Comparative Study on Growth Performance, Phenotypic Traits and Genotypic Variations of Geo-Graphically Isolated Two Strains of Koi (*Anabas Testudineus*) Exhibited in Same Environmental Conditions

Alam MA[1], Flura[1], Hasan KR[1], Behera BK[2], Meena DK*[2] and Sharma AP [2]

[1]*Bangladesh Fisheries Research Institute, Riverine Station, Chandpur*

[2] *Central Inland Fisheries Research Institute, Indian Council of Agricultural Research*

Barrackpore, Kolkata

***Abstract*-Local and Thai koi, samples collected from two different localities, were subjected to rear at the experimental ponds for a period of fifty days and the highest gain in length, weight and SGR were found in Thai koi as 12.23±0.38, 55.83±0.53 and 7.92±0.11 respectively. Fourteen morphometric characters were studied where eleven showed (TL, SL, HL, HBD, LBD, PCFL, PELFL, AFL, UJL and LJL) significant difference in Thai koi than the local ones (P<0.01). Of the nine meristic characters no. of dorsal fin rays (hard), anal fin rays (hard), caudal fin rays and scale along Lt. line (lower) as recorded from the Thai koi were significantly higher (p<0.01) than the local koi. The no. of dorsal fin rays (soft) in Thai koi was also significantly higher (p<0.05) than local koi. The counted no. of vertebra were also unlike in local and Thai koi (25 incase of local koi and 26 incase of Thai koi). The genetic variation of local and Thai koi was studied through ten enzymes systems that provided eleven scorable loci. Seven out of 11 gene loci were monomorphic in both the populations, 4 were polymorphic in Thai and 2 displayed polymorphism in local population. The genetic distance between local and Thai population was (D = 0.134). Present study revealed that although both the local and Thai koi belongs to the same species, growth performance of Thai koi was faster compared to local koi within same condition. UPGMA tree formed 2 clusters which indicate that the genetic relationship among the two strains of koi collected from different geographic region. This is a preliminary study which gives insight to researcher to investigate the genotypic and phenotypic traits along with growth performances. A more comprehensive study is needed to address the short comings of culture aspects, stimulated genotypic and phenotypic variability of two different geographically isolated strains but cultured in same environment.**

Key Words-***Anabas testudineus, Local and Thai Koi, Morphological and Genetic Variations.***

I. INTRODUCTION

Anabas testudineus is widely distributed in South and South- East Asia and is a highly esteemed food fish. Once upon a time it was abundantly available in almost all freshwater systems of South and South- East Asia including Bangladesh and India. But its recent trend showing a continuous dilapidated tendency due to its vulnerability causing by over fishing, pollution various man-made interventions, natural catastrophic and also the culture method is not established yet. In India also, it is an important air breathing fish, which can be considered for culture in the areas with low dissolved oxygen. It is a larvivorous feeder in habit. It is also popular for their lean meat, which contain easily digestible protein and fat of very low melting point and many essential amino acids making them ideal food. Although Bangladesh has developed the successful breeding technology, reducing contribution in total pond catch of Bangladesh from 2.83% [1] to 0.85%) [2] ,and substancial decline in India. In India partial success has been made in breeding technology but still a full proven technology yet to be developed which adding a great constraints in its culture adoptability, however the seed supply is done though Bangladesh to north-eastern state of of India.

One decade ago the contribution of koi was 2.83% in the total pond catch but later it turned down. Hence, fisheries biologists are thinking of its cultivation through intensive farming in India Bangladesh [3] which might be a prospective and directive tradition of farming of koi in India also. the main impediment is the unavailability of seed for any viable stocking program in whole Asian sub-continent. Therefore, hormone induced breeding could be the possible alternative for commercial culture of this species.

Side by side attempts were also made to boost up the aquaculture production through incorporation of Thai koi. Thai koi is resembles to local koi and its great aquaculture potentiality has already been caught the attention of farmers of Bangladesh and thus subsequently

disseminating in adjoining north-eastern states of India *i.e.* West Bengal, Bihar, and others also. It is evident from previous research that Koi grows well at high stocking densities and responds well to comparatively low cost and simple management practices that aid its suitability for marginal farmers to culture it in the derelict and perennial ponds of the Bangladeshand India. Growth is the function of time, environment, hormone and synthesis of absorbed food materials into tissue of the living system of organism [4]. Climbing perch (*Anabas testudineus*) can walk on land with the help of spines and possess an accessory air breathing organ [5]. The distinguishing characteristics of *A. testudineus* have also been provided ([6], [7], [8]). Several studies have been done to culture of climbing perch, *i.e.* fecundity [9], reproduction [10], domestication [11], breeding ([10],[12]), feeding [13],[14],[15]) and culture ([16],[17]). But no initiative was undertaken to assess the growth performances, morphological and genetic variation of local and Thai koi [18]. Infact, research on genetic variation of climbing perch is still in the pioneer level in Indian Sub-Continent. However, some studies conducted to address this aspect [19] in Thailand; Bangladesh [20],[21]) to assess the growth performance and morphological discrimination of local and Thai koi. The present study is an initiative to walk around this virgin area of growth performance, morphological and genetic variation of local and Thai koi. The results of the present investigation will ignite a keen interest among the different stake holder to think upon its beneficial enterprises despite of its lacking in different aspects. Therefore, a more inclusive study is must to harness the potential of Thai koi to cater the need of marginal to poorest of poor farmer, in terms of livelihood, nutritional security and economic viability.

