9 kg ha^{-1} and 222.8 kg ha^{-1} in *B. gonionotus* and 142.8 kg ha^{-1} and 132.5 kg ha^{-1} in *O. niloticus* respectively (Table 3). Significantly higher ($p<0.01$) gross and net yield were recorded in *B. ginionotus* than those of *O. niloticus*.

Income

At the end of the experiment the gross and net income obtained from fish were Tk. 5712.00 ha^{-1} and Tk. 2137.00 ha^{-1} for *O. niloticus* and Tk. 10286.00 ha^{-1} and Tk. 6399.00 ha^{-1} for *B. gonionotus* respectively (Table 4). The benefit-cost ratio obtained were 0.60 for *O. niloticus* and 1.65 for *B. gonionotus*. The profit obtained from *B. gonionotus* was more than double the profit obtained in *O. niloticus* under rice fish culture.

Table 4. Gross and net income with benefit - cost ratio from fish culture in rice fields

Treatment	Cost (Tk. ha^{-1})			Income(Tk. ha^{-1})		Benefit – cost ratio
	Land preparation	fingerling	Total	Gross	Net	
T_1 (*O. niloticus*)	450	6250x0.50= 3125	3575	142.8x40= 5712	2137	0.60
T_2 (*B. gonionotus*)	450	6250x0.55= 3437	3887	244.9x42= 10286	6399	1.65

Yield of rice and straw

The recorded yield of rice were found to be 4.4-4.7 t ha^{-1} in T_1, 4.5-4.8 t ha^{-1} in T_2 and 3.7-4.2 t ha^{-1} in T_3. The average yield of rice obtained in the treatments T_1, T_2 and T_3 were 4.6 t ha^{-1}, 4.7 t ha^{-1} and 3.9 t ha^{-1} respectively (Table 3). Rice yield increased by about 17% in T_1 and 19% in T_2 than the yield obtained in T_3 (i.e., without fish). Statistically significant differences ($p<0.01$) were recorded in the yield of rice between T_1 and T_3, and T_2 and T_3.

The recorded yield of straw were found to be 4.2-4.5 t ha^{-1} in T_1, 4.4-4.5 t ha^{-1} in T_2 and 3.4-3.7 t ha^{-1} in T_3. The average yield of the same recorded in T_1, T_2 and T_3 were 4.3 t ha^{-1}, 4.4 t ha^{-1} and 3.6 t ha^{-1} respectively after sun drying (Table 3). Straw yield was found to increase by 19% in T_1 and 22% in T_2 as compared to T_3 (i.e., rice monoculture). Statistically significant differences ($p<0.01$) were also recorded in the yield of straw between the treatments with fish and without fish.

Discussion

The water temperature recorded in three treatments during the study period was within suitable range for fish culture. Ghosh (1992) mentioned that the water temperature in the rice field ranging from 27-29^0 C are suitable for fish culture. The range of dissolved oxygen content (3.5-6.8 mg l^{-1}) of water in rice fields of the present study is quite similar to the finding (3.5-6.17 mg l^{-1}) of Ghosh *et al.* (1984). Gosh (1992) also stated that dissolved oxygen content of the water in rice field ranged form 3.0-4.4 mg l^{-1} in winter season. The dissolved oxygen content of the water in all the treatments were found to decrease gradually towards the end of the experiment. This might be associated with the gradual increase of shade on the water surface by rice canopy, which ultimately reduced the photosyntheitc activity of phyotoplankton and the obstraction of rice plants on the free movement of air in the rice fields. The pH values recorded in the present study were within the productive level as reported by Ghosh (1992). Whitton *et al.* (1987) also recorded the pH values between 6.53-7.08 in deepwater rice fields in Bangladesh.

Chlorophyll-a concentration is a good index of planktonic population. During the study period the values of chlorophyll-a concentration were found to range between 17.42 and 60.24 µg l^{-1} among all the treatments. Ali (1990) recorded the chlorophyll-a concentration of 45.2 µg l^{-1} in rice fields in Malaysia which is more or less close to the average values record in T_3 of the present study. Among all the treatments higher average concentration of chlorophyll-a was recorded in T_3 (rice alone) than rest of the two treatments (with fish) which might be attributed to the grazing pressure of fish on plankton. The fortnightly average values of chlorophyll-a content showed noticable fluctuations in all the treatments. This might be associated with fertilization, variation of water depth and grazing by fish.

In the present study it has been observed that between the two species *O. niloticus* showed higher SGR than that of *B. gonionotus* in both length and weight which might be associated with the lower survival of *O. niloticus* resulting in more food and space for the individuals survived. Between the two species *O. niloticus* showed much lower survival (35%) than that of *B. gonionotus* (72%) which might be associated with their schooling behaviour which makes them easily available to snakes and other predators. The survival of *O. niloticus* (68.4%) recorded by Rahman *et al.* (1995) was much higher than the survival recorded in the present study which might be attributed to the relatively smaller size of fingerlings stocked. But the survival recorded for *B. gonionotus* was almost close to the survival 65% and 68% recorded by Rahman *et al.* (1995) and Akhterruzzaman *et al.* (1993) respectively in their experiments.

The yield of fish obtained from the culture of *B. gonionotus* (244.9 kg ha^{-1} by gross, 222.8 kg ha^{-1} by net) was almost double the production recorded for *O. niloticus* (142.8 kg ha^{-1} in gross and 132.5 kg ha^{-1} in net) might be attributed to the much higher survival of *B. gnionotus* than that of *O. niloticus*. The production of *O. niloticus* (416.7 kg ha^{-1}) recorded by Haroon *et al.* (1992) was much higher than the production recorded in the present study might be due to bigger size of fingerlings stocked. But the production of *B. gonionotus* (229.4 kg ha^{-1}) obtained by Gupta and Mazid (1993) was almost similar to the production recorded in the present experiment.

The production of rice grain and straw obtained in T_1 (4.6 t ha^{-1} and 4.3 t ha^{-1}) and T_2 (4.7 t ha^{-1} and 4.4 t ha^{-1}) were found to differ significantly ($p<0.01$) from the production of T_3 (3.9 t ha^{-1} and 3.6 t ha^{-1}). The production of rice grain 4.4 t ha^{-1}, and 4.8 t ha^{-1} obtained by Gupta and Mazid (1993) and Kohinoor *et al.*(1993) respectively were almost similar to the production recorded in the present study. Rice grain and straw yield were found to increase by about 17% and 19% in T_1, and 19% and 22% in T_2 than those of T_3 respectively. Lightfoot *et al.* (1992) summarized published data on rice field from China, India, Indonesia, Philippines and Thiland to show that average percent increases in rice yields ranged from +4.6 to 28.6 due to fish culture. These increament of grain and straw yield might be due to the presence of fish in rice fields which reduces the incidence of weeds and pests by eating upon them. Akhteruzzaman *et al.* (1993) and Mazid *et al.* (1995) also stated that introduction of fish in the rice fields reduces the infestation of insects and weeds by feeding upon them and thereby improves the yield of rice.

Fish might have also increased the availability of nutrients in soil by their feces as well as by the increased bioperturbation of soil with the movement of fish. Roger (1988) stated that grazing of fish on the aquatic biomass contribute through their feces to nitrogen accumulation at the soil surface.

Conclusions

Culture of fish in the rice fields increase the yield of rice grain and straw. These additional yield of fish, grain and straw of rice will help to improve the economic condition and nutritional status of resource poor farmers. However, between the two species of fish, *B. gonionotus* may be recommended for concurrent rice-fish culture for obtaining better yield and income out of it.

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Toxic effects of dimecron to *Labeo rohita* Ham. fingerlings during acute and chronic exposures: histopathological changes

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Abstract
The exposure to the highest dimecron conc. (8 mg/l) resulted in severe histopathological changes in different tissues of *Labeo rohita* fingerling. Cell necrosis, cytoplasmic vacuolation and pycnotic nuclei were major abnormalities observed in liver tissue. The degeneration of glomeruli and proximal tubules, cytoplasmic vacuolation and focal haemorrhagic area were noted in case of kidney tissues. Major changes observed in intestinal tissues were degeneration of villi, disintegrity of mucosal layers, necrosis of epithelial cells etc. However, hypertrophy of cells and granulation of cytoplasm were major histopathological changes observed in fish at lower dimecron concs. (4 mg/l).

Keywords: Toxicity, Dimecron, Histopathology, *L. rohita*

Introduction

Histopathological changes may serve as a good indicator in determining toxic action of a chemical pollutant. Histological information along with physiological and biochemical data may provide a more complete and accurate description of the activity of a chemical agent (Mehrle and Mayer 1985).

Although major advances have been made in recent years, the use of histology as a tool of clinical pathology has not gained much attention as it should be. Most of the toxicological works are, however, concerned with measuring lethality rather than the pathological effects of contaminants on the tissue (Alabaster and Lloyed 1982, Rand and Petrocelli 1985). The status of toxicological research in Bangladesh is poor and that of histopathology is further merge. Kabir and Begum (1978) studied the histopathological changes in few organs of *H. fossilis* exposed to several granular insecticides. Similarly, Banu *et al.* (1984) investigated the effect of diazinon to *A. testudineus*. Given the kidney and liver as the vital organs for pesticide detoxification, this organs should be the potential organs for histopathological changes. Similarly, since intestine is also involved with absorption and detoxification of many chemical agents, it would be important tissue to be examined. Therefore, it was, thus, decided to investigate changes in liver, kidney and intestinal tissue of *L. rohita* in chronic exposure to dimecron.

Materials and methods

Experimental procedure

The experimental system consisted of 6 circular earthen tumblers and were of 40 litres capacity each. Oxgenation of individual tumbler was done by using air stones connected to a air compressor. Fingerlings of *Labeo rohita* were used as test animal and they were fed with mixture of rice bran and oil cake, twice daily at the rate of 2% body weight. Feeding was stopped two days before the commencement of toxicity trial. The pesticide concentration of "Dimecron 100SCW"- a widely used pesticide used in the present study, were selected arbitrarily on the basis of information obtained from a parallel bioassay study with same fish. In that particular study, the LC_{50} of the dimecron found to be approximately 20 mg/l. A conc. of 8 mg/l dimecron did not kill the fish during a 4-day exposure period, thought a level of 8 mg/l dimecron might not kill the fish during a prolonged exposure period but may induce noticeable stress response. The logic behind selecting this conc. was thus to demonstrate the toxic effects in the selected parameters. A further conc. of 4 mg/l was used to ascertain whether such a lower conc. is still able to produce stress on fish. After acclimation, six groups of fish, two groups served as control while other groups, in duplicate, were challenged by dimecron.

The dimecron conc. in the tumblers were achieved by adding calculated amount of freshly prepared stock solution of the toxicant directly in to the respective tumblers. The experiment was run for 42 days. The fish was inspected several times a day and any dead found was removed immediately. A natural photoperiod of approximately 12 hours dark: 12 hours light was available. At the termination of the experiment, the fish were sacrificed and kidney, liver, intestine and stomach were dissected and preserved for histopathological study.

Tissue samples were taken from all treatment groups. For each treatment, at least 6 fish were sampled randomly. For consistency, a fixed sections of the organ systems were sampled. After washing in physiological saline, the tissue samples were fixed in 10% buffered formalin and left for at least one week before further processing.

Tissue processing

Fixed tissue were cut into suitable pieces and labeled. The processing involved passing the tissue through different alcohol grades for dehydration. Processed tissue were then blocked in suitable moulds with molten wax and allowed to cool on a cool plate. The blocks were trimmed in order to bring the tissue to the surface of the block. Serial sections of 3–5 μ thickness were cut on a Leitz-wetzlar microtome using Richert-Jung disposable microtome blades. Sections were collected on prewashed wet glass slides. The slides were then marked and dried and no adhesive was used. Stained tissue sections were observed under an Olympus compound microscope and photomicrographs from representative histological sections were taken on Leitz-wetzlar photomicroscope.

Results

Liver: The TS of liver of control fish is shown in Fig. 1(a) and that of 4 and 8 mg/l treated fish is presented in Fig. 1(b-d), respectively. Fish at the highest concentrations showed severe pathological changes. The most conspicuous changes included necrosis of hepatocytes, pyknotic nuclei, cytoplasmic vacuolation. These changes were common for almost all specimen examined. Other less common changes included large haemorrhagic area with focal necrosis (Fig. 1.c) and dilation of sinusoid (Fig. 1.c-d). In these areas, the cell membrance of hepatocytes were disintegrated and the nuclei were scattered forming a syncytical mass (Fig. 1.b). Theses changes were recorded at least for 50–60% cases. The tissue at the lower dimecron (4 mg/l) showed hypertrophic changes in hepatocytea (Fig. 1.b), fatty infiltration and cytoplasmic vacuolation. Cytoplasm appeared to be grannular.

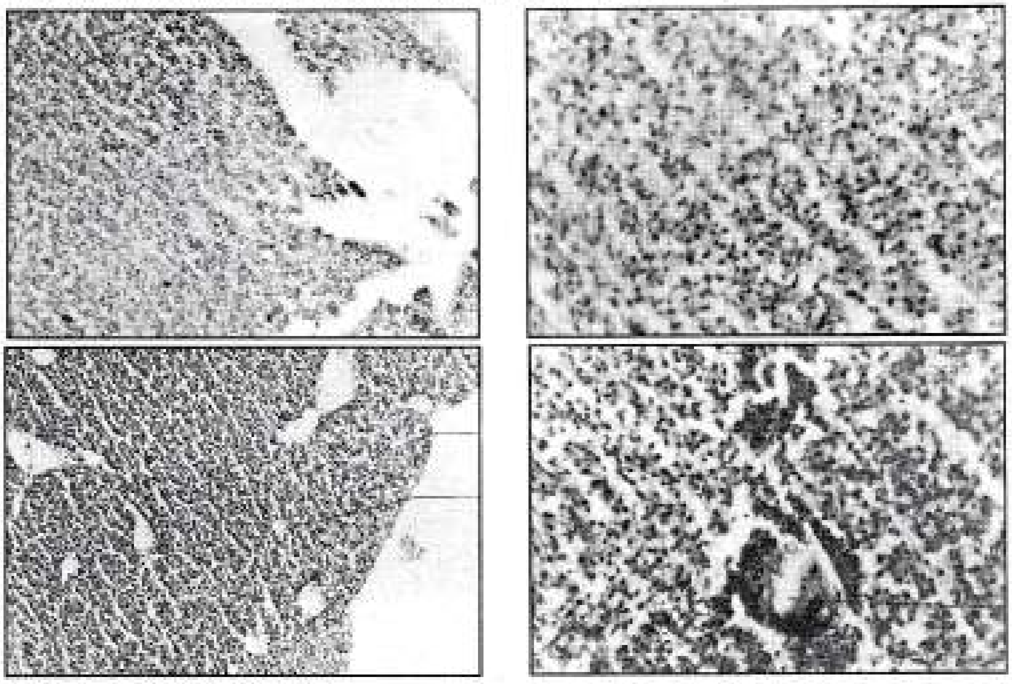

Fig. 1. a. TS of liver of control fish- the small uniform size of the hepatic parenchymal cells and their nuclei (H&E 162.5X)

b. TS of liver treated with 4 mg/l dimecron- Hypertrophic changes in hepatocytes & granular cytoplasm appeared (H&E 650X)

c. TS of liver treated with 8mg/l dimecron- Necrosis of hepatocytes and cytoplasmic vacuolation (H&E 162.5X)

d. TS of liver treated with 8mg/l dimecron- deeply stained nuclei and focal necrosis with haemorrhagic area (H&E 650X)

Kidney: The TS of kidney from control is shown in Fig. 2(a,b). The control sections show normal renal tubule with evenly distributed cytoplasm and normal nuclei in the central or basal part of the epithelial layer. The connective tissue show compact structure while the glomeruli were looped, blood vessels having connections with the tubule.

Fig. 2(c-e) shows the changes in kidney caused by dimecron treatment. The fish at 8 mg/l dimecron showed gross changes in the cell and tissue structure. In severe cases, degeneration of proximal tubules and glomeruli were seen. The epithelium of the tubules were basally vacuolated. In many cases, degenerative glomeruli clumped into crescent on the wall of the capsule (Fig. 2.d-e). As in liver, many haemorrhagic area with mass of degenerated cells were also noted. In most cases cytoplasmic vacuolation and pycnotic nuclei were observed. Dimecron concentration of 4 mg/l also produced various pathological changes (Fig. 2.c). The epithelial cells of the tubule appeared hypertrophied having large and swollen epithelial cells. The cells had deep stained nuclei and many cases the nuclei moved to the cell apices.

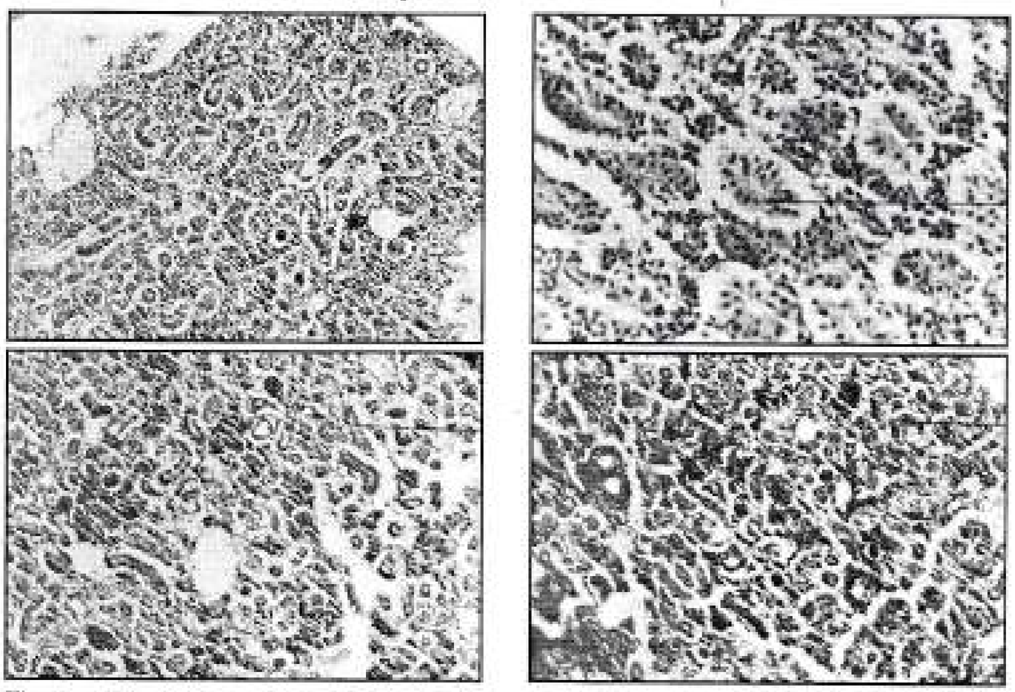

Fig. 2. a. TS of kidney of control fish showing normal structure- normal tubule and glomerulus (H&E 162.5X)

b. TS of kidney of control fish showing distal tubule with enenly distributed cytoplasm and normal nuclei (H&E 650X)

c. TS of kidney of fish treated with 4 mg/l dimecron- Hypertrophied epithelial cells and deep stained nuclei (H&E 162.5X)

d. TS of kidney of fish treated with 8 mg/l dimecron- Abnormal glomeruli and vacuolation of cytoplasm (H&E 162.5X)

Intestine: Fig. 3(a-b) shows the cross section of intestine from a control fish. It is evident that villi are normal and individual villus remain separated. Mucosal folds remain intact structurally. Cellular structure appeared normal. The intrigrity between various muscle abnormalities appeared. At the highest concentrations several degenerative processes were evident. Degenerative changes in the villi, particularly at the tip of the villi, were commonly seen in Fig. 3(d) and 3(f). In some cases complete loss of villi was also noted. Loss of structural integrity of mucosal folds were epithelium was another common observation. In some cases, characteristic inflamatory infiltration of submucosa was seen. The inclusion of that was clear exudate and pyknotic nuclei. Fish at the 4 mg/l dimecron also showed some changes. In few cases, the dagenerative changes at the tip of the villi were evident. However, no changes in the submucosal integrity was observed. The nuclei appeared to be dilated.

