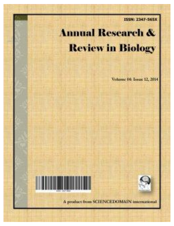

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Polyculture of Vietnamese koi *(Anabas testudineus)*: Emphasis on Seasonal Mini Water Ponds in Semi-Arid Zone of Bangladesh

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Authors' contributions

This work was carried out in collaboration between all authors. Author SA designed the study, performed the statistical analysis, wrote the protocol, and wrote the first draft of the manuscript. Authors KRH and MHM managed the analyses of the study. Author MIM managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

Concepts of polyculture of Vietnamese koi *(Anabas testudineus)* with others short cycle fish species especially in the semi-arid zone of Bangladesh helps to increase the production and utilization of water bodies. Optimization of stocking density with and economics of the culture system was evaluated to mini seasonals pond in Rangpur region, Bangladesh for a period 120 days (30 April to 30 August) ponds were randomly divided into three treatments with different stocking density, explicitly Vietnamese koi were stocked 74,000 ha^{-1}, 98,000ha^{-1} and 1,23,000 ha^{-1} with other fish species in T_1, T_2 and T_3 with triplicate. Fishes were given to commercially available pelleted feed (30% protein). Recorded water quality parameters were within the acceptable limit for fish culture. Sampling was done every fortnightly interval. After 120 days of culture period average harvesting

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weight was found 198.67±3.28 g, 179.67±9.06 g and 174.33±4.25 g in T_1, T_2 and T_3 respectively. Specific growth rate (SGR) in T_1 (4.19) was significantly higher (P<0.05) than T_3 (4.07) but less significant with T_2 (4.10). Survival rate in T_1 (85.3%) varied significantly among the treatment, however total production (kgha^{-1}) in T_3 was (17859.96±230.21) significantly higher (P<0.05) rather than T_2 (15237.46±669.31) and T_1 (13278.91± 78.0) but benefit cost ratio in T_1 (1.64±0.03) varied with T_2 (1.52±0.0) and T_3 (1.40±0.02). It can be calculated that there is a huge potentiality for utilization of seasonals ponds with proper culture technique of short cycle fishes in the semi-arid zone of Bangladesh.

Keywords: Polyculture; Vietnamese koi; Semi-arid; Northern; seasonal ponds.

1. INTRODUCTION

Fisheries sector play an important role in terms of the agricultural economy of Bangladesh and can contribute about 3.61% of National GDP and one fourth part (24.41%) in agricultural GDP [1]. In Bangladesh total pond area is 1, 46,890 ha which is experienced with accelerate growth rate and improvement of farming [2]. Pond aquaculture which is mostly related to closed water fisheries in Bangladesh which contribute 43.79% of the total fish production in 2014-15 [3]). The livelihood of the marginal farmer, especially moderate food supply, employment and income are facilities by Aquaculture [4].

Water retention capacity in the Northern region is decreasing day by reason. The number of the mini seasonal pond, ditches is increasing. According to the study report, about 55% of ponds are seasonal of which 60% containing water for 4-6 months [5]. These small water bodies are being used mainly for household activities and unplanned fish cultivation. Nilphamari and adjacent districts are such an area where culture technique of short cycle fish species will be the most wanted and effective for all kinds and types of fish farmers for increasing fish production and income generation. In this context, we introduced a new culture pattern polyculture of Vietnam koi(*Anabas testudineus*) in the semi arid zone of Bangladesh for proper utilization of mini seasonal water body and mitigation of climatic hazards. Although we have a native variety of koi (*Anabas testudineus*) is one of the most important freshwater fishes of Bangladesh. Species is considered as a valuable food fish species and recommended as a diet for the sick and convalescents as it contains a high amount of iron, copper and easily digestible poly-unsaturated fats and many essential amino acids [6,7]. Due to slower growth and grey body colour of Thai koi (*Anabas testudineus*) not prefered by the consumer, New varieties of koi introduced in our country from Vietnam in 2013 [8]. This species is faster in growth and similar body color with our native koi now a day's marginal farmer in northern region was very much interested in culture Vietnames koi. To increase the fish production especially in greater Rangpur division, development of suitable culture technology of short cycle fish species is very essential. However, no study has been done yet to optimize the stocking density of polyculture of Vietnamese koi in semi arid zone of Bangladesh. Such information is necessary for maximum utilization of seasonal mini ponds. Considering the above facts, the present study was undertaken to know the effects of different stocking density on growth, survival and production on polyculture of Vietnamese koi in greater Rangpur division of Bangladesh.