II. MATERIALS AND METHODS

A. Sample collection

The local koi was collected from the adjacent paddy field around the study area and Thai koi was collected from the Brahmaputra fish seed complex. Details of the sample collection, number of specimen and date of collection are given in Table 1. After collection of samples they were reared in six newly constructed ponds at the Southern side of the Fisheries Faculty Building under the same feeding strategy. Thirty individuals were collected randomly from each stock and subjected to morphological analysis.

Table 1: Source, sample size and collection date of the experimental fish

Sample No	Population	No of fry	Date of collection
1	Local koi	1000	July 10, 2004
2	Thai koi [Brahmaputra]	1000	July 7, 2004

B. Growth study

1) Experimental set up

Six newly constructed small (9.5 x 6.1 x 0.8 m^3) rectangular ponds with outlet and inlet facilities at the southern side of Fisheries Faculty building were used for the growth study of Thai and local koi (*A. testudineus*). The experiment was carried out for fifty days and sampling was done at 10 days interval to record length gain (cm) and weight gain (g).

2) Pond Preparation

The experimental ponds were fenced by nylon net with the help of bamboo sticks to ensure the experimental fishes confined in their respective ponds even if the ponds get inundated due to over raining. Lime at the rate of 1 kg/dec was applied to all the experimental ponds. Ten days after liming, cow dung at the rate of 20 kg/dec was applied to all the experimental ponds. Wheat flower (Atta) at the rate of 1 kg/dec was applied to all the experimental ponds before two days of stocking for huge production of zooplankton. Netting was done to remove small frog and water bug from the experimental ponds before three days of fingerling stocking.

3) Stocking and rearing of fry

Fry collected from two different localities were kept in cistern for about 10 hours for conditioning prior to release in ponds. Then samples were stocked in six experimental ponds having three replications for each population after proper conditioning at the afternoon. Each replication contained 200 fries (average length 1.95±0.58 cm and weight 0.55±0.19 g in case of local koi and 2.40±0.53 cm and 1.28±0.42 g in case of Thai koi). The stocked fry were reared separately for 50 days and a common supplemental feed containing 50% fishmeal, 20% wheat bran, 20% rice bran, 10% soybean meal was administered at the rate 8% body weight of all the stocked fishes twice a day.

4) Feeding of the experimental fish

Fish meal, soybean meal, wheat bran and rice bran were ground into powder form, and the required quantities of all ingredients mixed homogenously in such a way to make them into small sized ball and spread it to the pond surface. The quantity of feed was adjusted every 10 days on the basis of increase in the average body weight of the stocked biomass.

5) Proximate composition of feed ingredients

Proximate composition of the feed ingredients were determined following the standard methods given by Association of Official Analytical Chemists [22] in the Fish Nutrition Laboratory of the Faculty of Fisheries, Bangladesh

Agricultural University, Mymensingh. Proximate composition of the different feed ingredients is shown in Table 2 [23].

Table 2: Proximate composition of the feed ingredients

Ingredients	Dry matter (%)	Protein (P) (%)	Lipid (%)	Ash (%)	NFE* (%)
Fish meal	91.66	66.50	8.91	15.58	9.01
Soybean meal	90.14	49.53	1.52	8.33	40.62
Rice bran	91.35	14.92	4.38	12.31	68.39
Wheat bran	89.83	14.00	3.94	4.98	77.05

*NFE=Nitrogen free extract calculated as 100 - (moisture + protein + lipid + ash)

6) Water quality parameters

Physico-chemical parameters like temperature, pH, dissolved oxygen (DO) of the water of the ponds was measured periodically to assess the water conditions remained within acceptable limits and water was exchanged as required. Temperature was recorded by using a Celsius thermometer; dissolve oxygen (DO) and pH were measured directly by a portable digital DO meter (Lutron, DO-5509) and a digital pH meter (CORNING. Model 445), respectively. Before taking a measurement pH meter was properly adjusted with buffer solution of pH 7.

7) Sampling procedure

The culture potentiality on the growth performance under the same feeding strategy was assessed by recording the rate of growth in terms of gain in length (cm) and in weight (g) of fish every ten days. The length and weight were recorded by random sampling of 30 fish from each pond by using a small seine net. Weight was taken with a spring balance (DONGIL-15 kg x 50 g) and length with a measuring scale.

8) Data analysis of growth parameters

One way analysis of variance (ANOVA) was used to determine the effect of the same feeding strategy over the growth performance of three treatments for each population. This was done by following Duncan's New Multiple Range Test [24] to identify the level of variance between the two populations of koi.

C. Morphological study

1) Morphometric characters

The 14 morphometric characters were measured following the conventional method described [25] with slight modification as noted below: Total length (TL), Standard length (SL), Head length (HL), Pre-orbital distance (PrOD), Post orbital distance (POD), Eye length (EL), Highest body depth (HBD), Lowest body depth (LDP), Dorsal fin length (DFL), Pectoral fin length (PECFL), Pelvic fin length (PELFL), Anal fin length (AFL), Upper jaw length (UJL), Lower jaw length (LJL) to the nearest 0.1 cm using a slide calipers.

