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Length-weight relationship (LWR), condition factor (K) and relative condition factor (KN) of Kalibaus fish *Labeo calbasu* (Hamilton, 1822) of Kaptai Lake, Rangamati, Bangladesh

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Abstract
The length-weight relationship, condition factor and relative condition factor of combined sexes Kalibaus fish *Labeo calbasu* (Hamilton, 1822) of Kaptai Lake, Rangamati, Bangladesh were studied during August 2017 to December 2017. Length-weight(s) of 284 specimens of Kalibaus fish were collected for five consecutive months. The relation between total length and total weight of Kalibaus fishes of three groups were estimated as $\ln W_1 = -4.189 + 2.97.\ln L_1$, $\ln W_2 = -4.166 + 2.95.\ln L_2$, and $\ln W_3 = -4.082 + 2.93.\ln L_3$ for sexes combined. The analysis of correlation coefficient ($r = 0.9897, 0.9914$ & 0.9844) indicated that there were highly significant ($p< 0.01$) relationship between the length and the weight of fish of all three groups. The respective mean condition factors 1.396, 1.310 & 1.367 showed that Kalibaus fish was in a better environmental condition, but the respective growth coefficients 2.97, 2.95 & 2.93 and the respective mean relative condition factors 1.02, 1.00 & 1.03 showed that Kalibaus fish was in a good aquatic environment in Kaptai Lake. The growth patterns of fishes of all groups seemed to be isometric. The overall results showed that Kaptai Lake could be a good freshwater reservoir for growing up of *L. calbasu.*

Keywords: Length-weight relationship, condition factor, relative condition factor, kalibaus fish

Introduction
Length-weight relationship study of a fish is a pre-requisite for assessing the population health status of the species [1]. Condition factor indicates the well-being level of the species assuming whether it is maintaining equilibrium between length and weight [2]. Relative condition factor gives more concise result about the relationship. Length-weight relationship pattern along with associated condition factors draw a comparison with the populations of a given species grown under different aquatic environments. Kalibaus fish is a major species of carp family and have a high commercial importance. The fish is also known as black rohu in some regions of India and Bangladesh for its pale blackish body color [3]. It is a bottom feeder and can easily be reared in any freshwater ponds, lakes and deep pools of tributaries [4, 5]. The fish grows up to a length of 90 cm [6]. During the investigation an inventory of fish fauna made (2017) by Bangladesh Fisheries Research Institute, Riverine Sub-station, Rangamati revealed that *Catla catla*, *Labeo rohita*, *Labeo gonius*, *Labeo calbasu*, *Cirrhinus mrigala*, *Notopterus chitala*, *Wallago attu*, *Gudusia Chapra* and *Corica soborna* are the major fish species of Kaptai Lake of which *Gudusia chapra* and *Corica soborna* made about 50% of the total catch. So, Kaptai Lake has vast aquaculture potential.
According to Banglapedia, Kaptai Lake is the largest man made freshwater reservoir in Bangladesh. The lake was primarily created for hydroelectric power generation by damming the river Karnafuli near Kapati town in the Chittagong hill tracts. But the lake is now contributing to agriculture and aquaculture in multiple ways. Its surface area is 58300 ha, mean depth 9m, maximum depth 32m, water volume 524700 cu m, growing season 365 days. The lake is confined within the hill district Rangamati and embraces the upazilas of Rangamati Sadar, Kaptai, Nannerchar, Langadu, Baghaichhari, Barkal, Juraichhari and Belaichhari [7]. Water quality parameters, for example, moderate alkaline pH, dissolved oxygen (6.4-9.1 mg/l) and free carbon dioxide (4.7-6.0 mg/l) level etc.

proved that the lake is favorable for aquatic lives [8]. The present study was conducted to know the wellbeing condition of Kalibaus fish *Labeo calbasu* in Kaptai Lake.

