CULTURE TECHNIQUE OF SHING WITH OTHER HIGH-VALUE FISH SPECIES IN THE SEMI-ARID ZONE OF BANGLADESH

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ABSTRACT

This study was conducted in farmer's ponds within the northern region of Bangladesh to observe the growth and yield of Shing, *Heteropneustes fossilis* under a polyculture system. The highest total production of fish registered among the treatments in pattern-1 was 6,331 kg ha^{-1} with a benefit-cost ratio of 1.52. The best combinations were chosen for multi-location testing (MLT) to verify the previous results. After five months of multi-location testing of the selected combinations with Shing as the main species, the significantly ($P < 0.05$) highest production of Shing (5,828 kg ha^{-1}), total production of fishes (7,352 kg ha^{-1}) and benefit-cost ratio (1.73) were found.

RÉSUMÉ: Technique de culture du Shing avec des espèces de poissons de grande valeur dans la zone semi-aride du Bangladesh.

L'étude a été menée dans des étangs d'agriculteurs dans la région nord du Bangladesh pour observer la croissance et le rendement du Shing, *Heteropneustes fossilis* dans un système de polyculture. La meilleure production totale de poisson enregistrée parmi le modèle de traitement-1 était de 6.331 kg ha^{-1} avec un rapport avantages-coûts de 1,52. Ces meilleures combinaisons ont été choisies pour des tests multi-sites (MLT) afin de vérifier les résultats précédents. La combinaison sélectionnée après cinq mois de tests multi-sites avec Shing comme espèce principale, la production de Shing significativement ($P < 0,05$) la plus élevée (5,828 kg ha^{-1}), la production totale de poissons (7.352 kg ha^{-1}) et le bénéfice -un rapport de coût (1,73) a été trouvé.

REZUMAT: Tehnica de cultivare a speciei de pește pisica fosilă cu specii de pești de mare valoare în zona semi-aridă din Bangladesh.

Studiul a fost efectuat în iazurile fermierilor din regiunea de nord a Bangladeshului pentru a observa creșterea și randamentul pisicii fosile, *Heteropneustes fossilis*, în cadrul unui sistem de policultură. Cea mai bună producție totală de pește înregistrată între tratamente în modelul-1 a fost de 6.331 kg ha^{-1}, cu un raport beneficii/costuri de 1,52. Aceste combinații optime au fost alese pentru testarea în mai multe locații (MLT) pentru a verifica rezultatele anterioare. Combinația selectată, după cinci luni de testare în mai multe locații cu Shing ca specie principală, în mod semnificativ ($P < 0,05$) cea mai mare producție de Shing (5.828 kg ha^{-1}), cu o producția totală de pești (7352 kg ha^{-1}) și un raportul beneficiu-cost (1,73), dintre cele trei locații, a fost găsită în Dimla.

INTRODUCTION

The Northern region (Rangpur District) of Bangladesh is known as a drought and river bank erosion prone area. Most of the districts within this district have been experiencing frequent natural disasters and adverse impacts of climate change. Their ponds and canals are extremely depleted, even major rivers see reduced water volume for up to six-eight months. As a result, the number of seasonal waters (Mou et al., 2024; Hasan et al., 2023) is increasing with approximately 55% ponds being seasonal. 60% of those retain water for four-six months while 40% retain for six-nine months in a year and even more in some instances (Ahamed et al, 2017b). These small water bodies are being used mainly for household activities, but some are still abandoned due to their derelict and marshy nature. In this semi-arid zone, fish farmers are lacking appropriate fish culture techniques and most farmers utilize traditional methods (Ahamed et al., 2017a). The polyculture attempts on short cycle species such as Shing (*Heteropneustes fossilis*), Pabda (*Ompuk Pabda*), Rajpunti (*Barbodes gonionoutus*) and GIFT (*Oreochromis* sp.), etc., might have useful applications in those seasonal waters. The species is not only recognized for its delicious taste and market value but is also highly esteemed for its nutritional and medicinal properties (Ahamed et al., 2020). Bangladesh is ranked fourth position in inland fishery production just after China, India, and Myanmar and fifth position in marine water (FAO, 2018). The fisheries sector is inseparable from the life and lifestyle of the people of Bangladesh since it contributes 4.37% to the national GDP and almost one-fourth (23.37%) to the agricultural GDP (DoF, 2013). About 1.5 million people are directly employed by this sector (DoF, 2012). Within the northern region is where this culture technique would be most effective in increasing fish production as well as income for all types of fish farmers. In this context, culture techniques of these species are to be disseminated in this region. The polyculture technology of shing can help to meet the dietary needs and improve the socio-economic status of the people especially in the Northern region of Bangladesh.

