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Physico-Chemical Parameters, Length-Length and Length-Weight Relationships and Condition Factor of the Vulnerable *Gudusia chapra* in the Kaptai Lake, Rangamati, Bangladesh

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ABSTRACT

Fish growth is directly influenced by water quality and the abundance of food in their environment. The aim of this study was focused to determine the length-length, length-weight and condition factor of *Gudusia chapra* inhabiting in the largest man-made lake in Bangladesh aligned with water quality parameters (temperature, pH, dissolved oxygen (DO) and total dissolved solids (TDS)) of the lake. A total of 600 specimens were collected from October 2018 to March 2019 using a cast net. Three different forms of length (Total length, TL; Standard length, SL; and Fork length, FL) sided with the body weights (BW) of the samples were measured to determine the length-length and length-weight relationship. Temperature, DO, pH, and TDS were recorded to be 24.8 - 25.7°C (25.27±0.38), 6.9- 7.8 (7.37±0.05), 6.1 -6.7 mg/l (6.4±0.3) and 60-110 ppm (79±2.0), respectively. The mean TL, SL, FL and BW were 8.588 ± 0.780 cm, 6.830 ± 0.644 cm, 7.390 ± 0.708 cm and 5.712 ±1.636 g, respectively. The month-wise values of correlation coefficient (r) of the relationships between TL vs SL, TL vs SL, and SL vs FL were determined as 0.96 to 0.98, 0.91 to 0.98 and 0.91 to 0.96. The 'r^2' values of the TL vs BW, SL vs BW and FL vs BW vacillated 0.91 - 0.94, 0.92 - 0.94 and 0.90 - 0.92, respectively. The values of the 'r^2' reflected that every relationship had a high degree of positive correlation. Furthermore, the length-weight relationships of the fish had regression coefficients ranging from 2.50 to 2.93, suggesting a negative allometric growth trend. The condition factor (*K*) ranged from 0.97 to 1.25, suggesting that the lake organisms were in good health. The findings of this study might be used as basic biological information to manage a sustainable production of this vulnerable *G. chapra.*

INTRODUCTION

The majority of Bangladesh's small indigenous species (SIS) live in freshwater environments, including rivers, lakes, haors (very large bowl shaping natural depression connected with one or more rivers), baors (oxbow lake) beels (seasonally inundated paddy fields) and ponds.

The Kaptai Lake, which was formed in 1961 as a result of damming the Karnafully river to produce hydro-electricity, is the largest manmade freshwater lake in Bangladesh. It provides habitat with many freshwater aquatic species, such as many SIS like *G. chapra* (Indian rivershad), *Mystus vittatus* (Striped dwarf catfish), *Puntius serana* (Olive barb), *Chitala chitala* (Featherback), *Ompok pabda* (Pabdah catfish), *Pangasius bocourti* (Basa catfish), *Ailia coila* (Gangetic ailia), *Mastacembelus armatus* (Tire-track spiny eel), *Corica soborna* (Ganges river sprat), *Amblypharyngodon mola* (Mola carplet) etc. **(Ahmed *et al.*, 2006)**. One of the most common SIS in the Kaptai lake is the Indian rivershad (*G. chapra*) that is usually found all year round **(Basak *et al.*, 2016)**. *G. chapra* is a prolific breeder and small freshwater fish that belongs to the Clupeidae family of the Clupeiformes order. It is one of most important, tasty nutrient- dense and commercially valuable fish **(Kabir, 1998)** in Bangladesh. The species was once abundant nearly in all freshwater habitat of Bangladesh **(Talwar, 1991),** but different anthropeogenic and natural causes in the recent years forced the species to confine in limited areas and is now considered a vulnerable species in Bangladesh **(IUCN, 2015)**.

The physico-chemical and biological parameters of the dwelling water appear to be the most important factor for fish biomass increment. Water quality parameters (temperature, DO, transparency/turbidity, pH, total dissolved solids (TDS), alkalinity, ammonia content and hardness) affect fish growth, biomass, species composition in lentic and lotic habitats (**Sing *et al*., 1980)**. Temperature and oxygen fluctuations show a substantial effect on fish metabolism **(Boyd *et al*., 1998)**. The relationship between fish dwelling environment and its physico-chemical parameters indicates the ecosystem's success **(Isa *et al*., 2012)**.

Growth is a biological process that manifests itself in an organism's length and weight (**Hasan *et al*., 2020**). Length-length relationships (LLRs) can be beneficial in comparing growth in one stock to another **(Moutopoulos & Stergiou, 2002)**. Besides, length-weight relationships (LWRs) are a critical determinant of the growth-in-weight of a species owing to its length data **(Hasan *et al*., 2020; Hasan *et al*., 2021a)**. This relationship is used to assess condition factor (K), length-frequency distributions (LFDs), growth rate, fish maturity, and the spawning initiation of fish populations **(Le Cren, 1951; Paul *et al*., 2021; Hasan *et al*., 2021b)**.

For the management and safety of natural fish populations **(Arellano-Martineze & Ceballosvazquez, 2001)**, condition factor (K) provides comprehensive data of development and survivability **(Richter, 2007; Mojumder *et al.*, 2020)**, reproduction **(Imam *et al*., 2010; Ali *et al.*, 2021)**, physical condition **(Muchlisin *et al*., 2010)**, and feeding efficiency, disease and stress **(Victor *et al*., 2014)**. It also assists in assessing fish's overall efficacy and functionality **(Torres *et al.*, 2012; Ragheb, 2014)**.

Several studies on *G. chapra* have been conducted over the years, addressing length-length relationship **(Chondar, 1974; Azadi *et al*., 2007)** and length-weight relationship **(Sani *et al*., 2010; Sarkar *et al*., 2013; Ahamed *et al*., 2014; Sheikh *et al*., 2017)**. However, no notable research has been pesented on the length-length and length-weight relationships associated with the condition factor of *G. chapra* inhabiting the Kaptai Lake. Consequently, the current research was carried out to assess the physico-chemical parameters of the Kaptai Lake and investigate the length-length, length-weight and condition factor of *G. chapra* inhabiting this specific site.

