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Length-weight, length-length relationships and condition factor of *Gagata rhodobarbus* Bhakat & Sinha, 2019 (Siluriformes, Sisoridae)

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Abstract
This study describes the length-weight (LWR), length-length (LLR) relationships and condition factor for a small sisorid catfish, *Gagata rhodobarbus* Bhakat & Sinha, 2019 collected from Mayurakhshi river of the Gangetic river system. A total of 23 specimens were caught by traditional fishing gears from July 2017 to June 2018. Total length (TL), standard length (SL), fork length (FL), head length (HL), and snout length for each specimen were measured by dial caliper and body weight (BW) was taken by a digital balance. The 'b' value of the LWR indicates positive allometric growth (b = 3.06). The results further indicated that the LLRs were highly correlated (r^2>8158, *P*< 0.0001). Both the condition factor (K) and relative condition factor (Kn) of *G. rhodobarbus* indicate that the fish is in good condition (K = 0.627 and Kn = 1.003). This study presented the first reference on LWR, LLR, K and Kn for *G. rhodobarbus* in and from India.

Keywords: LWR, LLR, K and Kn of *Gagata rhodobarbus*

1. Introduction
Computing the mathematical relationship in between different lengths like total length, standard length, fork length, head length and snout length and length-weight of a fish is an important aspect of applied fishery biology. The length-length relationship is particularly important to study taxonomic differences (as the relationship varies widely in different species of fish) including effect of different environmental factors. The length-weight relationship provides basic information about population dynamics, ecology metamorphosis, maturity and stock management [1-10]. This relationship was initially used to find out somatic growth (isometric or allometric) of a fish [1, 11]. In the length-weight relationship the value of 'b' indicates growth of the fish. When the value of 'b' is 3, it indicates isometric growth and deviation from '3' indicates allometric growth. The value >3 indicates heavy weight gain (i. e. positive allometry) and the reverse i. e. < 3 indicates negative allometry.

Both the condition factor (K) and relative condition factor (Kn) act as growth indicator of a fish. In case of condition factor there is a proportionate relationship in between weight and size (length) of a particular species of fish. The value of K may vary on the size or weight gain of a fish. As for example, in the family Belontidae, the shape of the body of the fishes is long and cylindrical compared to that of carp (Cyprinidae), so the value of K be less in the fishes of family Belontidae than that of carp.

But the relative condition factor is more important to estimate the growth of a particular species of fish as it is not influenced by the size of the fish. Therefore in the said example, the value of relative condition factor may be same as it is calculated on the basis of weight only. According to LeCren [1], relative condition factor has two advantages over condition factor, namely i) it is not influenced by environmental or biological factors like fatness, gonadal development etc. and ii) length of individual fish do not influence the value of Kn.

The length-weight relationship of four species of *Gagata* was studied by different authors [12-15], but K and Kn values were not calculated in these species except *G. dolichonema* (for K only) [15] and *G. sexualis* (for Kn only) [12].

Gagata rhodobarbus Bhakat & Sinha, 2019 a new species of the genus *Gagata* Bleeker, 1858 was first identified and described by Bhakat and Sinha [16]. As there is no other information of this small sisorid catfish, the present study is an attempt to estimate length-length, length-

weight relationships and condition factor of the newly described *G. rhodobarbus.*

Materials and Methods

The samples were collected from Mayurakshi River at Tilpara barrage, Suri ($87^0 32' 00''$E, $23^0 55' 00''$N) from July 2017 to June 2018. The fish were caught with traditional fishing gears. All specimens (n = 23) were preserved in 6% formalin solution. For each individual total length (TL), standard length (SL), fork length (FL), head length (HL) and snout length were measured to the nearest 0.1 mm using dial caliper and whole body weight was taken on a digital balance with 0.01 gm accuracy.

The length-weight relationship was calculated using the expression: $W = aL^b$, where, W = Body weight (g) and L = Total length (cm). Parameters a and b were estimated by linear regression equation based on natural logarithm: Ln (W) = Ln (a) + b Ln (L). Additionally, 95% confidence interval (CI) of b, the coefficient of determination r^2, t and P values were estimated.

Moreover, relationships among TL, SL, FL, HL and snout length were calculated by linear regression. The condition factor (K) and relative condition factor (Kn) were calculated for each individual fish according to the following equation [1, 3]:

$K = (Wx100) / L^3$

$Kn = W / w$

Where,

W = Actual weight of fish in gm

L = Total length of fish in cm.

w = Calculated weight of fish in gm. (from linear regression equation).