2. MATERIALS AND METHODS

2.1 Experimental Site, Duration and Description of Ponds

The experiment was conducted in farmer's miniponds of Rangpur and Niphamari areas to observe the growth and yield of Vietnamese koi at different stocking density under polyculture system for a period of 4 months. Nine (09) seasonal ponds were selected for this experiment. The area of ponds ranges between 0.040 and 0.060 ha each. The on-farm ponds were selected with the supervision of Freshwater Sub-station and concerning of relevant Senior Upazilla Fishery Officer (SUFO/UFO) during the early May 2017.

2.2 Pond Preparation, Species Selection and Management of Ponds

The selected ponds were prepared as by drained and dry. Aquatic weeds were removed from the

Table 1. Experimental design of culture system with different stocking density and feeding rate

Treatments	Species composition	Stock. density (nos dec^{-1})	Initial length (cm)	Initial weight (g)	Feeding
T_1	Vietnamese koi	300	1.30	3.8	15-5%
	GIFT	10	3.0	5.5	
	Shorpunti	05	2.0	5.8	
T_2	Vietnamese koi	400			
	GIFT	10			
	Shorpunti	05			
T_3	Vietnamese koi	500			
	GIFT	10			
	Shorpunti	05			

ponds manually and harmful and unwanted fish species removed by using rotenone 25-35 g $dec^{-1}ft^{-1}$ and ponds were liming @1 kg dec^{-1}. After 5 days of liming, cow-dung 6 kg dec^{-1}, urea 100 g dec^{-1} and TSP 75 g dec^{-1} were applied at the initial stage during pond preparation. The short-cycle fishes like as Vietnamese koi, GIFT and Shorpunti were selected for adaptive trial in those listed ponds. About 5-10 cm fingerlings were stocked as per experimental design (Table 1) during early May 2017. Fish were fed commercially available fish feed 15-5% BWT 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.

2.3 The Experimental Design

Nine (9) earthen ponds were used for the treatments All Ponds were equal in size and condition) the randomize block design (RBD) was followed with three (3) treatments and three triplicate of each (Table 1). All experimental units were renovated and cleaned of aquatic vegetation. Total biomass were not fluctuate ± 10%

2.4 Sampling of the Experimental Fish and Monitoring Water Quality Parameters

A fortnightly sampling of fishes was made by using a cast net and weight of fishes was measured by using a digital electronic balance (OHAUS, Model CT 1200-S, USA) and length by a centimetre scale. Monitoring of water quality parameters viz. temperature, dissolved oxygen (DO) water *p*H, transparency, total ammonia (NH_3) was observed and recorded on spot throughout the experimental period by using standard procedures and methods. General conditions of the pond were monitored regularly and the water quality parameters were measured between 10.00 to 13.00 h during the culture period. The water temperature (°C) was measured by using a standard mercury thermometer, DO (mgl^{-1}) by DO meter (YSL, Model 58, USA), water *p*H by digital *p*H meter (Elico-Li-120), transparency (cm) by Secchi disc, ammonia (mgl^{-1}) by using universal pocket meters.