2) Meristic characters

The nine meristic characters were measured [25] and these were: Branchiostegal rays, Dorsal fin rays (hard and soft), Pectoral fin rays, Pelvic fin rays (hard and soft), Anal fin rays (hard and soft), No. of vertebrae, Caudal fin rays and Scale on lateral line. A magnifying glass was used to count the fin rays.

3) Other external features of local and Thai koi

Besides the difference in different morphometric and meristic characters some observable variations in different external features like- occipital shape, mouth shape, ventral view *etc.*, were studied.

4) Morphological data analysis

Non-parametric statistical analysis was used in all the comparisons [26]. Differences in morphometric characters and meristic counts of fish were analyzed using the Kruskal-Wallis non-parametric analysis of variance (ANOVA). In instances where significant differences between two groups were detected a non-parametric post hoc test [26] was conducted.

D. Genetic Study

Thirty specimens of local and Thai koi were selected randomly from the reared stocked and subjected to study the genetic variation. The muscle tissue were collected from the two populations of climbing perch and stored at -20^0 C until preparation of extracts for gel electrophoresis.

Enzyme systems were assessed using horizontal starch gel electrophoresis (STARCH-SIGMA-ALDRICH CHEME, Steinheim, Germany) in C.A 6.1 (citric-acid) and C.A.7 buffers according to [27] and gel staining procedures were based on the methods [28]. The enzymes examined were as follows: Alcohol dehydrogenase (ADH; EC 1.1.1.1), Esterase (EST; EC 3.1.1.1), Glycerol-3-phosphate dehydrogenase (G3PDH; EC 1.1.1.8), Glucose -6-phosphate dehydrogenase* (G6PDH; EC 1.1.1.49), Glucose-6-phosphate isomerase (GPI; EC 5.3.1.9), Isocitrate dehydrogenase (IDHP; EC 1.1.1.42), Lactate dehydrogenase (LDH; EC 1.1.1.27), Malate dehydrogenase (MDH; EC 1.1.1.37), Phosphoglucomutase (PGM; EC 5.4.2.2), Sorbitol dehydrogenase (SDH; EC 1.1.1.4).

Loci are shown in italics and alleles at each locus are designated by letters in alphabetical order, starting with the allele encoding the most anomaly migrating allozymes.

Allelic frequencies at each locus were calculated directly from observed genotypes. The proportion of polymorphic loci (a locus was considered as polymorphic when the frequency of the most common allele did not exceed 0.95), the observed average heterozygocity and expected average heterozygocity were calculated so as to show the extent of genetic variability for each population ([29],[30]) using the POPGENE (version 1.31) [31]. The analyses of chi-square (χ^2) test were performed using POPGENE, (version 1.32) [31]. To examine the genetic divergence and relationships among populations [32] standard genetic distance was calculated and a UPGMA tree based on the genetic distance matrix was constructed accordingly [33].

III. RESULTS

A. Growth study

The growth parameters *i.e.*, length gain, weight gain and specific growth rate are represented in Table 3. The highest gain in length, weight and specific growth rate were found in Thai koi and the parameters were significantly different from local koi (Table 3). Fish mortalities were keenly monitored and effective record keeping procedure was maintained to deduct the number of dead fish from the final harvest.

Table 3: Effects of feed on the growth of local and Thai koi during the 50 days of experimental period

Parameter	Local koi ($\bar{x}$ ±SE)	Thai koi ($\bar{x}$ ± SE)	*P*-value
Final length (cm)	12.72±0.24	14.67±0.38	0.0001**
Length gain (cm)	10.77±0.25	12.23±0.38	0.0028**
Final weight (g)	27.08±2.20	57.83±2.93	0.0000**
Weight gain (g)	26.54±0.47	55.83±0.53	0.0000**
Specific growth rate (SGR) (%day)	7.05±0.14	7.92±0.11	0.0236*
Survival rate (%)	62.67±3.81	81.67±3.51	0.5154

** Values of the parameter differs significantly (p<0.01); * Values of the parameter differs significantly (p<0.05).

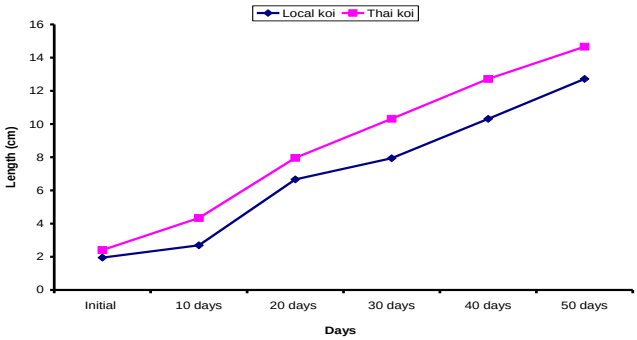

Fig 1: Comparative growth study in length gain (cm)