MATERIALS AND METHODS

This study was organized to examine the Kaptai Lake (22° 30′00″N 92° 13′00″E / 22.5000° N 92.2167 ° E) from October 2018 till March 2019 (Fig. 1). Limnologic conditions of the lake were recorded once a month from four different locations; namely, Rajbari point , Shuvalong point, Reserve-Bazar Ghatpoint and Tobolchuri Ghat point. Digital probe thermometer (Model: AR212), DO meter (Model: DO7031), pH meter (Model: HI 98107) and TDS meter (Model: TDS5031) were employed to record surface water temperature, dissolve oxygen level, pH and turbidity, respectively. A total of 600 specimens were purchased from the artisanal fishermen who used cast net. Samples were approximately taken twice a month, with 50 specimens of *G. chapra* (chapila) collected in each time (Fig. 2). After collection, the samples were put in 10% formalin solution and brought to the laboratory of the department of Fisheries and Marine Science, Noakhali Science and Technology University for further analysis. Total length (TL), Fork Length (FL) and Standard length (SL) of the collected *G. chapra* were measured with a manual slide calipers (nearest 0.01mm), whereas the body weight (BW) was determined to the nearest 0.01g accuracy, using a digital balance (Model: GF-603A). The relationships between SL and FL, TL and FL and TL and SL were defined as monthwise using the least squares method to suit a simple linear regression model following the successive equation: Y = a+bX, where Y = different body lengths; a = proportionality constant, and b = regression coefficient (**Alam *et al*., 2012)**.

The length-weight relationship was expressed using the following equation: $W= aL^b$ **(Froese, 2006),** where '*W*' is the body weight (BW, g) and '*L*' is the three different lengths (TL, FL and SL) in centimeter. The parameters '*a*' and '*b*' are estimated by linear regression analysis based on natural logarithms **(Arshad *et al*., 2008)** as follows: $\ln(w) = \ln(a) + b \ln(L)$, and the coefficient correlation 'r^2', and these factors were estimated on monthly basis. The Fulton's Condition factor (K) was calculated according to the formula described by **Fulton (1904)**. $K = (BW / L^3) \times 100$, Where, K = Fulton's condition factor; BW = body weight of fish (g), and L = standard length of fish (cm).

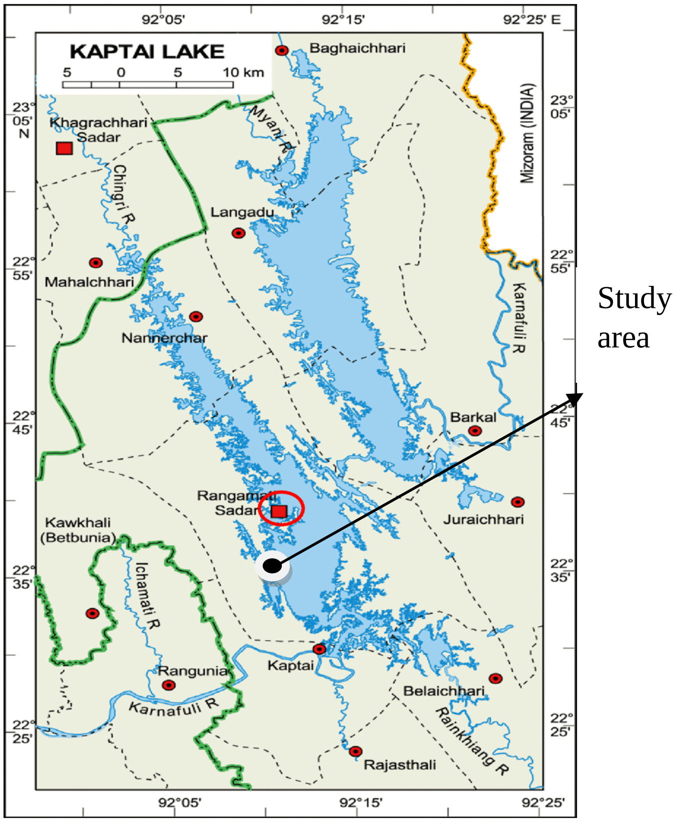

Fig. 1. Map of Kaptai Lake (Source: Banglapedia)

Fig. 2. Different size of *Gudusia chapra* in this experiment

All of the data was analyzed and related graphs and tables were generated using Microsoft Excel® (2013). Samples were analyzed monthwise and averages were calculated considering all the samples collected in six months. If not otherwise defined, data were presented as mean with standard deviation.

RESULTS

Limnologic condition of Kaptai Lake

In the study site, surface water temperature, pH, dissolved oxygen (DO) and TDS ranged from 24.8 - 25.7°C (25.27±0.38), 6.9- 7.8 (7.37±0.05), 6.1 -6.7 mg/l (6.4±0.3) and 60-110 ppm (79±2.0), respectively. The highest temperature (29.8°C) was recorded in October at Tobolchuri Ghat, while the lowest was determined in January (21.1°C) at Rajbari. The highest pH was (7.8) found at Reserve-Bazar Ghat in March and the lowest in January (6.9) at Rajbari and Reserve-Bazar Ghat (Table 1). The highest DO (6.76 mg/l) was observed at Tobolchuri Ghat in November and the lowest (6.1 mg/l) at Rajbari in February. Furthermore, the highest TDS (110 ppm) and the lowest (60 ppm) at Rajbari and Tobolchuri Ghat were determined in January and October (Table 1).

