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Assessment of morpho-meristic variations in wild and culture stocks of *Cirrhinus mrigala*

Deepti Negi, Raj Narayan Ram and Ashutosh Mishra

Abstract
The present study was undertaken to obtain a current database of the growth and health condition of *Cirrhinus mrigala* individuals selected from Baur reservoir, Haripura reservoir and stocking pond situated in the Tarai region of Uttarakhand. A total of 90 specimens were collected for morphometric analysis during the sampling period of eight months (September 2018 to April 2019). Results revealed that the value of condition factor (K) was higher in Baur (K=1.19) as compared to other habitats, revealing better fish growth. The growth coefficient value 'b' for selected candidate species from Baur (b=3.83), Haripura (b=3.46) and pond (b=3.12) showed positive allometric growth. A relation between the morphometric and total lengths was established and the range difference was used to determine the environmentally controlled, intermediate and genetically controlled characters. From the study, it is concluded that the Baur reservoir has a better hydrological regime and is less environmentally degraded, providing conducive conditions from fisheries point of view.

Keywords: Carp, condition factor, length-length relationship, growth

Introduction
India is home to more than 10% of the global fish diversity along with the carps having a commercial culture status, thus revolutionizing the freshwater aquaculture section to the level of a fast-growing industry. Carp is a common name for various species of the Cyprinidae family, which represents a very large group of freshwater fishes native to Asia and Europe. An important cultivable species among the carps is *Cirrhinus mrigala* widely known as Mrigal, Nain, Mirrgah, Mirki, Narain and Mori prominent in the South East Asian countries and is reported to be well established in the rivers of Indo-Gangetic plains of India and Pakistan. This species is widely studied as it holds commercial importance and form a major part of the Indian reservoir fisheries. The easiest and authentic methods to identify specimens are morphometric measurements and meristic counts which are mostly termed as morphological systematic [1]. These are two useful morphological aids mostly employed to delineate stocks of fish. The morphometric relationships between various body parts of fish help to distinguish between separate unit stocks of the same species, assess their well-being [2] and examine variations related to the habit and habitat among the variants of the species. Several researchers have concluded that information of the morphometric measurements of fishes and their statistical analysis is essential for determining their taxonomic status [3-5]. Many pieces of researches have shown that the cause of variation in the biometric characters can be partly attributed to intraspecific variability, which is under the influence of environmental parameters [6] hence applicable for examining short-term variations induced by the environment [7]. A more thorough understanding of the morphometrics of the fishes would thus contribute to the management of their populations and would further throw some light on the factors controlling the same (genetic, intermediate or environmental). On the basis of range difference, these morphometric characters may be categorized into environmentally (vast range), intermediate (moderate range) and genetically (narrow range) controlled characters. Although comparisons of the biometrics between cultured and wild fishes from several species have already been carried out by a number of authors [8, 9] there is a lack of information on the level of this variation in the selected fish species inhabiting the Tarai region of Uttarakhand, hence the purpose of the study is to determine the morpho-meristic characters of the candidate species, thereby providing information on their growth and condition in the selected aquatic environments leading to proper breeding and conservation strategies to manage the resources and enhance productivity.

2. Material and Methods

Two adjacent reservoirs (Haripura and Baur) and a pond situated in the Tarai belt of the Shivalik range of Himalayan foothills were selected for the study. Haripura reservoir is a freshwater storage reservoir situated at 29˚8' N Latitude and 79˚20' E Longitude Baur reservoir is situated at 29˚8' N Latitude 79˚18' E Longitude and is larger than the Haripura reservoir in terms of area as it covers a vast expanse of 1271.00 hectares. The stocking pond is located in the Instructional Fish Farm of College of Fisheries, G.B.P.U.A.T, Pantnagar, Uttarakhand situated at 28˚58' N Latitude, 79˚25' E Longitude and an altitude of 252 m above mean sea level.

A total of 90 specimens of Nain of variable size were collected from the selected water bodies during the sampling period of 8 months (September 2018 to April 2019), using gill nets and cast nets. Length and body weight of these fishes were measured with the help of a measuring scale and an electric balance after removing debris from the body surface. In the present study, fifteen morphometric and six meristic characters (Dorsal fin rays, Pectoral fin rays, Pelvic fin rays, Anal fin rays, Caudal fin rays and Lateral line scales) of each fish specimen were taken into account (Table 1). The data of length-weight relationship was analysed using the formula given by Le Cren [10]. Length–weight was expressed as $W= aL^b$, the logarithm transformation of which gives the linear equation Log W = log a + b log L, where W refers to weight (g), L is length (cm), 'a' is the intercept (constant) and 'b' is the regression coefficient (slope) of the linear regressions. The Length-length relationship was expressed using equation Y= a+ bX, where Y refers to dependent variable (morphometric lengths) and X refers to independent variable (total body length).

Fulton condition factor (K) and Relative condition factor (K_n)

$K = W/L^3 \times 100$

Where; W is fish body weight in grams, L is the standard length of fish in centimetres

$K_n = W_t / W_e$

Where; W_t is observed body weight, W_e is the theoretically estimated weight

For the purpose of this study, statistical calculations of the correlation coefficient, regression coefficient and determination coefficient were employed using SPSS software (16.0). The various regression analysis and graphs were made using MS Excel.