2.5 Data Analysis

One-way analysis of variance (ANOVA) (Duncan, 1993) by SPSS 20 (IBM) was performed to detect the significant differences among the treatments at 5% significance level. The values were given with means ±SD, and differences were considered significant at subset for alpha = 0.05 ($P \leq 0.05$).

3. RESULT AND DISCUSSION

3.1 Physiochemical Parameters

Physiochemical parameters play an important role in the health condition of a fish. The present study revealed that there was no significant difference ($P>0.05$) between temperature and transparency of the experimental pond in different treatments due to the same region. Boyd (1982) has also reported that the range of water temperature from 26.06 to 31.97°C is suitable for freshwater fish culture. [9] found transparency ranging from 15-55 cm in polyculture pond. [10] Recorded transparency ranging from 15 to 58 cm, [11] stated that the water temperature ranged from 22 to 34°C was suitable for culture of fish however the water pH ranged from 7.10 to 7.70 were found in the different ponds of our experiment. [12]) stated that the optimum pH range for carp polyculture in the pond is 6.5 to 9.0. Highest dissolved oxygen was found 6.30 in the T_1 in the month of May with a significant difference between T_1 and (T_2 & T_3). Due to the release of high faecal matter in the harvesting period, NH_3 content were found maximum 0.33 mgl^{-1} in the T_3 with high stocking density compare than T_2(0.23) and T_1 (0.17) when compared with ANOVA. Present results comparable with [13], they found 25-33, 7.68-7.19, 7.34-4.5 and 0.15-0.23 in case of temperature, pH, dissolved O_2 and NH3 in greater Rangpur region.

Table 2. Physicochemical parameters of the experimental ponds in different treatments

Parameters	T_1	T_2	T_3
Temperature (°C)	29.33±0.45	31.33±0.89	30± 0.47
Transparency (cm)	30.3±1.57	29.3±0.68	26.3±1.07
Water pH	7.26±0.08^a	7.5±0.08^{ab}	7.6±0.05^b
DO (mg l^{-1})	6.06±0.18^b	5.4±0.15^a	5.3±0.05^a
NH_3 (mg l^{-1})	0.17±0.03^a	0.23±0.02^{ab}	0.31±0.02^b

Table 3. Growth performances and nutrient utilization polyculture of *A. testudineus* observed in different treatments of the experiment over 120 days culture in ponds