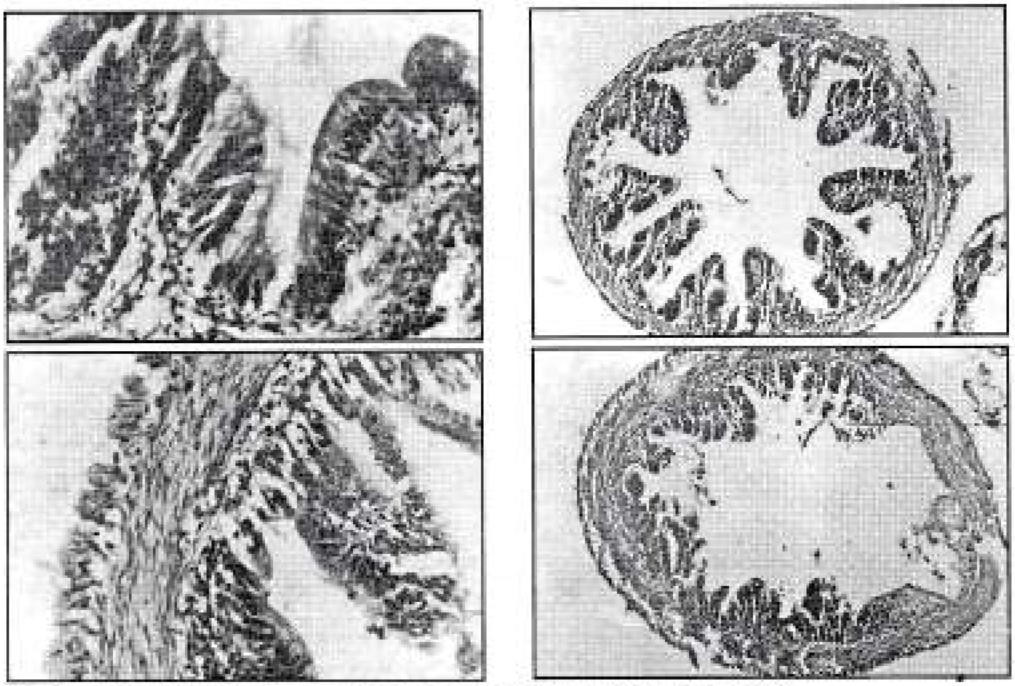

Fig. 3. a. TS of intestine from control fish- normal mucosal folds (H&E 650x)

b. TS of intestine of treated fish at 4 mg/l dimecron showing mild changes. Epithelial cells were hypertrophied (H&E 162.5X)

c. TS of intestine of treated fish at 4 mg/l dimecron. Necrotic changes at the tip of villi (H&E 650X)

d. TS of intestine of treated fish at 8 mg/l dimecron showing degenerative villi, particularly at the tip. Changes in mucosal layer. Presence of edematous cells (H&E 162.5X)

Discussion

The present study demonstrated the toxic effects of dimecron on the various tissues of fish during a 42-day expsoure period. The histopathological changes observed in this study were also reported in studies concerned with various pesticides and other pollutants and therefore, are not characteristics of organophosphorus but represent non-specific changes induced by exposure to pesticides. Again, many histopathological changes observed in an organ were also found in the tissues of other organs.

Most of the histopathological change, *viz.* hepatocyte necrosis, cytoplasmic vacuolation, pyknotic nuclei are often reported phenomena in toxicological studies. Cytoplasmic vacuolation due to exposure to pesticides has been reported by a number of workers in different tissues of fish. King (1962) has givern a detailed account of various histopathological symptoms of guppies and brown trout fry exposed to sublethal concentrations of DDT, mainly in the liver, kidney and intestine. Eller (1971) and Bhattachrya *et al.* (1975) have also reported vacuolation in liver cells of fishes exposed to endrin. Kabir & Begum (1978) also recorded this change in *A. testudineus* exposed to padan and furadan. Sastry and Malik (1979) also observed cytoplatmic vacuolation in the liver of *Channa punctatus* exposed to much lower concentrations of dimecron (0.32 mg/1) than used in the present study. Vacuolation of cytoplasm might have been occurred to due to grannulation and/or degeneration of cytoplasm accompanied by depletion of glycogen reserve.

Necrotic changes in the liver cells observed in present study was also reported in Garder and Laroche (1973), Battyacharia *et al.* (1975), although this was not observed by Sastry and Malik (1979) in *C. punctatus* exposed to dimecron. This difference could be due to the lower concentration of dimecron (0.32 mg/l) used by the later authors. Kabir and Begum (1978) also observed necrotic changes in liver cells, particularly in fish exposed at the higher concentrations of padan and furadan and supports our findings. Pycnotic muclei observed in our study have also been mentioned by Begum (1976) in *A. testudineus* exposed to various a number of pesticides.

It may be mentioned here that necrotic changes were not apparent in fish exposed to 4 mg/l dimecron even after 42 days of exposure. Indicating that higher concentrations and/or further longer period of exposes are required to bring about this changes in the liver cells. Necrosis of cells is a serious pathological change.

Deep coloured grannular accumulations in certain parts of liver tissue were noted by Begum (1976) and may be similar to the focal necrotic area with coagulated blood observed in this study and are indicative of advance stage of cell necrosis.

Kidney tissues showed gross pathology under dimecron exposure conditions. Severe changes were observed in fish at the highest concentration. Degenerative changes in the proximal tubule and glomerulus observed in the present study are in conformity with the results obtained by Smith *et al.* (1973). Degenerative glomeruli clumped into crescent on the wall of the capsule observed in the present study was also recorded in the study of Begum (1976) with basudin to *A. testudineus*. Cytoplasmic degeneration and vacuolation noted in the present case were also reported by the above authors. In the case of lower dimecron concentration the above changes were not apparent but hypertrophied tubule and epithelial cells were seen. These were also seen by Smith *et al.* (1973) and Kabir and Begum (1978). Hypertrophication of cells is indicative of increased activity. It seems that during dimecron exposure kidney function increases. It is now well established that kidney is involved with the detoxification process of organophosphorus compounds, therefore its presence in the kidney is obvious and may thus exerts its direct effects on kidney components.

Several pathological changes in the intestine of fish at the highest concentration included degeneration of villi, particularly at the tip, sloughing of mucosal layer, desquamation of cellular layers. Similar results were also observed in fish by Smith and Piper (1975) during exposure to ammonia. The detachment of mucosal layer could be due to the degeneration of the basal layer lamina propria. Ruptured and highly degenerated mucosa were also noted by Sastry and Malik (1979) in *C. Punctatus* exposed to 0.32 mg/l. In the present case, the lower concentration of dimecron (4 mg/1) did not induce such severe changes. The reason for such difference is not clearly understood. Cytoplasmic vocuolation in the columnar epithelium seen in the present case was also noted by Eisler *et al.* (1972). Changes in the nucleus of epithelial cells noted by Begum (1976) were also apparent in the present study. Since intestine is the site for absorptive of most chemicals, the action on the intestinal tissue is obvious. The pathological changes in intestine tissue may not only impair the absorption but also impair the digestion process due to the destruction of mucosal layer responsible for secretion of many digestive exzymes.

The present study detected many abnormalities in tissues caused by dimecron exposure, even at the lower concentration of dimecron used, although changes were less severe indicating that this level of dimecron is not safe from histopathological point of view. It is interpreted on the basis of histopathology that severe imbalance in many physiological process might have occurred in dimecron exposed fish.

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Incidence of epizootic ulcerative syndrome (EUS) in freshwater fishes in the endemic area of Punjab, Pakistan

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Abstract

Incidence of Epizootic Ulcerative Syndrome (EUS) has been recorded for the first time in freshwater fishes in the endemic area of Punjab, Pakistan. Survey of private fish farms, hatchery and natural water bodies was conducted in a radius of 14 Km from around river Ravi near Lahore (Punjab Province) Pakistan. Out Of 1628 fishes belonging to 18 genera, 517 fishes of 10 genera were found affected with EUS. The incidence of EUS in culturable fishes was higher in *Cirrhina mrigala* (15.4%) moderate in *Catla catla* (13.3%) and lower in *Labeo rohita* (5.0%). Exotic fish, Chinese carp *Ctenopharyngodon idella* and *Hypophthalmicthys molarix* were not affected with EUS. In non-culturable fishes the incidence of EUS was highest in *Channa punctatus* (72.8%) moderate in by *C. straitus* (65.45%) and comparatively lower *Puntius ticto* (43.7%). A slow growing temperature sensitive *Saprolegnia spp.* was isolated from all of EUS infected fish species. *Aeromonas spp. and Pseudomonas spp.* were isolated from the diseased fishes. Ectoparasites *viz. Lernaea, Argulus* and *Trichodina* spp. were also isolated from the skin and gills of infected fish species. The disease was more severe in water having low alkalinity (70 mg/l), hardness (75 mg/l) and low temperature of 10-12 °C.

Keywords: EUS, Bacteria, Water quality

Introduction

The Epizootic Ulcerative Syndrome (EUS) is a condition characterized by large cutaneous ulcerative lesions that periodically results in death in many species of wild and cultured freshwater fish, often involving a number of pathogens (FAO 1986). The same disease is also called Mycotic Granulomatosis (MG) in Japan (Egusa 1992) and Red Spot Disease (RSD) in Australia (Callinan *et al.* 1995). This disease was first noticed in 1972 in Australia (Chattopadhyay *et al.* 1990) and Southeast-Asia (Rodgers and Burke 1981). Its presence has also been reported in Southeastern United States (Noga and Dykstra 1986). It appears as if EUS is spreading more widely prevalent in Asian Countries. This has been reported from Philippines, (Reantaso 1990), eastern and western India (Das *et al.* 1990), Srilanka (Frenichs 1988), Bangladesh (Roberts *et al.* 1989), Bhutan (Phillips 1989) and Nepal (Shrestha 1990). EUS is believed to have entered India in 1988 and since then has been causing large-scale mortalities in both freshwater and brackish water fish (Das and Das 1993). Since Pakistan share a long eastern border with India, there was a possibility that disease could have been transmitted depending on aquatic environment contamination.

We in our preliminary survey in the Potohar Region of northern Punjab of Pakistan did not find presence of EUS (Rab *et al.* 1993). Recently some complaints of disease outbreak similar to EUS were received from Punjab (Pakistan). The present investigation in from of a comprehensive survey therefore, was designed to determine the incidence of EUS in different fish species, both in culture system and wild of Punjab, Pakistan

Materials and methods

A survey of water bodies was conducted from April to July'97, in a radius of 14 km around River Ravi near Lahore (Punjab Province), Pakistan. Four private fish farms, one private fish hatchery, 20 natural water bodies in the form of small and large ponds called Dhunds (mainly non drainable) and catches from River Ravi were included in the study.

The study area is located in flooded zone of Pakistan. Out of the total rainfall in these areas, about 70 percent are received during monsoon rainy season (July-September). The maximum temperature ranges from 40-45 ^{0}C in June. In winter, the temperature ranges between 10^{0}C-25^{0}C (November-February) in this area.

A total number of 1628 different fishes representing 18 genera were examined for the presence of EUS according to the previously described signs and symptoms (Touguthai 1985, Roberts *et al.* 1989, Shrestha 1990 and Prasad and Sinha (1990). The fishes were collected with the help of cast nets and from commercial catches of River Ravi.

Parasites were isolated and identified as described by Jaffry (1995). For bacteriological and fungal investigation, fishes were stored in ice and immediately transported to laboratory, as described by Callinan *et al.* (1989). EUS infected fishes (25) were preserved in 10% buffer formalin and sent to Aquatic Animal Health Research Institute (AAHRI) Bangkok, Thailand, for confirmation of EUS through Network of Aquaculture Center in Asia-Pacific (NACA).

Water quality parameters were tested on the spot at all sampling sites, using Digital Titrator (Model 16900-01) HACH water analysis kit and have been presented in Table1.

Table 1. Water quality parameters of different sites in the endemic area of Punjab, Pakistan

	Private fish farms	Natural water bodies	Ravi river
Temperature (°C)	12-27.5	11-27	10-26
pH	8.0-8.5	8.0-8.5	7.5-8.0
DO (mg/l)	7.1-10.6	7.9-10.5	2.5-9
Alkalinity (mg/l)	100	70	121

Acidity (mg/l)	20-70	42-86	42-61
Chloride (mg/l)	3.6-5.0	5.6-6.0	4.2-7.8
CO_2 (mg/l)	23.0-46.0	30.8-38.0	30.0-40.3
Hardness (mg/l)	95-120	75-110	110-230
Ammonia (mg/l)	0.1-0.2	Nil	0.7-1.3
Nitrite (mg/l)	Nil	Nil	Nil

Results

The incidence of EUS in freshwater fishes in the endemic area of Punjab in Pakistan is presented in Table2. The incidence of EUS in non-culturable fishes was highest in *Channa punctatus*(72.72%), moderate in *Channa straitus*(65.45%), and comparatively lower in *Puntius ticto* (43.66%). The incidence of EUS in culturable fishes was higher in *Cirrhinus mrigala* (15.38%), moderate in *Catla catla*(13.33%) and lower in *Labeo rohita*(4.96%). The clinical signs and symptoms related to EUS and exhibited by these different fish species in the endemic area of Pakistan are presented in (Table 2).

Table 2. Incidence of epizootic ulcerative syndrome in freshwater fishes in the endemic area of Punjab, Pakistan

Fish species	Incidence (no. infected/ no. observed)	Signs & symptom*			
		ul	ef	ha	rs
Culturable fishes					
1. *Cirrhina mrigala*	15.4(10/65)	+	+	-	+
2. *Catla catla*	13.4(22/165)	+	-	+	-
3. *Labeo rohita*	5.0(15/302)	+	-	+	-
Non-culturable fishes					
1. *Channa punctatus*	72.8(200/275)	+	+	+	+
2. *C. straitus*	65.5(108/165)	+	+	+	+
3. *Puntius ticto*	43.7(162/371)	+	-	+	+
4. *Cirrhina reba*	18.2(2/11)	-	+	-	-
5. *Heteropneustes fossilus*	14.3(2/14)	+	-	+	-
6. *P. sarana*	13.3(4/30)	+	-	+	-
7. *Labeo calbasu*	8.3(2/24)	+	+	+	-
8. *L. dyochelus*	-	-	-	-	-
9. *Mystus seenghala*	-	-	-	-	-
10. *Notopterus notopterus*	-	-	-	-	-
11. *N. chitala*	-	-	-	-	-
12. *Wallago attu*	-	-	-	-	-
13. *Mystus carasias*	-	-	-	-	-

* UL: Ulcer. EF: Eroded fin. HA: Hemorrhagic area. RS: Raised scale

The various types of pathogens associated with EUS in freshwater fishes in the endemic area of Punjab Pakistan are presented in Table 3. A specific slow growing temperature sensitive fungus, *Saprolegnia* sp. was isolated from all the EUS infected fish species. This fungus was present in form of bunches on the ulcerated skin and with deeply penetrated hyphae (Table-III). Among the parasitic infestation *Lernaea* sp. and *Argulus* sp. were isolated from some of the infected fishes (Table 3). *Trichodina* spp., were also isolated from the gills of infected fish species. Bacterial involvement in this disease was consistently present. *Aeromonas* spp. and *Pseudomonas* spp. were isolated from the diseased fishes (Table 3). Environmental monitoring revealed that the incidence of disease was more severe in water with low alkalinity (70 mg/l of $CaCO_3$) and hardness (75 mg/l of $CaCO_3$). The disease was mostly observed during the winter (November-February), when temperature fall to 10-12 °C (Table 3).

Table 3. Various type of pathogens associated with EUS in freshwater fishes in the endemic area of Punjab, Pakistan

EUS infected fishes	Pathogens isolated		
	Ecto parasite	Fungal	Bacterial
Culturable fishes			
1. *Labeo rohita*	LS	SS	AH,PS
2. *Cirrhina mrigala*	LS,AS,TS	SS	AH,PS
3. *Catla catla*	LS,AS	SS	AH
Non-culturable fishes			
1. *Labeo calbasu**	-	SS	AH
2. *Cirrhina reba*	LS	SS	AH,PS
3. *Puntius ticto*	LS,TS	SS	PS
4. *Heteropneustes fossilus*	-	SS	PS
5. *Puntius sarana*	LS	SS	AH,PS
6. *Channa punctatus*	TS	SS	AH,PS
7. *Channa straitus*	TS	SS	AH,PS

LS: *Lernaea* sp. AS: *Argulus* sp. TS: *Tricodina* sp. SS: *Saprolegnia* sp. AH: *Aeromonas hydrophila* PS: *Pseudomonas* sp.
*Pathogens were identify in other specimen examiner.

Fish sample analysis (AAHRI, Bangkok)

Case No.1 (*Channa punctatus*): Mycotic granulomae were observed among the myopathy lesion of the affected fish. Some metacercaria found encysted in the hypodermal layer of the skin, muscle and gill filament. *Trichodina spp.* has infected gill of the fish and cause hyperplasia and oedema of epithelial cells.

Case No.2 (*Channa punctatus*): The lesions of this fish sample were in the advance stage as compared to the sample No.1. Many mycotic granulomae were found in the muscle area and also in the mesenteries. *Trichodina spp.* and metacercarial cyst infected gills of the fish and cause hyperplasia and oedema of epithelial cells. Gill lamellae were joined together.