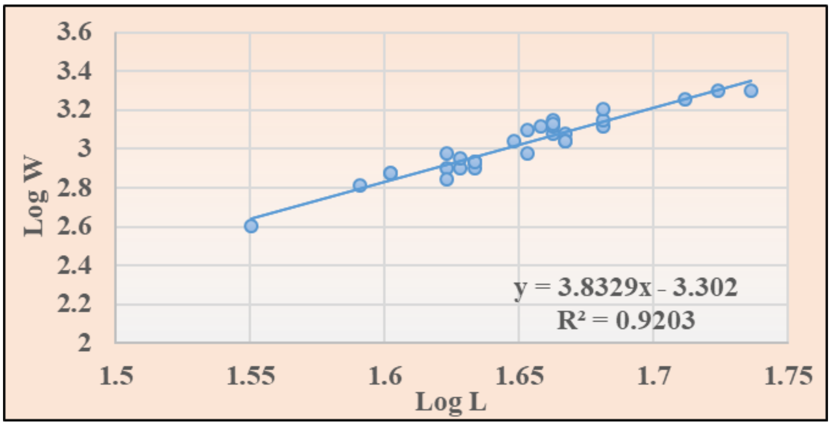
Table 1: General morphometric characters and their description

S. No.	Morphometric Variables	Description
1	Total length	Distance from the tip of the snout to the longest caudal fin ray
2	Standard length	Distance from the tip of the snout to the end of the vertebral column
3	Head length	Distance from the tip of the snout to the posterior margin of the operculum
4	Pre-dorsal length	Distance from the tip of the snout to the anterior end of the first dorsal fin base
5	Pre-anal length	Distance from the tip of the snout to the origin of the anal fin
6	Length of dorsal fin	Length of the longest fin ray of the dorsal fin
7	Length of pectoral fin	Length of the longest fin ray of the pectoral fin
8	Length of pelvic fin	Length of the longest fin ray of the pelvic fin
9	Length of anal fin	Length from origin of 1st anal fin ray to the origin of the last anal fin ray
10	Length of caudal fin	Length of the longest fin ray of the caudal fin
11	Depth of dorsal fin	Height of dorsal fin from base of origin of dorsal fin to end of longest fin ray
12	Caudal depth	Minimum vertical length of the body (minimum depth on caudal peduncle)
13	Distance between pectoral and pelvic fin	Distance from start of pectoral fin to the pelvic fin
14	Distance between pelvic and anal fin	Distance from start of pelvic fin to the anal fin
15	Body depth	Maximum vertical length of body (deepest part of the body)

3. Results and Discussion

3.1 Length-weight relationship

The mean length and mean weight for *C. mrigala* individuals were 44.80± 4.01 cm and 1113.33± 389.50 g in the Baur reservoir, 46.54± 2.78 cm and 1161.67± 267.71 g in Haripura and 32.15± 4.44 cm and 373.33± 176.77 g in the stocking pond, respectively. In the current investigation, the value of exponent 'b' ranged from 3.12 to 3.83 for all the three habitats of the present investigation. The growth coefficient 'b' for Nain in the Baur, Haripura and pond was 3.83, 3.46 and 3.12, respectively, showing positive allometry. The values of correlation coefficient 'r' varied between 0.87 to 0.97 with the highest value in the pond ecosystem manifesting a positive correlation between the total length and total weight and lowest value in the Haripura reservoir. The R^2 values were in the range of 0.79- 0.95 which indicated the fitness of the regression equation with highest and lowest values in pond and Haripura ecosystems respectively. The graph is presented in figure 1. The results are in consonance with the work of Ujjania *et al.* [11] who presented a comprehensive study determining the growth parameters for Mrigala collected from Mahi Bajaj Sagar reservoir situated in Rajasthan. The data from the study revealed the LWR to be significant with value of r= 0.970 and b= 3.362 exhibiting a positive allometric growth. Similar findings related to value of 'b' were delineated by Parmar and Bhatia [12] on Mrigal individuals collected from Pong reservoir. Soni and Ujjania [14] worked on the Vallabhsagar reservoir of Gujarat and noted positive allometric growth in collected specimens of Rohu (3.342) and Nain (3.048). According to Nandikeswari *et al.* [13] the habit and habitat of fish species determine fluctuations in their LWR.