Materials and Methods

Fresh fish samples were collected at monthly interval during August 2017 to December 2017 from Kaptai Lake, Rangamati district of Bangladesh. A total of 284 specimens of *Labeo calbasu* (Male female together) were collected from three areas of Kaptai Lake in three groups. The fishes were collected from three separate areas (First group-100 fishes from Tabalchhari, second group-94 fishes from Mohalchhari and third group-90 fishes from Langadu) of Kaptai Lake and the relevant data were recorded individually for each group. Fishes ranged in size from 15 to 42 centimeter (cm) in total length (L) and 52 to 1148 gram (g) in total weight (W), 16 to 40 cm in total length and 60 to 1000 g in total weight, 17 to 42 cm in total length and 76 to 930 g in total weight respectively were used for analysis of length weight relationships and for estimation of condition factors and relative condition factors. Lengths of the fishes were measured in centimeter and weights in gram. Fraction numbers were transformed into nearest round sum number.

Fish weight gain does not follow linear function. Its weight increases exponentially regarding length. So, the length-weight relationship of fish is usually calculated by using cube law $W=aL^b$ which was transformed into ln W = ln a + b.ln L equation by taking natural logarithm of both sides where W denotes weight in gram, L denotes the length in centimeter. The intercept (The value of y axis when value of x axis is zero) is a constant (a) and the growth coefficient (b), also the regression coefficient, is another constant expressing weight gain of fish relative to length increment were estimated by least square method from logarithmically transformed data [9, 10, 11]. The rate of original length-weight relationship was calculated by taking antilog of intercept (a). The association degree between length-weight variables was estimated by determination coefficient (R^2). The 95% confidence limits of the parameters were determined by analysis of variance. Values of exponent b provide information on fish growth. When b=3, growth pattern is assumed to be isometric (Increasing at the same rate). When the values of b significantly differ from 3, growth pattern is said to be allometric (Positive allometric if b>3, and negative allometric if b<3). The null hypothesis of the isometric growth (H_0: b=3) was tested by t-test using the statistic: $t_s = (b-3)/S_b$ where S_b is the standard error of the regression slopes. Graphical pictures were used to show the relationship pattern of the variables.

Condition factor (K) was calculated according to the standard method of Le Cren [1] ($K = (W \times 100)/L^3$), where W is the weight of fish in gram and L is the total length of fish in centimeter. Le Cren's [1] modified formula $Kn=W/aL^b$ was used for the estimation of relative condition factor where W is the observed fish weight in gram and aL^b is the expected fish weight in gram.

Results

The results of the length-weight relationships were calculated separately for each group by least square method. The estimated a, b and r values are shown in table 1. Analysis of correlation coefficients (r) showed that there were highly significant relationships ($p<0.01$) between length and weight of fishes of all three groups. The estimated growth coefficients were 2.97, 2.95 & 2.93 (table 1) while the mean condition factors were 1.396, 1.310 & 1.367 and mean relative condition factors were 1.02, 1.00 & 1.03 which are shown in (Table 2). Growth coefficients (b values) showed that the growth pattern of Kalibaus fish of Kaptai Lake was supposed to be isometric, because t-test showed that estimated b values had insignificant deviation from isometric growth pattern (b=3). The relevant results are shown in table 3. The respective mean condition factors showed that Kalibaus fish was in a better environmental condition, but the respective growth coefficients and the respective mean relative condition factors showed that Kalibaus fish was in a generally good aquatic environment in Kaptai Lake.

Table 1: Regression parameters of length-weight relationships (ln W = ln a + b.ln L)

Species	sex	N	Length range (cm)		Mean±SD	Weight range (gm)		Mean±SD				t-test	p-value
			min	max		min	Max		a	b	r		
Labeo calbasu	Combined Group-1	100	15	42	30.74 ±7.29	52	1148	469.48 ±274.27	-4.189	2.97	0.9897	68.54	<0.01
Labeo calbasu	Combined Group-2	94	16	40	31.78 ±6.59	60	1000	469.93 ±230.62	-4.166	2.95	0.9914	73.81	<0.01
Labeo calbasu	Combined Group-3	90	17	42	30.26 ±7.53	76	930	445.78 ±281.15	-4.082	2.93	0.9844	52.53	<0.01

Symbols: Length (L) in cm; weight (W) in gm; N=sample size; S.D=standard deviation

Table 2: Condition factors (K) and Relative condition factors (Kn) of Kalibaus fish.

