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Length-weight relationships and condition factors of five cyprinidae species (Subfamily-Barbinae) from three diverse rivers of Uttar Pradesh, India

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Abstract
This study describes the patterns of length-weight relationship and condition factor of five important small indigenous fish species (SIS) belonging to subfamily Barbinae viz. *Systomus sarana*, *Puntius chola, Puntius sophore, Pethia ticto*, and *Pethia conchonious* collected from three geographically isolated rivers (Ganga, Gomti and Sai) of Uttar Pradesh, India. A total of 977 individuals of different sizes were collected. Length-weight relationships (LWRs) were found highly correlated ($r2$ >0.992; P<0.001) in species *P. chola* and *S. sarana* of Gomti. The slope (b) of the functional regression between length and weight values varied from 2.249 to 3.231(mean b = 2.801±0.283). The results indicated that most of the population has shown negative allometric pattern (b<3) of growth. Whereas, the average values of condition factor (K) showed that studied species in these three rivers were in good condition. This study also provided first baseline data related to length-weight relationship and condition factor for five selected species of Sai river, Raibarely, Uttar Pradesh.

Keywords: *Puntius*, Gomti river, Ganga river, Sai river

1. Introduction
Fish is considered as a good indicator of riverine health [1-4]. Length-weight relationship study could be an inexpensive mean of detecting effects of pollution on fish fitness. This relationship could be helpful to compare some morphometric parameters among various species or among populations of the same species from geographical isolated bodies [5, 6]. The species-wise length-weight relationship is an important data required to understand composition of landing fishes. Further, length-weight relationships give information on the condition and growth patterns of fish [7]. The well-being of the fish can be calculated by this relationship, data generated can be helpful to determine effect of aquatic environment on the same species in isolated water bodies [8]. Generally, scientists in fisheries section use length-weight relationships parameters for observing fish health of any population/stock [9]. The length-weight relationships (LWR) are considerably essential in aquaculture and have become one of the standard methods used in fisheries. Even if one has only data related to either fish length or weight, then also with the help of LWR formula other variable could be computed. In this way it is very helpful in field study or for quick assessment when time constrains [10, 11]. In addition, the data on length and weight can also offer important indications to environmental changes and indication towards deployment of natural resources by the humans [12, 13].
Condition factor is also an important determinant of fishery science. It is based on the assumption that fish which is heavier at a particular length is superior in physiological state. Besides this, condition factor has been used as an indicator of growth and feeding intensity in fishes [14]. This parameter may also employ to find out the status of the aquatic body in which the fish thrive [13, 15]. Moreover, condition factor can be used for determination of the possible differences among different stocks [8, 16].
It is well known that river Ganga [17, 18], Gomti [19] and Sai [20] of Uttar Pradesh are highly polluted. Indigenous ichthyofaunal populations of fresh water rivers have been reduced critically due to both natural as well as anthropogenic causes [21-25]. Especially, there are continuous threats to small indigenous species (SIS). *Puntius*, *Pethia* and *Systomus* genera are belonging to the family Cyprinidae, subfamily Barbinae. These small to medium-sized SIS thrives in stagnant water bodies to fast flowing streams of tropical Asia [26].

These fishes have been listed under least concern category in the IUCN red list. However, some workers have also reported that these species are facing high risk of extinction and they have mentioned them under threatened category [27]. Literature revealed that there is insufficient information on the growth parameters of these species. Therefore, the main objective of this study is to determine and evaluate the length-weight relationships (LWRs) and condition factors for five species of freshwater Barbinae fishes covering three genera collected from three different rivers.

2. Materials and Methods

The specimens were collected randomly from April 2015 to February 2016 from the three geographically isolated rivers viz. Ganga, Gomti and Sai. Sampling sites details are provided in Table 1. Fishes were caught with the assistance of local fishermen using different nets (cast and gill). Identification of the specimens was confirmed using the morphological characters keys of Talwar and Jhingran, Vishwanath *et al*. and Pethiyagoda *et al*. [28-30]. Fishes were fixed in 10% formalin and transported to the laboratory, then total length of each individual was measured from the tip of snout to the extended tip of the caudal fin to the nearest 0.01mm (total length) by digital calliper and ruler and weighed to the nearest 0.01g (total weight) by digital weighing machine. The collected data were transformed into log values.