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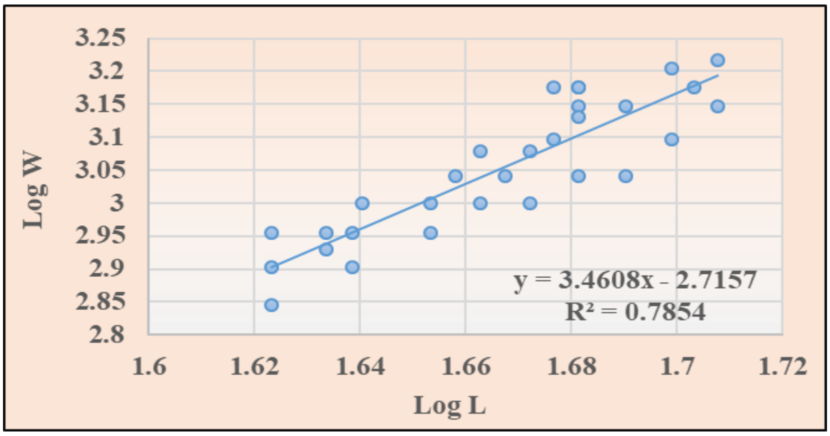

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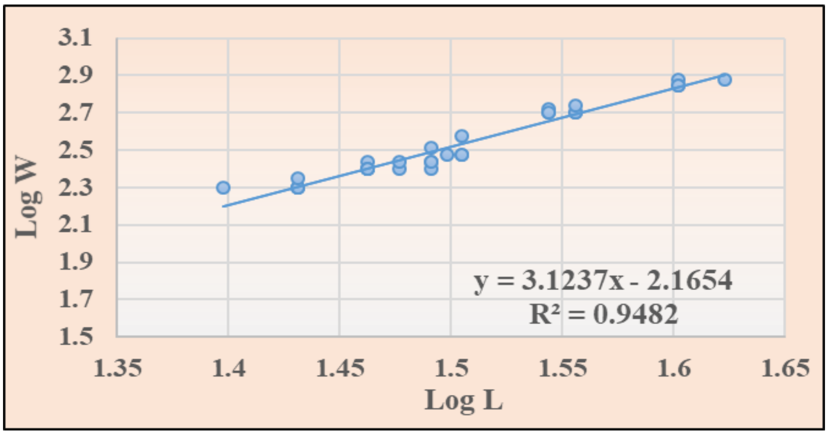

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Fig 1: Length- weight relationship of *Cirrhinus mrigala* individuals (a) Baur (b) Haripura and (c) pond during the study period

3.2 Length-Length Relationship (LLR)

The data for LLR of Nain individuals selected from Baur, Haripura and pond are presented in table 2, table 3 and table 4 and the graphical representation is depicted in figure 2, figure 3 and figure 4, respectively. In the Baur reservoir, maximum significant correlation in relation to the total body length was shown by standard length- TL (0.99) and minimum by dorsal fin depth- TL (0.61) where two, four and eight characters were observed to be influenced by environmental, genetic and intermediate factors, respectively. In the case of Haripura reservoir, the correlation coefficient (r) was significantly maximum in standard length- TL (0.96) and minimum in head length- TL (0.46). Based on the range difference, two characters were observed to be environmentally controlled, three genetically controlled and nine were intermediate characters. In the pond habitat, the highest value of correlation coefficient (r) was observed in pre-anal length- TL (0.97) and the lowest value in pelvic fin length- TL (0.58). Two, four and eight characters were found to be governed by environmental factors, genetic factors and intermediate factors respectively. The results showed a proportional positive increase in morphometric parameters with respect to the total fish length. Dasgupta [15] performed an extensive study on Mahseer species collected from the Garo hills of Meghalaya and reported high values of coefficient of correlation (r) indicating a high positive correlation of the morphometric characters with reference to the total body length. Various environmental (water depth, temperature, pH, turbidity) and biological factors (size, genetic profile) are known to be responsible for influencing variations between the body measurements [16-18]. It is pertinent to remark that alterations in the morphometric parameters of the fish may be attributed to changes in the environmental conditions of the water body due to factors like food unavailability and pollution. Sharma and Nagar [19] collected specimens of *Chela bacaila* from the Ubeshwar stream of Rajasthan and found that thirteen characters were genetically controlled, four were intermediate and one character was environmentally controlled pointing towards an undisturbed environment.

Table 2: Length- length relationship of *C. mrigala* individuals selected from Baur reservoir

In relation to total fish length (TL)	Minimum	Maximum	Range difference	Correlation coefficient (r)	Regression Equation	Control of characters
Standard Length	29.0	44.5	15.5	0.99*	y = 0.866x - 1.316	E
Head Length	6.0	9.0	3.0	0.84*	y = 0.152x + 0.498	I
Pre- dorsal length	14.0	22.0	8.0	0.94*	y = 0.414x - 1.178	I
Pre- anal length	23.5	38.0	14.5	0.98*	y = 0.726x - 1.803	E
Dorsal fin length	5.5	10.5	5.0	0.71*	y = 0.173x - 0.271	I
Anal fin length	2.0	5.0	3.0	0.94*	y = 0.172x - 4.314	I
Pectoral fin length	5.0	7.5	2.5	0.76*	y = 0.130x + 0.370	G
Pelvic fin length	4.3	7.0	2.7	0.80*	y = 0.118x - 0.026	G
Caudal fin length	6.7	10.0	3.3	0.83*	y = 0.161x + 0.983	I
Body depth	8.0	14.0	6.0	0.84*	y = 0.286x - 2.232	I
Dorsal fin depth	5.0	7.5	2.5	0.61*	y = 0.093x + 2.209	G
Caudal fin depth	3.5	5.8	2.3	0.78*	y = 0.097x + 0.304	G
Distance between pectoral and pelvic fin	10.0	15.0	5.0	0.93*	y = 0.282x - 0.343	I
Distance between pelvic and anal fin	9.0	14.5	5.5	0.84*	y = 0.235x + 0.563	I