Table 1. Water quality parameters at Kapatai lake from October 2018 to March 2019

Station	Parameter	Months. Years						
		Oct. 18	Nov. 18	Dec. 18	Jan. 19	Feb. 19	Mar. 19	Mean± SE
Rajbari	Tem.(°C)	28.4	26.2	24.9	21.5	22.2	24.7	24.8 ±2.6
	pH	7.2	7.1	7.3	6.9	7.6	7.7	7.3±0.3
	DO (mg/l)	6.52	6.74	6.30	6.21	6.10	6.40	6.4±0.2
	TDS (ppm)	60	70	80	110	90	70	80.0±17.9
Shuvalong	Tem.(°C)	29.2	26.8	25.6	21.7	23.4	24.9	25.3±2.6
	pH	7.1	7.3	7.4	7.1	7.7	7.7	7.4±0.3
	DO (mg/l)	6.54	6.73	6.31	6.24	6.13	6.42	6.4±0.2
	TDS (ppm)	70	80	70	90	90	80	80.0±8.9
Reserve-Bazar Ghat	Tem.(°C)	29.5	27.1	26.1	21.9	23.7	24.9	25.5±2.7
	pH	7.3	7.2	7.4	6.9	7.7	7.8	7.4±0.3
	DO (mg/l)	6.53	6.75	6.30	6.25	6.11	6.42	6.4±0.2
	TDS (ppm)	70	70	80	90	80	70	76.7±8.2
Tobolchuri Ghat	Tem.(°C)	29.8	27.5	26.5	21.8	23.9	24.8	25.7±2.8
	pH	7.4	7.1	7.3	7.1	7.6	7.7	7.4±0.3
	DO (mg/l)	6.54	6.76	6.30	6.24	6.13	6.44	6.4±0.2
	TDS (ppm)	61	73	76	106	94	70	80.0±16.7

Length-length relationships (LLRs)

Relationship between the total length and standard length

The coefficient correlation (r^2) ranged from 0.95 - 0.98, with TL and SL ranging from 6.5 - 12.8 cm and 5.4 - 10.5 cm, respectively. The initial growth index ‘a' fluctuated between -0.003 and -0.17, while the regression coefficient ‘b' ranged from 0.94 - 1.07. The coefficient correlation (r^2) values with respect to months were as follows: December (0.98) ≥January (0.98)> November (0.97)> February (0.96) ≥ March (0.96)>October (0.95). (Table 2).

Relationship between the total length and fork length

The range of coefficient correlation (r^2) of the inter- relationship between total and fork length was 0.91 - 0.95, where the range of fork length was 5.6 - 11.4 cm, respectively, and the values of ‘a’ fluctuated from -0.014 to -0.066 and ‘b’ from 0.95 to 1.00. The coefficient correlation (r^2) followed the succeeding order: in December (0.95) ≥ March (0.95)> November (0.94)> October (0.93)>February (0.92)>January (0.91) (Table 3).

Table 2. The relationship between the total length (TL) and standard length (SL)

Month. Year	Sex	N	TL (cm)			SL (cm)			a	b	r^2
			Min	Max	Mean TL± SD	Min	Max	Mean SL±SD			
Oct.18	Pooled	100	7.1	10.5	8.64±0.68	5.6	8.1	6.87±0.54	-0.04	0.94	0.95*
Nov.18		100	6.5	10.1	8.46±0.63	5.4	8.1	6.71±0.50	-0.06	0.95	0.97*
Dec.18		100	7.2	11.1	8.72±0.80	5.6	8.9	6.91±0.66	-0.11	1.01	0.98*
Jan.19		100	6.8	11.5	8.28±0.84	5.5	9.3	6.58±0.72	-0.17	1.07	0.98*
Feb.19		100	7.2	10.1	8.44±0.64	5.9	8	6.75±0.50	-0.003	0.89	0.96*
Mar.19		100	7.3	12.8	8.96±0.88	6	10.5	7.10±0.72	-0.07	0.96	0.96*

* Correlation is significant at the 0.01 level.

Relationship between the standard length and fork length

With regard to the relationship between standard and fork lengths, the coefficient correlation (r^2) ranged from 0.91 - 0.96, with the initial growth index ‘a' fluctuating between -0.034 and -0.114, and the regression coefficient ‘b' fluctuating between 0.90 and 1.00. December (r=0.96) was followed by November (r^2=0.94), February (r^2=0.93), March (r^2=0.93), October (r^2=0.92), and January (r^2=0.91). (Table 4). The inter-relationships among the length parameters were found highly significant ($p < 0.01$). (Tables 2 - 4).

Table 3. The relationship between the total length (TL) and fork length (FL)

Month. Year	Sex	N	TL (cm)			FL(cm)			a	b	r^2
			Min	Max	Mean TL± SD	Min	Max	Mean FL±SD			
Oct.18	Pooled	100	7.1	10.5	8.64±0.68	6.1	9.2	7.52±0.60	-0.016	0.95	0.93*
Nov.18		100	6.5	10.1	8.46±0.63	5.6	8.9	7.308±0.57	-0.055	0.99	0.94*
Dec.18		100	7.2	11.1	8.72±0.80	6	9.2	7.48±0.69	-0.032	0.96	0.95*
Jan.19		100	6.8	11.5	8.28±0.84	5.8	10	7.036±0.78	-0.064	0.99	0.91*
Feb.19		100	7.2	10.1	8.44±0.64	6.2	8.5	7.30±0.56	-0.014	0.95	0.92*
Mar.19		100	7.3	12.8	8.96±0.88	6.4	11.4	7.71±0.81	-0.066	1.00	0.95*

* Correlation is significant at the 0.01 level.

Table 4. The relationship between the standard length (TL) and fork length (FL)

Month. Year	Sex	N	SL (cm)			FL(cm)			a	b	r^2
			Min	Max	Mean SL± SD	Min	Max	Mean FL±SD			
Oct.18	Pooled	100	5.6	8.1	6.87±0.54	6.1	9.2	7.52±0.60	0.079	0.95	0.92*
Nov.18		100	5.4	8.1	6.71±0.50	5.6	8.9	7.30±0.57	0.034	1.00	0.94*
Dec.18		100	5.6	8.9	6.91±0.66	6	9.2	7.48±0.69	0.084	0.93	0.96*
Jan.19		100	5.5	9.3	6.58±0.72	5.8	10	7.03±0.78	0.097	0.91	0.91*
Feb.19		100	5.9	8	6.79±0.57	6.2	8.5	7.30±0.56	0.114	0.90	0.93*
Mar.19		100	6	10.5	7.10±0.71	6.4	11.4	7.71±0.81	0.057	0.97	0.93*

* Correlation is significant at the 0.01 level.

