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The growth and survival of seabass (*LATES CALCARIFER)* and tilapia (*OREOCHROMIS NILOTICUS)* using different stocking ratios

Juan Suárez Sánchez and Luz del Carmen

Institute of Marine Sciences and Fisheries, University of Chittagong, Chittagong-4331, Bangladesh.

Abstract

Disease outbreak in shrimp culture sector has abandoned the vast coastal areas of Bangladesh. These abandoned areas treated as 'brown fields' could be utilized for finfish culture using low cost inputs. This type of culture practice has the potential to be successful in the coastal waters due to having seasonally fluctuating salinity of 0 to 15 ppt. The present study was conducted to determine the growth and survival of seabass (*LATES CALCARIFER)* and tilapia (*OREOCHROMIS NILOTICUS)* using different stocking ratios without giving any supplementary feed to seabass. Tilapia was stocked at 1 individual/m^2. Tilapia fry was expected to provide food for seabass in the selected culture ponds. The stocking ratio of tilapia and seabass were 4:1, 5:1 and 6:1 in ponds with three replicates for each treatment. During 3 months culture period, the highest harvest weight of seabass and tilapia was recorded as 74.3 and 49.1 g/m^2, respectively and the highest survival rate of seabass and tilapia was recorded as 78.3 and 61.9%, respectively. The highest growth rate of seabass was recorded as 14.67 g/day and the highest biomass of seabass and tilapia (collectively) was found as 116.9 g/m^2. The present study reveals that seabass-tilapia polyculture may be a good solution to utilize the coastal brown fields of Cox's Bazar, Bangladesh.

Keywords: Polyculture, seabass (*Lates calcarifer),*tilapia (*Oreochromis niloticus),*brown fields.

INTRODUCTION

Due to unplanned and intensive shrimp farming, the coastal ecosystem has degraded and prone to disease outbreak during the last three decades which has left many small and large coastal ponds unutilized. These barren, unproductive abandoned shrimp farming areas are generally treated as brown fields. Though there is an opportunity to utilize these ponds, alternative culture practice has not yet been developed. To compensate the loss especially for the existing resources and employment generation of the poor farmers, it is necessary to develop an alternative technology such as finfish culture in this sector.

Seabass (*Lates calcarifer*) can be cultured in a variety of culture systems using marine water, brackish water and freshwater (Harpaza et al., 2005; FAO, 2006). In Asia, seabass may be cultured in brackish water ponds with tilapia (FAO, 2006). In Thailand, seabass has been cultured for decades in association with shrimp, mullet and milkfish (Rauangpanit et al., 1984). Moreover, attempts have been made to compare the culture practice of seabass with tilapia in Thailand and achieved mixed results (personal communication: Bart, AIT and Turner, NSF. Thailand).

Farming based on supplementary feed was conducted by using different types of feeds like trash fish, crustacean pellets, formulated feed, and live food (Corre and Hassan, 1995; Biswas et al., 2010; Boonyaratpalin et al., 1998; Bermudes et al., 2010). There are only a few studies published on culture of tilapia-seabass combination. Fortes (1985) indicated that seabass-tilapia combination of 1:15 ratio appears very promising result, whereas Tesorero (1995) reported 1:20 as the optimum ratio of seabass and tilapia in polyculture which had some advantages of among different stocking ratios. However, the additional crop of seabass in the seabass-tilapia combination made tilapia culture more attractive. Fortes and Genodepa (1997) showed a ratio of 1:5 was effective in an aqua farm condition. In Bangladesh, a preliminary result is also available from the study of a polyculture system of tilapia and seabass (Hossain et al., 1997). It was found that seabass shows a fast growth in the coastal environment of Cox's Bazar region (Das, 2000).

So, there is an opportunity to develop a new culture practice of tilapia and seabass in the existing brown fields and derelict areas. Tilapia is considered as a low-input species, as it can be cultured without supplementary feeding. It is a prolific breeder often resulting in over population. It tolerates a wide range of salinities (0 to 30 ppt) and can breed at salinity as high as 15 ppt (Watanabe et al., 1985). Similarly, seabass is an excellent cultivable species in variable water salinities ranging from 0 to 30 ppt (James and Marichamy, 1986; Kungvankij et al., 1986; Mukhopadhyay and Karmakar, 1981). However, polyculture of tilapia and seabass has the potential to be successful in Bangladesh because coastal areas of Cox's Bazar have seasonal fluctuation of salinity (5 to 15 ppt). So this polyculture system would be effective as tilapia utilize plankton in the culture ponds, while seabass consume tilapia fry as a live feed.