*Significant at 0.01 level of significance
Where, E is environmentally controlled, G is genetically controlled and I is intermediate characters

Table 3: Length- length relationship of *C. mrigala* individuals selected from Haripura reservoir

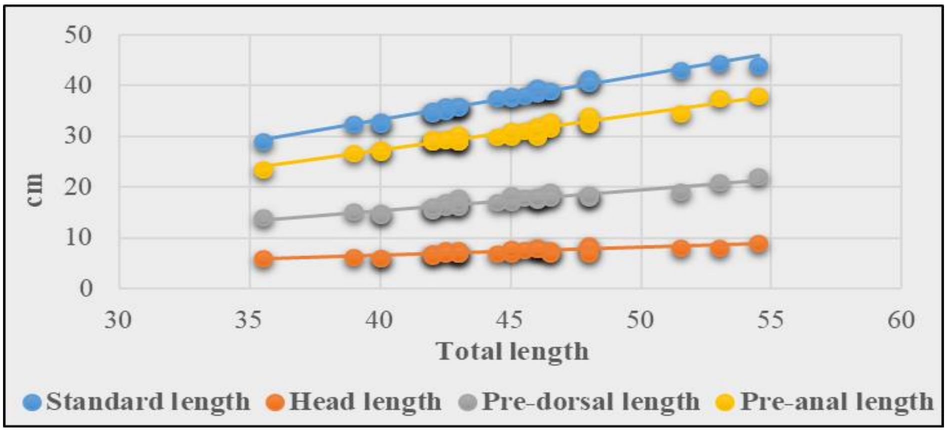
In relation to total fish length (TL)	Minimum	Maximum	Range difference	Correlation coefficient (r)	Regression Equation	Control of characters
Standard Length	34.5	43.5	9.0	0.96*	y = 0.956x - 5.404	E
Head Length	7.0	9.0	2.0	0.46*	y = 0.087x + 4.039	I
Pre- dorsal length	15.5	20.2	4.7	0.89*	y = 0.442x - 2.613	I
Pre- anal length	28.7	36.5	7.8	0.87*	y = 0.688x - 0.209	E
Dorsal fin length	7.0	9.0	2.0	0.72*	y = 0.161x + 0.470	I
Anal fin length	2.2	4.0	1.8	0.52*	y = 0.089x - 1.342	G
Pectoral fin length	5.0	8.0	3.0	0.77*	y = 0.199x - 2.484	I
Pelvic fin length	4.3	6.3	2.0	0.77*	y = 0.140x - 0.934	I
Caudal fin length	8.0	9.5	1.5	0.80*	y = 0.129x + 2.760	G
Body depth	9.0	13.5	4.5	0.77*	y = 0.411x - 7.429	I
Dorsal fin depth	5.2	7.5	2.3	0.79*	y = 0.166x - 1.167	I
Caudal fin depth	4.0	5.5	1.5	0.80*	y = 0.115x - 0.539	G
Distance between pectoral and pelvic fin	10.0	14.8	4.8	0.75*	y = 0.321x - 2.484	I
Distance between pelvic and anal fin	8.5	13.5	5.0	0.73*	y = 0.311x - 3.342	I

*Significant at 0.01 level of significance
Where, E is environmentally controlled, G is genetically controlled and I is intermediate characters

Table 4: Length- length relationship of *C. mrigala* individuals selected from stocking pond

In relation to total fish length (TL)	Minimum	Maximum	Range difference	Correlation coefficient (r)	Regression Equation	Control of characters
Standard Length	21.0	35	14	0.90*	y = 0.685x + 4.864	E
Head Length	2.8	7.0	4.2	0.86*	y = 0.194x - 1.683	I
Pre- dorsal length	9.0	15.0	6.0	0.93*	y = 0.350x - 0.201	I
Pre- anal length	16.5	29.0	12.5	0.97*	y = 0.768x - 3.838	E
Dorsal fin length	4.0	8.5	4.5	0.64*	y = 0.180x + 0.418	I
Anal fin length	2.0	3.8	1.8	0.78*	y = 0.082x + 0.290	G
Pectoral fin length	4.0	6.5	2.5	0.60*	y = 0.089x + 1.946	G
Pelvic fin length	3.0	5.0	2.0	0.58*	y = 0.068x + 1.960	G
Caudal fin length	5.2	9.0	3.8	0.81*	y = 0.171x + 1.366	I
Body depth	11.0	6.0	5.0	0.85*	y = 0.255x - 0.151	I
Dorsal fin depth	4.0	7.0	3.0	0.85*	y = 0.134x + 0.645	I
Caudal fin depth	2.5	4.5	2.0	0.83*	y = 0.090x + 0.560	G
Distance between pectoral and pelvic fin	5.8	11.2	5.4	0.938	y = 0.323x - 2.943	I
Distance between pelvic and anal fin	4.8	10.0	5.2	0.94*	y = 0.306x - 2.971	I