Length-weight relationships (LWRs)

Relationship between the total length (TL) and body weight (BW)

The pooled length and weight ranged from 6.5 - 12.8 cm and 2.89 - 16.42 g, respectively, with the initial growth index 'a' ranging from -1.57 to -1.98, and the regression coefficient 'b' ranging from 2.51 to 2.93. The correlation coefficient (r^2) ranged between 0.91 - 0.94, indicating strong positive relationship between length and weight of the species. The monthly chronological 'r^2' were in December (0.94) > March

(0.93) > October (0.92) ≥ November (0.92) > December (0.91) ≥ February (0.91). (Table 5).

Relationship between standard length (SL) and body weight (BW)

The pooled standard length and weight ranged from 5.4 - 10.5 cm and 2.89 - 16.42 g, respectively, where the range of coefficient correlation (r^2) was 0.92 - 0.94. In this relationship (SL *vs* BW), the initial growth index ‘a’ and the regression coefficient ‘b’ values ranged from -1.34 to -1.62 and 2.54 to 2.82, respectively. The monthly coefficient correlation (r^2) followed this order: in March (0.94) ≥January (0.94)> February (0.93)> October (0.92) ≥ November (0.92) ≥December (0.92). (Table 6).

Relationship between the fork length (FL) and body weight (BW)

The pooled fork length and body weight was 5.6 - 11.4 cm and 2.89 - 16.42 g, respectively, with the initial growth index ‘a’ ranging from -1.43 to -1.74 and regression coefficient ‘b’ from 2.50 to 2.84. (Table 7). The correlation coefficient (r^2) ranged between 0.90 - 0.942, indicating strong positive relationship between fork length and weight of the species. The monthly coefficient correlation (r^2) followed the following sequence: in March (0.92) ≥January (0.92) ≥ December (0.92)> February (0.91) ≥ October (0.91) > November (0.90). (Table 7).

The value of regression coefficient (b) was lower than 3 in the relationship of body weight with standard, total, and fork length, suggesting negative allometric growth of *G. chapra*. The coefficient value (r) correlation for both groups (LLRs and LWRs) suggests that the relationship was statistically significant (p>0.01).

Table 5. The relationship between the total length (TL) and body weight (BW)

Month. Year	Sex	N	TL (cm)			BW (g)			a	b	r^2
			Min	Max	Mean TL± SD	Min	Max	Mean BW±SD			
Oct.18	Pooled	100	7.1	10.5	8.64±0.68	3.34	9.34	5.51±1.27	-1.61	2.51	0.92*
Nov.18		100	6.5	10.1	8.46±0.63	2.89	9.74	5.55±1.28	-1.79	2.72	0.92*
Dec.18		100	7.2	11.1	8.72±0.80	4.21	7.39	6.47±1.72	-1.57	2.52	0.91*
Jan.19		100	6.8	11.5	8.28±0.84	2.94	10.14	5.30±1.85	-1.98	2.93	0.94*
Feb.19		100	7.2	10.1	8.44±0.64	3.21	8.89	5.20±1.23	-1.73	2.64	0.91*
Mar.19		100	7.3	12.8	8.96±0.88	3.60	16.42	6.23±1.94	-1.68	2.58	0.93*

* Correlation is significant at the 0.01 level.

Condition factor (K)

The condition factor (K) values were monthly changeable, recording values ranging from 0.97 to 1.25, with the mean value remaining at 1.06. The lowest (0.97) and highest (1.25) values were recorded in October and December, respectively. Fig. (3) depicts the monthly variance of Fulton's condition factor.

Table 6. The relationship between the standard length (SL) and body weight (BW)

Month. Year	Sex	N	SL (cm)			BW (g)			a	b	r^2
			Min	Max	Mean SL± SD	Min	Max	Mean BW±SD			
Oct.18	Pooled	100	5.6	8.1	6.87±0.54	3.34	9.34	5.51±1.27	-1.46	2.63	0.92*
Nov.18		100	5.4	8.1	6.71±0.50	2.89	9.74	5.55±1.28	-1.54	2.75	0.92*
Dec.18		100	5.6	8.9	6.91±0.66	4.21	7.39	6.47±1.72	-1.34	2.54	0.92*
Jan.19		100	5.5	9.3	6.58±0.72	2.94	10.14	5.30±1.85	-1.46	2.66	0.94*
Feb.19		100	5.9	8	6.78±0.57	3.21	8.89	5.20±1.23	-1.62	2.82	0.93*
Mar.19		100	6	10.5	7.10±0.71	3.60	16.42	6.23±1.94	-1.42	2.59	0.94*

* Correlation is significant at the 0.01 level.

Table 7. The relationship between fork length (FL) and body weight (BW)

Months .Year	Sex	N	FL (cm)			BW (g)			a	b	r^2
			Min	Max	Mean FL± SD	Min	Max	Mean TW±SD			
Oct.18	Pooled	100	6.1	9.2	7.52±0.60	3.34	9.34	5.51±1.27	-1.45	2.50	0.91*
Nov.18		100	5.6	8.9	7.30±0.57	2.89	9.74	5.55±1.28	-1.47	2.55	0.90*
Dec.18		100	6	9.2	7.48±0.69	4.21	7.39	6.47±1.72	-1.47	2.59	0.92*
Jan.19		100	5.8	10	7.03±0.78	2.94	10.14	5.30±1.85	-1.43	2.53	0.92*
Feb.19		100	6.2	8.5	7.3±0.56	3.21	8.89	5.20±1.23	-1.74	2.84	0.91*
Mar.19		100	6.4	11.4	7.71±0.81	3.60	16.42	6.23±1.94	-1.45	2.52	0.92*

* Correlation is significant at the 0.01 level.