Morphometric Parameters	Fish Species	T_1	T_2	T_3
initial length(cm)	*A. testudineus*	3.8±0.0	3.8±0.0	3.8±0.0
	O. niloticus	5.5±0.0	5.5±0.0	5.5±0.0
	B. gonionotus	5.8±0.0	5.8±0.0	5.8±0.0
final length(cm)	*A. testudineus*	19.63±0.38	19.53±0.38	18.90±0.20
	O. niloticus	22.76±0.62^b	22.16±0.49^{ab}	20.50±0.50^a
	B. gonionotus	22.36±0.20	21.96±0.48	21.86±0.58
Average initial weight (g)	*A. testudineus*	1.3±0.0	1.3±0.0	1.3±0.0
	O. niloticus	3.0±0.0	3.0±0.0	3.0±0.0
	B. gonionotus	2.0±0.0	2.0±0.0	2.0±0.0
Av. final weight (g)	*A. testudineus*	198.67±3.28^b	179.67±9.06^{ab}	174.33±4.25^a
	O. niloticus	264.33±26.40^b	261.00±14.46^b	191.67±14.34^a
	B. gonionotus	198.67±10.34	187.00±11.78	175.67±8.83
Weight gain[1] (g)	*A. testudineus*	197.37±3.28^b	178.37±9.06^{ab}	173.03±4.25^a
	O. niloticus	261.33±26.40^b	258.00±14.47^b	188.67±14.34^a
	B. gonionotus	196.67±10.34	185.00±11.78	173.67±8.83
% weight gain[2]	*A. testudineus*	15182.04±252.53^b	13720.48±697.03^{ab}	13310.27±327.33^a
	O. niloticus	8711.08±880.31^b	8599.97±482.27^b	6288.77±478.27^a
	B. gonionotus	9833.33±517.47	9250.00±589.49	8683.33±765.39
ADG (% day^{-1})[3]	*A. testudineus*	1.64±0.02^b	1.48±0.07^{ab}	1.43±0.03^a
	O. niloticus	2.17±0.21^b	2.14±0.12^b	1.57±0.12^a
	B. gonionotus	1.63±0.08	1.56±0.11	1.44±0.07
HC($^{g-1}$cm)[4]	*A. testudineus*	10.16±0.08^b	9.21±0.06^a	9.13±0.25^a
	O. niloticus	11.61±0.84^a	11.77±0.41^b	9.34±0.64^a
	B. gonionotus	9.02±0.28	8.35±0.45	8.01±0.19
SGR (% day^{-1})[5]	*A. testudineus*	4.19±0.01^b	4.10±0.04^{ab}	4.07±0.02^a
	O. niloticus	3.72±0.08^b	3.71±0.05^b	3.45±0.07^a
	B. gonionotus	3.82±0.04	3.77±0.05	3.72±0.04
FCR[6]	*A. testudineus*	1.18±0.014^a	1.30±0.014^b	1.40±0.014^c
Sruvival (%) [7]	*A. testudineus*	85.53±1.50^b	81.77±0.87^{ab}	80.67±3.05^a
	O. niloticus	77.67±4.05	76.67±3.71	75.00±3.00
	B. gonionotus	77.33±1.33^b	70.66±2.40^{ab}	68.00±2.00^a
Production(kg^{-1}treat)[8]	*A. testudineus*	509.00±11.11^a	587.28±48.66^b	702.50±15.54^c
	O. niloticus	20.70±3.08	20.08±1.97	14.28±0.54
	B. gonionotus	7.69±0.47^b	6.58±0.18^{ab}	5.96±0.26^a

3.2 Growth performance

The growth performance of experimental fish Vietnamese koi (*A. testudineus*) and others fishes in different treatments in terms of initial weight, final weight, mean weight grain, % weight gain, specific growth rate (SGR % day^{-1}), FCR, , survival rate (%) and production((kg^{-1}treat)) were calculated at the end of the experiment (Table 3).

Although there was no significant difference (P>0.05) in the initial weight and initial length of fishes, however, mean final weight, mean final weight gain and percent weight gain of Vietnamese koi varied significantly among the treatments and ranged between 162 to 205 g and 160 to 203 g, and 12361-15667 respectively among three treatments. The mean final weight, weight gain and percent weight gain of individual fish in T_1 was significantly higher (P<0.05) than the T_2 and T_3 (Table 3) due to lower stocking density of koi than T_2 and T_3 [14] found harvesting weight 140 g, 132 g and 129 g when Vietnamese were a culture with shing and GIFT with different stocking density, our result were higher than [14] due to less stocking density of alternative fish species. Our result also differs from [15,16] due to different culture system.

The specific growth rate of (*A. testudineus*) in T_1 (4.19) was significantly higher (P<0.05) than T_3 (4.07) but few significant with T_2 (4.10) and health condition (HC) in T_1 (10.16) significant with T_2 (9.21) and T_3 (9.13) respectively. Our findings were more or less similar to [17] who found maximum SGR value 3.93 with higher stocking density than those of our experiment. [18,19] and [8] who recorded a specific growth rate ranged 2.363 to 2.655%, 3.65 to 3.79%, 3.09 to 3.34% and 2.04 to 2.08 [8]) obtained the highest values of SGR at the lowest stocking densities which coincide with the present findings.

At the end of the experiment result shows that the ranges of FCR vary from 1.15 to 1.20, 1.28 to 1.33 and 1.35 to 1.40 among T_1, T_2 and T_3 respectively. Table 3 shows that significantly higher (P<0.05) FCR (1.38±0.014^c in T_3 followed by the T_2 and T_1.