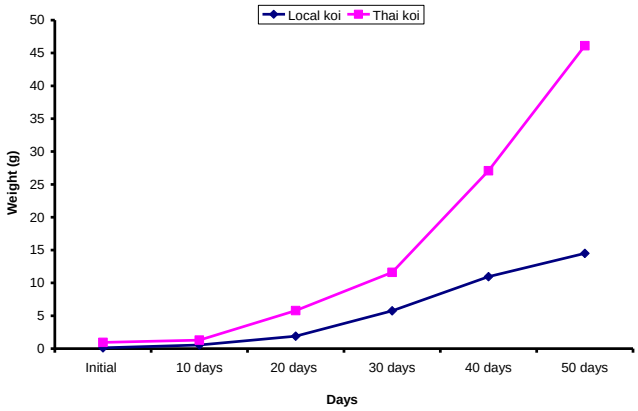

Fig 2: Comparative growth study in weight gain

B. Morphological study

1) Morphometric characters

Of the fourteen morphometric characters studied eleven showed (TL, SL, HL, HBD, LBD, PCFL, PELFL, AFL, UJL and LJL) significant difference in case of Thai koi than the local ones (P<0.01) (Table 4). Different proportions of the morphometric characters have been represented in Table 5 which revealed that the proportion of TL: HL, SL: HL and BD: JL were significantly higher in Thai koi than local koi (P<0.01), nevertheless the proportion of HL: JL was significantly higher in Thai koi than in local koi (P <0.05) (Table 5).

Table 4: Mean values of 14 morphometric characters as recorded from 2 populations(n = 30for each group of local and Thai populations

Characters	Local koi ($\bar{x}$ ± SE)	Thai koi ($\bar{x}$ ± SE)	P-value
Total Length (TL)	8.86±0.03	10.03±0.03	0.0000
Standard length (SL)	7.00±0.01	7.94±0.02	0.0000
Head length (HL)	2.40±0.01	2.63±0.21	0.0002
Pre-orbital distance (PrOD)	0.50±0.00	0.50±0.00	
Post orbital distance (POD)	1.00±0.00	1.00±0.00	
Eye length (EL)	0.50±0.00	0.50±0.00	
Body depth (BD)	2.40±0.07	2.72±0.06	0.0000
Body depth at anus (BDA)	2.40±0.07	2.72±0.06	0.0000
Dorsal fin length (DFL)	4.05±0.02	5.08±0.03	0.0000
Pectoral fin length (PECFL)	1.53±0.01	1.85±0.01	0.0000
Pelvic fin length (PELFL)	1.19±0.61	1.50±0.96	0.0000
Anal fin length (AFL)	2.83±0.21	3.17±0.77	0.0001
Upper jaw length (UJL)	1.71±0.02	1.81±0.01	0.0001
Lower jaw length (LJL)	1.51±0.06	1.61±0.041	0.0000

Table 5: Different lengths ratio between local and Thai Koi

Population	TL: SL	TL: HL	TL: BD	SL: HL	SL: BD	HL: JL	BD: JL
Local	1.27±0.00	3.68±0.02	3.70±0.03	2.91±0.02	2.91±0.02	1.40±0.01	1.40±0.01
Thai	1.27±0.00	3.86±0.04	3.72±0.03	3.02±0.03	2.93±0.02	1.45±0.02	1.50±0.01
P value	0.327	0.000**	0.572	0.009**	0.651	0.050*	0.000**

** Values of the parameter differs significantly (p<0.01); *Values of the parameter differs significantly (p<0.05).

Meristic characters

The nine meristic characters were recorded from Thai and local koi (Table 6). The no. of dorsal fin rays (hard), anal fin rays (hard), caudal fin rays and Scale along Lt. line (lower) as recorded from the Thai koi were significantly higher (p<0.01) than the local koi. Thai koi also demonstrated significantly higher (p<0.05) average value of dorsal fin rays (soft) than local koi. The other meristic parameters were very close for both. The no. of vertebrae were 26 in case of Thai koi and 25 in case of local koi.

Table 6: Mean values of nine meristic characters as recorded from 2 populations; n=30 for each group of Local and Thai populations

Population	Parameters studied						
	The mean propo-rtion of polymorphic loci (*P*) (%)	Mean number of allele per locus	The mean proportion of heterozygous loci per individual (*H*) (%)	Heterozygosity		Number of allele	
				Ho	*He*	*Na*	*Ne*
Local	18.18	1.18	6.66	0.097 ± 0.280	0.057 ± 0.153	1.181 ± 0.404	1.103 ± 0.297
Thai	36.36	1.36	13.33	0.127 ± 0.249	0.113 ± 0.195	1.363 ± 0.504	1.197 ± 0.368
Average	27.27	1.27	10.0	0.146 ± 0.270	0.144 ± 0.228	1.363 ± 0.504	1.276 ± 0.452

** Values of the parameter differs significantly (p<0.01)
*Values of the parameter differs significantly (p<0.05)

Ten enzyme systems were studied, detected eleven scorable loci in three populations of climbing perch (*A. testudineus*). Of the loci examined four showed polymorphism in Thai population while the local population encompasses polymorphism in two loci. The remaining seven loci were invariant in all populations. Loci *Est-1**, *G3pdh-1** and *Gpi-1** exhibited three genotypes (**aa* **ab* and **bb*), two genotypes (**aa* and **ab*) were found in *Mdh-1** whereas *Adh-1**, *Gpi-2**, *Idhp-1**, *Ldh-1**, *Mdh-2**, *Pgm-1** and *Sdh-1** loci were represented by only genotype (**aa*). The genotype frequencies observed at each locus were almost in agreements with Hardy- Weinberg's expectations (Table 7).