MATERIAL AND METHODS

Experiments were conducted in farmer's ponds located within the Nilphamari District of Bangladesh for five months from mid-July to mid-December of 2017 to observe the growth and yield performance of Shing, *Heteropneustes fossilis* under a polyculture system. Six seasonal ponds (10-15 decimal) were selected for each experiment. The six ponds were divided into three groups and each group was used for a treatment. Ponds were selected with the concern of relevant Subdistrict Fishery Officer (UFO/SUFO). The experimental designs are described as follows in table 1.

Table 1: Polyculture of Shing, (pattern-1) under different stocking densities in farmer's pond.

Treatments	Species wise stocking size (cm)	Stocking density (indi. dec^{-1})			
		Shing	Pabda	Rajpunti	GIFT
T_1	Shing (7-10) Pabda (5-7) Rajpunti (7-8) GIFT (5-6)	400	100	10	05
T_2		500	100	10	05
T_3		600	100	10	05

The ponds were prepared by dewatering and drying. Aquatic weeds were removed manually before lime was applied 1.0 kg decimal^{-1}. After seven days of liming, urea 100 g decimal^{-1} and TSP 75g decimal^{-1} were applied at the initial stage of pond preparation. The hatchery produced fingerlings (5-10 cm) of selected fish and ponds were stocked as per experimental design (Tabs. 1 and 2). Commercially available fish feed (containing 30-35% protein) was fed 15-5% BW day^{-1} to the fish. Length and weight data was collected every two weeks in the morning from 8.00 am to 9.00 am. Samplings were done by cast net. Fish length was measured using a measuring meter scale (cm) and weight was taken by a precision weighing balance (measuring range from 1.0 g to 1.0 kg). Water quality parameters of the experimental ponds were also monitored every two weeks. Water temperature (°C) was measured by a Celsius thermometer, transparency (cm) by secchi disc, water pH by digital pH meter (Hanna Co. Japan), dissolved oxygen (DO) (mg l^{-1}) by digital DO meter (Lutron PDO-519, Taiwan) and ammonia (NH_3) (mg l^{-1}) by ammonia test kit (Hanna Co. Japan). At the end of the experiment the ponds were completely dewatered, all fish were harvested and the different fish species counted. Then the final length-weight of each species was recorded. The parameters such as length gain, weight gain, % weight gain, SGR, FCR, and survival rate (%) and benefit cost ratio (BCR) were calculated and evaluated on the growth and yield of fish.

Exp-2 Dissemination of suitable polyculture patterns of short life cycle fish species in different parts of a semi-arid zone (northern part) of Bangladesh (2018).

Polycultures of *Heteropneustes fossilis* were tested under different treatments in seasonal farmer's ponds in the adjacent areas of FSS, Saidpur from mid-July to mid-December of 2017. Of them, 500 Shing+100 Pabda+10 Rajpunti+5 GIFT (indi. dec.$^{-1}$) from Shing polyculture (pattern-1) were selected due to technically sound, socially acceptable, and economically viable polyculture patterns. These combinations were disseminated in different aquatic ecological zones within the northern region of Bangladesh from May to September of 2018 through a multi-location testing (MLT) program. Multi location testing programs were conducted in different subdistricts of the northern region of Bangladesh to verify the research results of previously tested suitable culture patterns and exchange views among the researcher, and farmers. A total of six seasonal ponds were selected in six different subdistricts of the Rungpur region (Tab. 3). The six ponds were divided into two groups. Each group was considered as one pattern e.g. pattern-I and pattern-II and each pond or subdistrict was considered as one replication. The areas of ponds ranged between 10 and 15 decimal. The on-farm ponds were selected with the concern of relevant Senior Subdistrict Fishery Officer (SUFO/UFO). In preparation for the study selected ponds were drained and aquatic weeds were manually removed. Undesirable fish species were removed using rotenone 25-35 g dec^{-1} ft^{-1} if necessary and ponds were limed 1 kg dec^{-1}. After five days of liming, cow-dung six kg dec^{-1}, urea 100 g dec^{-1} and TSP 75 g dec^{-1} were applied at the initial stage of pond preparation. About 7-10 cm fingerlings of those fish were stocked as per experimental design (Tab. 3). Fish were fed commercially available fish feed 10-5% BW day^{-1} (containing 30-35% protein). Length-weight data and water quality parameters (viz., temperature, pH, DO, CO_2, NH_3, etc.) were collected fortnightly. The experimental design is presented in table 2.