Table: 1 Sampling regimes and their location with Latitude and Longitude

S. No.	Sampling regime	Location	Latitude and Longitude
1	Ganga river	Ganga barrage, Kanpur	26.507°N, 80.3169°E
2	Gomti river	Pakka pul, Lucknow	26.8727°N, 80.9162°E
3	Sai river	Takia kalan, Raebareli	26.235 °N, 81.2130°E

2.1 Length-Weight Relationship (LWR)

The length-weight relationship was estimated using the following equation $W = aL^b$ [11, 31].

Where, W=weight of fish in grams, L=length of fish in cm, *a*=constant and *b*=an exponential expressing relationship between length-weight.

The relationship ($W = aL^b$) when changed into the logarithmic form makes a straight line relationship graphically

$\text{Log } W = \text{Log } a + b \text{ Log } L$

Where,

W = Weight of fish (in g)

L = Length of fish (in cm)

a = y Intercept or the initial growth coefficient

b = Slope or the growth coefficient

2.2 Condition factor (Fulton's factor, K)

The well-being or plumpness of each species was studied by using Fulton's condition factor [7]. Fulton's condition factor was calculated by using following formula [32]:

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

Where 'K' is Fulton's condition factor, 'W' is net wet weight (g) of fish and 'L' is length in cm. The factor 100 is employed to bring K close to unity.

All statistical analyses were carried out using Microsoft excel (ver. 2007), GraphPad Prism software version 5.01 and Past software. To evaluate the variations among different regions, 95% confidence limits were used.

3. Results and Discussion

A Total of 977 fish specimens of five species belonging to three genera were sampled. Sample size (n), size range (cm TL), maximum reported length from FishBase [33] for each species, parameters *a* and *b* of the LWR and the correlation coefficient (r^2), 95% confidence range for b, a (intercept of regression) with 95% confidence range are provided in Table 2 and variations in values of condition factor of 5 different species among three rivers are depicted in Fig 1. The present study revealed that the coefficient of determination (r^2) ranged from 0.926 (*P. sophore*) to 0.98 (*P. chola*) for Ganga river, 0.912 (*P. conchonius*) to 0.994 (*P. chola*) for Gomti river and from 0.933 (*P. conchonius*) to 0.993 (*S. sarana*) for Sai river. The highest value of r^2 was 0.994 (*P. chola*) of Gomti river and lowest value also from Gomti river 0.912 (*P. conchonius*). All linear regressions were highly and statistically significant ($P<0.001$). The value of r^2 for *P. sophore* (Gomti) was similar to that of reported by Sarkar *et al.* [34] from Gomti. The r^2 value for *P. sophore* (Ganga) when compared to the value reported for the same by Sarkar *et al.* [34] was found less. In present study, r^2 value of *P. ticto* from Gomti river was reported higher than the value reported by Sarkar *et al.* [34] while from Ganga river, Sarkar *et al.* [34] found the value of r^2 for *P. ticto* was greater than the values reported in this study. In the present study, correlation coefficient for *P. conchonius* were 0.91, 0.93, and 0.97 for Gomti, Sai and Ganga respectively, which were within the range as reported by Mir and Mir [35] from river Jhelum of Kashmir.

In the present study, the observed value *b* from all the species taken from three rivers was found to be varied from 2.249 to 3.231. The value of *b* ranges from 2.959 (*P. chola*) to 2.4 (*P. ticto*) in Ganga river, 2.604 (*P. ticto*) to 3.215 (*P. sophore*) in Gomti river, 2.249 (*P. ticto*) to 3.231 (*P. sophore*) in Sai river. The mean value of *b* for all species was 2.746 in the Ganga, 2.865 in the Gomti and 2.815 in the Sai river. All *b* values from all the species taken from three rivers were consistent with the expected *b* value range of 2.5–3.5 [31], except *P. ticto* from Ganga ($b = 2.400$) and Sai river ($b=2.249$). Similar value of *b* in Ganga and Gomti river for *P. chola* indicates that aquatic environment of these two rivers are probably providing the similar condition for this species to grow.