Discussion

Incidence of EUS in freshwater fishes in the endemic area of Punjab Pakistan is being reported for the first time. This incidence of EUS in three culturable fish species (*C. mrigala*, *C. catla*, *L. rohita*) averaged 11.2 % and 7 non-culturable fish species averaged 33.7 %. These results are consistent with the earlier reports of Callinan *et al.* (1997) who reported that out-break of EUS in 18 countries of Asia- Pacific. Over 100 fish species have been recorded as being affected by EUS (Frerichs *et al.* 1988). Highest losses occurred in the snakehead *Channas* sp. (Roberts *et al.* 1989). Other included air breathers that live in swamps, marshes or ditches and many of them experience poor water conditions for most of the year (Supriyadi 1986). Wishwanath *et al.* (1997) reported that in India a total of eight species were consistently affected in freshwater belonging to *Channa* sp. and *Puntius sp.* The Indian major Carps (*C. mrigala*, *L. rohita* and *C. catla*) also appear susceptible to EUS (Kumer and Day 1992). EUS is believed to have entered India in 1988 and since then has been causing large-scale mortalities in both freshwater and brackish water fish (Das and Das 1993). Since Pakistan share a long eastern border with India, there was a possibility that disease could have been transmitted depending on aquatic environment contamination.

According to Willoughby *et al.* 1995, the essential etiological agent of EUS is an oomyce fungus *Aphanomyces invaders*. The type of ulcers produced in fish from India have been associated with pathogenic fungus of *saprolegnia* sp. (Anoymous 1992). The results of our study indicate that most likely a typical Saprolegnia sp. caused them. In India a broad spectrum of bacterial forms belonging to *Pseudomonas sp.*, *Bacillus sp.*, *Anthrobacter sp.*, *Staphylococcus sp.*, *Micrococcus sp.*, *Actinomycete sp.* and *Aeromonas hydrophila* were isolated from diseased fish sample (Kumar and Day 1992). However, in Pakistan only *Aeromonas sp. and Pseudomonas sp.*, were isolated from the diseased fish in the present study.

Although, Reungprach *et al.* (1983) found no direct relationship of ectoparasite to the occurrences EUS. The present study demonstrated that ectoparasites like *Lernaea sp.*, *Argulus sp. and Tricodina sp.* were also isolated from diseased fish. Perhaps parasite acts either as a pathogen or vector for a pathogen of EUS Roberts *et al.* (1986) . Alternatively parasites may at times induce stress in fish and predispose them to infection.

The incidence of disease appear to be seasonal in nature usually this occurs in real epidemic form after the monsoon season i.e. September onward. This is in agreement with the results of Jhingran (1990), Chinabut *et al.* (1995) and Vish Wanth *et al.* (1997), who has reported that low temperature usually is necessary for EUS out-break. The disease showed a decline from April onwards. This is possibly due to rise of water temperature.

Rodgers and Bruke (1981) opined that rapid seasonal depression of salinity and temperature are important environmental factors that predispose fish to be attacked by red spot disease. Monitoring at affected sites in Bangladesh, China, India and Lao PDR (Myanmar) during 1988 and 1989, it was found that out-breaks occurred during months with low temperature, (Philipps and Keddie 1990). Low chloride concentrations also make fish less tolerant to environmental toxin (Jhingran 1990). In the present study the alkalinity and hardness were comparatively low in the water samples. It is therefore, logical to believe that these factors might have predisposed the fish with a possible attack by fungus *Saprolegnia* sp.

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Bacterial load in pond water and different organs of a Indian major carp *Cirrhinus mrigala* Ham.

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Abstract
During the study period (August, 1993 to July,1994) the mean bacterial load in surface water was found to vary from 1.39 $x10^{6}$ (July'94) to 3.11$x10^{7}$CFU/ml (September'93), while that of bottom water ranged from 1.01$x10^{6}$ (May'94) to 5.90$x10^{7}$CFU/ml (October '93).The mean total number of bacterial load in body slime, liver and kidney was found to vary from 0.58$x10^{7}$ (July'94) to 2.37$x10^{7}$CFU/g (March'94),from 0.22$x10^{6}$(July'94)to 9.64$x10^{6}$CFU/g (March'94) from 0.15$x10^{3}$(July'94) to 9.36$x10^{6}$CFU/g (March'94), respectively. Bacterial load in slime was significantly correlated with bacterial load in liver, bacterial load in slime was significantly correlated with bacterial load in kidney and bacterial load in liver was significantly correlated with bacterial load in kidney.

Key words: Bacteria, *C. mrigala*, Pond water

Introduction

Wide ranges of bacterial flora are abundant in water and associated with fish specially, with the bottom living fishes. Effective water management in fish pond is one of the important factor contributing to the success of fish culture. Environment plays a crucial role in disrupting the balance between the host and the pathogen. Bacteria in aquatic systems, specially, freshwater systems have been employed as an index of abundance of the microbial community Horseley (1973) investigated relationship between the bacterial flora of salmon and its environment and observed that the bacteria of skin were similar with the bacteria in water. Frazier and Westhoff (1978) stated that the bacterial flora of living fish depends upon the microbial content of the water in which they live.

Study of aquatic bacteria associated with fish is very limited in Bangladesh. Few attempts have been taken in order to assess the bacterial population in aquatic environment and their involvement in causing disease in fish *Cirrhinus mrigala* H. is one of the cultured fish in Bangladesh and considered as one of the important components in our poly-culture system. Considering, the above reasons the present study was undertaken to investigate the bacterial load in pond water and different organs of the bottom living fish, *Cirrhinus mrigala H.*

Materials and methods

Sampling: Fish samples (Length26.37cm to 35.62cm) of mrigal, *Cirrhinus mrigala* H. were collected once a month from the selected experimental pond of the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh for period of 12 months as shown in Table 1. Water samples was collected also from the same pond once a month during the study period. Water samples were collected in sterilized reagent bottles both from the surface and bottom levels for bacterial population study as well as for studying the physico- chemical parameters.

Water study: Surface and bottom water of the pond was carried out followed the pour and spread plate method as stated in Standard Methods for the examination of Water and waste water (Lenore *et al.*1989). Petri dishes were set out, two plates per dilution were tested. Each dilution (0.1ml) was pipetted into the center of the petri dishes using a fresh pipette for each dilution. With a sterilized glass rod the content was spread as quickly as possible and the medium was allowed to set. Then the petri dishes were inverted and kept in incubator at 25^{0}C for 24-48hr.The plates having 30-300 colonies were counted for viable count. The colony or viable count /ml was calculated by multiplying the average number of colonies per countable plate by the reciprocal of the dilution.

Body slime: Fish samples collected for investigation were killed by a light hurt on the neck region and then the slimes were collected by scrapping with a sterile scalpel and were kept in a sterile weighing boat which were pre- weighed. Necessary dilution were made using physiological saline (0.85% NaCL) following the ten fold dilution method, Thus the samples were ready for inoculation in the culture medium.(TSA,Oxoid).

Liver: The body surface of fish samples were disinfected with 70% ethyl alcohol and their abdomen opened by aseptic dissection and then the liver was taken out carefully with the help of sterilized forceps (Austin and Al-Zaharani1988, Kabata1985). The liver samples after being weighed individually in a sterile weighing boat and was homogenized for preparation of suspension in physiological saline. Thereafter, the suspension was diluted with sterile physiological saline for inoculation on the culture media (TSA,Oxoid).

Kidney: The kidney samples were prepared following the same procedure as done for the preparation of liver.

Results and discussion

Average length and weight of fish samples were presented in Table 1. Length of fish ranged from 27.24cm to 35.62cm, while weight varied from 242.62g to 431.40g. The physico- chemical parameter of pond water is shown in Table 2. It was observed that the physico- chemical parameter did not show any significant variation from one month to another. The mean total bacterial load of surface water during August, 1993 to July'94 was found to vary from 1.39×10^5 CFU/ml(July'94) to 3.11×10^7CFU/ml(September'93) while that in case of bottom water ranged from 1.01×10^6CFU/ml(May'94) to 5.06×10^8CFU/ml(September' 93)(Table 3).The bacterial load in case of surface water was found to be higher from August'93 to March'94 then it became lower from April'94 to July'94 while that in case of bottom water was found to fluctuate irregularly.

Table 1. Average length and body weight of fish sample as recorded from August'93 to July'94

Month	Length (cm)	Weight (g)
1st phase		
Aug.'93	30.32	304.90
Sep.'93	30.88	330.67
Oct.'93	32.68	347.60
Nov.'93	34.53	408.05
Dec.'93	33.00	346.00
Jan.'94	34.55	378.50
Feb.'94	33.95	367.00
Mar.'94	35.25	415.00
Apr.94	35.17	377.00
May.'94	35.62	431.40
June.'94	27.24	242.62
Jul.'94	27.36	288.60
LSD (0.1%)	2.35	71.55

Data presented are average of ten fish.

Table 2. Monthly variation in physico- chemical parameters of the pond water during August'93 to July'94

Month	Temp.(°C)	pH	DO (mg/l)	Hardness (mg/l)	Ammonia (mg/l)
1st phase					
Aug.'93	33.0	8.5	8.5	32.0	0.010
Sep.'93	29.7	7.2	8.5	32.0	0.001
Oct.'93	29.5	7.2	8.0	24.0	0.001
Nov.'93	29.7	7.0	8.5	24.0	0.001
Dec.'93	27.0	7.5	8.0	25.0	0.010
Jan.'94	21.3	8.0	7.5	27.0	0.100
Feb.'94	22.7	8.5	8.0	28.0	0.010
Mar.'94	26.3	8.0	7.2	40.0	0.010
Apr.94	29.6	8.0	7.5	27.0	0.001
May.'94	27.9	7.5	7.0	35.0	0.010
June.'94	32.4	7.5	7.5	40.0	0.020
Jul.'94	35.3	8.0	7.5	40.0	1.020

Data presented are average of four replications

Table 3. Monthly variation in total number of bacterial load in pond water recorded during August'93 to July'94

Month	Bacterial load in pond water (CFU/ml)	
	Surface water	Bottom water
1st phase		
Aug.'93	$3.01x10^7$	$27.72x10^8$
Sep.'93	$3.11x10^7$	$5.06x10^6$
Oct.'93	$1.19x10^7$	$5.9x10^7$
Nov.'93	$2.50x10^7$	$2.48x10^7$
Dec.'93	$1.17x10^7$	$1.29x10^8$
Jan.'94	$1.79x10^7$	$1.81x10^8$
Feb.'94	$1.73x10^7$	$1.11x10^6$
Mar.'94	$1.17x10^7$	$1.04x10^6$
Apr.94	$1.38x10^6$	$1.44x10^8$
May.'94	$1.50x10^6$	$1.01x10^6$
June.'94	$1.27x10^5$	$1.15x10^7$
Jul.'94	$1.39x10^5$	$2.00x10^6$

Data presented are average of four replications

The bacterial load in body slime, liver and kidney of fish sample during August'93 to July'94 was found to vary from $0.58x10^3$ to $2.37x\ 10^7$ CFU/g from $0.22x10^3$ to $9.64x10^6$ CFU/g and from $0.15x10^3$ to $9.36x10^6$CFU/g, respectively during the experimental period. i.e., from August, 93 to July'94 (Table 4).The highest and the lowest bacterial load in all the three organs were found in the month of March'94 and July'94, respectively.

Table 4. Monthly variation in total number of bacterial load in fish sample

Month	Bacterial load in fish (CFU/g)		
	Body slime	Liver	Kidney
1st phase			
Aug.'93	$1.06x10^4$	$3.35x10^3$	$2.60x10^3$
Sep.'93	$5.78x10^5$	$6.74x10^4$	$5.29x10^4$
Oct.'93	$3.67x10^6$	$3.88x10^5$	$9.37x10^4$
Nov.'93	$1.32x10^7$	$1.48x10^6$	$4.85x10^5$
Dec.'93	$1.14x10^7$	$2.96x10^6$	$2.45x10^5$
Jan.'94	$5.79x10^6$	$1.44x10^5$	$5.56x10^5$
Feb.'94	$2.05x10^7$	$2.66x10^5$	$2.38x10^4$
Mar.'94	$2.37x10^7$	$9.64x10^6$	$9.36x10^6$
Apr.94	$6.85x10^5$	$2.37x10^4$	$5.18x10^5$
May.'94	$1.85x10^5$	$4.58x10^4$	$3.04x10^3$
June.'94	$1.20x10^3$	$0.23x10^3$	$0.18x10^3$
Jul.'94	$0.58x10^3$	$0.22x10^3$	$0.15x10^3$

Data presented are average of 10 fish.

The correlation of different parameters studied from August'93 to July'94 indicate that the body length of *C. mrigala* H. was significantly correlated with body weight, bacterial load in slime was significantly correlated with bacterial load in liver and in kidney and bacterial load in liver was significantly correlated with bacterial load in kidney(Tables 5 and 6).

Table 5. Correlation between growth parameters and bacterial load in body slime, liver and kidney of *Cirrhinus mrigala* as observed during the period from August'93 to July'94

Variables	r-value (r=10)
1. Body length (BL) x Body weight (BW)	0.9613***
BL X Bacterial load in slime	0.4939
BL X Bacterial load in liver	0.3431
BL X Bacterial load in kidney	0.3017
2. BW X Bacterial load in slime	0.4783
BW weight X Bacterial load in liver	0.6321
Body weight X Bacterial load in kidney	0.3280
3. Bacterial load in slime X Bacterial load in liver	0.7245**
Bacterial load in slime X Bacterial load in kidney	0.6487*
4. Bacterial load in slime X Bacterial load in kidney	0.9596***

* = Significant at 5% level ** = Significant at 1% level *** = Significant at 0.1% level

The monthly variation in total bacterial load in the pond water, body slime, liver and kidney of the experimental fish, and the existence of significant positive correlation between the bacterial load of body slime and the bacterial load of liver, between the bacterial load of body slime and bacterial load of kidney as well as between bacterial load of liver and bacterial load of kidney, might be due to feed (mustard oil cake, rice bran etc.) used as supplementary feed. Moreover, the month to month fluctuation in the bacterial load might be due to time to time addition of water in the pond. But no significant correlation was found between bacterial load with temperature of pond water. Moreover, the physico- chemical parameter of pond water did not show any significant variation from one month to another. Romanenko (1971) reported that the total bacterial number in reservoir water was $1.43\text{-}0.18 \times 10^6$/ml of water. The range of bacterial load in water of the experimental pond as recorded during the present study (1.01×10^6/ml to 5.06×10^6CFU/ml of water) more or less agree with his findings. Horseley (1973) investigated relationship between the bacterial flora of salmon and its environment. He recorded 10^2 to 10^3 bacteria per cm2 of skin and similar number of bacteria found/ ml of water. Chrganowski (1985) reported that the total bacterial population was 1.1×10^5 cells m-3 of water in lake Arlington and cell volume was substantially larger in winter than summer and were negatively correlated with temperature which differs from the findings of the present study where higher bacterial load in pond water was recorded in August and September which is probably due to shallowness of the experimental pond that presumably resulted in the existence of favourable condition for the growth of bacteria in August and September. Tewari and Mishra (1985) reported freshwater bacteria varied from 1 to $3.00x10^2$/ml in the lake water. Lio-Po *et al.* (1992) reported that total bacterial count CFU/mg) of skin was $1.2x10^3$ in apparently normal lesioned sample. They also added that the mean CFU/g tissue was $4.3x10^4$ in apparently normal specimen. They found that kidney sample likewise revealed the presence of bacteria. Araki and Kitamikadi (1978) pointed out that the population density of bacteria ranged from 0.0 to $1.8x10^5$ cell/ml of water in some river and pond waters of Japan. Iqbal (1995) reported that the total bacterial load in pond water, body slime and kidney of fish at Trisal Fish Seed Multiplication Farm, a GoB Farm, varied from $1.3x10^2$ to 5.9×10^5 CFU/ml of water, $5.4x10^3$ to $8.5x10^7$ CFU/g of body slime and 0.0 to $2.4x 10^4$ CFU/g of kidney, respectively, while that of Jhalak fish farm was $2.0x10^2$ to $3.0x10^6$ CFU/ml of water, $3.8x10^2$ to $2.3x10^8$ CFU/g of body slime and 0.0 to $5.3x10^4$ CFU/g of kidney which agree with the findings of the present study. The present study revealed that the bacterial population in different substrates were $1.39x 10^5$ to $3.11x 10^7$ CFU/ml in surface water$1.01x10^6$ to $5.90x 10^7$ CFU/ml in bottom water, $0.58x10^3$ to $2.37 x10^7$ CFU/g in body slime, $0.22x10^5$ to $9.64 x10^6$ CFU/g in liver and $0.15x10^3$ to $9.36x 10^6$ CFU/g in kidney. The study revealed that there is an existence of positive correlation of bacterial load in body slime with liver as well as with kidney of *C. mrigala*.

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Effect of pond aeration on growth and survival of *Penaeus monodon* Fab.

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Abstract
The effect of paddle wheel aeration on shrimp growth and survival were studied at a commercial farm at Chandipur coast of Orissa, India, at different stocking densities of *Penaeus monodon*. Four different aeration patterns were adopted and evaluated. Influence of individual aeration pattern on average survival rate was not highly significant ($p<0.05$) at different stocking densities, while different aeration patterns had significant influence ($p<0.001$) on survival rate of *P. monodon*. It was also estimated that 1.77 hp (aerator) is needed for every 1000 kg shrimp biomass which corresponds to 1 hp/565 kg biomass of shrimp. Higher growth rate was mostly observed during 63-98 days of culture, when six 2 hp aerators were in use. Size variation in growth was higher during initial stage of rearing, while it was reduced to significant level towards the last phase of rearing as number of aerator and hour of operation increased.

Key words: *P. monodon*, Semi-intensive, Aeration, Paddle wheel

Introduction

Aeration play a key role in semi-intensive shrimp farming and reflect the pond out put as it helps in diffusing atmospheric oxygen in to the pond water and maintain dissolved oxygen level, keep the feeding zone clean and accumulate sediment at the centre, uniform water circulation (Sanares *et al.* 1986), mobilize nutrients in water column, enhancing the growth of phytoplankton and decompose organic matter due to highly facilitative aerobic environment (Mohanty 1997). Aeration is required in semi-intensive ponds when organic loading from feed drives the pond ecosystem from autotrophy to heterotrophy, as heterotrophic ponds exhibit negative net oxygen production due to excess oxygen consumption. Therefore, aeration serves to counter act oxygen depletion and stabilize diurnal dissolved oxygen level. This study however, examined the effects of paddle wheel aerator on growth, survival rate and yield of *P. monodon*, examined the effects of paddle wheel aerator on growth, survival rate and yield of *P. monodon* at different stocking density and evaluated optimum aeration requirements.