Table 2: Experimental design of pattern-1 in different Subdistrict of Rungpur region.

Culture pattern	Replication (one pond/subdistrict)	Species combination	Stock density (indi. decl^{-1})
Pattern-1	Saidpur, Niphamari+Hatibanda, Lalmonirhat+Dimla, Niphamari	Shing+Pabda+ Rajpunti+GIFT	500+100+10+5

At the end of the experiment the selected ponds were completely dewatered and all the fish were harvested and counted species wise. Then the final length-weight of each species was recorded. The parameters such as length gain, weight gain, % weight gain, SGR, FCR, survival (%) and benefit cost ratio (BCR) were calculated. Data were analysed using MS Excel and one-way analysis of variance (ANOVA) (Duncan, 1993) and SPSS 20 (Chicago, USA) to detect significant differences among the treatments at 5% level. The values were given with means ± SD, and differences were considered significant at subset for alpha = 0.05 ($p \leq 0.05$).

RESULTS AND DISCUSSION

Growth performances of Shing, *Heteropneustes fossillis* under polyculture in farmer's pond

The growth parameters such as weight gain, SGR, survival rate (%), production of Shing and total production of candidate species were studied and presented in table 3. In this experiment, the final weights of Shing were 55.5, 52.3, and 42.2 g in T_1, T_2 and T_3 respectively. The highest weight gain (53.5 g) was found in T_1 and the lowest (40.2 g) was found in T_3. The weight gain of Shing was found to be significantly identical ($P < 0.05$) in T_1 and T_2 but higher than T_3. A more or less similar growth pattern was observed by Mou et al. (2018) who stated the growth of Shing varied between 49.5 and 69.4 g from six months. The growth performances of Shing were found to be inversely related with the stocking density. This might be due to competition for food and space. The SGR of Shing was 2.21, 2.17 and 2.03% day^{-1} respectively in T_1, T_2 and T_3. After analysis, the SGR showed to be significantly ($P < 0.05$) similar in T_1 and T_2 but lower in T_3. The FCR values were higher in T_3 (2.65) and lower in T_1 (2.51). Analytical results showed, the FCR values were directly related with the stocking density. Overall, the FCR values were at acceptable levels and indicated utilization of food soundly, which agrees with Hossain et al. (2018) and Ahamed et al (2018). The survival rate was estimated after harvesting the fish by dewatering the ponds. The survival (%) values of shing were 84, 80 and 73, respectively in T_1, T_2 and T_3. The survival of Shing was found significantly ($P < 0.05$) different among the three treatments and inversely related with the stocking density. The reason for this might again be space and food competition among the individuals. These findings agreed with Hossain et al. (2019). The production of Shing was recorded to be 4,620, 5,080 and 4,599, respectively in T_1, T_2 and T_3. Based on analysis, the production (kg ha^{-1}) of Shing in T_2 showed to be significantly ($P < 0.01$) higher followed by T_1 and T_3. The total fish production (kg ha^{-1}) was 5,896, 6,331 and 5894 in T_1, T_2 and T_3 respectively. The total production was also significantly ($P < 0.05$) higher in T_2 than in T_1 and T_3. The production is directly related with stocking density, survival and individual growth. Individual growth and survival of Shing were both higher in T_1 but T_2 had higher production. The higher production in T_2 was due to having a more dense population than $T_{1,}$ because individual weight and survival of Shing was not found significantly ($P < 0.05$) different between T_1 and T_2. In the present study, the values of survival and individual growth of shing were relatively sensible at impact on the production in T_2 than that of T_1 and T_3. The present findings are supported by the findings of Hasan et al. (2023) who obtained higher production from a higher stocking density but also found that individual growth was inversely related with the stocking density.

Table 3: Growth performances of *Heteropneustes fossillis* under polyculture in farmer's pond; within rows values with different superscripts are significantly different ($P < 0.05$).