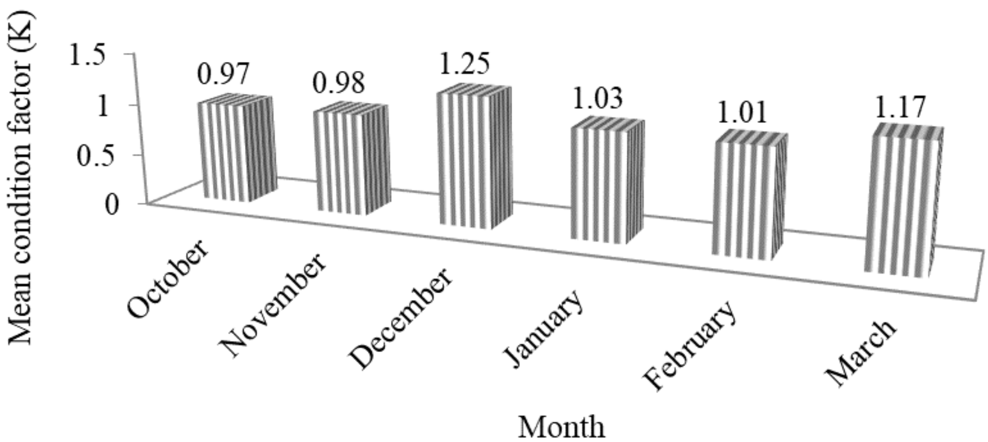

Fig. 3. Month-wise mean condition factors of *Gudusia chapra*

DISCUSSION

The surface water temperature recorded was fluctuating from 21.5 to 29.5°C, which is almost close to the temperature ranges determined in the study of **Ahmed *et al.* (1999)** who referred to degrees of 23-32.1°C, whereas another study assessed degrees ranging between 21.1 and 32.8°C **(Rahman *et al*., 2014)**. Although the surface water temperature in Kapatai Lake varied throughout the year, the present temperature range appears to be optimum for fish growth. Fish reproduction, growth and development, and even feeding are greatly influenced by water temperature **(Sigurd *et. al.*, 2008)**. Physicochemical properties of water may differ depending on the time of day, season, place and depth of water. It was noticed that, the pH of water slightly fluctuated during the present study period (7.30 - 7.40). This range is similar to the finding in various other studies **(ARG, 1986; Haldar *et al*., 1992; Ahmed *et al*., 1999)** . Yet, it differs from that depicted in the study of **Chowdhury and Mazu (1981)**. Moreover, the water's DO level (6.4±0.2 mg/l) was found higher in the current analysis compared to the minimum required level (≥ 5 ppm). Similarly, other studies also found DO levels above 5 mg/l, for example, 6.4 to 9.1 mg/1 **(Ahmed *et al*., 1999),** 6.10 to 6.80 mg/l **(Rahman *et al*., 2014)** and 8.28 to 9.59 mg/l **(Rahman *et al*., 2017)**. Such a result might be due to a very large volume of open waters in the lake. Dissolved oxygen (DO) is remarkably a significant parameter for fish survival and health **(APHA, 1989)**. However, many other factors, including temperature, wind, rain, waves, photosynthesis, respiration rate and oxidation of waste substances, affect the DO level of water and ultimately aquatic organisms.

The present study found a higher value of TDS (an average of 80 ppm) in Kaptai Lake during the dry season (January and February) compared to the pre-dry season (an average of 70 ppm) (October to December). Similarly, the level of TDS in Kaptai Lake, a were reported to be between 53 and 55 ppm **(Barua *et al*., 2016)**. The upstream and downstream were conspicuously recorded between 30 and 60 ppm and higher in the rainy season compared to the dry season **(Karmakar *et al.*, 2011)**. Whereas, the TDS level was denoted to be 41.33 ppm **(Ahmed *et al.*, 2010)**. TDS indicates the presence of various minerals (e.g., inorganic salts and soluble organic matter) in water, which may come from natural sources, sewage, urban and agricultural run-off and industrial wastewater **(WHO/UNEP & GEMS, 1989)**. The presence of TDS is essential for fish growth and production (suitable range 160 to 200 ppm) **(Huq & Alam, 2005; Rahman *et al.*, 2015)**. However, a high level of suspended solids in water can harm fish and other aquatic organisms causing high turbidity that interferes with light penetration inhibiting primary production.

The present study shows that all LLRs are positively correlated ($r^2 \geq 0.91$). Previous studies show the LLRs on G. *chapra* in which **Hossain *et al.*, (2009)** has reported that SL=0.170+1.201TL ($r^2 = 0.99$). While, SL was calculated to be =1.0076TL-0.11998 ($r^2 = 0.99$) in the study of **Azadi *et al*. (2007**). SL=1.818+0.7717TL ($r^2 = 0.93$) was determined in the study of **Chondar (1974)**, and FL= 0.853TL+0.192 and $r^2 = 0.99$ **(Hossain *et al.*, 2009)**. On the other hand, FL=0.991TL-0.05239 and $r^2 = 0.99$ **(Azadi *et al.*, 2007)**, while, FL= 0.998SL-0.307 ($r^2 = 0.99$) in the study of **Hossain *et al*. (2009)**. These results are almost close to the present findings.