*Significant at 0.01 level of significance
Where, E is environmentally controlled, G is genetically controlled and I is intermediate characters



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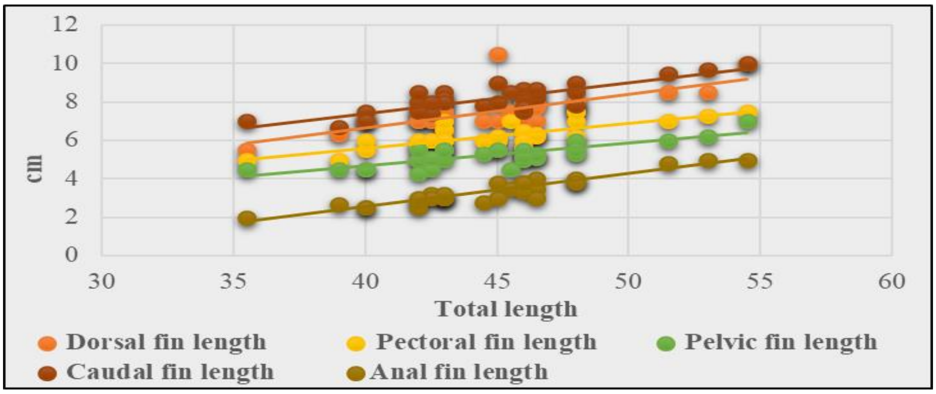

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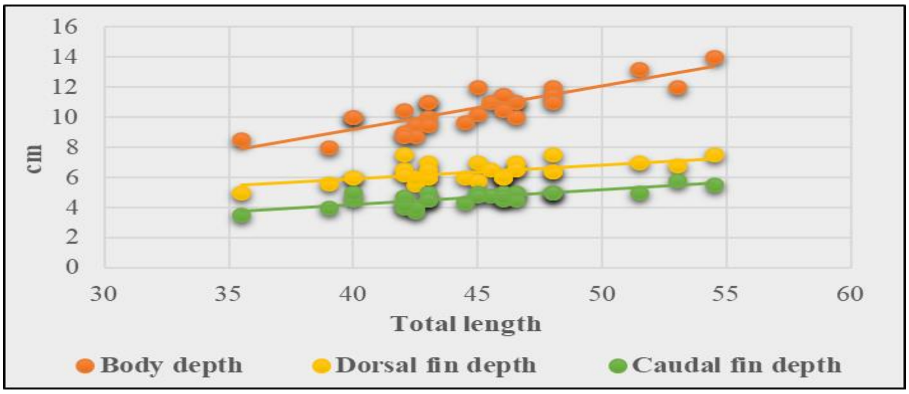

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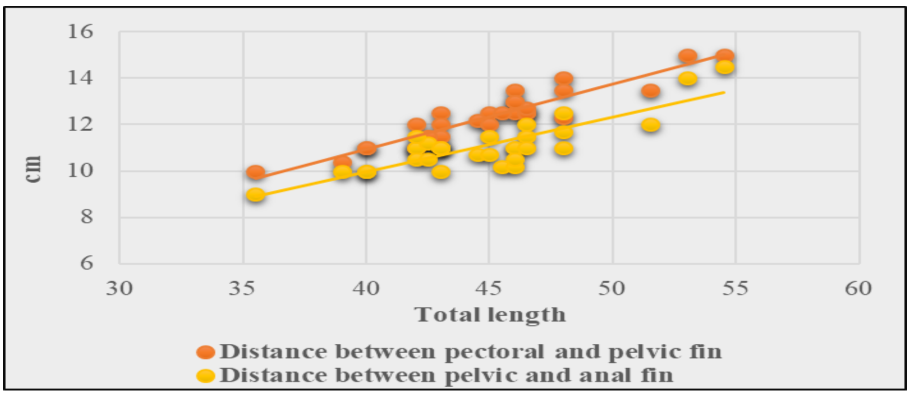
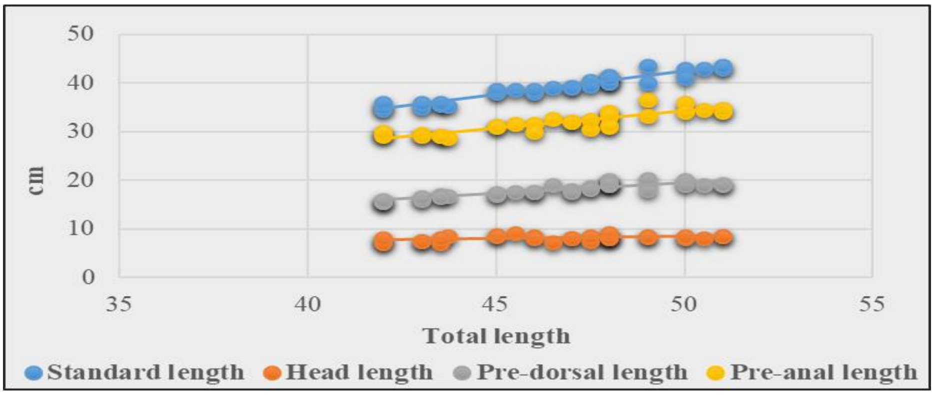