Parameters	Treatments		
	T_1	T_2	T_3
[3] Stock. dens. of Shing (indi. dec^{-1})	400	500	600
Culture period (months)	05	05	05
Initial weight (g)	2.0 ± 0.1	2.0 ± 0.1	2.0 ± .01
Final weight (g)	55.5 ± 5.2^{a}	52.3 ± 6.5^{a}	42.2 ± 7.5^{b}
Weight gain (g)	53.5 ± 4.1^{a}	50.3 ± 5.5^{a}	40.2 ± 6.7^{b}
SGR (% day^{-1})	2.21 ± 0.03^{a}	2.17 ± 0.03^{a}	2.03 ± 0.02^{b}
FCR	2.51 ± 0.01^{c}	2.55 ± 0.01^{b}	2.65 ± 0.01^{a}
Survival (%)	84 ± 1.0^{a}	80 ± 2.6^{a}	73 ± 2.6^{ab}
Production of Shing (kg ha^{-1})	4620 ± 30^{b}	5,080 ± 75^{a}	4599 ± 20^{b}
Total production (kg ha^{-1})	5,896 ± 87^{b}	6,331 ± 211^{a}	5894 ± 100^{b}

Physiochemical parameters of the experimental ponds

The water quality parameters viz., temperature (^{o}C), transparency (cm), water pH, DO (mg l^{-1}) and ammonia (mg l^{-1}) of experimental ponds under three different treatments were monitored and presented in table 4. The water temperature varied between 27.8°C and 28.5°C during the experiment and there were no significant differences among the treatments. The range was selected due to being suitable for fish culture as reported by Rahman et al. (2018) and Hossain et al. (2022) who stated that 25.5℃ to 30.0℃ is favorable for fish culture. The values of water transparency were 26.5, 26.6 and 27.1 cm respectively, in T_1, T_2 and T_3. Similar values were reported by Kohinoor and Rahman (2015) who recorded 26.8 to 30.4 cm transparency in successful Koi culture ponds. The mean values of pH were 7.8, 7.7 and 7.6 in treatment T_1, T_2 and T_3 respectively. According to Boyd (1982), the pH values of water ranging from 7.3 to 9.0 indicated that the experimental ponds were suitable for fish culture. The DO concentration ranged from 5.4 to 6.0 mg l^{-1} during the experiment and no significant difference was observed among the treatments. Hasan et al. (2023) reported that dissolved oxygen content for fish culture should be maintained from 5.0 to 8.0 mg l^{-1}. So, it is to be assumed that the dissolved oxygen level was suitable for fish culture in the present study. Ammonia varied from 0.08 to 0.12 mg l^{-1} among the treatments. Shamsuddin et al. (2022), Ahamed et al. (2018), and Huque et al. (2008) stated that ammonia levels varied between 0.16 and 0.24 mg l^{-1} in Shing polyculture ponds within the northern region of Bangladesh. This finding agrees with the findings of the present study. Based on experimental results and the above discussion it can be concluded that the water quality parameters of the present study were ideal for fish culture.

Table 4: Physiochemical parameters of the experimental ponds of H. fossillis polyculture.

Water quality parameters	T_1	T_2	T_3
Water temperature (^oC)	28.0 ± 2.5	27.8 ± 3.0	28.5 ± 2.0
Water transparency (cm)	26.5 ± 1.5	26.6 ± 2.0	27.1 ± 1.0
Water pH	7.8 ± 1.0	7.7 ± 1.5	7.6 ± 1.0
DO (mg l^{-1})	6.0 ± 0.5	5.5 ± 0.6	5.4 ± 0.5
NH_3 (mg l^{-1})	0.08 ± 0.01	0.10 ± 0.01	0.12 ± 0.01
Water temperature (^oC)	28.0 ± 2.5	27.8 ± 3.0	28.5 ± 2.0
Water transparency (cm)	26.5 ± 1.5	26.6 ± 2.0	27.1 ± 1.0