Table 7: Allele frequency at 11 presumptive loci in three populations of koi (*A. testudineus*)

Locus	Allele	Local	Thai
*Adh-1**	**a*	1.000	1.000
*Est-1**	**a*	0.933	0.366
	**b*	0.066	0.633
P		0.736NS	0.392NS
*G3pdh-1**	**a*	0.533	0.450
	**b*	0.466	0.550
P		0.000***	0.003***
*Gpi-1**	**a*	0.000	0.966
	**b*	1.000	0.033
P		NS	0.000***
*Gpi-2**	**a*	1.000	1.000
*Idhp-1**	**a*	1.000	1.000
*Ldh-1**	**a*	1.000	1.000
*Mdh-1**	**a*	1.000	0.883
	**b*	0.000	0.116
P		NS	0.506NS
*Mdh-2**	**a*	1.000	1.000
*Pgm**	**a*	1.000	1.000
*Sdh-1**	**a*	1.000	1.000

P: Probability of chi-square value, *** significant level: p<0.01,
** significant level: p<0.05,* significant level: p<0.10; NS: Non-Significant.

The mean proportion of polymorphic loci were 18.18 in local population whereas the Thai population exhibited the proportion (36.36).The mean number of allele ranged from 1.18 (local) to 1.36 (Thai). The *Ho* and *He* values ranged

from 0.097 to 0.127 and 0.057 to 0.113 respectively and the *Na* and *Ne* values ranged from 1.181 to 1.363 and 1.103 to 1.197 respectively. All populations showed excess heterozygote at least in one locus. The number of heterogeneous loci in allelic frequencies was lower in local population in comparison with those of Thai population's.

Table 8: Genetic variabilities at 11 loci in three populations of koi (*A. testudineus*)

Characters	Local	Thai	P value
BR	10.0±0.00	10.0±0.00	
DFR (Hard)	16.80±0.09	17.47±0.14	0.0000**
DFR (Soft)	9.00±0. 07	9.03±0. 08	0.0218*
PCFR	13.77±0.10	13.60±0.09	0.2582*
PEFR (Hard)	1.0±0.00	1.0±0.00	
PEFR (Soft)	5.0±0.00	5.0±0.00	
AFR (hard)	9.53±0.06	9.97±0.09	0.0001**
AFR (Soft)	10.0±0.00	10.0±0.00	
CFR	15.43±0.01	16.10± 0.01	0.0000**
No. of vertebrae	25.0±0.00	26.0±0.00	
Scale along lt. line (Upper)	11.50±0.53	11.87±0.50	0.0137*
Scale along lt. line (lower)	16.97±0.74	17.67±0.80	0.005**
Scale on lt. line (Upper)	4.17±0.07	4.20±0.09	0.0746*
Scale on lt. line (lower)	7.73±0.11	8.03±0.11	0.0711*

Ho = Observed heterozygocity, *He* = Expected heterozygocity
Na = Observed no. of alleles, *Ne* = Effective no. of alleles

The genetic distance (*D*) among three populations was calculated and found to range from 0.022 to 0.134. The minimum genetic distance (*D* = 0.022) was observed between cross and Thai populations, while the maximum value (*D* = 0.134) was found between the local and Thai populations (Table 9).

Table 9: Nei's (1972) original measures of genetic identity (*I*) (above diagonal) and genetic distance (*D*) (below diagonal) estimated among 3 populations of *A. testudineus* based on 11 loci.

Populations	Local	Cross	Thai
Local	-	0.950	0.874
Cross	0.050	-	0.977
Thai	0.134	0.022	-

The UPGMA dendrogram [33] erected from [32] genetic distances as showed that the populations formed two clusters (Fig 3). The local population differs from Thai population by the genetic distance of 0.134 (Table 9).

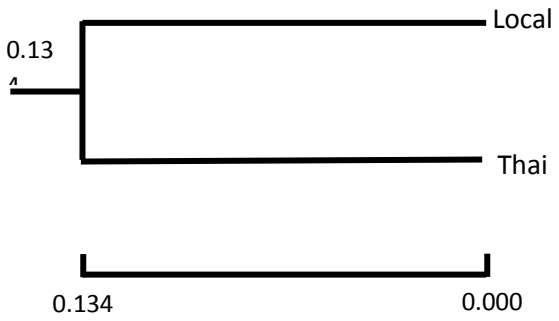

Fig 3: UPGMA dendrogram showing genetic distances

IV. DISCUSSION

Thai koi was incorporated in our aquaculture few years ago from Thailand and its faster growth rate impressed the farmers. But the information about the comparative growth performance, morphological and genetic variation of local and Thai koi is still inadequate. Some authors conducted some works dealing with taxonomic comparison [34] and growth and feed utilization of climbing perch [35] in Bangladesh. Hence, present study is the first trial ever taken in Bangladesh to elucidate the growth performance and morphological variation of local and Thai koi. Genetic variation of cross koi (♀ local × ♂ Thai) with their parents was determined for the first in Bangladesh [20]. Not surprisingly that, another initiative was taken [21] to assess the growth performance and morphological discrimination of local and Thai koi. But the complete information about the growth performance, morphological and genetic variation of local and Thai koi was lacking behind to recommend for commercial cultivation. Therefore, necessary documentation of growth performance, morphological and genetic variation of local and Thai koi needs to be provided all together for promoting management practice and enhance the aquaculture production. With this view, combining the previous two works ([20],[21]) recent initiative was taken to publicize this bench marking findings in Asian sub-continent including India.