The present study provides additional data for LWRs of *G. chapra* in addition to other published datasets on LWRs. The range of regression coefficient (*b*) values for the LWRs were 2.51 to 2.93, which is within the acceptable range of 2.5 to 3.5 **(Froese, 2006)**. Generally, the *b* value indicates variation in fish growth and weight; for example, the *b* value equals 3 shows isometric growth, which means species have optimum growth and development **(Jobling, 2008)**. Nevertheless, *b* value in the current study is less than 3, suggesting the fish had a negative allometric growth, indicating lower feeding abilities (slow growth rate and fewer body weight) or a little fluctuation of environmental conditions such as physico-chemical parameters **(Das *et al*., 2015; Kalita *et al*., 2016)**. Kaptai Lake seems to be suitable for living as the other previous studied habitats of *G. chapra* showed negative allometric growth ($b < 3$) for females (**Vinci *et al*., 2005; Ahmed *et al*., 2007; Ahamed *et al*., 2014)**. In contrast, few other studies have shown allometric growth ($b > 3$) for males **(Hossain *et al*., 2009; Ahamed *et al*., 2014)**. However, the *b* value was calculated for the pooled *G. chapra,* and the current *b* value range is similar to the finding (2.85) of **Kumari *et al.* (2019)**. It is noticeable that, habitat, season, gut content, diet, sex, size range, health and general fish condition are factors that affect fish length-weight relationships **(Paul *et al*., 2021)**.

The robustness of fish is determined by food supply and environmental conditions (**Dadzie *et al*., 2008; Hossain *et al*., 2012)**. The value of $K > 1$ means that the Lake's ecosystem is ideal for the growth of the fish **(Le Cren, 1951)**. Except in October and November, Fulton's condition factor (*K*) showed positive growth (i.e., $K > 1$) for *G. chapra*. The *K* value of *G. chapra* in the old Brahmaputra River, Bangladesh **(Ahamed *et***

***al*., 2014)** was 1.24 to 2.28, which is higher than the present study (K= 0.97 to 1.25), and this may indicate that fish were in a more appropriate and stable state than those in the Kaptai Lake. On the other hand, in Kaptai Lake, the value of *K* was a little bit lower, which may be due to the indiscriminate harvesting of this species.

CONCLUSION

The length-length and length-weight relationships were found to be strongly correlated in the current research. As a result, any change in any of those parameters affect all the other parameters mentioned in this analysis. At the same time, Fulton's condition factor reflects the fact that, while the Kaptai Lake was not ideal for Chapila fish, it was adequate because the mean K values ranged from 0.97 to 1.25. Between the relationship of length and body weight, negative allometric growth was studied. To summarize, the study provided some basic information on the length-length relationship, length-weight relationship, and condition factor for *G. chapra* from the Kaptai Lake that would be useful to fishery managers, strategists and scientists.

REFERENCES

Ahamed, F.; Lama, B.; Ahmed, Z.F.; Hossain, M.Y. and Ohtomi, J. (2014). Population biology of the Indian river shad, *Gudusia chapra* (Clupeidae) in the Old Brahmaputra River, north-eastern Bangladesh. Sains Malays., 43(11): 1645-1655.

Ahmed, K.K.U.; Rahman, S. and Ahammed, S.U. (2006). Managing fisheries resources in Kaptai reservoir, Bangladesh. Outlook on Agric., 35(4):281–289. https://doi.org/10.5367/000000006779398281

Ahmed, K.K.; Haque, M.K.I. and Haque, M.E. (1999). Studies on some physico-chemical factors of Kaptai Lake. Bangladesh J. Fish. Res., 3(1): 33-39.

Ahmed, M.J.; Haque, M.R.; Ahsan, A.; Siraj, S.; Bhuiyan, M.H.R.; Bhattacharjee, S.C. and Islam, S. (2010). Physicochemical assessment of surface and groundwater quality of the greater chittagong region of Bangladesh. Pak. J. Anal. Environ. Chem., 11 (2): 1 – 11.

Ahmed, Z.F.; Smith, C.; Ahamed, F. and Hossain, M.Y. (2007). Growth and reproduction of the Indian River shad, *Gudusia chapra* (Clupeidae). Folia Zoologica-Praha., 56(4), 429.

Alam M.M.; Galib S.M.; Islam M.M.; Flowra F. A. and Hussain M.A. (2012). Morphometric study of the wild population of pool barb *Puntius sophore*

(Hamilton, 1822) in the River Padma, Rajshahi, Bangladesh. Trends Fish. Res., 1(2): 10–13.

Ali, M.N.; Paul, S.K.; Ahmed, Z.F.; Saha, D.; Fatema. M.K. and Majumdar, P.R. (2021). Reproductive biology of the silver hatchet *Chela cachius* (hamilton 1822) in a perennial water body in Bangladesh. Egypt. J. Aquat. Biol. Fish., Vol. 25(4): 313 – 327. https://doi.org/10.21608/ejabf.2021.189056

APHA. (1989). Standard method for, examination of water & waste,'16th edition- American Health Association, Washington DC., USA, PP. 1268.

Aquatic Research Group (ARG). (1986). Hydrobiology of the Kaptai reservoir. University of Chittagong, FAO /UNDP Final Report No. DP /BGD /79 /015-4/FI. 192 pp.

Arellano-Martinez, M. and Ceballosvazquez, B.P. (2001). Reproductive activity and condition index of *Holocanthus passer* (Teleostei: Pomacanthidae) in the Gulf of California, Mexico. Rev. Biol. Trop., 49: 939-943.

Arshad, A.; Jimmy, A.; Nurul Amin, S.M.; Japar, B.S. and Harah, Z.M. (2008). Length-weight relationships of five fish collected from seagrass beds of the Sungai Pulai estuary, Peninsular Malaysia. J. Appl. Ichthyol., 24(3): 328–329. https://doi.org/10.1111/j.1439-0426.2007.01026.x

Azadi, M.A. and Rahman, A.S. (2007). Morphometric and meristic study of *Gudusia chapra* (Ham. 1822) and *Gonialosa manmina* (Ham. 1822) (Clupeidae) from the Kaptai lake, Bangladesh. Chittagong Univ. J. Biol. Sci., 3(1 & 2): 21-31. https://doi.org/10.3329/cujbs.v3i1.13403

Barua, R.; Barua, S.; Zohora, F.T.; Mutsuddi, R.; Uddin, M.S.; Hasegawa, H.; Ismail, M. and Rahman, M. (2016). Bacteriological and physicochemical characteristics of Kaptai lake water in terms of public health significance. Int. J. Sci. Res. Envt. Sci., 4(2): 0031-0039. https://doi.org/10.12983/ijsres-2016-p0031-0039

Basak, S.S.; Basher, M.A.; Saha, A.K. and Roy, N.C. (2016). Fish diversity of Kaptai lake in an area to Rangamati hill district. J. Sylhet Agril. Univ., 3(2):223-233.

