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Farzana Hossain
Department of Fisheries, Bangladesh

KM Abdul Halim
Department of Fisheries, Bangladesh

A Baker Siddique
Department of Aquaculture, Bangladesh Agricultural University, Mymensingh, Bangladesh

S Monira Shanta
Department of Fisheries Biology and Genetics, Bangladesh Agricultural University, Mymensingh, Bangladesh

M Fazla Rabbi
Department of Fisheries Biology and Genetics, Bangladesh Agricultural University, Mymensingh, Bangladesh

Rafiul Islam
Department of Fisheries Biology and Genetics, Bangladesh Agricultural University, Mymensingh, Bangladesh

M Rafiqul Azam
Department of Fisheries, Bangladesh

M Rafiqur Rahman
Department of Fisheries Biology and Genetics, Bangladesh Agricultural University, Mymensingh, Bangladesh

Correspondence
M Rafiqur Rahman
Department of Fisheries Biology and Genetics, Bangladesh Agricultural University, Mymensingh, Bangladesh

Polyculture of stinging catfish (*Heteropneustes fossilis*) with Indian major carps in ponds

Farzana Hossain, KM Abdul Halim, A Baker Siddique, S Monira Shanta, M Fazla Rabbi, Rafiul Islam, M Rafiqul Azam and M Rafiqur Rahman

Abstract
Stinging Catfish (*Heteropneustes fossilis*) was cultured with Indian major carp's; rohu (*Labeo rohita*), catla (*Catla catla*), and mrigal (*Cirrhinus chirrosus*) in ponds over a period of 5 months from 01 March 2017 to 30 July 2017. Six earthen ponds (0.12 ha) were divided into three treatments. Three treatments differing in stocking densities of *H. fossilis* such as 24000 (T1), 30000 (T2) and 36000 (T3) per hectare were tested with two replicates each. However, rohu (6175 piece/ha), catla (2470 pieces/ha) and mrigal (3705 piece/ha) were stocked with *H. fossilis* in each treatments. Mega commercial fish feed was applied at the rate of 6 to 2% of their body weight. The water quality parameters were recorded during the experimental period and found within the acceptable range for fish culture. The final weight of *H. fossilis* was found 35.44±1.32g in T1 which showed the better performance followed by T2 and T3. Significantly better FCR was found in T1 followed by T2 and T3. The highest total production was recorded in T1 (6610.27 kg/ha/5 months) followed by T2 (6533.78 kg/ha/5 months) and T3 (6366.42 kg/ha/5 months). The highest benefit was found in T1 (BDT 3, 24,947) followed by T2 (BDT 2, 56,781) and T3 (BDT 1, 97,993) which indicate T1 is more efficient and profitable culture technology during polyculture of *H. fossilis* with Indian major carps in ponds. So, it could be concluded that *H. fossilis* might be suggested to polyculture with Indian major carps in ponds to maintain stocking density 24000 piece/ha of *H. fossilis*.

Keywords: polyculture, stinging catfish, rohu, catla, mrigal, ponds

Introduction
The basic principles of the polyculture of fish rests on the ideas that when compatible species of different feeding habits are cultured in the same pond for better utilization of natural foods of different strata and zones without any harm to each other but selection of different fish species plays an important role for any culture practices [1, 2]. Stocking density and species combination of different fish also plays a vital role on overall production of fish. Higher density of a species may affect the growth rate of fishes and lower density of a species may reduce the overall production. Ahmed [3] reported that in species selection for polyculture, primary importance was given to Indian major carps; rohu (*Labeo rohita*), catla (*Catla catla*), and mrigal (*Cirrhinus chirrosus)*. Sometimes calbasu (*Labeo calbasu*) has been included in the polyculture in the pond culture in Indian sub-continent including Bangladesh. But the culture technique of stinging catfish in seasonal ponds with Farmed Tilapia and Magur developed by the Bangladesh Fisheries Research Institute in northern parts of Bangladesh [4]. The aims of the present work were to create a base for the development of aquaculture technology of the stinging catfish (*Heteropneustes* fossilis) with Indian major carps in commercial aquaculture of Bangladesh