Materials and methods

The present study was carried out at "Shrimp Culture Pilot Project" at Chandipur coast Orissa, India during 1996-97. Three ponds of 7500m^2 each (P_1, P_2, P_3) and three ponds of 600m^2 each (P_4, P_5, P_6) were selected for proposed study. Stocking density of *P. monodon* was 35, 25, 15, 30, 20, and 10 PL for pond no. P_1, P_2, P_3, P_4, P_5, and P_6 respectively, through out the four crop of experimental periods. Artificial high energy supplemental feed (NOVO feed, Thailand) was used through out the experimental periods, while periodic water exchange (2-30%), liming, fertilization and pond aeration using paddle wheel aerator was a regular practice. Four different aeration patterns were evaluated (one pattern/crop) to study the utility of aerators, its operation timing and effects on growth and survival of *P. monodon*.

Physioco-chemical parameters of pond water e.g. dissolved oxygen (DO), temperature, pH, turbidity, CO_2 and salinity were monitored *in situ* every day between 0700-0800 hours and 1500-1600 hours. Weekly analysis of other physioco-chemical parameters of pond water, discharge water and monthly analysis of pond soil and sediment samples were carried out using standard methods (APHA 1989, Biswas 1993, Dash and Pattanaik 1994). Field test instruments were in use to analyze water pH (Checker 1, HANNA, USA), soil pH (DM 13), water salinity (S 10, ATAGO, Japan) and DO (YSI 55, USA).

Weekly growth study was carried out by sampling prior to feeding, so that complete evacuation of gut was ensured. Growth performance and factors affecting growth were statistically analyzed. Weekly condition factor were analyzed as described by Bal and Rao (1990). Weekly average body weight, average daily growth, survival rate, biomass, feed requirement, % feed used, amount of check tray feed, feed increment per day and FCR was estimated using formulas as described by Mohanty (1997).

Results and discussion

During the four crop experimental period the mean maximum and mean minimum of various physioco-chemical parameters of pond water were recorded (Table 1). As the day of culture increased, increased trend of H_2S, NH_3 and BOD, and decreased trend of turbidity was observed which may be due to increased feed input (Fugimura 1989), metabolic waste, increased biomass and organic load (Mohanty 1997). The average values of soil pH, EC, organic carbon, $CaCO_3$, available-N and P were gradually increased as the days of culture increased. Correlation of shrimp yield with soil pH, soil salinity and organic carbon contents was found significant at 5% level, while with available-N, it was highly significant ($P<0.01$). Growth performance, yield and survival rate at different stocking density and aeration pattern was recorded (Table 2). The feed conversion ratio (FCR) was recorded highest (1.649) in P_1, crop-II and lowest (1.285) in P_6, crop-IV. Overall growth performance was good at stocking density of 20-30 pcs/m^2, while overall yield and survival rate was higher under 3rd pattern of aeration (Table 2).

Table 1. Crop-wise mean maximum and minimum values of physioco-chemical parameters

Parameters	1st crop 1996		2nd crop 1996		3rd crop 1997		4th crop 1997	
	Max.	Min.	Max.	Min.	Max.	Min.	Max.	Min.
Temp. (°C)	3.18	23.0	27.7	15.9	32.1	22.6	26.9	15.6
DO (mg/l)	8.2	4.7	7.1	4.2	.3	3.9	8.8	3.8
pH	8.5	7.0	8.3	6.6	8.4	6.8	8.4	6.6
Salinity (mg/l)	28.0	16.0	10.0	3.0	29.0	13.0	17.0	2.0
Turbidity (cm)	80.0	18.0	73.0	11.0	84.0	13.0	65.0	9.0
Total alkalinity (mg/l)	143.0	91.0	143.0	76.0	152.0	86.0	139.0	78.0
Free CO_2 (mg/l)	3.91	0.8	5.84	1.2	3.12	0.93	2.96	0.89
H2S (mg/l)	0.13	0	0.16	0	0.13	0	0.13	0
NH_3 (mg/l)	0.2	0	0.12	0	0.2	0.002	0.1	0
P (mg/l)	0.076	0.05	0.11	0.06	0.088	0.062	0.14	0.057

Table 2. Pond-wise crop result at different aeration pattern

Pond no.	Crop I			Crop II			Crop III			Crop IV		
	ADG (g)	Yield (t/ha)	SR (%)	ADG (g)	Yield (t/ha)	SR (%)	ADG (g)	Yield (t/ha)	SR (%)	ADG (g)	Yield (t/ha)	SR (%)
1	0.24	8.75	70.9	0.23	1.22	13.3	0.23	9.0	90.01	0.26	5.44	47.64
2	0.24	6.4	83.7	0.23	2.13	32.04	0.23	8.74	89.04	0.27	5.07	57.94
3	0.26	3.72	73.24	0.22	1.07	26.35	0.27	3.58	75.01	0.25	3.17	70.31
4	0.25	7.75	78.15	0.22	1.94	27.71	0.24	8.3	93.0	0.27	5.81	56.82
5	0.25	4.98	85.87	0.22	1.58	32.98	0.28	5.17	77.1	0.26	4.38	59.49
6	0.25	1.84	70.1	0.21	1.11	48.72	0.27	2.83	80.08	0.28	1.84	55.02

ADG = Average daily growth, SR = Survival rate

Ponds can be aerated continuously during night time or an emergency basis. Day time aeration is generally not necessary and could be counter productive (Sanares *et al.* 1986) but heavily fed ponds may require continuous aeration to mix water and to avoid anaerobic bottom condition where, aeration hour is generally increased from 12 h/night to 24 h/day as the rearing period increases. In some instances, aeration does not result in increased production and drive production cost to economic non-viability (Stern *et al.* 1991). However, in the present experiment, it was observed that, influence of individual aeration pattern on average survival rate of *P. monodon* was not highly significant at different stocking densities (Table 3), while third aeration pattern showed better performance over other patterns (Table 4), which was also found economically viable to reduce production cost/kg shrimp.

Table 3. Crop-wise aeration pattern

Days of culture	Aerators/ha	Hours of mechanical aerator operation			
		1st crop	2nd crop	3rd crop	4th crop
1-15	4, 2 HP	10	8	9	8
16-30	4, 2HP	12	10	11	10
31-45	4, 2HP	14	12	13	12
46-60	4, 2HP + 2, 1HP	16	14	15	14
60-75	6, 2HP	17	15	16	15
76-90	6, 2HP	18	16	17	16
91-110	8, 2HP	19	17	18	18
111-130	8, 2HP	22	19	20	20
Above 131	8, 2HP	22	19	20	20
	Results	Pattern A	Pattern B	Pattern C	Pattern D
	Survival rate (%)	70.1-85.8	13.5-48.7	75-93	47.6-70.3

Table 4. Influence of different aeration pattern on average survival rate (%) of *P. monodon* at different stocking densities (ANOVA)

Sources of variation	Degree of freedom	Sum of squares	Mean square	Calculated F value	Tabulated F value	P value	Significant level
Between SD	5	236.79	47.36	0.57	2.9	<0.05	NS
Between aeration pattern	3	10104.60	3368.20	40.70	9.3	<0.001	*
Error	15	1241.24	82.75	-	-		

CV = 14.68%, Standard error of treatment mean = 5.25, Standard error of differences of two means = 7.43, Critical difference value = 15.82

Aeration requirement in semi-intensive shrimp ponds vary depending upon stocking density, feeding rate, days of culture and biomass. Fugimura (1989) suggested that, supplemental aeration is required only when shrimp biomass exceeds 0.2 kg/m^2. Sandifer *et al.* (1988) recommended 0.79 hp (aerator)/1000 kg shrimp while, Wyban and Sweeny (1991) recommended 1.33 hp/1000 kg shrimp. However, in the present study 16 hp/ha were needed to get the maximum production of 9.01 t/ha, which corresponds to 1.77 hp/1000 kg shrimp or 1 hp/565 kg shrimp, whereas, Aekapan (1995) recommended 1 hp aerator for every 400 kg of shrimp biomass. Growth performance of *P. monodon* in term of average daily growth and size variation was better under third pattern of aerato schedule against that of 1st, 2nd and 4th (Figs. 1 and 2). Different aeration pattern showed significant influence (p<0.001) on average survival rate of *P. monodon* (Table 2) and survival rate ranged between 70.1-85.8, 13.5-48.7, 75.0-93.0 and 47.6-70.3 under 1st, 2nd, 3rd and 4th pattern of aeration (Table 3). However, pond-wise and crop-wise culture performance indicated better survival and growth in crops-I and III than crops-II and IV, probably due to seasonal variation (Imai 1977), low temperature, salinity and pH (Law 1988), high turbidity (Mohanty 1996) and poor phytoplankton population (Chien 1992). Crop-wise weekly mean maximum and minimum DO level in pond water were 8.2-4.7, 7.1-4.2, 8.3-3.9 and 8.8-3.8 ppm during 1st, 2nd, 3rd and 4th crop respectively. However, comparative analysis indicated better survival of *P. monodon* in 3rd crop at 3rd pattern of aeration (Table 4). Irrespective of stocking density, higher growth rate was mostly observed during 63-98 days of culture when 6-2 hp aerators/pond were in use, which closely agrees to the findings of Wyban *et al.* (1989) as overall management practice were same for all the ponds. Size variation in growth was higher in initial stages of rearing while it was reduced to significant level towards last phase of raring (Figs. 1 and 2), probably due to increased number of aerator and hour of aeration.

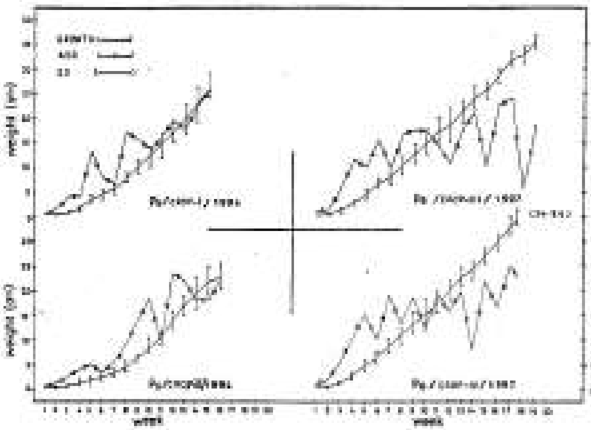

Fig. 1. Growth performance of *P. monodon* in pond-6, during four crops (SD, 10pcs/m^2)

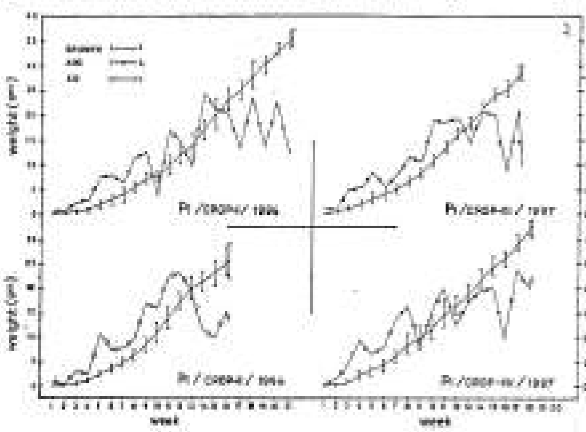

Fig. 2. Growth performance of *P. monodon* in pond-1, during four crops (SD, 35pcs/m^2)

Continuous aeration is not desirable, when DO level remains above desirable limit, especially during day times in the early days of culture and should continue during the period of low pH and plankton dei-off (Mohanty 1997). During later stage of culture when biomass and organic load in pond increase (Aekapan 1995), oxygen consumption rate increases. To supplement the oxygen requirement at this stage, additional use of aerator (approximately one 1 hp aerator for every 565 kg increase in biomass) is required. However, rational use of aerator and its position (Fig. 3) is of critical importance in managing pond bottom condition and reducing operational cost. Keeping the experimental results (Table 3) and economics of the culture operation in view, aeration hour (without affecting the survival rate of *P. monodon*) can be restricted to 9 h/day at 1-15, 11 h/day at 16-30, 13 h/day at 31-45, 15 h/day at 46-60, 16 h/day at 61-75, 17 h/day at 76-90, 18 h/day at 91-110 days of culture and 20 h/day at 111 to date of harvesting.

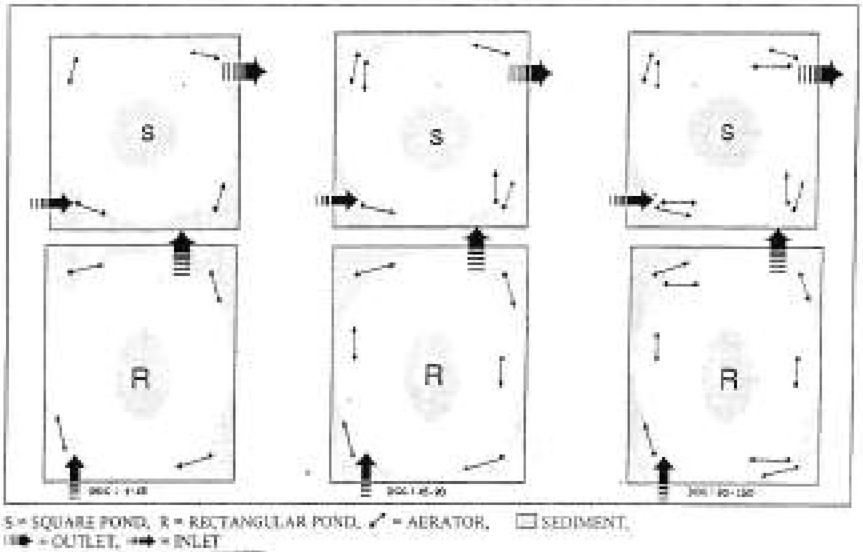

Fig. 3. Recommended position of aerators at moderate (20-30 pcsm/m2) stocking density.

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The potential of mixed culture of freshwater giant prawn *Macrobrachium rosenbergii* de Man and tiger shrimp *Penaeus monodon* Fab. at Khulna region, Bangladesh

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Abstract
The freshwater giant prawn (golda), *Macrobrachium rosenbergii* and tiger shrimp (bagda), *Penaeus monodon* were stocked together with or without fin fishes at different stocking rates in semi-saline waters at Khulna region and their growth, survival, yield and cost-return analysis were made. Survival rate of golda and bagda ranged from 23.0 to 36.8% and 8.2 to 24%, respectively. The both species were significantly affected by their own stocking density. The average final weight of golda and bagda ranged from 62.4 to 73.3 g and 32.0 to 66.4 g. The bivariate analysis of average final weight of both golda and bagda revealed that golda positively and bagda negatively influenced by the total stocking density. However, the results of the individual sizes of both golda and bagda showed an increase in the proportions of smaller animals and a decrease in the proportion of larger ones with increasing stocking rates. The harvesting weights of all animals in the experimental ghers were in marketable sizes although their prices varied with the individual size. The total production comprised of both golda and bagda ranged from 514.6 to 952.8 kg ha^{-1}, over a culture period of 10 months. Return on investment ranged from 51.0 to 125.7%.

Key words : Polyculture, *Macrobrachium rosenbergii*, *Penaeus monodon*, Cost-return

Introduction

The rapid expansion of shrimp culture over the last decade and its contribution to foreign exchange earnings has been quite remarkable. Shrimp culture covered an area of 1.4 lakh ha in 1995-'96 in contrast to 0.87 ha in 1985-'86 (DoF 1998). The biology of these two species are mostly associated with the salinity of the environment. The former is regarded as the marine or brackishwater species and the latter as freshwater species depending on their environment. In most cases, monoculture of both the species are being practiced and recently, polyculture with fin fish has been started (Hoq *et al.* 1996). However, as the market price of fin fish is much lower than that of shrimp, farmers could not show interest to practice polyculture with fin fish rather than mixed culture of both marine and freshwater shrimp species in the same ghers or ponds. There are a vast area of semi-saline waters in wide-spread coastal belt of Bangladesh in which salinity fluctuate from about 0 to 20 ppt. This type of waterbodies could be used for culturing of both golda and bagda. However, farmers in this region is practicing mixed culture of golda and bagda round the year without comprehensive study on their biological characteristics, inter-species relationship, stocking ratios and production performance. Under the Aquaculture Research for Sustainable Development Project, Bangladesh Fisheries Research Institute (BFRI) undertook this study to determine growth, survival, yield and economics of golda and bagda in polyculture system.

Materials and methods

Experimental site and gher preparation

The experiment was conducted for a period of 10 months from April'97 to January '98 in four farmer's ghers at Dumuria Thana of Khulna district. All ghers were newly constructed and equal in size and depth with an area of 0.5 ha and an average depth of 1.0 m. The experimental area was low-land floodplain area beside the river Hamkura which is a dead one, flowing only in the rainy season. Lands of gher were leased from land owner for a period of 10 years except gher 4. In December-January, embankments of the ghers were constructed. Each gher was made in such a way that a deep drain (about 2.5 m) at the two border side of the ghers were made and the soil was used to make the embankment. Embankments were made wider (1 m) for escaping break down during the rainy season. Different types of vegetables were cultured on to the embankment.

The ghers were ploughed and treated with lime (80 kg/gher) and cowdung (500 kg/gher) in February. In March, the ghers were filled up with water by low-lift pump and afterwards ghers were received rain water.

Stocking of shrimp and fish

Stocking of shrimp and fish seeds started from April and continued up to June, 1997 on an irregular basis in all of the experimental ghers. As practiced, farmers did not agree to stock fin fish alongside the shrimp, but they were motivated to stock few fin fish in the experimental ghers except gher 4. However, farmers had the freedom to maintain all aspects of stocking and management practices with a little suggestion from the respective scientist. Fry *Macrobrachium rossenbergii* (locally called golda) and *Penaeus monodon* (locally called bagda), and fingerlings of fin fish were procured from natural sources through local traders. Detailed species combinations and stocking densities in different ghers are presented in Table 1.

Table 1. Species combinations and stocking densities in different experimental ghers

Species	Gher 1	Gher 2	Gher 3	Gher 4
Macrobrachium rossenbergii	27,600	9,250	8,500	16,500
Penaeus monodon	6,900	9,250	8,500	1,000
Fin fish	500	1500	500	--
Total	35,000	20,000	17,500	17,500

Gher management

A feeding programme was maintained to each pond on more or less regular and daily basis as appeared in Table 2. A mixture of rice bran and fish meal with or without mustard oil cake was supplied in the morning and snail meat in the evening to the experimental ghers. No fertilizer was applied to the ghers during the culture period.

Some shelters made of coconut branches and plastic pipe were kept on the bottom of ghers so that the shrimps could take shelter during their molting. Shrimp and fish samples were collected monthly with a cast net to check up their health condition.

Table 2. Summary of the feeding programme applied to the experimental ghers

Food Item	Gher 1	Gher 2	Gher 3	Gher 4
Rice/wheat bran (kg)	1.0	2.0	3.5	1.0
Mustard oil cake (kg)	1.0	Nil	Nil	Nil
Fish meal (kg)	0.5	1.0	1.0	1.0
Snail meat (kg)	2.5	3.5	4.0	4.0
Total	5.0	6.5	8.5	6.0

Study of water quality parameters

Some water quality observations – temperature, pH, salinity, Dissolved Oxygen (DO) and total hardness were recorded during 1000-1100 h at monthly intervals using a HACH kit (FF-2).