MATERIALS AND METHODS

Nine ponds of different sizes (169 to 805 m^2) owned by the marginal farmers were selected in the coastal area of Chakaria, Cox's Bazar, Bangladesh. Ponds were dried and renovated with respect to dykes, depth, slope, bottom elevation, supply and drainage facilities. Soil pH was assessed prior to application of treatments. These ponds were limed at a rate of 1000 to 2000 kg/ha. Then inorganic fertilizer was applied (100 to 200 kg/ha; Urea: TSP, 2:1) followed by organic fertilizer at a rate of 4 to 5 ton/ha (cow dung: chicken manure, 3:1). Ponds were filled with water up to 1.2 m. After 3 to 5 days when the colour of the water turned into green, ponds were stocked with adult tilapia (*Oreochromis niloticus;* female: male = 3:1) of size 50 to 70 g. Tilapia was stocked at 1 indivisual/m^2. They were acclimatized by gradually increasing salinity to the pond conditions before stocking to their respective culture ponds.

Recruitment of tilapia fry was observed 3 weeks after stocking of adult tilapia. In the meantime, the fingerlings of seabass (12 to 18 cm with 30 to 70 g) were stocked into the culture ponds such that tilapia: seabass was 4:1, 5:1 and 6:1 in three replicates. The fingerlings were collected from the local fry collectors of the coastal area during the months of June to July and acclimatized by gradually decreasing salinity before stocking. Water parameters were taken twice a month from the experimental ponds. Both soil and water pH was recorded by soil pH meter and pen pH meter, respectively; salinity and secchi depth by refractometer and secchi disc, respectively; dissolved oxygen (DO), free CO_2, alkalinity and hardness measured by titration methods followed by APHA (1976). Fish samples were taken monthly by seine net for determination of weight and survival rate during the culture period.

A randomized block design (RBD) for three treatments (Seabass: Tilapia ratio) with three replicates was applied. Three stocking ratios were analyzed with one-way analysis of variance (ANOVA) and the differences were compared at 5% level of significance.

RESULTS

The initial soil pH of nine ponds as recorded was 6.4, 6.0, 5.5, 5.7, 6.1, 6.2, 4.2, 5.7 and 5.2, respectively. As the initial soil pH of ponds, 1, 2, 5 and 6 was found satisfactory (above 6), liming was not applied to those ponds. It was found that after treatment with lime, the pH value of both soil and water has been improved to a certain extent in most of the ponds except in Pond 7 where water pH retained in between 4.8 to 5.5. Though the project site was in coastal area but variation of water salinity was not too much (0 to 4 ppt) during observation period and DO was found in acceptable range of 4 to 8.9 mg/L in most of the ponds. Analysis of water in respect to free CO_2, alkalinity and hardness showed no detrimental impact to the water conditions of culture ponds (Table 1).

In this study, seabass attained very fast growth more than 1300 g within 90 days culture period in Pond 1 that shows the growth rate of 10 to 15 g/day (Table 2). This is the first record of such growth in our coastal environment that is yet not available in the scientific world. The satisfactory results are available from most of the culture ponds (Ponds 1 to 6, 8 and 9) that may be due to their favourable ecological conditions. The highest harvest weight of seabass and tilapia was recorded as 74.27 and 49.09 g/m^2, respectively and the highest survival rate of seabass and tilapia was recorded as 78.33 and 61.90%, respectively. The highest growth rate of seabass was 14.67 g/day and the highest biomass of seabass and tilapia (collectively) was found as 116.85 g/m^2. The harvested data showed that after 90 days of culture period, the biomass of seabass and tilapia (collectively) varies within the range of 771.4 to 1168.5 kg/ha among the nine culture ponds (Tables 2 to 4).

The growth of seabass was very smooth and sharp especially when the supply of tilapia fry was quite enough for the requirement of the juveniles' seabass during first 2 months culture period. Then the growth of seabass was sluggish due to increase of food consumption rate of growing seabass which was also proved from the records of reduced number of tilapia fry in the culture ponds and in that period the mouth of young seabass was sufficiently wide even to engulf certain big size tilapia due to their cannibalistic habit. That is why the decision of harvest was made after 3 months culture period when it was found that the difference in size between the fish

Table 1. Physico-chemical parameters of the different fish culture ponds.