The Asian stinging catfish, *H. fossilis* (Bloch), is a species of air sac catfish. It is locally known as shingi. It is an indigenous stinging cat fish of South-East-Asia which has hardy and survives in adverse ecological condition, high nutritive value as well as high market price [5, 6]. It is characterized by an accessory respiratory organ (air breathing organ) which enables it to exist for hours when out of water or in indefinitely oxygen-poor water and even in moist mud [7]. The species is not only recognized for its delicious taste and market value but is also highly esteemed from nutritional and medicinal properties of view [8]. It contains high amount of iron (226 mg/100 g) and fairly high content of calcium compared to many other freshwater fishes [9]. *H. fossilis* is of high economic importance and of great demand because of it's medicinal

Value [10]. Being a lean fish it is very suitable for people who are unable to utilize animal fats [11]. The fish is recommended for patients after recovery from malaria for its invigorating qualities [12].

Now a day's stinging catfish and carps polyculture is not a new thought in Bangladesh but there is no available information on different ration of stinging catfish (*H. fossilis*) and carps in a polyculture system. It is also very essential to showing the benefit cost ratio of the culture technologies to the farmer so fur they can easily understand how much of benefit they can achieved and more interested on such type of culture technologies. Hence, the present research works has been designed and proposed to polyculture techniques of *H. fossilis* with Indian major carps i.e. rohu (*L. rohita*), catla (*C. catla*), and mrigal (*C. chirrosus*) in ponds; to assess the water quality parameters of experimental ponds and analyze the benefit cost ratio of culture technologies.

Materials and Methods

The experiment was conducted in farmer's pond under semi-intensive rearing system in Modonpur, Netrokona Sadar, and Netrokona for a period of 5 months from 1 March 2017 to 30 July 2017. A total of six perennial ponds were divided under three treatments i.e. T1, T2 and T3 each having two replicates.

The area of each pond was 0.12 ha with an average water depth of 4.5 feet. All the ponds were more or less similar shape, size, basin conformation and bottom type. The ponds were flood free rain fed, free from aquatic vegetation and well exposed to sunlight. Each ponds have inlet and outlet to provide water and when needed. After selection, at first broken dikes and holes of all ponds were repaired. After that, all kinds of aquatic vegetation (floating, emergent, submerged and spreading) were removed manually and the branches of all trees on the ponds were trimmed off. The predatory and undesirable fishes were eradicated by netting repeatedly and cleaned by poisoning with rotenone at the rate of 25g/decimal/feet water. Liming was done immediately after poisoning at the rate of 1kg/decimal. Five days after liming, all the ponds were manured with cow dung at the rate of 10 kg/decimal, urea and TSP were used in all of those ponds at the rate of 150 g and 75 g per decimal, respectively. Soon after the appearance of light-plankton bloom, all the ponds were stocked more or less similar weight of stinging catfish (*H. fossilis*), rohu (*L. rohita*), catla (C. *catla*) and mrigal (*C. chirrosus*). The stocking density of rohu, catla and mrigal was same in all the treatment but various stocking densities were stocked in case of stinging catfish. At the stocking, fingerlings of *H. fossilis* and Indian major carps were stocked as per experimental design (Table-1).

Table 1: Layout of the experimental design with species composition and stocking density under three treatments

Treatments	Species composition	Stocking densities (No of fish/ha)	Average weight (g)
T1	Catla (*Catla catla*)	2470	20.84±1.23
	Rohu (*Labeo rohita*)	6175	15.01±2.14
	Mrigal (*Cirrhinus cirrhosus*)	3705	13.93±1.13
	Shing (*Heteropneustes fossilis*)	24000	5.21±0.16
T2	Catla (*Catla catla*)	2470	21.02±0.23
	Rohu (*Labeo rohita*)	6175	14.92±1.32
	Mrigal (*Cirrhinus cirrhosus*)	3705	14.01±0.82
	Shing (*Heteropneustes fossilis*)	30000	5.21±0.16
T3	Catla (*Catla catla*)	2470	20.93±0.79
	Rohu (*Labeo rohita*)	6175	14.98±0.85
	Mrigal (*Cirrhinus cirrhosus*)	3705	13.86±1.10
	Shing (*Heteropneustes fossilis*)	36000	5.21±0.16

For the proper growth of fishes, commercially available mega fish feed was applied throughout the experimental period @ of 6 to 2% of their body weight. The feeding was adjusted on the basis of monthly sampling of fishes. In each sampling ten fish of each species from each pond were caught by cast net. The weight was taken by ordinary balance.