(d)

Fig 2: Relationship of total length (cm) with (a) standard length (cm), head length (cm), pre-dorsal length (cm), pre-anal length (cm) (b) dorsal fin length (cm), pectoral fin length (cm), pelvic fin length (cm), anal fin length (cm), caudal fin length (cm) (c) body depth (cm), dorsal fin depth (cm), caudal fin depth (cm) and (d) distance between pectoral and pelvic fin (cm), distance between pelvic and anal fin (cm) of *Cirrhinus mrigala* individuals from Baur reservoir



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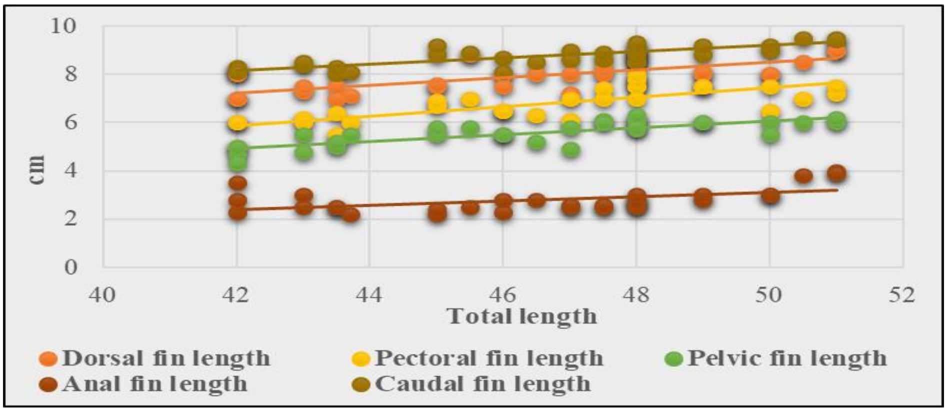

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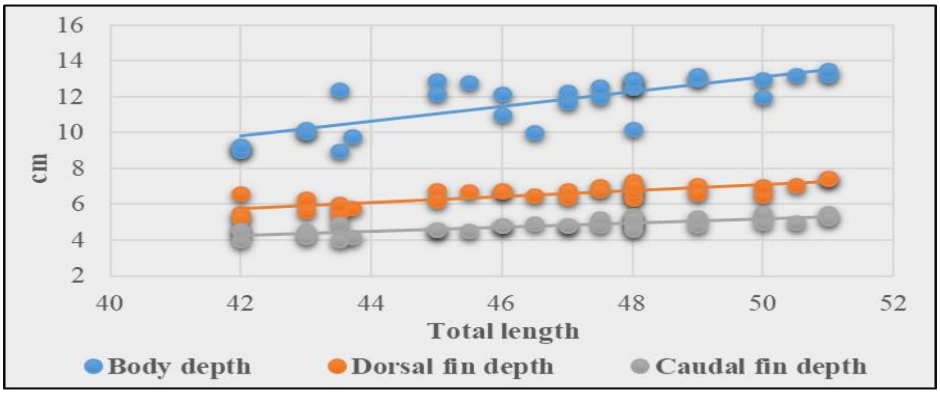

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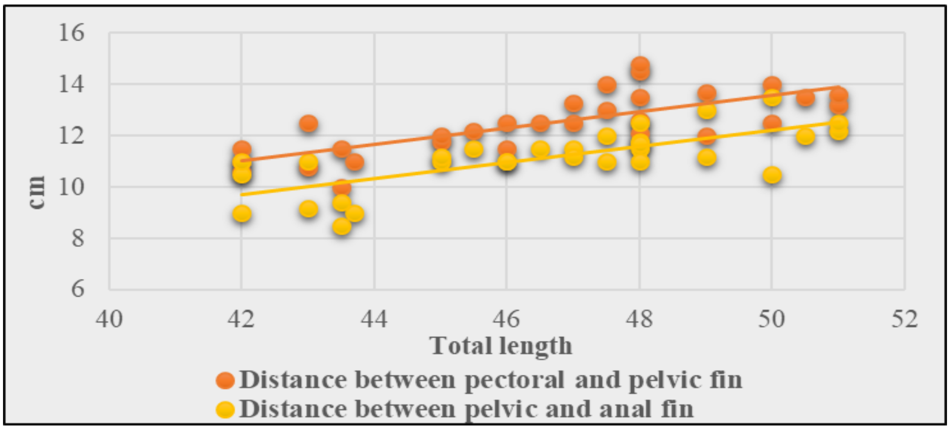