In the present study the observed variation in the growth performance exhibited by the local and Thai koi was probably due to their genetic differences as all the populations were reared under the same feeding strategy. The water quality parameters such as temperature, dissolved oxygen, pH and alkalinity of the six experimental ponds were within the suitable range and same for fish farming during the entire study period. Availability of suitable feed in sufficient quantity is one of the indispensable requirements for proper rearing of fish, another crucial factor like stocking density having direct effect on the

growth of fish and its production [36], though it was alike in all experimental ponds.

The growth increment in length and weight gain as obtained in the present study was appreciating and higher in comparison to [37] who conducted an experiment with *Pangasius hypophthalamus*. The better genetic makeup of koi population could be attributed in showing such performance. The reasons behind the lower growth performances of local koi than Thai koi can also be interpreted from the genetic point of view. Local koi is an endangered species and supposed to breed within a confined group as the number of breeder are small and this has endorsed the local koi in exhibiting poor growth performance than the Thai koi. On the contrary, Thai koi was imported from Thailand in our country and may be their original predecessors were enriched with higher genetic variation which has resulted in showing better growth performances. Thai koi exhibit better genetic variations than the local one was proved [38].

The SGR as obtained in the present study for Thai (7.92%) and local koi (7.05%) was higher than the results (0.02 to 0.68%) found [37] for *P. hypophthalmus* but lower than the value of 8.09 to 9.21% obtained [39] in case of *Heteropneustes fossilis*. Nevertheless, the deteriorative growth performance exhibited by the local koi than the Thai koi may be due to poor genetic variation of local koi than the Thai [20].

In the present study some morphometric characters (TL, SL, HL, HBD, LBD, PCFL, PELFL, AFL, UJL and LJL) tend to be significantly different in two populations. But the observed morphological differences may be due to the fact that their genetic quality might be different. The present findings more or less agree with those of [40] who reported that the average values of each character varied considerably by population, representing its unique characteristics.

Variation in the meristic counts as obtained in the present study might be due to the fact that Thai koi is an exotic fish, so some of this meristic count might have been influenced by the breeding and rearing conditions in new environments. The meristic counts of fishes are considered to be affected by environmental factors such as water temperature, pH etc. in fresh water was reported ([41],[42]).

The taxonomic formula as well as morphological characters should have within the same range for individuals of every species. In the present study, slight variation was observed in morphological characters but it was within the range of *Anabas* genus [43]. According [44] both local and Thai koi belongs to the same species. Hence the observable difference found in local and Thai koi may be due to the origin of samples from two different geographical regions.

The mean number of alleles was higher in Thai koi than the local ones. The abundance of local koi was gradually plummeting since the last few decades and now it is near about endangered. It has become confined in certain geographical regions. Due to the persistence of the small number of population and breeding among them, their genetic variability may gradually decline and possess lower number of alleles than the Thai koi. The mean proportion of heterozygous loci per individual was higher in Thai koi and then the value found in local population. Intensive isolation may cause the local population in encompassing less heterozygocity. The average observed (*Ho*) and expected (*He*) heterozygocity was higher in Thai koi than the local ones. Due to the gradual declining of local koi and intensive isolation in certain geographical area, the chance of random matting is limited. It could result in less gene exchange among the population and exhibit lower amount of observed and expected heterozygocity. Based on [32] genetic distance (*D*-value), the UPGMA dendrogram showed two distinct groups (Fig. 3), local population was separated by the D = 0.134 from the Thai population. In second group, the cross population was differentiated from Thai population by the D = 0.022. This indicates that local and Thai koi differ genetically and it depends much on geographical feature. Genetic distance between local and Thai populations may be caused by the events such as development of geographical barriers as they have come from two different geographical regions. Consequently, natural gene flow is impossible between local and Thai populations.