Kaushik and Bordoloi [36] carried out their study in different wetlands of Lakhimpur, Assam and reported the *b* values for *P. sophore*, *P. chola* and *P. ticto*. When compared these values with findings of the present study, value of *b* found comparatively less for all five species collected from the rivers (Ganga, Gomti and Sai). This indicates condition of wetlands were better than any of these three rivers.

In the Ganga river out of five species all exhibits negative allometric growth, in Gomti river four species revealed negative allometric growth ($b<3$) and one positive allometric growth ($b>3$) (*P. sophore*). However, the river Sai revealed least number of negative allometric species i.e. 3 negative allometric ($b<3$) and one isometric (*P. chola*) also one positive allometric growth (*P. sophore*). The coefficient *b* was

close to isometric value (≈3.000) only in *P. chola* from Sai river this shows the weight of *P. chola* was found to be nearly the cube of its length.

The species which were common in ecologically different regions also revealed different growth patterns. *P. sophore* exhibited negative allometric growth in Ganga river and isometric growth in river Sai while positive allometric growth in Gomti. Further, *P. chola* of Gomti and Ganga revealed negative allometric growth but in Sai river this fish shown isometric growth.

According to Bagenal and Tesch, Gonçalves *et al*. Taskavak and Bilecenoglu, Özaydin and Taskavak [7, 5, 37, 38], the parameter *b*, unlike the parameter *a*, may vary seasonally, and even daily, and between habitats thus, disparities in *b* values can be attributed to the one or more factors or their combination. Factors which were not accounted in the present study are quantity of specimen's examined; differences in the observed length ranges of the specimens caught, methods used in preservation of samples, surroundings; degree of stomach fullness; maturity of genitalia; sex; general condition of fish or their health etc [39, 40].

The value of condition factor of selected species ranged from 0.48 -2.47 average condition factors of all five fish species were found to be 1.51, 1.50 and 1.55 of Gomti, Ganga and Sai river respectively. The value of condition factor for *S. sarana* was less in comparison to that of reported by Lal *et al*. [41] from the Godavari, Som river and Jaisamand Lake and Ravi river but more than the values reported by Das *et al*. [42] from deeper Beel wetland of Assam. In the present study, value of K for *P. ticto* found to be varied between 1.85-1.89. However, Lal *et al*. [41] reported comparatively higher value of K for *P. ticto* from Som river and Jaisamand lake. Fulton's condition factor (K) values for all the specimens of *S. sarana* from Ganga ranged between 0.92 and 1.33 with an average of 1.20±0.083. The average of 'K' values of diverge rivers obtained in the present study were more than 1 that showed all the species studied were in good health condition [43, 44]. Differences in values of K indicate the state of sexual maturity, size ranges, age and sex composition of the population. It might be differed also due to degree of food sources availability, season or environmental conditions [45, 46]. No published information is available for comparing any of the selected species from the Sai river. So far, the present study is the first length-weight relationship and condition factor study from this river. Therefore, the present findings will be an important contribution to the database.

Table 2: Parameters of logarithmic regression equation of length-weight relationship in Barbinae fish