Results and Discussions

The LWR of *Gagata rhodobarbus* is

Log BW = 3.060logTL – 5.314

[b = 3.06; 95% CI of b = 2.556 – 3.564; r^2 = 0.8835; t = 51.83; *P*< 0.0001], (Fig. 1)

The values of 'b' were within the limits of 2.5 – 3.5 reported by Froese [3] for most fishes. In relation to growth pattern, 'b' value is an important indicator that denotes isometric or allometric growth. When 'b' value is exactly 3.0, it indicates isometric growth [11]. Wootton [17] pointed out that when 'b' value is significantly larger or smaller than 3.0.indicates positive or negative allometric growth. In the positive allometric growth (b > 3), weight increment is faster than length but the reverse is true for negative allometric growth (b< 3). Among other four species of *Gagata*, *G. yousufi* [14] and *G. dolichonema* [15] showed negative allometric growth (b = 2.813 and 2.3550 respectively) but in other two species, *G. sexualis* [13] and *G. cenia* [12] growth is positively allometric (b = 3.268 and 3.17 respectively). In the present study 'b' value of length-weight relationship of 23 specimens is 3.06 or 3.1 indicates that overall growth of *G. rhodobarbus* is positively allometric. This proves that growth of different species under a particular genera vary widely. In an ideal condition, where growth of fish is normal, the value of 'b' should be '3' [18]. But Martin [19] observed the value of 'b' ranged from 2.5 to 4.0 instead of '3' in most cases. Actually the value of 'b' depends upon several factors which control the growth. Some of the major important factors are habitat, season, stomach fullness, age, sex, size, spawning and physiology of fishes [1, 20].

Length-length relationships (Standard Length vs Total Length, Fork Length vs Total Length, Head Length vs Total Length, Head Length vs Standard Length, Fork Length vs Standard Length, Fork Length vs Head Length, Fork Length vs snout length, Total Length vs snout length, Standard Length vs snout length, Head Length vs snout length) are given in Table 1 and Fig. 2. All LLRs were highly significant (*P*< 0.0001). Similar studies were carried out by several authors on different fishes [9, 10, 12-15, 21-23].

In *G. rhodobarbus*, the value of condition factor (K) ranges from 0.544 to 0.798 (mean = 0.627). The K value of *G. dolichonema* ranges from 0.7520 to 0.9113 but in the present species K value is comparatively lower. According to Bennet [24] fishes with K value above 0.56 are considered as in good condition. Here the mean value of K of *G. rhodobarbus* is 0.63 indicates that fish is also in good condition.

Koushlesh *et al.* [13] reported Kn values of five small fishes including *G. sexualis* ranges from 1.004 to 1.028. The relative condition factor (Kn) of *G. rhodobarbus* varies from 0.857 to 1.140 (mean = 1.003). Relative condition factor above 1 or close to 1 indicate that fish is in good condition. The fluctuation in the value of K and Kn in fish has been mainly assigned to dependency on many factors such as feeding intensity, fish size and availability of fish [1].

In conclusion, this paper has provided basic data on LWR, LLRs, K and Kn of *G. rhodobarbus* that would be beneficial for fishery managers to impose suitable regulations for sustainable fishery management in the Mayurakhshi River in future.

Table 1: Descriptive statistics and estimated parameters of length-length relationships in between total length (TL), standard length (SL), fork length (FL), head length (HL) and snout length (Sn.L) of *G. rhodobarbus* from Mayurakhshi river in India.

Sl. No.	Equation	r^2	95% CI of b	t	P
1.	SL = 0.779TL – 1.765	0.9825	0.7319 – 0.8262	9.6378	<0.0001
2.	FL = 0.916TL – 2.765	0.9750	0.8491 – 0.9824	4.5586	<0.0001
3.	HL = 0.220TL – 0.459	0.9281	0.1925 – 0.2481	38.0219	<0.0001
4.	HL = 0.282SL + 0.070	0.9408	0.2501 – 0.3144	32.6736	<0.0001
5.	FL = 1.165SL – 0.169	0.9750	1.080 – 1.250	4.9693	<0.0001
6.	FL = 3.927HL + 2.441	0.9375	3.466 – 4.387	34.3235	<0.0001
7.	FL = 8.455Sn.L + 11.760	0.8747	7.003 – 9.907	42.0858	<0.0001
8.	TL = 9.292Sn.L + 15.530	0.9087	7.955 – 10.630	45.2495	<0.0001
9.	SL = 7.236Sn.L + 10.350	0.8922	6.094 – 8.378	41.9222	<0.0001
10.	HL = 2.013Sn.L + 3.1520	0.8158	1.579 – 2.448	25.8667	<0.0001