Economic analysis

A simple economic analysis was conducted to estimate the benefit cost ratio (BCR) of Shing polycultures (Tab. 6). The total production (kg ha^{-1}) of fish was recorded as 5,896, 6,331 and 5,894, respectively in T_1, T_2 and T_3. The results were similar to those found by Ahamed et al. (2017a) who reported a production range from 6,981 to 7,793 kg ha^{-1} where the stocking density of Shing ranged from 500 to 700 indi. $dec.^{-1}$ during a five month polyculture. The highest production cost (Tk. ha^{-1}) was recorded in T_3 (1,362,392) and the lowest was T_1 (1,159,508) (Tab. 5). The expenditures in three treatments varied significantly ($P < 0.05$) among themselves. On the basis of analysis, the gross return (Tk. ha^{-1}) was found significantly ($P < 0.05$) highest in T_2 (1,877,570) followed by T_3 (1,736,143) and then T_1 (1,731,253). In the case of gross margin (Tk. ha^{-1}), it was significantly ($P < 0.05$) highest in T_2 (644,570) followed by T_1 (571,828) and T_3 (373,752). Furthermore, significantly ($P < 0.05$) higher BCR were recorded in T_2 (1.52) followed by T_1 (1.48) and then T_3 (1.27). This BCR in the present study aligned with the findings of Ahamed et al. (2017b) who stated that the BCR ranged from 1.32 to 1.69 when the stocking density of Shing ranged from 500 to 700 indi. $dec.^{-1}$ induring a five month polyculture. Previous study results agreed with the findings of the present study and the results indicated that improvement of growth, survival and production of Shing through polyculture was possible in seasonal waters. Alongside the economic aspect species combinations were also considered as an important factor for large scale production. After a discussion of the results and consideration of economic aspectsit can be concluded that T_2 (500 Shing+100 Pabda+10 Rajpunti+5 GIFT indi. $dec.^{-1}$) is the best combination for Shing polycultures in seasonal ponds within the Semi-arid zone of Bangladesh.

During the first year of the study polyculture testing of Shing, *Heteropneustes fossilis*, Tengra and *M. vittatus* were carried out in the seasonal ponds of farmers adjacent to FSS, Saidpur. Different treatments were tested and of them, the 500 Shing+100 Pabda+10 Rajpunti+5 GIFT (indi. $dec.^{-1}$) combination from Shing polyculture and the 500 Tengra+100 Magur+10 Rajpunti+5 GIFT (indi. $dec.^{-1}$) combination from Tengra polyculture were selected for multi-location testing due to having the highest yield and economic viability. For this reason, the two chosen combinations were demonstrated in different subdistrict within the northern region of Bangladesh from May 2018 to September 2018.

Table 5: Benefit and cost analysis of Shing under polyculture in three treatments; within rows values with different superscripts are significantly different ($P < 0.05$).

Item wise expenditure	T_1	T_2	T_3
Pond preparation (Tk. ha^{-1})	25,000	25,000	25,000
Fingerling cost (Tk.ha^{-1})	2,71,500	3,29,000	4,04,583
Lime and fertilizer (Tk.ha^{-1})	12,500	12,500	12,500
Feed costs(Tk.ha^{-1})	8,00,258	8,16,375	8,88,391
Transport, labor etc.(Tk.ha^{-1})	50,000	50,000	50000
Total production costs (Tk. ha^{-1})	11,59,258 ± 4409^c	12,32,875 ± 2281^b	13,80,474 ± 12291^a
Income and output			
Total production (kg ha^{-1})	5,896 ± 87^b	6,331 ± 211^a	5894 ± 100^b
Gross return (Tk. ha^{-1})	17,31,253±1397^b	18,77,570 ± 400^a	17,36,143±3755^b
Gross margin (Tk. ha^{-1})	5,71,828 ± 3402^b	6,44,570 ± 8886^a	3,73,752 ± 2558^c
Benefit cost ratio (BCR)	1.49^b	1.52^a	1.25^c