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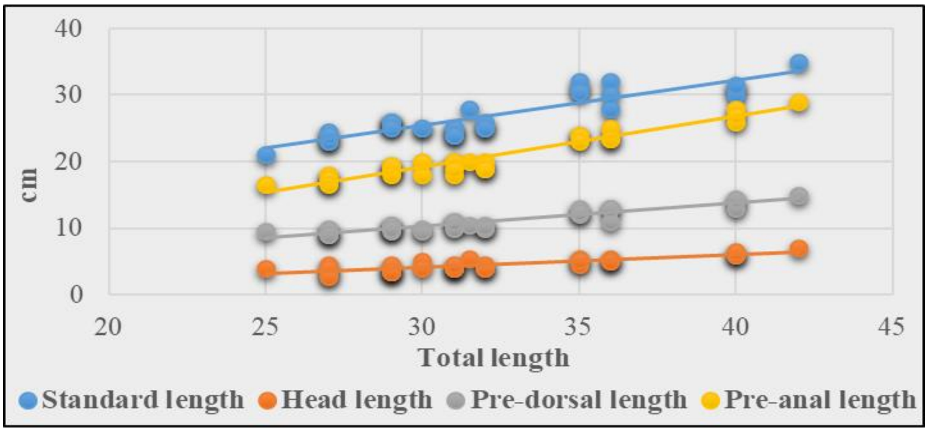
Fig 3: Relationship of total length (cm) with (a) standard length (cm), head length (cm), pre-dorsal length (cm), pre-anal length (cm) (b) dorsal fin length (cm), pectoral fin length (cm), pelvic fin length (cm), anal fin length (cm), caudal fin length (cm) (c) body depth (cm), dorsal fin depth (cm), caudal fin depth (cm) and (d) distance between pectoral and pelvic fin (cm), distance between pelvic and anal fin (cm) of *Cirrhinus mrigala* individuals from Haripura reservoir



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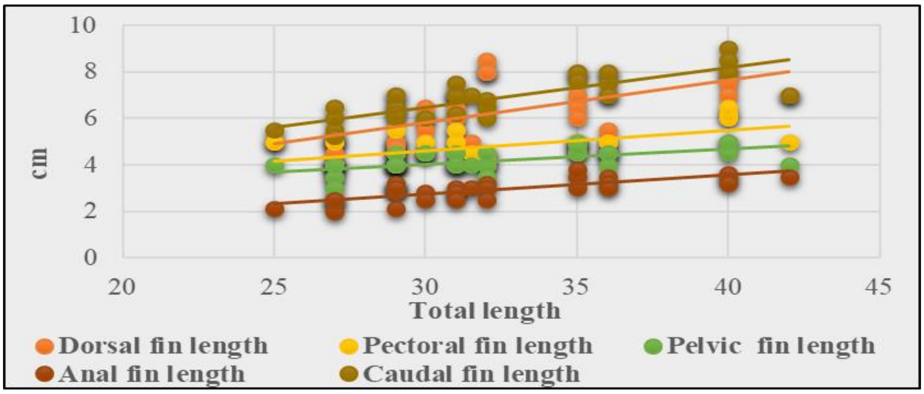

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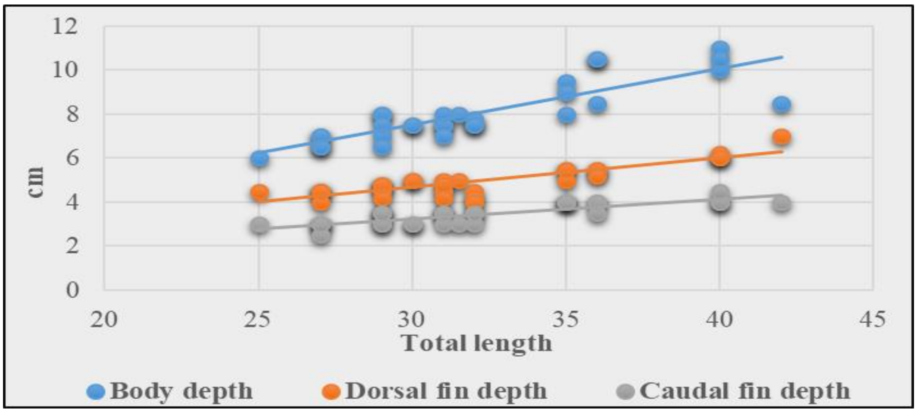

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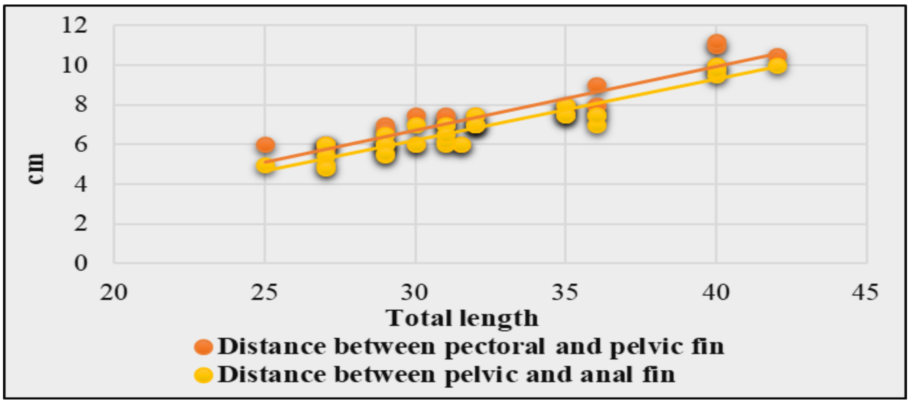