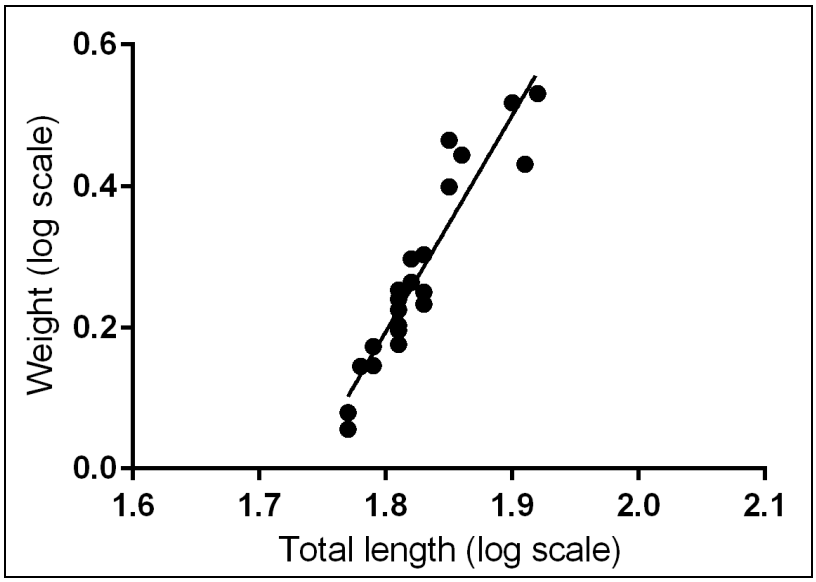
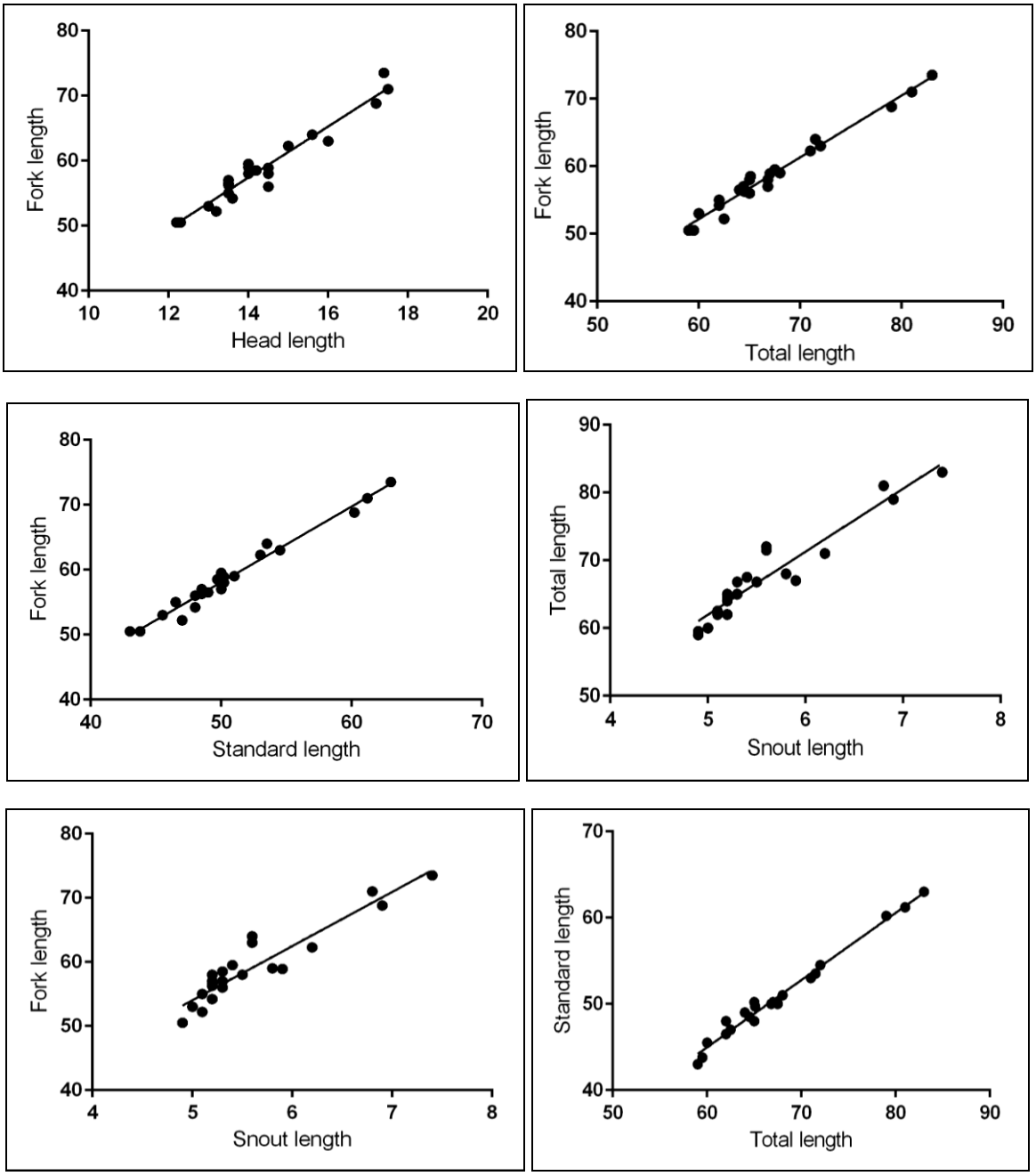