Water quality parameters of pond water were monitored monthly between 09.00 and 10.00 hr. Temperature (°C) and dissolved oxygen (mg/l) were determined directly by a digital water quality analyzer Hanna DO meter (Model-HI 9146, Romania), pH by a digital pH-meter (Milwaukee pH meter, Model-PH55/PH56, USA) and ammonia nitrogen by a UV VIS Spectrophotometer water analysis kit (DR 6000TM, USA). Total alkalinity was estimated following the standard method [13, 14].

To evaluate the fish growth performance weight gain (g), specific growth rate (SGR%/day), food conversion ratio, survival rate (%), individual production and total production were measured after end of the experiment. The following parameters were used to evaluate the growth performance of experimental fishes:

Weight gain (g) = Mean final weight (g) - Mean initial weight (g)

Specific growth rate

$$\text{SGR (\% per day)} = \frac{\text{Ln final weight} - \text{ln initial weight}}{\text{Number of experimental days}} \times 100$$ [15]

$$\text{Food conversion ratio (FCR)} = \frac{\text{Feed fed (dry matter)}}{\text{Live weight gain}}$$ [16]

$$\text{Survival rate (\%)} = \frac{\text{No. of fish harvested}}{\text{No. of fish stocked}} \times 100$$

After 5 months of culture, all the fishes were harvested by netting repeatedly with seine net from each pond and finally drying the ponds. The fishes were counted and weighed individually. Then the final growth gained by each species was recorded by measuring weight (g) of individual fish. The species wise and total production for each treatment was determined by multiplying the average weight (g) gained by total number of survived fish at the end of the experiment.

Statistical analysis

The collected data of the experiment was analyzed by one way analysis of variance by computer (SPSS package program). Comparison between treatment means was carried out by analysis of variance (ANOVA) followed by Duncan's Multiple Range Test [17].

Results

Water quality parameters

Water quality parameters of the experimental ponds were recorded during the experimental period and presented in Table 2. Water temperature of the ponds under different treatments was recorded monthly. The water temperature was more or less similar in different ponds. The mean values of water temperature were 31.74±1.67, 31.56±1.32 and 31.49±1.10 ^{0}C in T1, T2 and T3 respectively. The ranges of water temperature were 27.50 to 33.00 ^{0}C in T1, 27.00-32.50 ^{0}C in T2 and 27.50-32.00 ^{0}C in T3, respectively. The values of dissolved oxygen ranged from 5.47 to 6.57 mg/l, 5.42 to 6.62 mg/l and 5.12 to 5.97 mg/l and mean values were 6.32±0.32, 6.02±0.13 and 5.93±0.54 mg/l in treatments 1, 2 and 3 respectively. The mean values of dissolved oxygen were more or less similar in all treatments and there was

Table 2: Physico-chemical characters of water in the cultural ponds during the experimental period

Parameter	Treatments		
	T1	T2	T3
Water temperature (°C)	31.74±1.67^a	31.56±1.32^a	31.49±1.10^a
Dissolved oxygen (mg/l)	6.32±0.32^a	6.02±0.13^a	5.93±0.54^a
pH	7.12±1.01^a	7.75±0.82^a	7.93±0.78^a
Total alkalinity (mg/l)	112.42±1.22^c	123.19±2.34^b	138.74±3.51^a
Ammonia (NH_3) (mg/l)	0.18±0.010^c	0.24±0.012^b	0.36±0.019^a

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

No significant ($p > 0.05$) difference among treatments. The pH values of the pond water under the three treatments were found acceptable range for fish culture. The pH values of water were varied from 6.98 to 8.24 and the mean values were 7.12±1.01, 7.75±0.82 and 7.93±0.78 in T1, T2 and T3, respectively. The ranges of total alkalinity were 87 to 122 mg/, 95 to 133 mg/ and 112 to 156 mg/ in T1, T2 and T3, respectively. The mean value of total alkalinity was recorded in 112.42±7.22, 123.19±6.34 and 138.74±8.51 mg/l in T1, T2 and T3, respectively. The ranges of ammonia were 0.12 to 0.27, 0.17 to 0.32 and 0.24 to 0.49 mg/l in T1, T2 and T3, respectively. The highest value of ammonia was recorded as 0.49 mg/l in T3 and the lowest value was 0.12 mg/l in T1.