Polyculture of Shing, *Heteropneustes fossilis* in multi-location testing

After the culture tenure, growth parameters and production of Shing, the total production of cultured fish and the economics of multi-location trials are presented in table 6. The initial weight (g) of Shing was 1.90, 1.87 and 1.92 respectively in Saidpur, Hatibandha, Dimla. The highest final weight of Shing was recorded (59.3 g) in Dimla Subdistrict. The final weight gain (g) of Shing varied in different locations and the value of Dimla (57.38) was found to be higher compared to that of Saidpur (54.33) and Hatibandha Subdistrict (52.33). The highest SGR (2.29) was in Dimla. The survival rate (78%) was significantly ($P < 0.05$) higher in Saidpur followed by Hatibandha and Dimla Subdistrict. Ahamed et al. (2017a) also found similar results in their case studying the adaptability of stinging catfish within the Northern region. The production of Shing (5,828 kg ha-^{1}) and the total production of fish (7,352 kg ha-^{1}) were found to be highest in Dimla Subdistrict followed by Saidpur and then Hatiandha. The gross return (Tk. ha^{-1}) 2,135,000, gross margin (Tk ha^{-1}) 906,000 and benefit cost ratio (1.73) were significantly ($p < 0.05$) higher in Dimla Subdistrict compared to Saidpur and Hatibandha. Ahamed et al. (2018) mention that in case of Vietnamese koi generated the highest return over a period of four months Tk. 7, 26,780/ ha. The lowest net return was found to be Tk. 2, 64,160/ha within T-2 in the semi-arid zone of Bangladesh. This variation could be attributed to different species, culture systems and market prices. Significantly higher ($P < 0.05$) BCR was recorded in T-1 (1.64) with low production cost and comparatively higher net profit than other treatments. According to multi location results, the production of Shing, total production of fish and the BCR were found higher and more satisfactory than that of the 1^{st} year, which might be due to suitable stocking density and appropriate culture periods. Therefore, the combinations including 500 Shing+100 Pabda+10 Rajpunti+5 GIFT indi. dec. $^{-1}$ can be recommended for culture in the northern region of Bangladesh. It is also important to remember that this type of culture pattern is appropriate in seasonal water bodies with no requirement of additional water supply during the culture period ranging from May to October.

Table 6: Growth and yield performances of *Heteropneustes fossilis* under polyculture in multi-location of northern part of Bangladesh; within rows values with different superscripts are significantly different ($P < 0.05$).

Parameters	Multi-location			Average
	Saidpur	Hatibandha	Dimla	
Stock. dens of Shing (indi. dec^{-1})	500	500	500	500
Culture period (months)	5	5	5	5
Initial weight (g)	56.3 ± 0.9^{b}	1.87 ± 0.0	1.92 ± 0.0	1.9 ± 0.3
Final weight (g)	56.3 ± 0.9^{b}	54.2 ± 0.3^{c}	59.30 ± 0.9^{a}	56.6 ± 2.6
Weight gain (g)	54.3 ± 0.9^{b}	52.3 ± 0.3^{c}	57.38 ± 0.9^{a}	54.66 ± 2.6
SGR (% day^{-1})	2.25 ± 0.02^{ab}	2.24 ± 0.02^{b}	2.29 ± 0.02^{a}	2.26 ± 0.3
FCR	2.63 ± 0.01	2.64 ± 0.02	2.62 ± 0.01	2.63 ± 0.1
Survival (%)	78 ± 1.5^{a}	75 ± 1.0^{b}	74 ± 1.5^{b}	75.67 ± 2.1
Production of Shing (kg ha^{-1})	5476 ± 2.0^{b}	5351 ± 3.5^{c}	5,828 ± 3.1^{a}	5552 ± 247
Total production (kg ha^{-1})	7039 ± 70.3^{b}	6766 ± 40^{c}	7352 ± 2.5^{a}	7052 ± 193
Total cost (Tk. ha^{-1})	1221500 ± 15.3	1221650 ± 10	1229000 ± 10	1224050 ± 4287
Gross return (Tk. ha^{-1})	2040850 ± 5.7^{b}	1976375 ± 5.0^{c}	2135000 ± 7.6^{a}	2050742 ± 79773
Gross margin (Tk. ha^{-1})	819350 ± 18.5^{b}	759875 ± 8.1^{c}	906000 ± 10.4^{a}	826692 ± 73482
BCR	1.67^{b}	1.62^{c}	1.73^{a}	1.67

CONCLUSIONS

Polycultures of Shing (*Heteropneustes fossilis*) are economically viable. Considering the growth and survival, Shing was found as the most suitable stocking density for a polyculture system. Fish farmers should follow the combination 500 Shing+100 Pabda+10 Rajpunti+5 GIFT indi. dec.$^{-1}$ for a Shing polyculture. Within the context of fish production, Shing polycultures were found suitable for semi-arid zones. From an economic perspective, Tengra polycultures and Shing polycultures were identical. An appropriate culture period from April to August and overwintered fingerlings were identified as the keys to a successful fish culture in seasonal ponds. Water quality parameters were also found suitable for fish culture. Fish farmers were very much interested in Shing polycultures due to this being a modern technique. The study as a whole explored new culture techniques for the Northern semi-arid region of Bangladesh.

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