Boyd, C.E. and Tucker, C.S. (1998). Pond aquaculture water quality management. Kluwer academic publishers, USA, 240pp. https://doi.org/10.1007/978-1-4615-5407-3

Chondar, S.L. (1974). Morphometric characters and their relationship in *Gudusia chapra* (HAM.). In Proceedings of the Indian Academy of Sciences, Springer India-Section B, 80(2): 51-67. https://doi.org/10.1007/BF03050659

Chowdhury, S.H. and Mazumder, A. (1981). Limnology of lake Kaptai-I: Physico-chemical features. Bangladesh J. Zool., 9(1): 59-72.

Dadzie, S.; Abou- Seedo, F. and Manyala, J.O. (2008). Length–length relationship, length–weight relationship, gonadosomatic index, condition factor, size at maturity and fecundity of *Parastromateus niger* (Carangidae) in Kuwaiti waters. J. Appl. Ichthyol., 24(3): 334-336. https://doi.org/10.1111/j.1439-0426.2008.01061.x

Das, P.; Rahman, W.; Talukdar, K. and Deka, P. (2015). Length-weight relationship and relative condition factor of *Heteropneustes fossilis* (Bloch) of Deepar Beel, a Ramsar site of Assam, India. Int. J. Appl. Res., 1(12): 1024-1027. https://doi.org/10.21077/ijf.2019.66.3.81017-18

Froese, R. (2006). Cube law, condition factor and weight–length relationships: history, meta-analysis and recommendations. J. Appl. Ichthyol., 22(4): 241-253. https://doi.org/10.1111/j.1439-0426.2006.00805.x

Fulton, T. W. (1904). The rate of growth of fishes. Twenty-second Annual Report, 141-241.

Haldar, G.C.; Mazid, M.A. and Ahmed, K.K. (1992). Limnology and primary production of Kaptai lake, Bangladesh. In: Reservoir Fisheries of Asia (ed. S.S. De Silva). Proceedings of the 2nd Asian reservoir fisheries workshop held in Hangzhou, People's Republic of China, 15-19 October, 1990. IDRC, Ottawa. ON, Canada. IDRC-291e. pp. 2-11.

Hasan, M.R.; Mamun, A.-A. and Hossain, M.Y. (2020). Length-weight relationships of 12 indigenous fishes and 3 shellfishes from mangrove and floodplain ecosystems in Southwestern Bangladesh. Egypt. J. Aquat. Biol. Fish., 24, 69–74. https://doi.org/10.21608/ejabf.2020.103532

Hasan, M.R.; Mamun, A.-A. and Hossain, M.Y. (2021a). Biometric indices of four crustaceans and two mangrove fishes from coastal waters in Bangladesh. Thalassas. An Int. J. Mar. Sci., 37, 561–567. https://doi.org/10.1007/s41208-021-00355-8

Hasan, M.R.; Mamun, A.-A. and Hossain, M.Y. (2021b). Biometric indices of eleven mangrove fish species from southwest. Egypt. J. Aquat. Res., 47, 207–213. https://doi.org/10.1016/j.ejar.2020.11.002

Hossain, M.Y.; Jasmine, S.; Ibrahim, A.H.M.; Ahmed, Z.F.; Rahman, M.M. and Ohtomi, J. (2009). Length–weight and length–length relationships of 10 small fish species from the Ganges, Bangladesh. J. Appl. Ichthyol., 25(1): 117-119. https://doi.org/10.1111/j.1439-0426.2008.01168.x

Hossain, M.Y.; Rahman, M.M.; Jewel, M.A.S.; Ahmed, Z.F.; Ahamed, F.; Fulanda, B.; Abdallah, E.M. and Ohtomi, J. (2012). Condition- and form-factor of the five threatened fishes from the Jamuna (Brahmaputra River distributary) River, northern Bangladesh. Sains Malays., 41: 671–678. https://doi.org/10.1016/j.aquaculture.2008.06.042

Huq, S.M.I. and Alam, M.D. (2005). A handbook on analysis of soil, plant and water. BACER-DU, University of Dhaka, Bangladesh. pp. 246.

Imam T.S.; Bala U.; Balarabe, M.L. and Oyeyi T.I. (2010). Length-weight relationship and condition factor of four fish species from Wasai Reservoir in Kano, Nigeria. Afr. J. Gen. Agric., 6(3): 125-130.

Isa, M.M.; Basri, M.N.A.; Zawawi, M-Z.M.; Yahya, K.S. and Nor S. A.M. (2012). Length-weight relationship of some important estuarine fish species for Merbok estuary, Kedon. J. Nat. Res., 2(2): 8-18.

IUCN, Bangladesh. (2015). Red List of Bangladesh. Volume 5: Freshwater Fishes. IUCN, International Union for Conservation of Nature, Bangladesh Country Office, Dhaka, Bangladesh, xvi+360 pp.

Jobling, M. (2008). Environmental factors and rates of development and growth. In: Hart, P.J., Reynolds, J.D. (Eds.), Handbook of Fish Biology and Fisheries, Vol. 1: Fish Biology. Blackwell Publishing Ltd., Oxford, pp. 97–122. https://doi.org/10.1002/9780470693803.ch5

Kabir, A.K.M.A.; Hossain, M. A.; Rahmatullah, S. M.; Dewan, S. and Islam, M.S. (1998). Studies on the gonadosomatic index and fecundity of chapila (*Gudusia chapra* Ham.). Bangladesh J. Fish. Res., 2(2): 195-200.