Harvesting

The farmers started harvesting of farmed animals in irregular basis from August 1997 to January 1998 with a seine net and sold the products to the local depot. The grade (size) of shrimp, quantity, respective price and total cost were recorded regularly. In January, all the ghers were de-watered and all the marketable animals were harvested.

Results and discussion

Physico-chemical parameters of the experimental ghers are shown in Table 3. Temperature varied from 18.5 to 33.5°C with the mean values of 31.1, 30.2, 29.6 and 30.5°C in ghers 1, 2, 3 and 4, respectively. Ling (1969) recommended the range of temperature from 22-32°C for optimum growth of freshwater prawn which was the case in the present study. The pH of water was almost around the neutral and ranged from 7.0 to 8.5 in gher 1, 6.5 to 8.5 in gher 2, 7.0 to 8.5 in gher 3 and 7.0 to 8.0 in gher 4. The trend of salinity of the gher was almost same in all the experimental ghers. It ranged 0-15 ppt with the mean values of 10.3, 9.5, 8.8 and 9.8 ppt in ghers 1, 2, 3 and 4, respectively. The salinity was higher at the beginning of the experiment and gradually declined with the rainfall. Siddiqui *et al.* (1997) reported 5 ppt salinity for prawn culture in their study. Dissolved oxygen (DO) varied from 4.0 to 7.1 mg l^{-1} with the mean values of 5.1, 5.8, 6.0 and 6.1 in ghers 1, 2, 3 and 4, respectively. Total hardness varied from 40.0 to 80.0 mg l^{-1}

with the highest mean value in gher 4. However, mean total hardness content of water of gher 1, 2, 3 and 4 were 54.8, 55.6, 54.0 and 74.0 mg l^{-1}, respectively. New (1995) recommended the total hardness level for prawn culture is 40-60 mg $CaCO_3$ /l which agreed with the present study. However, all the water quality parameters were within the acceptable range for prawn culture (Ling, 1969; New, 1995; Siddiqui *et al.*, 1997).

Table 3. Mean values of water quality parameters of different ghers during the study period

Parameters	Gher 1	Gher 2	Gher 3	Gher 4
Temperature (°C)	31.1	30.2	29.6	30.5
	(18.5-33.5)	(19.0-32.5)	(18.5-33.0)	(19.5-33.0)
pH	(7.0-8.5)	(6.5-8.5)	(7.0-8.5)	(7.0-8.0)
Salinity (g/ l)	10.3	9.5	10.8	9.8
	(0.5-15.0)	(0.0-14.0)	(0.5-14.5)	(0.0-15.0)
Dissolved Oxygen (mg/l)	5.1	5.8	6.0	6.1
	(4.5-6.0)	(4.0-6.5)	(4.0-6.6)	(4.5-7.1)
Total Hardness (mg/l)	54.8	55.6	54.0	74.0
	(44.0-63.5)	(45.0-71.5)	(40.0-65.0)	(45.0-80.0)

The yield parameters of the two shrimp species in different ghers are shown in Table 4. The farmers used the fin fish for self consumption, hiring the labour to catch prawn and giving the relatives. For this reason, the account of the fin fish was not considered in this study.

Survival rate of golda and bagda ranged from 23.0 to 36.8% and 8.2 to 24%, respectively in this study. The highest survival of golda was observed in the gher 2 where the medium stocking density (40,000 ha^{-1}) and equal ratio of golda and bagda along with fin fish at the rate of 3000 ha^{-1} was maintained. However, the lowest survival rate was recorded from gher 1 where the highest stocking density (70,000 ha^{-1}) and four times higher number of golda in comparison to bagda along with fin fish at the rate of 1000 ha^{-1} was cultured. On the other hand, bagda showed the higher survival rate in the gher 4 where the lowest density of bagda and no fin fish stocked. However, the lowest survival rate of bagda was observed in the gher 2 where golda showed the highest survival indicating that the both species were affected by increasing stocking density and there was an antagonistic relationship between the two species. Hoq *et al.* (1996) reported that the survival rate of prawn ranged from 32.2 to 75.7% (mean 51.1%) in a polyculture with fin fish which is quite higher than that of the present study. Scott *et al.* (1988) found an average 63% survival of golda in a polyculture with golda and gold shiner. The lower survival of the present study might be due to stocking of fry rather than juveniles in the present study which are available and cheaper in comparison to juvenile ones. It is fact that availability of shrimp seeds both of golda and bagda mainly depends on the natural sources and is decreasing day by day. Juveniles prawn are scarce and expensive in this region. The regressions of survival rate of both golda and bagda on total stocking density

Table 4. Yield parameters of Golda and Bagda in different ghers

Gher/Pond		Gher 1				Gher 2						Gher 3			
Species	Golda	Bagda	Fish	Total	Golda	Bagda	Fish	Total	Golda	Bagda	Fish	Total	Golda	Bagda	Total
No. stocked	55200	13800	1000	70000	18500	18500	3000	40000	17000	17000	1000	35000	33000	2000	35000
No. harvest	12696	2622	-	14700	6808	1517	-	9000	6069	3825	-	10185	7821	480	8330
Survival (%)	23.0	19.0	-	21.0	36.8	8.2	-	22.5	35.7	22.5	-	29.1	23.7	24.0	23.8
Av. final wt (g)	68.44	32.0	-	41.8	73.3	49.8	-	61.5	70.6	22.5	-	46.6	62.4	66.4	64.4
Production (Kg/ha)	868.9	83.9	-	952.8	499.0	75.5	-	574.5	428.5	86.1	-	514.6	488.0	32.0	520

are slightly negative but not significant (Fig. 1). Whereas, the survival affected by their own stocking density (Golda r = -0.87; Bagda r = -0.63). Wohlfarth *et al.* (1985) reported that prawns were influenced only by their own stocking ratio which correlated positively with yield and negatively with individual growth in a polyculture trial with fin fishes.

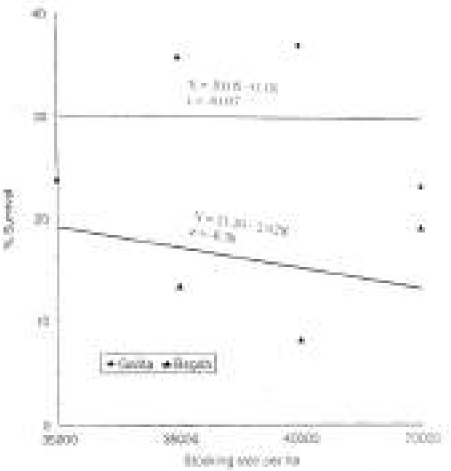

Fig. 1. Bivariate analysis of survival on total stocking density.

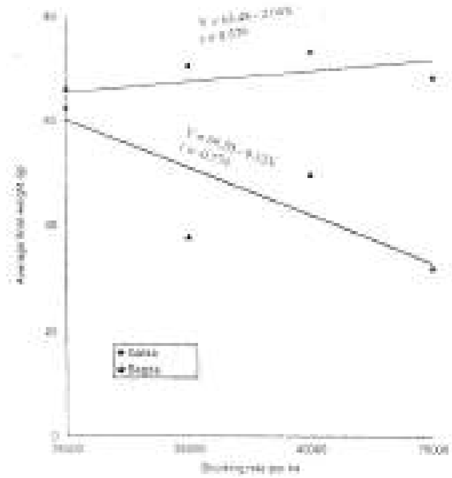

Fig. 2. Bivariate analysis of final weight on total stocking density.

A clearly distinguishable growth was observed among the ghers when final weight of golda and bagda was taken into consideration. Average final weight of golda were 68.4, 73.3, 70.6 and 62.4 g in Ghers 1, 2, 3 and 4, respectively. Whereas, average final weight of bagda were 32.0 g in Gher 1, 49.8 g in gher 2, 37.8 g in gher 3 and 66.4 g in gher 4. The bivariate analysis of average final weight of both golda and bagda (Fig. 2) revealed that golda positively and bagda negatively influenced by the total stocking density. The average highest final weight of golda and bagda in the gher 2 and 4 respectively, are attributed to be the lower stocking density of the species resulting less intra-species competition for food and space. Siddiqui *et al.* (1997) cultured *M. rosenbergii* at a stocking density of 100,000 ha^{-1} in concrete tank and reported that the final mean body weight decreased with the increasing stocking density. The positive correlation between stocking rate and final weight of golda in the present study indicated that the stocking density might be increased within a certain limits without hampering growth rate.

The growth increment data were extrapolated in order to express the result in hectare. The production of golda in ghers 1, 2, 3 and 4 were 868.9, 499.0, 428.5 and 488.0 kg ha^{-1}, respectively. Whereas, the production of bagda were 83.9, 75.5, 86.1 and 32.0 kg ha^{-1} in ghers 1, 2, 3 and 4, respectively. However, the total production comprised of both golda and bagda in ghers 1, 2, 3 and 4 were 740.3, 574.5, 514.6 and 520.0 kg ha^{-1}, respectively. The overall production of all the experimental ghers were satisfactory in comparison to shrimp production of about 70-100 kg/ha owing to the practice of traditional extensive culture technologies in the experimental region (Wahab 1998). Hoq *et al.* (1996) reported the highest prawn production of 428.4 kg/ha in a polyculture system with golda and other fin fishes in the same region. However, the bivariate analysis of stocking density and total production as appeared in Fig. 3 revealed that the production was increased with the stocking density. Similar observation was reported by Hoq *et al.* (1996) in a polyculture of *M. rosenbergii* with the fin fishes. The results of the individual sizes of both golda and bagda as appeared in Table 4 showed an increase in the proportions of smaller animals and a decrease in the proportion of larger ones with increasing stocking rates. The harvesting weights of all animals in the experimental ghers were in marketable sizes although their prices varied with the individual size. However, since the marketable size of prawn had not been hampered by higher stocking density, we recommend the higher stocking density (70,000 ha^{-1}) with a ratio of 4:1 for golda and bagda with few fin fishes.

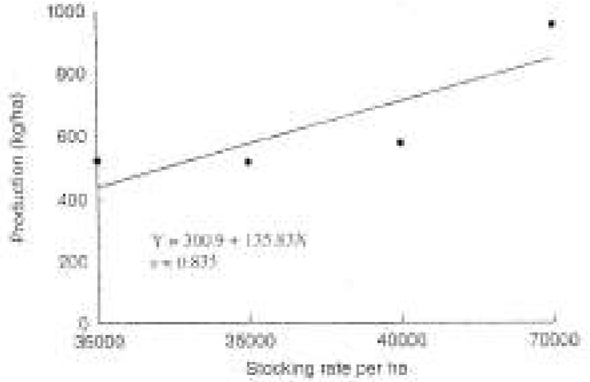

Fig. 3. Regression analysis of production and total stocking density.

Cost-return analysis of the experiments is presented in Table 5. The main items for expenditure were land rental value, gher construction and preparation, seeds, feeds, etc. Although gher 4 was not leased, same amount of rental value was supposed for comparing it to the others. A slightly higher amount of money was spent for construction and preparation of the gher 1. The large amount of money was used for feeding purpose in gher 3 followed by gher 2, 4 and 1. Cost-return analysis of the experimental ghers indicates that it is a highly profitable business. The analysis also revealed that the profit as well as production characteristics of shrimp were independent of supplemental feed. The growth of prawn mostly resulted from utilizing natural food components (Schroeder 1983) stimulated by the manure and its degradation products (Wohlfarth and Schroeder 1979). The soil fertility of the experimental ghers was very high and the decomposed products of plants and silts were observed during the construction of ghers. However, it might be better to apply the manure instead of supplemental feed to the ghers. Among the ghers, economic return was better in gher 1 followed by gher 2, 4 and 3. Return on investment in gher 1, 2, 3, and 4 were 125.7, 119.3, 61.3 and 51.0%, respectively.

Table 5. Cost-return analysis of experimental ghers

Gher/pond	Gher 1	Gher 2	Gher 3	Gher 4
Input costs (Tk.)				
Land rental value	10,000	10,000	10,000	10,000
Gher construction and preparation	17,400	13,365	13,600	13,030
Shrimp/fish seeds	19,534	12,646	17,816	12,906
Cowdung & Lime	680	680	680	680
Feed	8750	13,800	16,950	13,200
Total input cost	56,364	50,491	59,046	49,816
Total return	127,225	110,711	95,233	75,247
Net profit	70,861	60,220	36,187	25,431
Return on investment (%)	125.7	119.3	61.3	51.0

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Observation on some of the environmental parameters of selected shrimp farms in Khulna, Bangladesh

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Abstract
In recent years, the ecological degradation, loss of technological sustenance and other multidimensional consequences caused by shrimp farming have made the experts and authorities bound to rethink about the development of the industry. The present study describes the water and sediment quality, and culture and management techniques in five selected shrimp farms at Paikgacha, Khulna throughout a production cycle from March to September 1997. The water quality parameters were found to be more or less suitable throughout the cycle. The concentration of the limiting major nutrients such as nitrogen and phosphorus and minor nutrients such as calcium and magnesium were satisfactorily high, concentrations of the organic matter content were also high. Remarkable negative correlation of shrimp production with secchi depth was observed among the farms. Production per cycle ranged between 273 kg/ha and as low as 63 kg/ha.

Key words: Extensive shrimp culture, Water quality, Sediments.

Introduction

Shrimp farming in the coastal waters of Bangladesh has expanded as elsewhere in the region in the last two decades. In the early seventies, Bangladesh entered the world export market of shrimp and since then shrimp has become a very high priced commodity. Consequently, more and more areas were brought under brackishwater aquaculture and more people engaged themselves in the shrimp farming practice. The increasing demand and steadily rising price of shrimp in the international market caused a silent revolution in the development of brackishwater farming. The role of shrimp farming in supplying animal protein, in income generation, in earning foreign exchange and in the socio-economic development of the country is worth exploring.

Shrimp culture techniques used in Bangladesh are different, depending on many factors. Karim and Aftabuzzaman (1995) and DOF (1997) divided shrimp culture techniques into extensive, improved extensive, semi-intensive and intensive types on the basis of the degree of management applied. With these four types, Deb (1998) added a new one namely, traditional, where least or no management practice is applied. Since different methods require different degrees of management, the production rates also differ remarkably with the method employed. Water and soil quality parameters of shrimp farms are important not only for the fact that production is affected by them but also that water and sediment quality problems are now common in shrimp farms in many parts of the world. Furthermore, environmental problems caused by changes in water and soil quality due to shrimp farming are now a global concern. Various aspects of water and sediment qualities in shrimp farms and their effects on the environment have been studied by Hopkins *et al.* (1995), NACA (1995), Dierberg and Kiattisimkul (1996), Hariati *et al.* (1996), Smith (1996), Deb (1998), and Islam *et al.* (1998).

The present investigation was conducted with the objective of exploring the culture methods followed by the shrimp farmers, the degree of management applied, the water and sediment quality parameters maintained during the farming cycle and the rate of production in relation to the inputs used. Such base line information is undoubtedly important to justify the introduction of more effective and advanced management practices.

Materials and methods

The study area

The study was conducted at Paikgacha Thana in Khulna, a southwest district of Bangladesh. Paikgacha is a famous shrimp farming area with about one thousand small and large farms. Five farms located in different unions were selected for the present study. Among the selected farms, 3 were fed by the Kopotaksya River and the rest 2 by the Shibsa River. The farms are located in the medium saline zone according to salinity zonation.

Shrimp farming techniques

After completion of paddy culture (from August to December), lands are ploughed and left to dry out for about a week in the sunshine. After ploughing the lands, agricultural lime (calcium carbonate, $CaCO_3$) is applied at the rate of 500-1000 kg/ha, which is usually followed by fertilization (after 7 to 10 days of liming) by organic and inorganic fertilizers. Organic fertilizer (cowdung) is applied at the rate of 1,000-3,000 kg/ha and inorganic fertilizers (urea: TSP = 1:1) at the rate of 100 kg/ha.

Water is introduced into the farm during the new moon or full moon, when there is a high tide. Water in the farm is usually supplied 3 to 5 days after fertilization. After 7 to 10 days of fertilization, shrimp fry are transferred from the nursery ponds to the farms. Farmers usually do not maintain particular stocking density, being affected by the availability of fry and financial status of the farmers. However, most farmers try to stock at a density of 20,000-25,000 PL per hectare (2 to 2.5 PL m^{-2}).

Water quality parameters

Sampling for water quality parameters was done fortnightly to investigate the chemical parameters during the culture period. The parameters studied were temperature, transparency, salinity, pH, dissolved oxygen (DO), total hardness, total suspended solids (TSS), nitrate nitrogen (NO_3-N), ammonia nitrogen and phosphate phosphorus (PO_4-P).

Water samples were taken from at least three spots inside each farm; in addition, samples were also taken from inlet and outlet. Water temperature was recorded in the field by a Celsius thermometer. pH of water was measured by a pH-meter (JENWAY3020). Dissolved oxygen was measured by a digital DO-meter (YSI58). Salinity of water was determined in the field by a salinity refractometer. TSS of water was determined by using the methods described by Strickland and Parsons (1972).

To determine the remaining chemical parameters, water was filtered by a hand filter set and accordingly preserved, brought to and analyzed at the Laboratory of the Faculty of Fisheries, Bangladesh Agricultural University, Mymensingh.

Sediment quality parameters

Samples of sediments from the farms were collected and air-dried. Samples were analyzed for pH, total dry matter (T-DM), organic matter, ash, calcium, magnesium, kjeldahl nitrogen, total phosphorus, and total sulfur. Analyses of the accurately preserved samples of sediments were done at Rogaland Research, Stavanger, Norway.

Production and yield

Data on the total production of individual farm as well as the production of each species of shrimp, and crab were collected from the farm record book of each farmer, and data on the production of white finfish were also obtained for each farm. All data represent a single production cycle. The total gross return at the end of a cycle is also recorded for each farm from the cash register of the farmer.

Result and discussion

Shrimp farming techniques

According to the information obtained from the farmers, it was found that in all the selected farms the methods used for shrimp farming is extensive or rarely improved extensive. The culture period extends from January-February to July-August. Mixed culture of tiger shrimp or 'bagda' (*Penaeus monodon*) with heterogeneous species is followed in all the farms. Species other than bagda such as *Metapenaeus monoceros*, *Penaeus semisulcatus* and *Penaeus indicus* are common in all the farms. *Macrobrachium rosenbergii* in farm-1 and farm-3, *Penaeus penicillatus* in farm-1, farm-2, farm-4 and one species of crab in farm-4 were found in addition to the species mentioned above. Besides this, a few species of finfish were also common in all farms. However, in all the farms, *P.*

monodon was the major species. A shrimp production cycle was followed by another cycle of paddy. For shrimp seed, the farmers rely solely on the natural stock.