Growth performance and production of fishes

The mean initial weight (g), final weight (g), weight gain (g), specific growth rate (SGR,% per day), food conversion ratio (FCR) and survival rate of fishes (kg/ha/5 months) during the study period were recorded and presented in Table 3. There was no significant difference in Table 3.

Table 3: Growth performances and production of shing and Indian major carps under the three treatments over a culture period of 5 months

Parameters	Species	T1	T2	T3
Initial mean wt. (g)	*C. catla*	20.84±1.23^a	21.02±0.23^a	20.93±0.79^a
	L. rohita	15.01±2.14^a	14.92±1.32^a	14.98±0.85^a
	C. chirrosus	13.93±1.13^a	14.01±0.82^a	13.86±1.10^a
	H. fossilis	5.21±0.16	5.21±0.16	5.21±0.16
Final mean wt. (g)	*C. catla*	570.25±5.89^a	568.23±7.02^a	563.87±4.57^a
	L. rohita	505.12±6.19^a	501.33±7.12^a	496.87±5.64^a
	C. chirrosus	455.21±4.02^a	449.86±3.89^a	433.76±4.84^b
	H. fossilis	35.44±1.32^a	30.59±1.89^b	24.82±1.58^c
Mean weight gain(g)	*C. catla*	549.41±5.89^a	547.21±7.02^a	542.94±4.57^a
	L. rohita	490.11±6.19^a	486.41±7.12^a	481.89±5.64^a
	C. chirrosus	441.28±4.02^a	435.85±3.89^a	419.90±4.84^b
	H. fossilis	30.23±1.32^a	25.38±1.89^b	19.61±1.58^c
Specific growth rate (%/day)	*C. catla*	2.20±0.01^a	2.24±0.06^a	2.24±0.06^a
	L. rohita	2.31±0.05^a	2.29±0.05^a	2.31±0.03^a
	C. chirrosus	2.28±0.07^a	2.28±0.05^a	2.27±0.04^a
	H. fossilis	1.29±0.02^a	1.21±0.04^b	1.01±0.04^c
Survival rate (%)	*C. catla*	96.19±0.49^a	95.80±0.31^a	96.41±0.58^a
	L. rohita	95.26±0.30^a	94.83±0.41^a	95.87±0.54^a
	C. chirrosus	93.78±0.34^a	93.11±0.23^a	93.73±1.19^a
	H. fossilis	81.78±0.65^a	78.20±0.49^b	69.48±1.33^c
FCR		1.41±0.02^c	1.52±0.01^b	1.58±0.04^a
Species-wise production (Kg/ha/6 month)	*C. catla*	1361.16±1.95^a	1338.84±3.75^a	1351.14±3.55^a
	L. rohita	2975.97±2.62^a	2927.45±1.08^a	2926.63±3.80^a
	C. chirrosus	1579.73±3.00^a	1546.75±3.27^a	1471.45±4.21^a
	H. fossilis	693.42±3.08^b	720.74±4.38^a	617.20±5.12^b
Total production (Kg/ha/6 month)		6610.27	6533.78	6366.42

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

Initial weight, final weight, weight gain, specific growth rate and survival rate of rohu and catla among the treatments. Mrigal showed significantly lower growth performance in T3 than T1 and T1. On the other hand, stinging catfish showed significantly higher ($p < 0.05$) growth performance in T1 than T2 and T3. Significantly the lowest food conversion ratio was found in T1 and the highest in T3. This might be due to lower stocking density of shing in T1 than T2 and T3.

At the end of the experiment, species-wise production of rohu, catla and mrigal were not significantly different among the treatments except stinging catfish. The production of stinging catfish recorded significantly higher ($p < 0.05$) in T2 than T1 and T3. The total highest productions of fishes were recorded in T1 (6610.27 kg/ha/5 months) followed by T2 (6533.78 kg/ha/5 months) and T3 (6366.42 kg/ha/5 months).

Cost-benefit analysis

A simple cost-benefit analysis was done to estimate the return against investment and profitability that had been generated proper combination and stocking densities in polyculture of stinging catfish with Indian major carps. The total cost of production (BDT/ha) was lower in T1 (6, 64,431) than those in T2 (7, 06,781) and T3 (7, 09,131) (Table 4). The net benefits were calculated from three culture types of culture system as BDT 3, 24,947, 2, 56,781 and 1, 97,993 per hectare for T1, T2 and T3, respectively.