Species	Sex	N	Length range (cm)		Weight range (g)		Condition factor(K) for min/max		Mean K value	Expected weight (g)		Relative condition factor (Kn) for min/max		Mean Kn value
			Min	max	Min	Max	min	max		min	max	min	Max	
Labeo Calbasu	Combined Group-1	100	15	42	52	1148	1.54	1.55	1.396	47	1007	1.09	1.14	1.02
Labeo Calbasu	Combined Group-2	94	16	40	60	1000	1.46	1.56	1.310	55	825	1.09	1.21	1.00
Labeo Calbasu	Combined Group-3	90	17	42	76	930	1.55	1.26	1.367	68	964	1.12	0.96	1.03

Symbols: Length in centimeter, weight in gram and N=sample size.

Table 3: T-stat values for comparison between estimated b values and isometric b values.

Species	Sex	N	Length range (cm)		Mean±SD	Weight range (gm)		Mean±SD	Estimated b values	Isometric b values	S_b	t-Stat (b-3) /S_b	p-value
			Min	Max		min	Max						
Labeo calbasu	Combined Group-1	100	15	42	30.74 ±7.29	52	1148	469.48 ±274.27	2.97	3.0	0.043	0.69	<0.01
Labeo calbasu	Combined Group-2	94	16	40	31.78 ±6.59	60	1000	469.93 ±230.62	2.95	3.0	0.039	1.28	<0.01
Labeo calbasu	Combined Group-3	90	17	42	30.26 ±7.53	76	930	445.78 ±281.15	2.93	3.0	0.056	1.25	<0.01

Logarithmically transformed data on length-weight of three groups of Kalibaus fishes have been graphically presented and the relationships are shown in figure 1, 2 & 3 respectively.

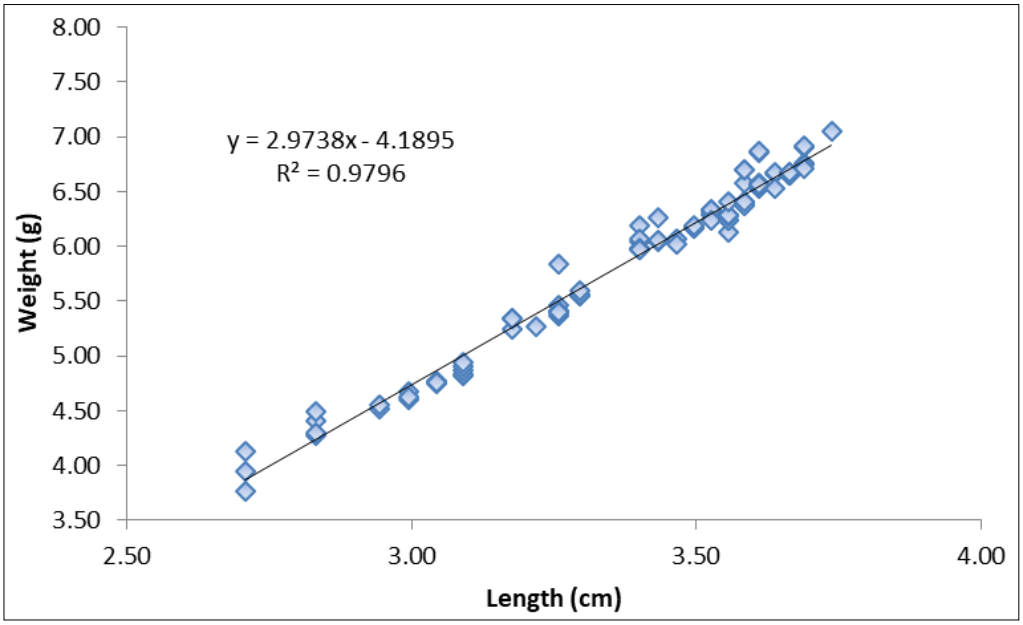

Fig 1: Length-weight relationship of Kalibaus *Labeo calbasu* of Tabalchhari area.