Fig 1: Length-weight relationship for *G. rhodobarbus* from Mayurakhshi river, India (Log BW = 3.060 log TL – 5.314, r^2 = 0.8835, *P*< 0.0001).



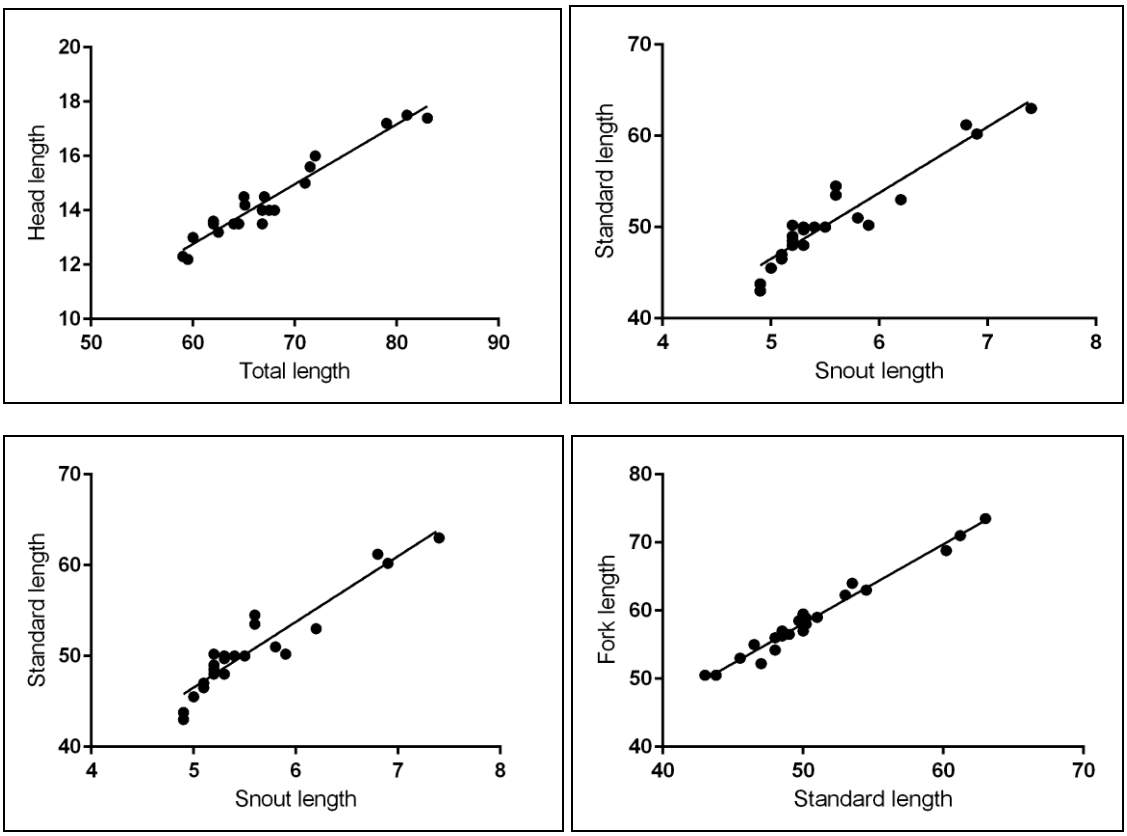


Fig 2: Length-length relationships in between TL, SL, HL, FL and snout length of *G. rhodobarbus* from Mayurakhshi River, India. (Regression equation, r^2, and P values are presented in Table 1.).

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