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Fig 4: Relationship of total length (cm) with (a) standard length (cm), head length (cm), pre-dorsal length (cm), pre-anal length (cm) (b) dorsal fin length (cm), pectoral fin length (cm), pelvic fin length (cm), anal fin length (cm), caudal fin length (cm) (c) body depth (cm), dorsal fin depth (cm), caudal fin depth (cm) and (d) distance between pectoral and pelvic fin (cm), distance between pelvic and anal fin (cm) of *Cirrhinus mrigala* individuals from stocking pond

3.3 Condition factor (K) and Relative condition factor (Kn)

The results manifested that the *Cirrhinus mrigala* selected from the Baur reservoir showed maximum K value (1.19) followed by the Haripura reservoir (1.14) and the stocking pond (1.05). ANOVA revealed a significant difference in the condition factor of Nain among the three habitats (p<0.05). The values of relative condition factor varied between 1.01-1.06 with highest Kn value in the specimens of Baur reservoir and lowest in those from the pond ecosystem. Values of both K and Kn were greater than 1, thus, indicating conducive environmental conditions for the fish species in all the three habitats. In corroboration with the present study, Saxena and Saksena [20] recorded K values for Mrigal from Raipur reservoir of Gwalior in the range of 0.90-1.40. Pandey and Sharma [21] reported the K values for Nain to be 0.98-1.03 from a pond in Uttar Pradesh. The value of K for Nain specimens collected from the Baur reservoir was observed to be highest revealing better growth and health of the species which may be attributed to deeper waters, high DO levels, low TDS, food abundance, less sedimentation load and little anthropogenic impact in the ecosystem.

3.4 Meristic count

A comparative account of the meristic characters of *C. mrigala* from the selected habitats is given in table 5. The dorsal fin rays number was in the range of 15-16 in all the three habitats. The number of pectoral fin rays oscillated between 15-18 with 15-17 in Baur and 15-18 in Haripura and 15-16 in pond ecosystem. The number of pelvic fin rays varied from 8-9 with 8-9 in both Baur and pond and 9 in Haripura. The anal fin rays were 6-9 in Baur, 6-7 in Haripura and 6-8 in pond. The caudal fin rays were observed to be in the range of 17-22 with 19-22 in both Baur and Haripura and 17-20 in pond. The count of lateral line scales varied from 41-43 in both Baur and Haripura and 42-44 in pond habitat. Variations in the meristic counts of Japanese charr, *Salvelinus leucomaenis* has been recorded by Nakamura [22]. The results are not in agreement with the work of Hazarika *et al.* [23], who observed the meristic counts to be constant in *Barilius bendelisis.* According to Yousefian [24] and Sfakianakis *et al.* [25], variations in the meristic parameters are related to genetic factors and temperature respectively. Similar observations were recorded by Misra [26] and Rahman [27] in *C. mrigala* with fin formula being D. 15-16, P. 15, V. 9, A. 8, C. 19, L.I. 40-45 and D. 16, P1. 17, P2. 9, A. 8, respectively.

Table 5: Comparative account of meristic characters and fin formula of *Cirrhinus mrigala* individuals selected from Baur reservoir, Haripura reservoir and stocking pond

Meristic characters	Range		
	Baur	**Haripura**	**Pond**
Dorsal fin rays (DFR)	15-16	15-16	15-16
Pectoral fin rays (PFR)	15-17	15-18	15-16
Pelvic fin rays (PVR)	8-9	9	8-9
Anal fin rays (AFR)	6-9	6-7	6-8
Caudal fin rays (CFR)	19-22	19-22	17-20
Lateral line scales (LLS)	41-43	41-43	42-44
Fin Formula			
Baur = D. 15-16, P. 15-17, Pl. 8-9, A. 6-9, C. 19-22, L. 41-43			
Haripura = D. 15-16, P. 15-18, Pl. 9, A. 6-7, C. 19-22, L. 41-43			
Pond = D. 15-16, P. 15-16, Pl. 8-9, A. 6-8, C. 17-20, L. 42-44			

4. Conclusion

The study revealed that the *C. mrigala* specimens collected from the Baur reservoir showed higher values of K and Kn indicating conduciveness of the environment for fish growth and survival. The individuals from all habitats exhibited positive allometric growth as Baur provides a healthy environment and Haripura provides a suitable feeding niche for the fish, as the water here is shallow with profuse macrophyte decomposition that provides detritus material for the fish to feed on. In both the reservoirs, the candidate fish species showed two environmentally controlled morphometric reflecting less environmental influence on the habitats. However, those collected from Haripura reservoir, showed more intermediate characters (*i.e.* nine) as compared to the other two concluding that if proper management techniques are not implemented, they would get converted into environmentally controlled characters and the habitat may further degrade in the future.

5. Acknowledgement

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