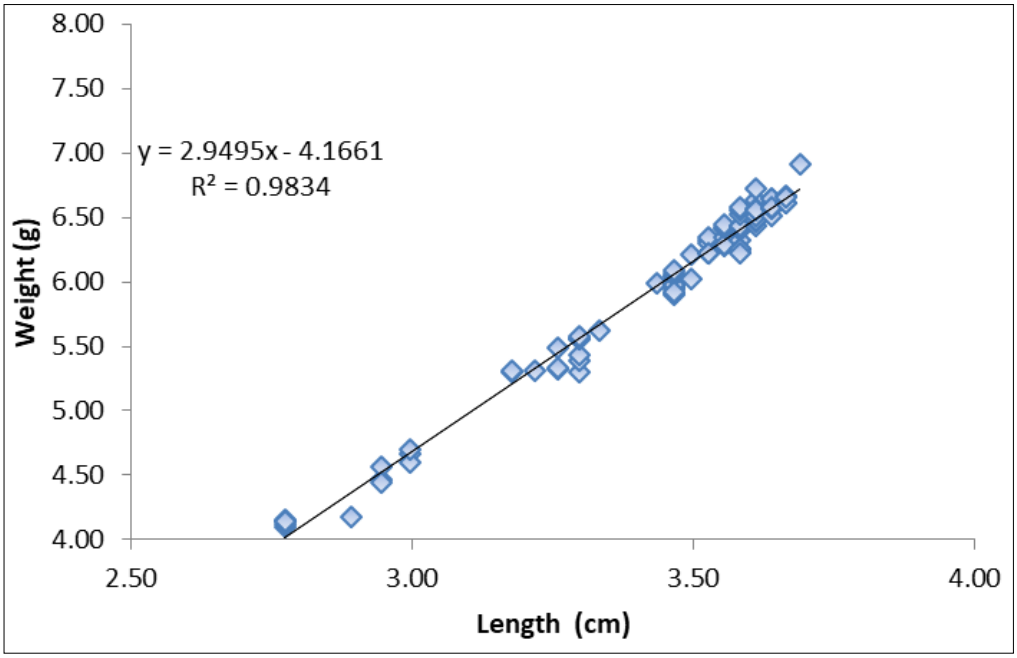

Fig 2: Length-weight relationship of Kalibaus *Labeo calbasu* of Mahalchhari area.

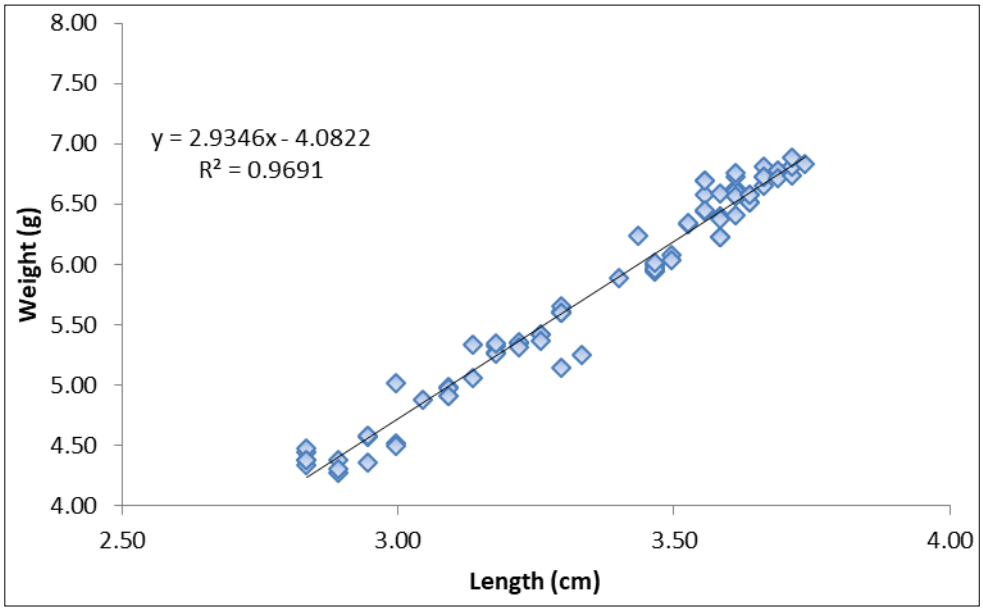

Fig 3: Length-weight relationship of Kalibaus *Labeo calbasu* of Langadu area.