Sub family	Genus	Species	Sites	N	Max. Known Fish base Length (cm)	Max. Length (cm)	Min. Length (cm)	a	95 CL of a	b	95 CL of b	r^2	Type of growth
Barbinae	*Pethia*	*conchonius*	Ganga	50	14	11	3.8	-1.711	-1.822 to -1.599	2.548	0.6597 to 0.6820	0.971	NA
			Gomti	69		10.2	4.1	-1.789	-1.959 to -1.620	2.636	0.6633 to 0.6925	0.912	NA
			Sai	38		10.2	4.5	-1.816	-2.024 to -1.609	2.665	0.6616 to 0.6988	0.933	NA
		ticto	Ganga	96	10	8.9	4.9	-1.237	-1.346 to -1.129	2.400	0.4971 to 0.5323	0.935	NA
			Gomti	108		8.9	3.8	-1.411	-1.485 to -1.338	2.604	0.5320 to 0.5513	0.968	NA
			Sai	99		9.6	4.9	-1.091	-1.173 to -1.009	2.249	0.4685 to 0.5003	0.958	NA
	Puntius	*chola*	Ganga	30	15	11.5	5	-2.129	-2.304 to -1.953	2.959	0.6278 to 0.6637	0.980	NA
			Gomti	46		11.9	5.6	-1.782	-1.851 to -1.712	2.96	0.5930 to 0.6108	0.994	NA
			Sai	31		11.9	4.9	-1.834	-1.944 to -1.724	3.015	0.5945 to 0.6214	0.990	ISO
		sophore	Ganga	119	18	12.2	4.4	-1.746	-1.892 to -1.601	2.951	0.5718 to 0.6097	0.926	NA
			Gomti	90		10.9	4	-1.982	-2.119 to -1.846	3.215	0.6016 to 0.6304	0.955	PA
			Sai	91		12.1	5	-2.000	-2.161 to -1.838	3.231	0.6002 to 0.6355	0.941	PA
	Systomus	*sarana*	Ganga	40	42	15.2	8.52	-1.784	-1.933 to -1.634	2.872	0.5981 to 0.6420	0.978	NA
			Gomti	29		13.9	6.4	-1.830	-1.934 to -1.726	2.909	0.6151 to 0.6420	0.992	NA
			Sai	41		15.2	5	-1.834	-1.915 to -1.753	2.917	0.6178 to 0.6393	0.993	NA

NA=negative allometric, PA=positive allometric, ISO=isometric

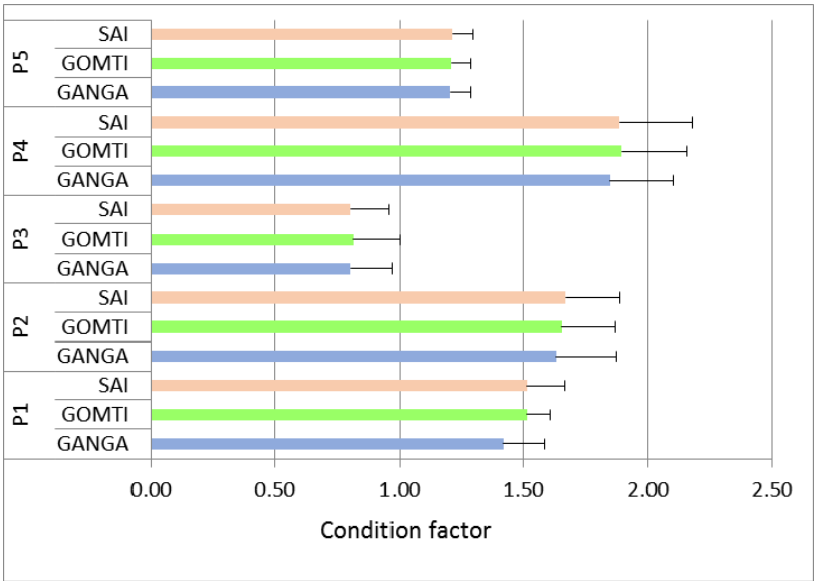

Fig 1: Variation in value of K±SD of 5 different species among three rivers (P1= *P.chola*, P2= *P. sophore*, P3=*P. conchonius*, P4=*P. ticto*, P5=*S. sarana*)

4. Conclusion

The present study indicates that there were variations in studied growth parameters of fish species in relation to aquatic ecological unit but it is ahead of this study to tell whether these variations are controlled by genes or are due to environmental induced plasticity. In this respect, Common garden experiment for further investigation is suggested. The present study of length-weight relationship and condition factor offers new vision to the researchers, environmentalist and policymakers to impose adequate regulation for sustainable fishery management.

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