V. CONCLUSION

The present study revealed some important information in terms of growth performance, morphological and genetic variation of local and Thai koi such as the growth performance of Thai koi was better than local koi within the same feeding strategy and same physico-chemical parameters. Nevertheless, Thai koi encompasses more genetic variation than the local ones. Hence, Thai koi would be culturally viable for farmers of Bangladesh. This study could be a base line for establishing the well proven breeding technology of this potential fish species in India. The loss of genetic variation in local koi could be attributed due to combined effects of small founder population, mating between the closely related individuals and genetic drift. Since, the technology has been already developed in Bangladesh, and India is therefore, relying on Bangladesh for seed supply. So, there is scope for India to take this opportunity to join hands with Bangladesh and create a seed hub in South-East Asia to cater the need of seed supply which would lead to abet food security in the Asian subcontinents. India is bestowed with vast inland fisheries resources in the form of reservoirs, flood plain wetlands, brackish water estuaries which are having untapped fish production potential. Despite of this huge opportunity still constraint lies in the form of unavailability of quality seed ,

and a suitable candidate species also as Indian aquaculture revolves around the Indian major carps; Catla, Rohu and Mrigal. However, the growth performance of the craps is not remarkable in enclosure particularly raising of fry to fingerlings. Therefore, koi may be a suitable fish species for enclosure culture system in order to its cost effective and simple grow out management. Considering the present study as a directive, additional comprehensive research in different unstudied aspects with advance tools and technology is highly warranted.

REFERENCES

[1] DoF. (1992). Fish Catch Statistics of Bangladesh 1991-1992. Department of Fisheries, Dhaka, Bangladesh, 41 pp.

[2] DoF. (1999). Fish Catch Statistics of Bangladesh 1998-1999. Department of Fisheries, Dhaka, Bangladesh, 41 pp.

[3] DoF. (2002). Fisheries fortnight Souvenir. Department of Fisheries. Ministry of Fisheries and Livestock, Government of the People Republic of Bangladesh, (Dhaka), 87 pp.

[4] Hasan, M. (2003).Growth and feed utilization of Tilapia, *Oreochromis niloticus* (Linn) fed with different protein sources with and without vitamin. Dhaka University Journal of Biological Sciences. 12: 105-113.

[5] Eschmeyer, VN. (1998). Catalog of Fishes. California Academy of Sciences. San Francisco. Fish Base- A Global information on Fishes, 625 p.

[6] Sterba, G. (1973). Freshwater Fishes of the World. (English translation and revision from German). Topical Fish Hobbyist Publications, Inc., Neptune city, 442 p.

[7] Kottelat, M., Whitten, A.J., Kartikasari, SN., Wirjoatmodjo S. (1993). Freshwater fishes of Western Indonesia and Sulawesi. Periplus Editions Ltd., Republic of Indonesia, 221 p.

[8] Talwar, PK., Jhingran, AG. (1991). Inland fishes of India and adjacent countries. Vol 1. A.A. Balkema, Rotterdam, 541 p.

[9] Kasi, M., Arumugam, J., Sandragasan, D., dan Jegathambigai, R. (2009). Studies on the fecundity of native fish climbing perch (*Anabas testudineus*, Bloch) in Malaysia. American European Journal for Sustainability Agriculture. 3(3): 266-274.

[10] Kohinoor, AHM., Islam, MS., Jahan, DA., Khan, MM., Hussain, MG (2012). Growth and Production performances of crossbred Climbing perch koi, *Anabas testudineus* in Bangladesh. International Journal for Agrilculture Research Innovative and Technology. 2(1):19-25.

[11] Cacot, P.,Lazard, J. (2009). Domestication of the indigenous Mekong fish species: The issues and the aquaculture potential. Cahiers Agriculture. 18(2):125-135.

[12] Atal, S., Kabir, R., Ali, M. (2009). Breeding Performance of Thai Koi *Anabas testudineus* (Bloch, 1972) in different months of the breeding season under two sex ratios. Bangladesh Research Publication Journal. 2: 667-673.

[13] Alam, MA. (2006). Allozyme marker for the analysis of genetic variation of cross koi (♀local x ♂Thai) *Anabas testudineus* with their parents. M.S. Thesis. Department of Fisheries Biology and Genetics, Bangladesh Agricultural University, Mymensingh, 78 p.

[14] Begum, M., Minar, MH. (2012). Weight-length Relationships of Koi (*Anabas testudineus*) along with Condition Factor Fed on Formulated Feed. Trends in Fisheries Research. 1(2): 1-6.

[15] Ali, MZ., Zaher, M., Alam, MJ., Hussain, MG. (2012). Effect of dietary carbohydrate to lipid ratios on growth, feed conversion, protein utilisation and body composition in climbing perch, *Anabas testudineus*. Internayional Journal Fisheries and Aquaculture. 4(1): 1–6.

[16] Chotipuntu, P., Avakul, P. (2011). Aquaculture Potential of Climbing Perch, *Anabas testudineus*, in Brackish Water. Walailak Journal of Science and Technology. 7(1):15-21.

[17] Chakraborty, BK., Nur, NN. (2012). Growth and Yield Performance of Shingi, *Heteropneustes fossilis* and Koi,*Anabas testudineus* in Bangladesh under semi-intensive culture systems. International Journal for Agriculture Research Innovatives and Technology. 2(2):15-24.

[18] Bungas, K., Arfiati, D., Marsoedi., Halim, H. (2013). Effects of Protein Levels on the Growth of Climbing Perch, *Anabas testudineus* Galam type, in Peat Water. International Research Journal of Biological Sciences. 2(4): 55-58.

[19] Sekino, M., Hara, M. (2000). Genetic characteristics and relationships of climbing perch *A. testudineus* populations in Thailand. Fisheries Sciences. 66 (5):840- 845.