Discussion

The present study provides a comprehensive information on length-weight relationship, condition factor and relative condition factor of Kalibaus fish *Labeo calbasu* (Hamilton, 1822) of Kaptai Lake (latitude 22˚09' N and longitude 92˚17' E), Rangamati, Bangladesh. Like other animal, the lengths and weights of fishes are correlated. But these two variables do not follow linear relationship. For this, fish length-weight relationships are calculated by cube law $W=aL^3$ which is generally expressed as $W=aL^b$. The highest b value was obtained as 2.97 in first group of fish collected from Tabalchhari followed by second group of fish from Mahalchhari (b value 2.95) and then third group of fish from Langadu (b value 2.93). Though there were differences in b values of three groups but statistically the groups did not vary significantly from standard b value (b=3). So, we can assume that the growth of fishes was isometric by pattern. Because, t-stat values showed insignificant differences ($p<0.01$) between the observed b values and the standard growth coefficient b=3 (table 3). Desai and Shrivastava [12] observed an exponent value of 2.9143 for *Cirrhinus mrigala* from Rihand reservoir. Johal and Kingra [13] reported exponent values varying between 2.752 to 3.545 in three Indian major carps.

Calculation of condition factor (K) is a quick method for assessing the prevailing health condition of a selective fish population. The K values of individuals of a fish population may differ with the spawning season, feed availability and rate of fat deposition into liver and muscle of the species [14]. The estimated mean condition factor of the fishes of Tabalchhari (K=1.396), the fishes of Mahalchhari (K=1.310) and the fishes of Langadu (K=1.367) indicated that the fishes of all three groups were in a same feeding condition. Rathore *et al*. [15] observed that the K values of *Labeo rohita* varied between 1.273 and 1.637 while different length groups of the fish had the K values 1.575, 1.320 and 1.273. Chouhary *et al*. [16] reported that the 'K' values of *Labeo calbasu* varied between 1.15 and 1.26. In the present study, the estimated K values varied between 0.87 and 1.95 while average K values of group 1, group 2 and group 3 were 1.396, 1.310 and 1.367 respectively. The lowest K value was found from the fishes of Langadu area and the highest K value was found from the fishes of Tabalchhari area. The observed average K values are more or less similar to the reported K values. Inter-population mixing and gonad maturation level might affect the condition factor of an individual fish species [17]. Uninterrupted waterbody of Kaptai Lake indicated that inter-population mixing opportunity for Kalibaus fish might hamper the K values of the individual members of the species under investigation.

The relative condition factor (Kn) is defined as the ratio between the observed weight (g) and the theoretically expected weight (g) for a given length (cm) [1]. Thus, the relative condition factor (Kn) shows relative growth increment regarding expected value [18, 19]. When the observed weight (W) of an individual fish is equal to the theoretically expected weight (aL^b) for a specific length, then its Kn value is equal to standard or expected value Kn=1.0 [20]. However, if the observed weight of a fish is significantly less than the expected weight, (if Kn<1.0), it will indicate that the species is being nourished under poor feeding condition or passing post spawning period. But, if the observed weight of a fish is significantly greater than the expected weight (Kn>1.0), it will reveal that the species is being nourished upon better feeding condition or passing spawning or pre-spawning period. Hence, Kn values obtained for any particular fish species can be used to know the wellbeing condition of the species [21, 22, 23]. Pandey and Sharma [24] estimated the Kn values as 1.0129 and 0.9967 for *Labeo rohita* and *Catla catla* species respectively. The results of the present study (Kn = 1.02, 1.0 & 1.03) had the conformity with these observations. The calculated mean relative condition factors showed that the Kalibaus fishes of the experimental three groups were in a same wellbeing condition.

Conclusion

The study of length-weight relationship data of *Labeo calbasu* species could be very useful tools in fisheries research, because it permits the conversion of growth in-length equation to growth-in-weight that can be used in fisheries management, fisheries biology and aquatic ecology [25, 26]. The value of condition factor (K) of *L. calbasu* revealed that the ecological aspect of Kaptai Lake was found to be suitable for their growth. As the mean relative condition factor values for all three groups of Kalibaus fish were equal to expected or

standard value Kn=1.0 [18, 19], and the mean condition factor values were greater than theoretical value (K>1), therefore it is to be concluded that the Kaptai Lake could be a better culture ground for *L. calbasu* and might be considered as the reservation tank for the species.

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