Item	P*-1	P-2	P-3	P-4	P-5	P-6	P-7	P-8	P-9
Water temperature (°C)	29 - 32	29 - 32	29 - 32	29 - 32	30 - 32	30 - 32	30 - 32	30 - 32	30 - 32
Soil pH	6.2 - 6.8	6.1 - 6.8	5.5 - 5.7	5.7 - 5.9	6.1 - 6.4	6.2 - 6.4	4.2 - 5.2	5.7 - 6.4	5.2 - 6.3
Water pH	7.5 - 8.9	7.0 - 8.7	6.8 - 9.1	6.3 - 7.4	6.9 - 8.7	7.4 - 8.7	4.8 - 5.2	5.5 - 6.7	5.6 - 7.6
Salinity (ppt)	0 - 5	0 - 6	0 - 3	0 - 2	0 - 2	0 - 2	0 - 5	0 - 4	0 - 4
DO (mg/L)	4.2 - 6.1	3.9 - 6.7	5.0 - 6.3	4.0 - 5.4	5.2 - 6.7	5.7 - 6.9	4.4 - 7.5	3.9 - 6.4	4.1 - 8.9
Free CO_2 (mg/L)	4-14	7-15	4-18	10 - 13	3-10	3-10	11 - 39	8-18	6-10
Alkalinity (mg/L)	48 - 76	42 - 78	26 - 54	30 - 46	30 - 46	34 - 54	24 - 26	34 - 62	28 - 50
Hardness (mg/L)	75 - 136	88 - 152	87 - 122	72 - 145	36 - 52	26 - 51	58 - 181	44 - 145	99 - 165
Secchi depth (cm)	25 - 29	20 - 29	23 - 24	28 - 59	15 - 18	15 - 18	92 - 96	32 - 96	30 - 73

*P = Pond No. Soil and water pH by pH meter, salinity and secchi depth by refractometer and secchi disc, respectively; DO, free CO_2, alkalinity and hardness determined by titration methods followed by APHA (1976).

Table 2. Production in experimental ponds with stocking ratio of seabass-tilapia at 1:4.

Item	Pond 1		Pond 4		Pond 8	
Area (m^2)	805		286		240	
Fish type	Seabass	Tilapia	Seabass	Tilapia	Seabass	Tilapia
No. of fish stocked	201	805	72	286	60	240
No. of fish recovered	120	294	54	119	47	104
Survival rate (%)	59.7	36.5	75.0	41.6	78.3	43.3
Initial weight (g)	35-70	50-70	35-55	55-70	30-55	50-70
Final weight (g)	450 - 1390	85 - 150	200 - 700	85 - 140	225 - 750	80 - 135
Biomass (kg)	43.20	29.19	21.24	12.18	12.20	9.88
Total biomass (kg)	72.39		33.42		22.08	
Production (kg/ha)	899.26		1168.5		920	

within the population of the same ponds varied significantly due to food scarcity of seabass. This was due to avoid a further deteriorating condition which could have resulted in greater loss of fish biomass due to cannibalistic habit.

The size range of seabass was quite wide during harvest especially in the ponds with the highest stocking of 4:1. There was also a higher percentage of fish below 200 g in the culture ponds 1, 4 and 8 in comparison to other ponds where stocking density was 5:1 or 6:1. In this situation, it would be expected that the occurrence of cannibalism would be much greater in the higher stocking (4:1) compared to lower stocking (6:1) of seabass. Considering the factors such as the fingerlings were collected from same area, pond preparation and management were the same, water quality was almost similar, stocking density among three categories was not so wide and feed type and source were also similar, it is therefore, likely that the differences in biomass of production in all three categories of ponds were more or less same (Tables 2 to 4).

It is evident from the one-way ANOVA (Table 5) that there is no significant difference ($p > 0.05$) among the different treatments on the production of total biomass. That means there is no significant difference ($p > 0.05$) among the different levels of stocking density. On the other hand, it can comment that the effects of all proportions of stocking densities are the same that is, no benefit can be gained from applying different stocking densities in order to get higher product of biomass, while it is evident from the same task that there is a significant ($p < 0.05$) effect of pond conditions on the production. It might happen due to the inherent physicochemical and biological parameters of the pond soil and water.

DISCUSSION

Though the growth record of seabass is excellent and highly satisfactory, there was an abrupt size variation of seabass in the culture ponds. Those fishes which were to be stunted to less than 200 g during harvest were transferred to another pond for an additional culture period of 1 or 2 months. The growth of seabass was

Table 3. Production in experimental ponds showing stocking ratio of seabass-tilapia at 1:5.