Table 4: Cost and benefits analysis of polyculture of shing with Indian major carps in ponds from one hectare ponds over a culture period of 5 months.

Item wise expenditure/ Operational costs	T1 (BDT)*	T2 (BDT)	T3 (BDT)
A. Cost			
1.Pond lease value for 6 month	32,110	32,110	32,110
2. Price of fingerlings			
i. Catla @TK 3.50/piece	8,645	8,645	8,645
ii. Rohu @TK 3.50/piece	21,613	21,613	21,613
iii. Mrigal@TK 2.50/piece	9,263	9,263	9,263
iv. Shing@TK 2.00/piece	48,000	60,000	72,000
3. Feeds	4,69,600	5,01,150	4,92,700
4. Lime, fertilizer etc	30,000	30,000	30,000
5. Human labor, Transport etc.	50,000	50,000	50,000
Total Cost	6,64,431	7,06,781	7,09,131
B. Incomes			
i. Catla	1,70,1451	1,67,355	1,68,893
ii. Rohu	4,16,636	4,09,843	4,09,728
iii. Mrigal	1,73,770	1,70,143	1,61,860
iv. Shing	2,28,827	2,16,222	1,66,644
Total return	9,89,378	9,63,562	9,07,124
Net Profit (B-A)	3,24,947	2,56,781	1,97,993

*BDT 80.00 =1 US$

Discussion

Water quality parameters

Water quality parameters such as water temperature, dissolved oxygen, pH, total alkalinity and ammonia were recorded in the present study and showed very little variation among the treatments. The water temperature was suitable ranges for fish culture and there was no significant difference ($p > 0.05$) among the treatments when ANOVA was performed. Ali *et al.* [18] recorded water temperature range of 28.91 to 29.13 ^{0}C from earthen ponds of shaprpunti culture. Ahmed *et al.* [19] recorded water temperature of 30.41 ^{0}C from a pond situated at Bangladesh Agricultural University Campus, Mymensingh. These result strongly agreed with the present findings. Dissolved oxygen is one of the most important factors for fish culture which was recorded during the experimental period. The mean values of dissolved oxygen were more or less similar in all treatments and there was no significant ($p > 0.05$) difference among them. Similar results were found by Ali *et al.* [18], Ahamed *et al.* [4], Moniruzzaman and Mollah [20], Ahmed *et al.* [19] and Mollah *et al.* [21]. The pH values of the different treatments ponds water were found to be slightly alkaline and highest water pH were recorded 8.24 in theT3 and lowest 6.98 in the T1. The pH values of the pond water under the three treatments were found acceptable range for fish culture. Hossain *et al.* [22] reported that average values of pH ranged from 6.5 to 8.1 in Kailla beel. Dewan *et al.* [23] stated that the optimum pH range for carp polyculture in pond is 6.5 to 9.0. Similar results were found by Ali *et al.* [18], Ahmed *et al.* [19], Israfil [24] and Kabir [25]. The highest total alkalinity was recorded in T3 (156 mg/l) and lowest in T1 (87 mg/) and the variations among the treatments were statistically significant ($p < 0.05$). The total alkalinity was suitable ranges for fish culture. Total alkalinity of productive ponds should be 20 ppm or more [26]. According to Mairs [27] a total alkalinity of 40 mg/l or more to be productive than the water bodies with lower alkalinity. Ali *et al.* [18] recorded the total alkalinity from 59 to 77 in monoculture of Thai sharpunti in ponds. Uddin [28] reported total alkalinity values between 45 and 140 mg/l. in polyculture system in ponds. These values of present findings suitable ranges for fish culture according to Mairs [27], Uddin [28] and Ali *et al.* [18], The mean values of ammonia were significant ($p < 0.05$) difference among the treatments. Highest ammonia content were recorded in T3 (0.36) due to high stocking density and more amount of fecal materials were release in the ponds and minimum in the T1 (0.18) due to lower stocking density compared to T2 and T3. Ahamed *et al.* [4] recorded ammonia ranges 0.17 to 0.21 in polyculture of stinging Catfish (*H. fossilis*) in seasonal water bodies of greater northern region, Bangladesh. Paul [29], Kohinoor *et al.* [30] and Wahid *et al.* [31] also recorded of 0.01 to 0.99 mg/l in BAU campus; Mymensingh which agreed the present findings.