The present findings of all aspects of traditional extensive shrimp culture methods agree with that of Karim and Aftabuzzaman (1995) and DOF (1997).

Water quality parameters

The results of the water quality parameters of the selected farms have been shown in Table 1. The highest mean temperature of 31.08° C was recorded inside the farm 1 and farm 3 and the lowest, 25.8° C, at the outlet of farm 5. For all farms, the temperatures of the inlet and outlet were always lower than that obtained inside. This may be due to the fact that the temperature of incoming water was lower than that of the farms and that there may be a heat exchange between the outlet and the discharge water. Higher temperatures inside the farms may be attributed to higher thermal conductivity of water due to lower water depth (Islam *et al.* 1998). However, variation in water temperatures between farms was not significant and the temperatures were within acceptable ranges for shrimp culture (FRI 1998). Slight variations in temperatures in farms may be due to variation in water depth (Hariati *et al.* 1996).

The highest transparency, 25 cm, was recorded inside the farm 4 and the lowest, 12 cm at the outlet of farm-1. The higher overall mean transparency, 22 cm, was also recorded in farm-4 and the lower, 14 cm, in farm-1. Remarkable negative correlation between transparency and production (kg/ha) was observed among the farms. Hariati *et al.*(1996) reported that the reason for higher production at lower transparency being a higher survival rate caused by the availability of algae and particulate matter to the shrimp at the bottom, which graze on them. There was also remarkable variation in the transparency values among the farms, which may be due to variation in the rate of fertilizers used. Although TSS in farm-1 was slightly higher than that of the others, the higher dissolved oxygen concentrations of the farm support the fact that the lower values of transparency were due to the concentration of plankton, this was also true for farm-2. This findings were similar to that of Hariati *et al.* (1996). The transparency values were within the range required for shrimp farming as per standard set out by NACA (1995) and Hariati (1996).

The range of salinity was from 2.0 ppt. at the outlet of farm 4 to 8.8 ppt. at the outlet of farm-1. The highest overall mean salinity was 6.7 ppt in the farm-5 and the lowest, 2.9 ppt. was in the farm-4. Higher salinities were observed at the outlets than that at the inlets and insides of all farms except farm-4, where higher value was found inside. Farm-4 was also an exception in that the variations in mean salinity among the other farms was little. According to NACA (1995), the optimum salinity range for tiger shrimp is 10.0-20.0 ppt. In this respect, the experimental farms were not suitable for shrimp culture. The drop in salinity values was due to heavy rainfall in the monsoon. However, Chakrabarti *et al.* (1985) reported that high salinities at stocking favour PL survival and Sinderman and Lightner (1988) reported that lower salinities towards the end of the production cycle when the shrimp biomass was high reduce the chance of occurrence of *Vibrio* spp. infections.

Table 1. Mean values of water quality parameters in selected shrimp farms during the study period

Farm		Temperature (^{0}C)	Secchi disc Transparency (cm)	Salinity (ppt)	Total Hardness (mg/l)	Dissolved Oxygen (mg/l)	pH	TSS (mg/l)	NO_3-N (mg/l)	NH_3- N (mg/l)	PO_4-P (mg/l)
1.	Inlet	29.5±1.5	15±3.8	4.6±3.7	552.5±48.5	6.5±0.1	7.8±0.3	1.8±0.2	1.60±0.3	1.66±0.4	0.144±0.02
	Inside	31.1±1.6	23±5.8	5.7±3.3	784.2±67.9	4.5±3.5	8.1±0.2	1.9±0.0	1.28±0.6	2.08±0.4	0.143±0.02
	Outlet	28.1±2.0	12±0.2	8.8±0.0	1054.2±33.0	6.7±2.4	6.9±0.3	2.9±0.3	1.89±0.8	2.14±0.4	0.384±0.02
2.	Inlet	29.5±1.5	14±0.5	5.1±4.2	553.5±47.5	7.0±0.2	7.9±0.1	1.9±0.0	0.95±0.9	1.79±0.1	0.156±0.05
	Inside	29.7±0.4	20±5.0	6. 7±3.8	662.3±45.0	4.1±0.0	8.3±0.1	2.1±0.2	1.1±0.4	2.15±0.1	0.228±0.08
	Outlet	29.1±1.9	12±0.2	7.1±0.1	1105.2±0.3	5.9±3.1	5.1±0.8	2.9±0.1	1.9±0.8	2.01±0.6	0.304±0.78
3.	Inlet	29.3±0.0	22±0.0	4.4±0.0	730.9±0.0	5.2±0.0	7.8±0.0	1.0±0.0	1.8±0.0	1.7±0.0	0.165±0.00
	Inside	31.1±1.4	19±3.8	5.5±2.9	630.5±17.9	4.1±0.1	8.2±0.5	1.9±0.0	1.1±0.3	1.89±0.04	0.133±0.01
	Outlet	31.0±2.0	19±6.0	5.6±3.6	1107.0±95.0	6.3±0.0	8.3±0.3	2.2±0.2	0.7±0.2	2.04±0.2	0.129±0.02
4.	Inlet	28.0±0.0	19±0.0	2.4±0.0	607.6±0.0	4.3±0.0	7.0±0.0	1.7±0.0	1.6±0.0	1.95±0.0	0.296±0.00
	Inside	29.6±1.1	20±2.5	4.4±2.5	734.5±103.9	5.4±0.1	8.2±0.1	1.9±0.2	1.48±0.1	1.87±0.2	0.216±0.10
	Outlet	28.0±0.0	10±0.0	2.0±0.0	1154.0±0.0	6.7±0.0	9.0±0.0	2.1±0.0	0.1±0.0	2.43±0.0	0.154±0.00
5.	Inlet	29.5±1.5	10±1.8	6.5±4.7	568.5±140.5	5.4±0.1	8.1±0.2	1.9±0.1	1.15±0.5	1.95±0.1	0.112±0.02
	Inside	31.0±1.4	23±5.0	6.7±4.5	787.9±20.7	4.7±0.2	8.6±0.3	1.7±0.2	0.98±0.5	1.99±0.1	0.141±0.01
	Outlet	25.8±0.0	15±0.0	7.0±0.0	988.0±0.0	6.1±0.0	7.1±0.0	2.1±0.0	1.9±0.0	1.08±0.0	0.244±0.0

The highest dissolved oxygen concentration of 7.0 mg/l was recorded at the inlet of the farm-2 and the lowest, 4.1 mg/l, inside the same. The overall mean of DO was higher in farm-2 and lower in farm-3, 5.7 and 5.3 mg/l respectively. According to NACA (1995), Boyd 1994 and Chin and Ong 1994 who suggested respectively >5 mg/l and 3.8-5.0 mg/l, the DO concentrations were favourable throughout the experimental period. DO values at the inlets and outlets were always higher than that inside the farms which may be due to higher rate of water movements at the inlets and outlets than inside the farms. However, no significant variation in the overall mean values was among the farms.

The highest value of pH , 9.0, was observed at the outlet of the farm-4 and the lowest, 5.0, at the outlet from farm-5. The overall mean pH was higher in farm-3 and farm-4 (8.1) and lower in farm-2 (7.8). No significant variation in p^H among the farms was observed. Chakrabarti *et al.* (1985) stated that many variations in pH usually do not occur in shrimp farms owing to the buffering capacity of brackishwater. The overall mean pH values were suitable for shrimp culture as the optimum range of 7.5-8.9 was recommended by NACA (1995).

The highest value of total hardness was observed at the outlet of the farm-4 (1154 mg/l) and the lowest at the inlet of farm-1 (553 mg/l). The overall mean values ranged between 774 mg/l in farm-2 and 832 mg/l in farm-4. The variation in total hardness among farms may be attributed either to the variation in soil in different regions or to the variation in lime doses applied. But the values can be considered suitable according to Clarke (1954) as reported by Islam *et al.* (1998).

The recorded highest value of TSS at the outlet of the farm-1 and farm-2 was 2.9 mg/l and the lowest at the inlet of farm-3 was 1.0 mg/l. The range of overall mean value was 1.7-2.3 mg/l in farm-2 and farm-3 respectively. Deb (1998) reported the range of TSS being 119-225 mg/l in intensive shrimp pond effluent water. Dierberg and Kiattisimkul (1996) also reported higher values in intensive shrimp farms (184 and 5810 mg/l). The much lower values in the experimental farms may be due to the fact that inputs used in extensive farming are negligible as compared to that in intensive system.

Higher nitrate nitrogen of 1.90 mg/l was found at the outlets of farm-2 and farm-5 while lower value of 0.1 mg/l was recorded at the outlet of farm-4. The overall mean value was higher in farm-1 (1.59 mg/l) and lower in farm-4 (1.06 mg/l). Nitrate content was found to be more or less homogeneous between inlet, outlet and inside for farm-1, 2 and farm-5. But the outlet values of farm-3 and farm-4 were found to be remarkably different from that at inlet and inside. This may be due to the fact that the nitrate was used up by phytoplankton before being accumulated at the outlet. Logical supports to this opinion are that for both the farms, the values decreased gradually from inlet through inside to the outlet and that the overall values were also lower in these two farms than the other three. Deb (1998) reported nitrate range of 0.05-1.54 mg/l in intensive shrimp pond effluent water. NACA (1995) reported that even at concentrations of 300 mg/l of nitrate, it is reported that shrimp can grow normally. The nitrate values found in the present study were acceptable for shrimp farming as reported by Allan *et al.* (1995).

The minimum and maximum values of ammonia nitrogen (TAN = NH_4^+-N + NH_3-N) of 1.08 mg/l and 2.43 mg/l were recorded at the outlet of farm-5 and farm-4 respectively. The overall mean value was minimum at the farm-5 (1.67 mg/l) and maximum at the farm-4 (2.08 mg/l). Concentrations at the inlet, outlet and within the farms as well as the overall mean values among the farms were not found to vary significantly.

Ionized ammonia, or ammonium (NH_4^+), is considered non-toxic to fish and crustaceans animals, while the unionized form, ammonia (NH_3), is highly toxic. For successful production of penaeids, the unionized ammonia (NH_3) should not be more than 0.10 mg/l (NACA, 1995). In a recent paper, Wahab *et al.* (in press) indicated peak concentrations of unionized ammonia of 0.5 – 1.0 mg/l in several of these farms due to increased pH in the afternoon (pH > 8.5). Allan *et al.* (1990) proved a growth reduction of 5% in *Penaeus monodon* at 0.21 mg NH_3-N/l. Obviously, the ammonia peaks in the afternoon fluctuated within the "sub-lethal" range and consequently might have created stressing conditions for the shrimp stocks. Outbreaks of White Spot Disease and other viral diseases, accounting for the major part of the mortality losses in Bangladeshi shrimp farms since 1994, often occur in ponds with poor environmental conditions.

The phosphate phosphorus content ranged from 0.112 mg/l at the inlet of farm 5 to 0.384 mg/l at the outlet of farm 1. The overall mean phosphate content of individual farm ranged from 0.142 mg/l in farm 3 to 0.229 mg/l in farm 2. Variation in the phosphate content between inlet, outlet and inside did not follow any well- defined pattern; such variations were found to occur in different manners in each farm. NACA (1995) reported that phosphate content of shrimp pond water increases with increasing stocking density. NACA (1995) also reported values of 0.0-0.02 and 0.0-0.18 mg/l of phosphate for lower and higher stocking respectively. The high amount of phosphate phosphorus content in the experimental farms might be due to heavy shower in the monsoon (David *et al.* 1969, Lin 1989, Lee and Wickins 1992).

Sediment quality parameters

The major parameters of sediments such as pH, total dry matter (TDM), organic matter, calcium, magnesium, Kjeldahl nitrogen (K-TN), total phosphorus (TP) and total sulfur (TS) are shown in Table 2. The range of pH was from 6.83 in farm-2 to 9.12 in farm-4. TDM ranged between 855 and 951 g/kg original samples in farm-2 and farm-4 respectively. The highest organic matter content of 99.4 g/kg DM was recorded in farm-4 and the lowest of 76.5 g/kg DM in farm-2. Calcium was recorded from 42.2 g/kg DM in farm-2 to 92.5 g/kg DM in farm-1. The highest concentration of magnesium was 15.3 g/kg DM in farm-2 and the lowest, 11.6 g/kg DM in farm-3. The Kjeldahl nitrogen ranged between 160 mg/100g DM in farm-1 and less than 50g/100 g DM in farm-4. The values of total phosphorus were between 33.2 mg and 40.7 mg/100g of DM in farm-3 and farm-4 respectively. The total sulfur content ranged between 74.3 mg/100g DM in farm-4 and 466 mg/100g DM in farm-3 respectively.

Table 2. Sediment quality parameters of the selected shrimp farms

Soil quality parameters	Farm-1	Farm-2	Farm-3	Farm-4	Farm-5
PH	7.79	6.83	7.02	9.12	8.98
T-DM (g/kg)	926	855	865	951	909
Organic matter (g/kg)	92.9	76.5	82.3	99.4	84.3
Ash (g/kg DM)	934	932	941	966	956
Calcium (mg/kg DM)	9,250	4,220	7,200	34,500	25,200
Magnesium (mg/kg DM)	11,740	15,300	11,550	11,600	12,580
Total -N (mg/100g)	160	130	120	<50	70
Total-P (mg/kg)	378	353	332	407	380
Total-S (mg/kg)	1,300	1,210	4,660	743	842

Soil conditions are reported to play a more important role than the water conditions do in brackish water productivity (Boyd *et al.* 1994, NACA, 1995). Chakrabarti *et al.*(1985) stated that like temperature and salinity in the water phase, organic carbon, available nitrogen and available phosphorus in the soil phase were found to have direct relation with *P. monodon* production. A more or less similar statement was also made by Boyd *et al.* (1994). The overall values of pH of the sediments were found to agree with the values reported by Chakrabarti *et al.* (1985). However, slightly acidic pH of the farm-2 may be due to the formation of acid sulphate soil (Deb 1998). The values of the other parameters were found to be surprisingly higher as compared to the values reported by Chakrabarti *et al.* (1985), NACA (1995), Dierberg (1996) and Smith (1996). The higher values are supposed to be due to the lack of proper sediment and waste management practice for long periods.

Production performances

The results of the production (per hectare per cycle) have been given in Table 3. The minimum production of 63 kg/ha was recorded in farm-4 and the maximum, 273 kg/ha in farm-3. Variations in production among farms are due to the variations in inputs used and post-stocking managerial caring. However, the production rates of the farms (except for the farm 4) agree with that reported by Karim and Aftabuzzaman (1995).

Table 3. Production data of the selected shrimp farms

Farm	Total production in the cycle studied								Av.
	Bagda	Horina	Chali	Chaca	Finfish	Golda	Kakra	Soft bagda	prod^n/ ha (kg)
1	9094.0	405.4	867.0	154.8	396.6	6.7	-	-	273
2	2925.0	115.4	76.3	13.9	226.9	-	17.82	5.6	63
3	10286.0	637.4	805.3	186.9	457.5	-	-	8.5	229
4	9462.5	697.7	898.6	121.6	727.5	37.0	-	88.6	128
5	6020.1	850.9	1182.2	38.80	345.3	-	-	-	141

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Resource productivity and economic performance of producing fish seeds in government and private farms in Bangladesh

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Abstract
The effect of various factors on spawn and fingerlings production in government and private farms was measured in this study. Primary data were collected from 45 private and 11 government farms from 9 selected districts covering major fish seed producing areas of Bangladesh. Results from Cobb-Douglas production function analysis indicated that the included variables had some positive impacts on returns from spawn and fingerlings. No input was found to be over used and increasing returns to scale was observed. Tabular analysis indicated that higher amount of input use produced higher level of yield, gross return and net return. The government farms were under utilized. For increased supply of fish seeds in the country more amount of specified inputs (feed and fertilizer) should be used for producing spawn and fingerlings especially in government farms.

Introduction

Although culture fishery under scientific management is relatively a new gesture in Bangladesh it expanded rapidly in the last decade. During 198384 to 1993-94 pond fish production increased from 107,944 MT to 222,542 MT representing more than 10.62 percent annual increase as against only. 4.47 percent increase in overall fish production in the country. This, however, created high demand for quality fish seeds. On the other hand, due to some man-made and natural problems, fish seed collection from the rivers declined in recent years. During 1987-91, collection of hatchling from natural sources decreased from 22000 kg to 6000 kg (Islam 1997) and to 5872 kg in 1994 (DOF 1994). To bridge this gap in supply of quality fish seeds government has established 102 fish seed multiplication farms (FSMFs) covering almost all districts in the country. Private entrepreneurs also came forward to produce fish seeds with a remarkable pace in it. In 1982, there were only three private FSFMs. The number increased dramatically to 40 farms by 1985, to 214 farms by 1987 and 439 farms by 1994. As a result production of hatchling in private sector hatcheries increased from 6500 kg in 1987 to 24500 kg in 1991 (Islam 1997) and to 69356 kg in 1994. Production of hatchling in government farms also increased from 1068 kg in 1987 to 3180 kg in 1994 (DOF 1993-94). This recorded 23.60 percent increase in overall supply of hatchling during 1987 to 1994. The scenario indicated high demand for fish seeds in the country. This demand for fish seeds will be increasing further if it is possible to bring all suitable ponds (about 25460 ha or 17 percent total ponds) under intensive cultivation.

It is argued that successful culture fishery depends mainly on the availability of quality fish seeds, the research work, however, on the economics of fish seed production was lacking in the past. The shortage of fish seed (major carps) has been identified by various agencies as one of the main constraints for aquacultural development Bangladesh. A few empirical studies (Ali *et al.* 1982, Gill and Motahar 1982, Islam and Dewan 1987) observed that pond fish production was suffering due to shortage of fish seeds. Islam and Dewan (1988) studied the economic status of fish seed multiplication farms, however, with a limited coverage in terms of both farm categories and sample size. But no study of this nature has been conducted with a reasonably large size of sample and various types of farming. Keeping this in view, the present study has been designed to analyze profitability as well as productivity of resources used in fish seed production under government and private management practices by types of farming.

The paper is organized into four distinct sections. Following this introductory section, methodology is discussed in the second section. Results and discussion are presented in section three. Finally conclusions and policy implications are made in the section four.

Methodology

Source of data

Primary data for this study was collected through personal interview of managers of FSMFs during January to September 1997 covering nine districts of the country. On the basis of easy accessibility and/or high concentration of fish seed farms; Mymensingh, Gazipur, Jessore, Jhenaidah, Bogra and Comilla districts ere selected in this study for both government and private FSMFs. However, Pabna, Natore and Joypurhat districts were selected only for government FSMFs. From these districts a total of 56 FSMFs were selected purposively of which 11 were government farms, 45 private farms. All the sample government farms were hatchery-cum-nursery. On the other hand, the sample private farms consisted of 21 hatchery-cum-nursery and 12 each from hatchery and nursery.