After the study period maximum and minimum survival rate of fishes, Vietnamese koi found 85% in T_1 and 80% in T_3 with significant difference (P<0.05) among the treatments (Table 3). The survival rate in the present study was observed to be more or less similar to the findings of

Table 4. Benefit and cost analysis of Vietnamese koi (*A. testudineus)* per hectare of the experimental ponds for a period of 120 days

Items wise expenditures/ operational costs	T_1	T_2	T_3
Pond preparation (BDT ha^{-1})	12355	12355	12355
Price of fry[1](BDT ha^{-1})	92662.5	122314.5	151966.5
Feed costs(BDT ha^{-1})	813296.70	1040274.52	1313995.43
Lime, chemical, transport, harvest etc .(BDT ha^{-1})	49,420	49420	49420
Total production costs (BDT ha^{-1})[2]	967734.20±19571.88^a	1224364.60±51255.32^b	1527736.93±3884.32^c
Incomes and outputs			
Total production (kg ha^{-1})	13278.91± 78.03^a	15237.46±669.31^b	17859.96±230.21^c
Gross production value (BDT ha^{-1})[3]	1591864.02±9702.05^a	1869503.00±13224.61^b	2142168.32±27633.76^c
Net profit (BDT ha^{-1})[4]	624129.81±9960.93	645141.730±64948.08	614431.39±2452.73
Benefit cost ratio (BCR)[5]	1.64±0.03^c	1.52±0.03^b	1.40±0.02^a

Values are means of data obtained ± Std. Error (mean ± SE). Values in the same row with the same superscripts are not significantly different (P>0.05). The absence of superscripts indicates no significant difference between treatments

[14,20]. However, significance difference ($P<0.05$) were found in total production ((kg^{-1}Treat)) of *A. testudineus*) in T_3 (702.50 kg), rather than T_2 (587.28 kg) and 509.00 kg in T_1 (Table). Likewise, there is a significant difference of total production in case of *B. gonionotus* and non significance with *O. niloticus* among the treatments.

3.3 Economic Analysis

Economic analysis (Table 4) was performed to estimate the net profit from different treatments of the culture system. The production cost inT_1, T_2 and T_3 were Tk. 967734.20, Tk. 1224364.60 and Tk. 1527736.93 ha^{-1}, respectively. Gross Production value was 1591864.02Tkha^{-1}, 1869503Tkha^{-1} and 2142168.32Tkha^{-1} respectively with significant difference ($P<0.05$) among the treatments (Table 4). Although there is no significance difference in net profit achieved in T_2 (645141.730T Tkha^{-1}), T_1 (624129.41 Tkha^{-1}) and T_3 (614431.39 Tkha^{-1}). [21] generated the highest return over a period of four months Tk. 7, 26,780/ ha. while the lowest net return was found Tk. 2,64,160/ha from T-2 (Thai Koi). But significantly higher ($P<0.05$) BCR were recorded in T_1 (1.64) with low production cost comparatively higher net profit rather than other treatments. [22] stated that the benefit-cost ratio was 1.35, 1.52 and 1.30 in T1, T_2 and T_3.our result was higher than [23]considering Growth rate, Production, Feed Conversion Ratio (FCR), Survival (%) and Specific Growth Rate (SGR).

4. CONCLUSION

From this experiment, it can be concluded that polyculture of Vietnamese koi might be a good potential option to the utilization of mini seasonal pond, especially in greater Rangpur region. Moreover, further research is needed to optimize the stocking density especially in semi arid zone of Bangladesh with *H. fossillis* should be added for more profit. This new technology in aquaculture may play an important role in ensuring higher fish production in the semi arid zone of Bangladesh.

ETHICAL APPROVAL

As per international standard or university standard written ethical approval has been collected and preserved by the authors.

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COMPETING INTERESTS

Authors have declared that no competing interests exist.

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