Item	Pond 3		Pond 5		Pond 7	
Area (m^2)	385		504		169	
Fish type	Seabass	Tilapia	Seabass	Tilapia	Seabass	Tilapia
No. of fish stocked	77	385	101	504	34	169
No. of fish recovered	46	160	58	177	18	104
Survival rate (%)	59.7	41.6	57.4	35.1	52.9	61.90
Initial weight (g)	30-60	55-70	30-55	55-65	30-40	55-70
Final weight (g)	350 - 1000	85 - 135	150 - 750	85 - 140	275 - 600	80 - 130
Biomass (kg)	18.12	18.90	24.27	18.59	6.47	7.02
Total biomass (kg)	37.02		42.86		13.49	
Production (kg/ha)	961.6		850.3		798.2	

Table 4. Production in experimental ponds showing stocking ratio of seabass-tilapia at 1:6

Item	Pond 2		Pond 6		Pond 9	
Area (m^2)	583		530		175	
Fish type	Seabass	Tilapia	Seabass	Tilapia	Seabass	Tilapia
No of fish stocked	97	583	88	530	9	175
No of fish recovered	46	203	53	172	16	82
Survival rate (%)	67.0	34.8	60.2	32.5	55.7	46.9
Initial weight (g)	30-65	55-70	30-60	50-70	30-40	55-65
Final weight (g)	500 - 1200	85 - 130	475 - 1150	85 - 135	250 - 570	85 - 130
Biomass (kg)	26.72	22.54	22.10	20.41	5.19	8.31
Total biomass (kg)	49.26		42.51		13.50	
Production (kg/ha)	844.9		802.1		771.4	

significantly higher during the first 2 months in comparison to the later month, which could be explained by the presence of more tilapia to be prayed upon the first phase of the culture period (Advance, 1984). The decision to harvest was made after 3 months culture period when it was found that the difference in size between fish within the population of same pond varied significantly ($p < 0.05$). This was done to avoid a further deteriorating condition that could have resulted in greater loss of fish very frequently due to shortage of food and cannibalism. The variation in size of seabass was found wide during harvest due to high stocking densities that caused tremendous effect on growth and survival rate. Seabass performed a tremendous growth record in the present study showing daily average growth rate of more than 10 g by using tilapia fry only in the culture ponds. Danakusumah and Ismail (1986) reported that average individual daily growth was 1.3 to 1.5 gm for those cultured with formulated feed and 2.65 to 3.58 gm for those with trash fish. Sugama and Eda (1986) showed that the average daily growth of 4.62 to 6.05 g in net cage culture with trash fish. Growth and production are dependent on the amount of supplied feed (Bardach et al., 1972). ICAR (2010) reported that seabass attain 450 to 950 g after 270 days of culture from seabass tilapia polyfarming at Kakdwip, India. Similar types of work were also performed by the KAU (2012). Awang (1986) stated that seabass were reared about 5 to 9 months in cages to raise market size of about 500 g (1.55 to 3.0 g/day) using trash fish. Genodepa (1986) also harvested 351.5 g of seabass with a stocking size of 221.5 g having a culture period of 94 days (daily growth rate of 1.3 g) using trash fish in a monoculture pond.

Conclusion

The newly developed concept of an alternative eco-friendly technology on ‘integrated tilapia-seabass polyculture’ is treated as a milestone in the brackish water aquaculture in Bangladesh. The implications of this research are to bring back the fertility of the coastal land,

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Table 5. ANOVA table for biomass of seabass.

Source of variance	Sum of square	Degree of freedom	Mean sum of square	Observed F	Calculated F at 5%
Treatment	145.59	2	72.80	2.08	6.94
Block	788.72	2	394.36	11.27	6.94
Error	140.01	4	35.00		

utilization of vast unutilized or underutilized derelict coastal areas, low cost but profitable and quick return on the investment, easy tech and risk-covered in comparison to shrimp culture, eco-friendly affordable environmentally sustainable technology and employment opportunity for the marginal farmers. To meet the increasing demand of animal protein as well as to raise the economic progress of the country, the policy makers among government, non-government and other related organizations should take immediate steps to extend the eco-friendly technology of tilapia-seabass polyculture for the increase of fish production especially in the coastal areas which were abandoned by shrimp farming.

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