Producing spawn in hatchery through induced breeding and rearing fingerlings in nursery ponds are two district stages of fish seed production. Therefore, inputs use and output gain in these two activities fare different. Costs and returns of producing fish seeds can be measured on per hectare and per Taka investment. However, costs and returns of FSMFs depend mainly on the utilization of available physical facilities. The farms which invest a huge amount for establishment of physical facilities, but can not utilize these rationally due to some social and technical problems, may not be profitable, specially in the case of hatchery. Therefore, measurement on per Taka investment was omitted in this study.

Cost (depreciation) of farm structures/hatchery equipment, buildings and machinery (pump, tube wells) were not calculated. Because due to uncertainty, it is very difficult to estimate longevity of these items and there consecutive use in different years. Moreover, these items were jointly used for both spawn and fingerlings production and therefore costs for these items were not calculated. Only a particular type of costs like repair and maintenance were estimated. However, depreciation costs of minor equipment like *hapa*, dish plate for spawn production and dram and fishing net for fingerlings production were included in this study.

Selection of model

The individual effect of inputs and factors used in fish seed production can be explained to certain degree with the help of production function analysis of various types. In this study, linear and Cobb-Douglas forms of production function were initially estimated to determine the effect of variable inputs. Finally Cobb-Douglas production function model was sorted out because of its better goodness of fit. For spawn and fingerlings production as well as for farms under government and private ownership separate equations were estimated.

Input costs both for spawn and fingerlings production were considered as independent variables whereas the value of output (gross return) accrued from respective activities were considered as dependent variables. Multicolinearity was tested and necessa4ry independent variables were chosen finally to determine the factor contribution to spawn and fingerlings production. Eight inputs or independent variables were hypothesized to explain both spawn and fingerlings production in the study area. The form of regression model was as described below:

$$Y_1/Y_2 = aX_1^{b2}, X_2^{b2} \ldots\ldots\ldots\ldots\ldots\ldots X_3^{b3} + U_4$$

$$\text{Or } LnY_1/Y_2 = Lna + b_1LnX_1 + b_2LnX_2 + \ldots\ldots + b_3LnX_3 + U_4$$

Where, for spawn production,

Y_1 = gross return (Tk/ha), X_1 = brood fish (Tk/ha), X_2 = Hormone (Tk/ha), X_3 = feed (Tk/ha), X_4 = fuel (Tk/ha), X_5 = electricity (Tk/ha), X_6 = human labour, X_7 = minor equipment (Tk/ha) and X_8 = repairing and maintenance of machinery and hatchery equipment (Tk/ha); and

For fingerlings production,

Y_2 = gross return (Tk/ha), X_1 = spawn (Tk/ha), X_2 = Feed (Tk/ha), X_3 = Fertilizer (Tk/ha), X_4 = chemicals (Tk/ha), X_5 = Poison (Tk/ha), X_6 = Fuel (Tk/ha), X_7 = human labour (Tk/ha) and X_8 = lease value of pond (Tk/ha), a = intercept, b_1 to b_8 = regression coefficients (parameters) to be estimated, U = error term.

The production coefficients of Cobb-Douglas form are elasticity of production. The parameters (b_1 to b_8) indicate transformation ratios of the various inputs used in spawn and fingerlings production.

Description of explanatory variables

Most of the explanatory variables related to using inputs for producing spawn and fingerlings were included in the respective regression models. The variables used in each farm category represented 73% to 85% and 62% to 83% of total costs of spawn and fingerlings production respectively. Therefore, these variables were hypothesized were hypothesized to have significant effect on the gross return from spawn and/fingerling production.

Good quality of brood fish and optimum application of hormone can produce higher amount of spawn and thereby ensures higher gross return. That is why costs of brood fish and hormone were included in the regression model.

Application of fertilizer (organic and inorganic) in brood and nursery pond increases the production of plankton taken as feed by brood fish and fingerlings which leads to increase growth of brood fish, and growth and survivability of fingerlings. But it is very difficult to maintain a certain level of plankton for all time in the ponds. So it is required to supply some artificial or supplementary feeds which brood fish and fingerlings take directly as feed. Therefore, artificial feeding help to increase growth of brood fish, and growth and survivability of fingerlings. Right stocking of spawn also ensures growth and survivability of fingerlings and hence the production of quality fish seed. Therefore, it is quite logical to hypothesize that, costs for spawn, feed and fertilizer will have significant effect on the output of fish seed production.

Chemicals are applied to maintain optimum level of acidity and turbidity of pond soil and pond water. Ponds are dried and treated with poisons to reduce economic losses due to diseases, parasites, predators and weed fishes.

Labour use in different operation of fish seed production determines good management of the practice. And it is assumed that production of well management pond will be higher than that of poorly management one.

Production of spawn requires sophisticated equipment for which every farm has to invest huge amount and also requires repairing and regular maintenance. Actually volume of spawn production depends mainly on costs for these items. Fuel and electricity keep the equipment running for larger production. So costs for repair and maintenance of hatchery were included in the regression model. Due to longevity of machinery and hatchery equipment, cost for these items were not incorporated in the regression model. But cost for minor equipment was analyzed.

A fertile and productive pond produces higher amount of fish seeds but causes for higher lease value. Therefore, higher lease value is attributed as higher output.

Results and discussion

The estimated values of coefficients and related statistics of Cobb-Douglas production function for spawn and fingerlings are shown in Table 1 and 2 respectively. In he case of spawn production, the coefficients of multiple determination, R^2, were 0.89

and 0.95 respectively in private FSMFs with hatchery and hatchery cum nursery while it was estimated 0.98 in government FSMFs with hatchery cum nursery. Therefore, all included variables in the model explained 89 to 98 percent variation in gross return from spawn in different categories of FSMFS. On the other hand, the R^2 values in the case of fingerlings production were 0.96 and 0.87 respectively for private FSMFs with nursery and hatchery cum nursery and 0.98 in government FSMFS with hatchery cum nursery. The independent variables incorporated in the model, therefore, explained 87 to 98 percent variation in gross return from fingerlings in the sample farms. The coefficient of the regression equation fitted for spawn production in private FSMFs with hatchery and fingerlings production in private FSMFs with hatchery was relatively weak. However, the F-values of all regression equations for both spawn and fingerlings production was significant at 1 percent level which implies that all included explanatory variables was important for explaining the variation in gross return from fish seed production.

All the estimated coefficients have proper (positive) sign with a range of 0.16 to 3.58 for spawn production and 0.40 to 1.53 for fingerlings production. Out of 10 coefficients for spawn production under private farms, 5 were significant at 1 percent, 4 were at 5 percent and only 1 was at 10 percent level. However, all 5 coefficients for spawn production in government farm were significant at 1 percent level. On the other hand, for fingerlings production all included 9 coefficients were significant at 1 percent level while out of 5 coefficients for fingerlings production in government farms 3 years significant at 1 percent and 2 were 5 percent level.

The sum of coefficients of Cobb-Douglas production function determines the returns to scale of production. It may be increasing decreasing of constant depending on the ratios of input to output. For all production function functions of both spawn and fingerlings, increasing returns to scale were found which indicate that doubling all inputs would result more than double output. For spawn production, its range was 1.37 to 8.13 and that for fingerlings production, it was 1.68 to 5.25 for spawn production, the higher returns to scale (8.13) was in private FSMF s with hatchery cum nursery pond which indicates that if all the inputs specified in the function are increased by 1percent, gross return will increase by 8.13 percent. The lowest return to scale (1.37) was found in government FSMF s with hatchery cum nursery pond. For fingerlings production, the highest and the lowest returns to scale were found in private FSMF s with nursery pond (5.25) and in private FSMF s with hatchery cum nursery pond (1.68) respectively.

The coefficients for brood fish and spawn respectively for spawn and fingerlings production were statistically signification at 1 percent level for all categories of FSNF s. In the case of spawn production, coefficients of brood fish was found highest (1.10) in private FSMF s with hatchery cum nursery pond which indicates that if the cost of brood fish is increased by 1 percent, keeping all other variables constant, gross returns from spawn production will increase by 1.10 percent. In the case of fingerling production, coefficient of spawn was found highest (1.22) in government FSMF s with hatchery cum nursery pond.

Table 1. Estimated values of coefficients and related statistics of Cobb-Douglas production function model for spawn

Explanatory variables	Private FSMFs with hatchery	Private FSMFs with hatchery cum nursery pond	Government FSMFs with hatchery cum nursery pond
Intercept	1.51	5.09	2.59
Brood fish (X_1)	0.74[a]	1.10[a]	0.16[a]
Hormone (X_2)	0.20[a]	-	-
Feed (X_3)	-	0.78[b]	0.29[a]
Fuel (X_4)	-	0.60[b]	0.25[a]
Electricity (X_5)	-	-	0.46[a]
Human labour (X_6)	-	1.09[a]	-
Minor equipment (X_7)	0.33[a]	0.98[a]	0.21[a]
Repairing & maintenance (X_8)	2.75[a]	3.58[a]	-
R^2	0.89	0.95	0.98
F	14.65[a]	21.10[a]	41.26[a]
Return to scale ($\Sigma b'_i$)	4.02	8.13	1.37

[a] Significant at 1% level. [b] Significant at 5% level. [c] Significant at 10% level.

In both categories of farming under private ownership, the highest coefficient value in spawn production function was for repairing and maintenance of machinery and hatchery equipment. These coefficient values were 2.75 and 3.58 respectively in private FSMF s with hatchery and hatchery cum nursery pond. These results indicate that the cost of repairing and maintenance of machinery and hatchery equipment has relatively greater impact of the profitability of spawn production. Because, every farm has to invest a huge amount for establishment of these items. Actually, volume of spawn production depends mainly on these items.

Table 2. Estimated value of coefficients and related statistics of Cobb-Douglas production function model for fingerlings

Explanatory variables	Private FSMFs with hatchery	Private FSMFs with hatchery cum nursery pond	Government FSMFs with hatchery cum nursery pond
Intercept	2.92	2.49	1.26
Spawn (X_1)	0.49[a]	0.73[a]	1.22[a]
Feed (X_2)	1.53[a]	-	0.70[b]
Fertilizer (X_3)	0.91[a]	-	1.22[a]
Chemicals (X_4)	0.48[a]	0.48[a]	0.40[b]
Poison (X_5)	-	-	0.99[a]
Fuel (X_6)	0.65[a]	-	-
Human labour (X_7)	1.19[a]	-	-
Lease value of pond (X_8)	-	0.47[b]	-
R^2	0.96	0.87	0.98
F	21.00[a]	53.91[a]	108.15[a]
Return to scale (Σb_i)	5.25	1.68	4.53

[a] Significant at 1% level. [b] Significant at 5% level.

In the case of fingerling production, the coefficients of feed was found to be highest (1.53) in private FSMF s with nursery pond followed by spawn (1.22) and fertilizer (1.22) in government FSMF s with hatchery cum nursery pond. This is most logical because, material inputs like spawn, feed and fertilizer have relatively greater impact on gross return from fingerlings production.

The overall performance of regression models for both spawn and fingerlings production was good as indicated by the estimated R^2 and F-values. The coefficients were also significant. The estimated values of the models confirm that the included variables had some positive impact on gross returns from spawn and fingerlings. No input was found to be overused and increasing return to scale was observed which indicated that input use in both spawn and fingerlings production might be increased to a certain level.

Interrelationship between input use and yield and economic returns

In addition to functional analysis, tabular technique was used in this study to show how yields and economic returns vary with the amount and kind of inputs used for spawn and fingerlings production under private and government. Only material inputs were studied FSMFs. Tables 3 and 4 show the interrelation between the average quantity of inputs used and achievements of yield and economic return in different types of FSMFs. These tables reveal that the variations in input use, except land, between private and government farms as well as within the private farms were quite logical. Private farm owners used higher amount of input per hectare compared to government farms for producing spawn and fingerlings and received relatively higher level of yield and gross returns. The farm size as well as size of government ponds for spawn and fingerlings production were larger than the ponds under private ownership, but the amount of inputs used and receiving yield and economic return per hectare for the two activities in government farms were much lower by several times compared to private ones. However, within the private FSMFs, there was a small variation in input use and accordingly yield per hectare and economic returns were justified. Size of ponds were inversely related with the level of economic returns obtained in different FSMFs. That is, fish seed production increases as the size of pond decreases (Tables 3 and 4).

In the case of spawn production, private FSMFs with hatchery cum nursery pond used a little higher amount of most of the inputs and therefore obtained higher yield compared to private FSMFs with only hatchery. Functional analysis also shows better fit of the regression model for spawn production in private FSMFs with hatchery cum nursery pond with significant impact of feed on gross return from spawn. Although the levels of input use in government FSMFs with hatchery cum nursery was much lower, the coefficients of feed were significant which indicated opportunity to increase the level of feed inputs.

In the case of fingerlings, the private FSMFs with only nursery pond used lower amount of organic manure and feed but used higher amount of chemicals for which it required lower amount of poisons compared to the private FSMFs with hatchery cum nursery pond. The former also used higher amount of spawn. Therefore, the FSMFs with only nursery obtained higher yield as well as economic returns. On the other hand, the FSMFs with hatchery cum nursery pond used lower amount of chemicals for which it needed much more higher level of poison to apply to check fingerlings loss in the farm but sacrificed certain amount of yield and economic returns.

Table 3. Interrelationship between input use and yield of spawn under different cfategories of FSFs

Particulars	Resource use and yield by category of FSMFs		
	Private		Government
	FSMFs with hatchery	FSMFs with hatchery cum nursery pond	FSMFs with hatchery cum nursery pond
Farm size (ha)	0.87	0.40	4.21
Pond size (ha)	0.16	0.18	0.87
Fertilizer (kg/ha)			
Organic	15709	36525	7710
Inorganic	2962	1600	269
Feed (kg/ha)			
Rice bran	5829	6260	362
Wheat bran	767	2128	524
Oil cake	6841	9263	1591
Fish meal	210	798	293
Chemicals (kg/ha)			
Lime	1641	1483	225
Potash	0.48	-	-
Poison (kg/ha)			
Insecticides	5.94	22.85	1.84
Pesticides	3.64	10.83	0.91
Hormone (gm/ton of brood fish)	8.93	24.65	13.93
Yield (kg/ha)	588.44	599.93	36.38
Gross return (Tk/ha)	1562768	1498513	76452
Total cost (Tk/ha)	549545	618370	74401
Net return (Tk/ha)	1013223	880143	2051

Tabular analysis shows that government FSMFs used lower amount of all inputs in producing fingerlings but the amount were much more lower in the case of spawn production compared to the private farms. The regression analyses also support these results as most of the coefficient values of included variables for fingerlings production were significant. Although the regression analyses of government FSMFs show better fit, the government farms were under utilized which is reflected in the tabular analyses.

Table 4. Interrelationship between input use and yield of fingerlings under different categories of FSMFs

Particulars	Resource use and yield by category of FSMFs		
	Private		Government
	FSMFs with hatchery	FSMFs with hatchery cum nursery pond	FSMFs with hatchery cum nursery pond
Farm size (ha)	2.03	1.55	3.07
Pond size (ha)	0.24	0.40	0.50
Spawn (kg/ha)	10.16	6.63	3.35
Fertilizer (kg/ha)			
Organic	12488	18648	8227
Inorganic	1199	860	187
Feed (kg/ha)			
Rice bran	3489	4950	196
Wheat bran	503	2315	286
Oil cake	5511	4068	258
Chemicals (kg/ha)			
Lime	1506	726	113
Potash	29	-	-
Poison (kg/ha)			
Insecticides	4.84	11.25	1.04
Pesticides	1.02	5.87	0.59
Yield (Nos. 000/ha)	1617	1032	342
Gross return (Tk/ha)	254696	213121	38166
Total cost (Tk/ha)	200894	187520	37267
Net return (Tk/ha)	53802	25601	899

Conclusions

The findings of the study indicate that there is a scope of increasing level of input use in both spawn and fingerlings production in government and private farms specially in government farms. The government fish seed farms were under utilized with lower level of input use and economic returns. Regardless the farm category the most effective inputs were observed to be feed and fertilizer. Hence fish seed production could be increased through intensification of all inputs used in the production process.

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Economics of pond fish culture in some selected areas of Bangladesh

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Abstract

A simple costs and return analysis was done to determine the profitability of pond fish culture in three selected thanas namely Nertakona Sadar, Purbadhala and Kendua under Netrakona district. Cobb-douglas production function model was used to estimate the contribution of key variables to the production process of pond fish culture. It was found that cost of pond fish production was Tk. 10,103/ha/yr and the per hectare fish yield was 943 kg/yr and the average gross and net return were Tk. 49,515 and Tk. 39,412 respectively. It was found that medium and small farms had the higher yield because of efficient use of production inputs compared to large farms. It was also observed that ownership of pond, number of species and human labour had negative impact on pond fish output, while depth of pond water, farm size, fish seed, fertilizer and artificial feed had significant positive effects on pond fish output.

Key words: Fish culture, Economics

Introduction

Pond fish production can be increased through introduction of efficient management and scientific aquaculture. Application of manure, fertilizer, quality feeds and aeration can further increase the production to 9,000 kg/ha/yr while from unfertilized pond, it usually does not exceed 500 kg/ha/yr (MPO 1984). On the other hand, socioeconomic studies on the pond fish farming seemed urgently needed to assess the profitability of pond fish production, to estimate the contribution of key variables of fish production practices to the farm output. The results of this study will be helpful to the farmers, extension workers, farm management researchers as well as to other relevant persons to generate policy alternatives for inland fish culture mainly pond fish culture in Bangladesh.

Materials and methods

In total 48 stocking ponds, 16 from each of the selected thanas namely Netrakona Sadar, Purbadhala and Kendua of Netrakona district of Bangladesh, were selected for the study. Fish pond with different types of cultural and management practices, such as i) traditional practices, ii) improved traditional practices, iii) semi-intensive aquaculture and of different sizes of farms (small, medium, large) were included in the sample. Both tabular and statistical analysis were used in this study. Statistical analysis was used to show the effect of input use and other related factors of ponds fish farming.

To determine the effects of variable inputs, two forms of production functions were initially estimated for pond fish culture. These were liner and Cobb-Douglas forms. Finally, Cobb-Douglas production function was chosen on the basis of a best fit and significant result on output. Eight variables were taken into account to explain the pond fish production in the study area. Regression analysis (Ordinary least square method) was used to determine the effect of this inputs. Care was taken to see that the chosen variables are not multicolinear.