[20] Alam, M.A., Rahman, L., Khan, MMR., Rahman, SMZ. (2006). Allozyme marker for the analysis of genetic variation of cross koi (♀ local × ♂ Thai) *Anabas testudineus* with their parents. Molecular Biology and Biotechnology Journal. 4 (1&2): 09-12.

[21] Alam, MA., Noor, AM., Khan, MMR., Rahman, L. (2007). Growth performance and morphological variations of local and thai koi (*anabas testudineus*). Bangladesh Journal of Fisheries Research. 11(2): 163-171.

[22] AOAC. (1980). Official methods of analysis of the Association of Official Analytical Chemists (ed. W. Hoewitz), 13th edition, Washington, D.C, 178 pp.

[23] Alam, MJ., Mustafa, MG., Islam, MM. (2010). Effects of some Artificial diets on the Growth Performance, Survival Rate and Biomass of the fry of climbing perch, *Anabas testudineus* (Bloch, 1792). Nature Science. 8(2): 36-42.

[24] Duncan, DB. (1955). Multiple Ranges and Multiple F-Test. Biom., 11: 1-42.

[25] Hubbs, CL., Lagler, KF. (1958). Fishes of the Great Lakes region. 2nd (ed.) Cranbrook Inst. Science Bulletin. 26: 1-213.

[26] Zar, JA. (1996). Biostatisstical Analysis. 3rd (ed.) Prentice Hall, Engle wood Cliffs, New Jersey.

[27] Hara, MM., Sekino., Na-Nakorn, U. (1998). differentiation of natural populatons of the snake-head fish, *Chana striatus* in Thailand. Fisheries Sciences. 64: 882-885.

[28] Shaw, CR., Prasad, R. (1970). Starch gel electrophoresis of enzymes: A compilation of recipes. Biochemical Genetics. 4: 297–320.

[29] Lewontin, RC., Hubby, JL. (1966). A molecular approach to the study of genetic heterozygosity in natural populations. II. Amount of variation and degree of heterozygosity in natural populations of *Drosophila pseudoobscura*. Genetics. 54: 595-609.

[30] Lewontin, RC. (1974). The genetic basis of evolutionary change. Columbia University Press, New York.

[31] Yeh, FC., Yang, RC., Boyle, T. (1999). POPGENE VERSION 1.31: Microsoft Window- based Freeware for Population Genetic Analysis. ftp://ftp.microsoft.com/Softlib/HPGL.EXE.

[32] Nei, M. (1972). Genetic distance between populations. The American Nature. 106: 283-292.

[33] Nei, M. (1978). Estimation of average heterozygosity and genetic distance from a small number of individuals. Genetics. 89: 583-590.

[34] Hassan, MM., Khan, MGQ., Hasanat, MA. (2005). Taxonomic comparison of the populations of climbing perch, *Anabas testudineus* (Bloch) in Bangladesh. Journal of Bangladesh Agriculture University. 3 (2): 297-302.

[35] Mustafa, MG., Dewan, AH., Wahed, MA., Khaleque, MA., Ahmed, B., Chowdhury, MM. (2004). Growth and feed utilization of climbing perch, *Anabas testudineus* (Bloch) fed on formulated diet using local ingredients. Bangladesh Journal of Zoology. 32(2): 159-164.

[36] Backiel, T., Le, Cren ED. (1978). Some density relationship for population parameters. In: Gerking, S.D. (editor). Ecology of freshwater fish production. Blackwell Scientific Publications, Oxford, 279-302 pp.

[37] Khan, MMR., Alam. MS., Barua, S., Bhuiyan, MH. (2004). Growth performances and morphological variations among Thai pangas, *Pangasius hypophthalamous* collected from four different hatcheries in Mymensingh. Progress in Agriculture. 15 (1): 141-149.

[38] Alam, MA. (2006). Allozyme marker for the analysis of genetic variation of cross koi (♀local x ♂Thai) *Anabas testudineus* with their parents. M.S. Thesis. Department of Fisheries Biology and Genetics, Bangladesh Agricultural University, Mymensingh, 78 p.

[39] Samad, MA. Islam, MA., Khaleque, MA., Amin, MR., Alam, MS. (2004). Fry rearing and culture of indigenous catfish, Shingi (*Heteropnustes fossilis* Bloch, 1794) Progress in Agriculture. 15(1): 121-131.

[40] Yokogawa, K. (1998). Morphological variabilities and genetic structures of largemouth bass *Micropterus salmoides* in Japanese fresh waters. Suisanzoshoku. 46(3): 321-332.

[41] Schreck, C.B. and Moyle. P.B. (1990). Methods for Fish Biology. American Fish Society, Bethesda, 684 p.

[42] Kurata, H. (1975). Environmental conditions, in "Feeding and growth of larval fish" (ed. By the Japanese Society of Fisheries), Koseishakoseikaku, Tokyo, 45-46 (in Japanese).

[43] Bardach, JE., Ryther, JH., McLarney, WO. (1972). Aquaculture, the farming and husbandry of freshwater and marine organisms. John Wiley & Sons. Inc. New York, 368 Roberts, TR. (1989). The freshwater fishes of Western Borneo (Kalimantan Barat, Indonesia). Memoirs of the California Academy of Science 14. California Academy.