Growth performance and production of fishes

Stocking density directly effect on growth and survival and production of *H. fossilis* was conducted and observed in term of final weight, weight gain, SGR of *H. fossilis, L. rohita, C. catla* and *C. chirrosus* in earthen ponds varied on different stocking densities of *H. fossilis*. T1 showed significantly highest growth ($p < 0.05$) of *H. fossilis* than those of T2 and T3. This is due to lower number of *H. fossilis* in T1 than T2 and T3. The growth performance of Indian major carps more or less similar in all treatments as the stocking density was same. Ahamed *et al*. [4] recorded performance of growth of shing during culture with Magur, Tilapia and Silver barb in seasonal ponds. The lower growth performances *H. fossilis* were in T3 and T2 than T1 that might be due to competition for food and habitat for higher number of *H. fossilis*. The present findings of shing coincide with the findings of Narejo *et al*. [32] who achieved best growth at lower stocking densities in shing farming. The value of FCR decreased in T1 (1.41) than T2 (1.52) and T3 (1.58) due lower stocking density and higher growth which is supported by Pechsiri and Yakupitiyage [33]. Comparatively less amount of feed was applied according to feeding demand and ultimately FCR values of different treatments were very low but acceptable and indicated better food utilization, which is agreed by Islam [34]. The survival rate of shing was significantly higher in T1 (81.78%) than T2 and T3 but no significant differences was found among Indian major carps. The reason for reduced survival rate in treatment T3 might be due to higher stocking density of shing which is supported by Ahamed *et al*. [4], Chakraborty *et al*. [35]. The fish production of *H. fossilis* were found higher in T2 (720.74±4.38 kg/ha/5 months) followed by T1 (693.42±3.08 kg/ha/5 months) and T3 (617.20±5.12 kg/ha/5 months) and there was found significant difference ($p > 0.05$) among the treatments. But the individual production of rohu, catla and mrigal showed no significantly differences among the treatments. The findings of the present research work agreed with the findings of Mollah [36], Narejo [32] and Siddik and Khan [37].

Cost-benefit analysis

The cost benefit analysis was carried out to estimate the economic return under low input management. The expenditures in T2 and T3 were more or less similar and not found significantly differences. The lowest expenditure was recorded in T1 (BDT 6, 64,431/ha) followed by T2 (BDT 7, 06,781/ha) and T3 (BDT 7, 09,131/ha). However, comparatively higher net profit was found in T1 (BDT 3, 24,947/ ha) followed by T2 (BDT 2, 56,781/ ha) and T 3 (BDT 1, 97,993/ha) due to lower stocking density of *H. fossilis* and higher individual weight of *H. fossilis* were found in T1 than others treatments. Ahamed *et al*. [4] recorded the cost and benefit of adaptability of polyculture of stinging catfish (*H. fossilis*) in seasonal water bodies of greater northern region, Bangladesh and got the net benefit of BDT 9,59,116.04/ha/5 months where fish were fed formulated feed. Kohinoor *et al*. [38] observed that monoculture of Raj punti (*Puntius gonionutus*) gave a net benefit BDT 68,135 to 75,028/ha from 6 months cultured. In the present study, the net benefit was more or less similar with the above findings. Among the treatments in five months culture of Shing (*H. fossilis*) with Indian major carps in polyculture system, individuals 24000/ha stocking density may be recommended for fish farmers in ponds but further study were needed to optimize the stocking density of Shing (*H. fossilis*) in polyculture system with Indian major carps in commercial fish farming.

Conclusion

Polyculture of stinging catfish (*H. fossilis*) with Indian major carps are not being practicing commercially at the farmer's level because is no available information on appropriate ratios of shing (*H. fossilis*) with Indian major carp's polyculture system. So it can be concluded that that the stocking density of *H. fossilis* is advisable 24000 pieces/ha when culture with rohu, catla and mrigal in ponds for better economic efficiency. But further research are needed to optimize the stocking density of shing culture with Indian major carps, nutrient requirements, effects of physiochemical parameters and feeding frequency for better growth performance as well as more production and benefit.

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