The general model in multiple regression form takes the following stage:

$Y = ax_1^{b1}x_2^{b2}$--x_8^{b8}

or $\text{Log } Y = \text{Log}a + b^1\text{Log}x_1 + b^2\text{Log}x_2 +$--------------$+ b^8\text{Log}x_8$

Where Y= Gross value of output (Tk/ha)

X_1 = Cost of fry and fingerlings (Tk/ha)	X_2= Cost of fertilizer (Tk/ha)
X_3= Cost of feed (Tk/ha)	X_4=Cost of human labour (Tk/ha)
X_5= Pond size (Hectare)	X_6= Pond ownership
X_7= Stocked species number	X_8= Depth of pond water (Meter)

a= Constant or intercept value (Tk/ha) b_i= Production co-efficient to be estimated

i= 1,2,3,--------------------,8.

Results and discussion

Cost of fish production

The items of cost of pond fish production for the selected locations are presented in Table 1. All these costs were counted for one production year. From the table, it appears that per hectare cost was the highest in Purbadhala (Tk. 11, 844/ha) due to high human labour cost and the lowest in Netrakona Sadar (Tk. 9341/ ha) and the average cost for all locations was Tk.10,103/ha/yr.

Table 1. Itemized costs of pond fish production per hectare per year according to locations

Cost items	Netrakona Sadar (Tk)	Purbadhala (Tk)	Kendua (Tk)	All locations	
				Total cost (Tk)	%of total cost
Material input cost	4,625	11,161	5,071	6,308	62.44
-Fish seed	4,948	4,786	5,478	5,386	53.31
-Fertilizer	489	478	481	482	4.87
-Artificial feed	608	288	495	440	4.36
-Human labour	3,058	4,235	3,843	3,795	37.56
Total costs	9,341	11,844	11,631	10,103	100.00

According to farm size groups, the items of cost of pond fish production per hectare in the selected areas are present in Table 2. From the table it appears that medium farm incurred the highest cost (10843 Tk/ha) and the small farms incurred the lowest cost (Tk. 8656/ha). Table 2 reveals that total materials cost comprised the highest amount in all the sampled areas i.e. 62.44 percent of the total cost and the fish seed stocking cost was the maximum i.e. 53.31 percent of the total costs. From Table 2 it can be seen that the material cost was the highest i.e. Tk. 7,622 per hectare in medium farm followed by small and large farms i.e. Tk. 6,913 and Tk. 4,274/ha, respectively. Per hectare cost of stocking of fry and fingerlings and fertilizer followed the same trend. But per hectare cost of artificial feed used in ponds was maximum in medium farms followed by large and small farms.

Table 2. Itemized costs of pond fish production per hectare per year according to farm size

Cost items	Small farm (Tk)	Medium farm (Tk)	Large farm (Tk)	All farms	
				Total cost (Tk)	%of total cost
Material input cost	6913	7622	4274	6308	62.44
-Fish seed	6213	6596	3394	5386	53.13
-Fertilizer	476	573	443	482	4.77
-Artificial feed	224	513	437	440	4.36
Human labour (Tk)	1743	3221	5466	3795	37.56
Total costs	8,656	10,843	9,740	10,103	100.00

Human labour cost per/ha was maximum in Purbadhala (Tk. 4,235) followed by Kendua (Tk. 3,843) and minimum in Netrakona Sadar (Tk. 3,058) and average human labour cost per hectare for all locations was Tk. 3,795 and the amount represented 37.56 percent of total cost . According to farm size per hectare labour cost was maximum in large farm i.e. Tk. 5,466 followed by medium and small farms i.e. Tk. 3,221 and Tk. 1,743, respectively.

Returns from the fish pond

Farm returns can be measured items of yield, gross return and net return. Per hectare costs and returns of pond fish production in different location are presented in Table 3. From the table, it can be seen that per hectare gross returns and net returns for all locations were Tk. 49,515 and Tk. 39,412, respectively. In the study areas, yield per hectare was maximum in Netrakona Sadar (964 kg) as expected, the net return was also the highest in Netrokona Sadar.

Table 3. Per hectare yearly costs and returns of pond fish production according to location

Locations	Yield (Kg)	Gross return (Tk)	Total cost (Tk)	Net return (Tk)
Netrakona Sadar	964	51,631	9,341	42,290
Purbadhala	935	46,659	11,844	34,815
Kendua	935	51,420	11,631	39,789
All Locations	943	49,515	10,103	39,412

Per hectare costs and returns of pond fish production according to farms size groups are presented in Table 4 and it is evident from the table that a higher investment on pond fish production yielded, as expected, higher gross returns as well the highest in medium farms i.e. Tk. 52,404 and Tk. 41,561, respectively and the lowest in large farms i.e. Tk. 45,855 and Tk. 36,115 respectively. The results presented in Table 4 clearly indicate that the pond fish culture is a profitable business, but there is a difference in profitability among different groups of farmers. It can be seen from Table 4 that the medium farmers obtained highest profit from pond fish culture. In another word, the field level performances of the owners of medium farms seem to be better than those of the small and large farms in terms of per hectare yield, gross returns, net returns and also considering net returns per invested Taka together with benefit-cost ratio (un discounted measure). As a result, the owners of the pond perhaps manage their pond more effectively and efficiently. The results also imply that at least a required standard size of pond is needed to minimize costs is to maximize the net return.

Table 4. Per hectare yearly costs and returns of pond fish production according to farm size

Size of farm	Yield (Kg)	Gross returns (Tk)	Total costs (Tk)	Net returns (Tk)
Small	873	48,982	8,656	40,326
Medium	1004	52,404	10,843	41,561
Large	891	45,855	9,740	36,115
All farms	943	49,515	10,103	31,412

Pond fish production and relative factors

Pond fish production is the outcome of using various combinations of the required inputs in the production process of pond fish culture. Besides these, in pond fish culture there are some inherent characteristics of pond and factors that affect its environment and production such as, age of pond, depth of pond, size of pond, pond ownership, and these factors can be employed to explain the variation of pond fish output (Islam and Dewan 1987). Similarly in this study, the materials inputs like stocking of fry and fingerlings, feed, fertilizer, human labour and inherent inputs such as: size of pond, pond ownership, depth of pond water and species number have been included to explain the variability of productivity of fish pond.

Estimated values of the coefficients and related statistics of Cobb-Douglas production function are shown in Table 5. The table reveals the following features:

Table 5. Estimated values of coefficients related statistics of Cobb-Douglas production function model

Explanatory variables	Netrakona Sadar	Purbadhala	Kendua	All locations
Intercept	4.003	7.269	2.799	7.8338
Fish seed (X_1)	-0.013	-0.59***	-0.4115***	-0.1392**
Fertilizer (X_2)	0.981*	0.108	2.3149***	0.4156*
Feed (X_3)	0.092***	0.303	0.1575	0.1102***
Labour (X_4)	0.040	0.149	0.1944	0.0664
Pond size (X_5)	-0.175	0.359***	-0.5031	0.4275**
Pond ownership (X_6)	-0.123	-0.012	-0.0630	-0.0487
Stocked species nos. (X_7)	-0.032	-0.035	-0.4854	-0.4087
Depth of pond water (X_8)	-0.061	0.250***	-0.7814	0.2770***
R^2	0.976	0.978	0.8476	0.9355
F-value	78.436*	82.484*	78.436*	86.176*
$\sum bi$	1.0974	0.9091	0.9350	0.7750

* = Significance at 1% level, ** = Significance at 5% level, *** = Significance at 10% level

The Cobb-Douglas production function fitted the data well for different location in the study area. The aggregate function performed better as well. The performance was measured by the estimated F and R^2 values. Islam (1987) also estimated a Cobb-Douglas production function to explain the productivity of fish ponds.

The coefficients of multiple determination, R^2 ranged from 0.847 in Kendua to 0.978 in Purbadhala. Considering all location R^2 was 0.935 which indicates that about 94.0 percent of the total variation of output of fish farming is explained by independent variables included in the model and it also indicates that excluded variables accounted for only about 6.0 percent of the variation in pond fish production . For this study, it was not possible to incorporate other explanatory variables due to non-availability of the required data.

The "F" values of the individual equations and the pooled equation are highly significant implying that all the included explanatory variables are important for explain the variation of pond fish production. Therefore, F values of the individual coefficients of the relevant inputs should be expected to become significant. The nature of input-output relationship is expected to be determined by the magnitude of the estimated production co-efficient of individual equation. Degrees of freedom for statistical significance of the selected production function were sufficient. The results were tested on 1.0 percent, 5.0 percent and 10.0 percent levels of significance. The summation of the production coefficients of the selected pond fish farmers indicates returns to scale.

In total there are 32 input coefficients (Table 5) and out of these, fifteen coefficients have improper (negative) sign, while the remaining 17 coefficients show positive impact on gross return. Out of 32 coefficients 2 coefficients are significant at 1.0 percent, 2 coefficients are significant at 5.0 percent and 8 coefficients are significant at 10.0 percent level of confidence. The relative contribution of specified factors affecting productivity of fish pond can be seen from the estimate of regression equation . From Table 5, it appears that the cost of fertilizer has positive effect on income. This indicates that there is an opportunity to increase the gross returns per hectare by spending additional Taka for fertilizer. Based on all locations, it appears that the cost of fertilizer is significant at 1.0 percent level and the production co-efficient is 0.4156. From the Table 5 it also appears that the cost of fish feed is significant at 10.0 percent level and the production co-efficient is 0.1102 based on all locations. Cost of fish seed shows the negative effect on income under different selected areas.

Only in Kendua the estimated co-efficient for labour has improper sign and the value of production coefficient of labour by all location is 0.0664. This indicates that there may be over use of human labour which brings about negative impact on farm returns.

Among the inherent inputs farm size is highly significant and the production co-efficient is 0.4275 based on all locations, i.e. it contributes 0.43 percent of gross farm income for each 1.0 percent increase in pond area. Based on all sample ponds, depth of pond water is also significant and the production coefficient is 0.2770 based on all location, i.e. it contributes 0.28 percent of gross farm income for each 1.0 percent increase in the pond area.

Based on all sample ponds the co-efficient of number of ownership and stocked number of species in the pond showed improper sign. It has been indicated by many researchers that multiple ownership is one of the basic constraints to improve the pond condition and to take production decision efficiently. Therefore, this type of pond is less productive than those having single ownership. Number of species stocked for all locations shows a significant negative impact on gross farm income. Therefore, a standard level of stocking number is needed for obtaining better yield.

The summation of the production coefficients of selected pond (ignoring the different areas) i. e. the elasticity of production ($\sum b_i$) is equal to 0.7750. This means that the production function exhibits diminishing return to scale. In other words, if all the inputs specified in the function are increased by 1 percent gross return will increase by 0.78 percent . All the study areas show the diminishing return to scale in pond fish production at present market prices of specified inputs and outputs.

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Scientific Note

Relationship between total length and mouth gap of some commercially important carp fry

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Abstract
The estimated regression equation for total length and mouth gape computed were Log TL = Log 0.23 + 0.663 log MG (vertically) (r = 0.960) and Log TL = Log 0.08 + 0.686 log MG (horizontally) (r = 0.949). In case of rohu average total length from 11350 mm to 23775 mm and mouth gape 805 μm to 1225 μm (vertically) and 700 μm to 1110 μm (horizontally) between the first day of mouth opening up to 15 days. The regression equation for total length and mouth gap were Log TL = Log 0.20 + 0.660 log MG (vertically) (r = 0.935) and Log TL = Log 0.02 + 0698 log MG (horizontally) (r = 0.907). In case of silver carp average total length from 12800 μm to 33555 μm and mouth gape 690 μm to 1210 μm (vertically) and 615 μm to 1115 μm (horizontally) between the first day of mouth opening up to 15 days. The regression equation for total length and mouth gape were Log TL = Log 0.36 + 0.596 log MG (vertically) (r = 0.936) and Log TL = Log 0.26 + 0.607 log MG (horizontally) (r = 0.891). The relationship between total length and mouth gape (vertically and horizontally) of the studied fry were found to be linear and highly significant.

Key words: Total length- mouth gape relationship, Carp fry

In Bangladesh, the commercially important carps fry were traditionally reared without providing any feed and fertilizer. There were very few published data on mouth size of larval fishes and predictable food size. Shirota (1970) measured the size of the mouth in several fish species both fresh water and marine, during antigenic growth. Hunter (1980) reviewed the effect of mouth size on the feeding behavior of marine fish larvae. Considering all these in mind, the present study was designed to examine the relationship between total length and mouth gape of catla, rohu and silver carp fry.

Three carp species of both native and exotic origin, namely, *C. catla*, *L. rohita* and *H. molitrix* were selected for determination of total length and mouth gape of these fish fry. The study were conducted in a rain fed artificial pond situated at the experimental pond area of the Department of Aquaculture, Bangladesh Agricultural University, Mymensingh for one month. The total length and mouth gap of live fish fry were measured. The fry with closed mouth were preserved in 5% formalin. For this purpose some live fry were placed on a glass slide, with little water sufficient to keep it alive and the fry had respiratory trouble, then it frequently opened mouth. Some measurement were taken with the fry previously preserved in 5% formalin. For measuring mouth gap, a needle was used for creating some pressure upon the jaws laterally. The total length were measured from the anterior most tip of snout to the posterior most tip of the caudal fin. Then the measurement were taken with the help of an ocular micrometer fitted in a compound microscope. The distance of each division of ocular micrometer was determined by calibrating the ocular micrometer division with those of an stage micrometer. Total length and mouth gape of fish fry were measured to the nearest milimicron (μm).

The total number of fry of each specimen were plotted against total length of fish and mouth gape. The arithmetic relationship between them are as follows:

Total length - Mouth gap: $TL = a + b\ MG$ (r = ...)

TL = Total length , MG = Mouth gape, a = Intercept, b = Regression co-efficient and r = Correlation co-efficient.

The logarithmic relationship between total and mouth gape derived from the following formula:

Log Total length - Log Mouth gap: $\text{Log } TL = \text{Log } a + b \text{ Log } MG$ (r = ...)

The results of the relationship between total length and mouth gape (vertically and horizontally) of the three species namely catla, rohu and silver carp at their fry stage were presented in Table 1.

From the result it was observed that the size of the studied fry attained an average total length ranged from 11065 μm to 12800 μm at the time of their first exogenous feeding. Silver carp had highest total length and catla had lowest total length, respectively. Similar result was observed by Mustufa *et al.* (1994) where they found highest total length for silver carp and lowest total length for catla.

Dabrowski and Bardega (1984) reported 6400 μm total length of silver carp at the commencement of exogenous feeding. Shafi and Quddus (1982) reported catla attained 7560 μm total length at the commencement of first feeding and also reported total length of 7570 μm in case of rohu, when the yolk sac was fully absorbed.

In the present study, seven days after first feeding silver carp attained 21755 μm body length. Ahmed *et al.* (1990) recorded 12400 μm reared in plastic bowl and Ling *et al.* (1980) recorded 18000 μm total length in case of silver carp in natural condition. Catla attained 17360 μm of total length 7 days after first feeding. Shafi and Quddus (1982) recorded 16500 μm of total length in case of catla after 7 days of exogenous feeding and attained 17840 μm in case of rohu. In this study period total length of catla, rohu and silver carp attained 26350 μm, 23775 μm and 33555 μm, respectively.

Alvarez *et al.* (1993) recorded growth rate of *Mugil lisa* at 550 μm / day. In this study catla, rohu and silver carp grew 1019 μm/day, 828.33 μm/day and 1383.67 μm/day, respectively up to 15 days of age. Within the study period sliver carp attained the highest total length 33555 μm and rohu attained the lowest total length 23775 μm.

Table 1. Total length-mouth gap (vertically and horizontally) relationship in *Catla catla*, *Labeo rohita* and *Hypophthalmichthys molitrix* (arithmetic and logarithmic value)

Species		Intercept (a)	Regression co-efficient (b)	Correlation co-efficient (r)	Fitted line TL = a+b MG	Fitted line Log TL = Log a + bLog MG
Catla catla (Ver.)	Arithmetic value	390.39	0.040	0.953*	TL = 390.39 + 0.040 MG	-
Catla catla (Hor.)	Arithmetic value	325.91	0.037	0.945*	TL = 325.91 + 0.037 MG	-
Catla catla (Ver.)	Logarithmic value	0.23	0.663	0.960*	-	Log TL = Log0.23 + 0.663Log MG
Catla catla (Hor.)	Logarithmic value	0.08	0.686	0.949*	-	Log TL = Log0.08 + 0.686Log MG
Labeo rohita (Ver.)	Arithmetic value	297.53	0.039	0.949*	TL = 297.53 + 0.039 MG	-
Labeo rohita (Hor.)	Arithmetic value	240.24	0.037	0.916*	TL = 240.24 + 0.037 MG	-
Labeo rohita (Ver.)	Logarithmic value	0.20	0.660	0.935*	-	Log TL = Log0.20 + 0.660Log MG
Labeo rohita (Hor.)	Logarithmic value	0.02	0.698	0.907*	-	Log TL = Log0.02 + 0.698Log MG
Hypophthalmichthys molitrix (Ver.)	Arithmetic value	309.55	0.026	0.951*	TL = 309.55 + 0.026 MG	-
Hypophthalmichthys molitrix (Hor.)	Arithmetic value	250.69	0.024	0.918*	TL = 250.69 + 0.024 MG	-
Hypophthalmichthys molitrix (Ver.)	Logarithmic value	0.36	0.596	0.936*	-	Log TL = Log0.36 + 0.596Log MG
Hypophthalmichthys molitrix (Hor.)	Logarithmic value	0.26	0.607	0.891*	-	Log TL = Log0.36 + 0.607Log MG

Ver. = Vertically, Hor. = Horizontally ,* Significant

Mouth gap (vertically) of the studied fry at the initial stage of mouth opening was recorded to be lower 690 μm in case of silver carp and higher 820 μm in case of catla and mouth gape (horizontally) was recorded to be lower 615 μm in case of silver carp and higher 735 μm in catla.

A linear relationship was recorded between total length and mouth gape in the present study. Similar linear relationship were recorded by Dabruwski and Bardega (1984) in case of silver carp, grass carp and bighead carp. Guma'a (1978) found linear relationship between mouth opening height and body length in case of *Perca fluviatilis*. Osmani and Kohinoor (1994) observed linear relationship between mouth size and total length in case of *Ompok pabda* and *Mystus golio*. Hunter and Kimbrell (1980) observed that the mouth size of larvae generally increases with larval size. Shirota (1970) studied the relationship among mouth size, food size and growth of various larval fishes and obtained on definite relationship between the mouth size and the total body length but observed a close relationship between the mouth size of various larval fishes (ranged from 200 μm -1000 μm) and the size of their natural foods. Mathias and Li (1982) studied with larvae and juveniles of walleye and described the relationship mouth opening height and body length by a linear regression. The relationship between total length and mouth gape in all cases studied were found to be linear in the arithmetic and logarithmic form. The regression co-efficient was nearer to one and the correlation co-efficient between total length and mouth gap were stronger. This means that the growth of the fish was isometric and with the increase in total length , the mouth gap increased.

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