Kalita, B.; Sarma, S. R. and Deka, P. (2016). A comparison on length-weight relationship and relative condition factor of two species of Trichogaster of Nitai Beel of Kamrup District of Assam, India. Int. J. Zool. Stud., 1(3): 9-12.

Karmakar, S.; Haque, S.M.S.; Hossain, M.M. and Shafiq, M. (2011). Water quality of Kaptai reservoir in Chittagong hill tracts of Bangladesh. J. For. Res., 22(1): 87−92. https://doi.org/10.1007/s11676-011-0131-6

Kumari, S.; Sandhya, K.M.; Karnatak, G.; Lianthuamluaia, Sarkar, U.K.; Panda, D. and Mishal, P. (2019). Length-weight relationship and condition factor of *Gudusia chapra* (Hamilton, 1822) from Panchet Reservoir, Jharkhand, India. Indian J. Fish., 66(3): 136-139. https://doi.org/10.21077/ijf.2019.66.3.81017-18

Le Cren, E.D. (1951). The length-weight relationship and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). J. Anim. Ecol., 201-219. https://doi.org/10.2307/1540

Mojumder, N.; Saha, D.; Utsa, S.S.; Maruf, M.K.K. and Paul, S.K. (2020). Biology of the endangered queen loach (*Botia dario*) collected from wild sources in Bangladesh. AACL Bioflux, 13(5):2599-2609.

Moutopoulos, D.K. and Stergiou, K.I. (2002). Length–weight and length–length relationships of fish species from the Aegean Sea (Greece). J. Appl. Ichthyol., 18:200–203. https://doi.org/10.1046/j.1439-0426.2002.00281.x

Muchlisin, Z.A.; Musman, M. and Siti Azizah, M.N. (2010). Length-weight relationships and condition factors of two threatened fishes, *Rasbora tawarensis* and *Poropuntius tawarensis*, endemic to Lake Laut Tawar, Aceh Province, Indonesia. J. Appl. Ichthyol., 26:949-953. https://doi.org/10.1111/j.1439-0426.2010.01524.x

Paul, S.K.; Habib, M.A.; Ali, M.N.; Majumdar, P.R. and Saha, D. (2021). Meristic and morphometric characteristics relationships, condition factor and breeding biology of Indian potashi (*Neotropius atherinoides*) in the adjacent river of chalon beel, Bangladesh. J. Surv. Fish. Sci., 8(1), 47-64. https://doi.org/10.18331/SFS2021.8.1.4

Ragheb E. (2014). Fishery biology of Catfish (*Chrysichthys auratus*, Family: Bagridae) from Damietta branch of the River Nile, Egypt. Egypt. J. Aquat. Res., 40: 171-180. https://doi.org/10.1016/j.ejar.2014.06.001

Rahman, M. Z.; Zaman, M.F.; Khandokar, S.; Jaman, M.H.; Hossain, M.L. and Bappa, S.B. (2015). Water quality assessment of a shrimp farm: A study in a salinity prone area of Bangladesh. Int. J. Fish. Aquat. Stud., 2 (5): 09-19.

Rahman, M.M.; Bashar, M. A.; Farhana, Z. and Hossain, M. Y. (2014). Temporal variation of physicochemical parameters in kaptai lake, Bangladesh. World J. Fish & Marine Sci., 6 (5): 475-478. https://doi.org/10.5829/idosi.wjfms.2014.06.05.8696

Rahman, M.M.; Rahman, M. and Huda, M.K. (2017). Seasonal variations of chemical properties of water of the Kaptai lake, Rangamati, Bangladesh. Jahangirnagar Univ. J. Biol. Sci., 6(2): 11-17. https://doi.org/10.3329/jujbs.v6i2.36586

Richter, T.J. (2007): Development and evaluation of standard weight equations for bridgelip sucker and large scale suckers. N. Am. J. Fish. Manag., 27: 936–939. https://doi.org/10.1577/M06-087.1

Sani, R.; Gupta, B.K.; Sarkar, U.K.; Pandey, A.; Dubey, V.K. and Singh, L.W. (2010). Length–weight relationships of 14 Indian freshwater fish species from the Betwa (Yamuna River tributary) and Gomti (Ganga River tributary) rivers. J. Appl. Ichthyol., 26(3): 456-459. https://doi.org/10.1111/j.1439-0426.2009.01388.x

Sarkar, U.K.; Khan, G.E.; Dabas, A.; Pathak, A.K.; Mir, J.I.; Rebello, S.C. and Singh, S.P. (2013). Length weight relationship and condition factor of selected freshwater fish species found in River Ganga, Gomti and Rapti, India. J. Environ. Biol., 34: 951-956.

Sheikh, J.; Singha, N.; Nag, R. and Deka, P. (2017). Length-weight relationship and relative condition factor of *Gudusia chapra* (Hamilton, 1822) of Dalani Beel (wetland) of Assam, India, Int. J. Fish. Aquat. Stud., 5(3): 485-489.

Sigurd, O H.; Imsland, A.K. and Sigurd, O.S. (2008). The effect of temperature and fish size on growth, feed intake, food conversion efficiency and stomach evacuation rate of Atlantic salmon post-smolts, Aquacul., 283(1-4): 36-42. https://doi.org/10.1016/j.aquaculture.2008.06.042

Singh, R.K.; Shrivastava, N.P. and Desai, V.R. (1980). Seasonal and diurnal variations in physico-chemical conditions of water and plankton in lotic sector of Rihand reservoir (U. P.). J. Inland Fish. Soc. India., 12(1): 100–111.

Torres, M.; Ramos, F. and Sobrino, I. (2012). Length-weight relationships of 76 fish species from the Gulf of Cadiz (SW Spain). Fish. Res., 127: 171-175. https://doi.org/10.1016/j.fishres.2012.02.001

Victor, R.M.; Sivakumar, R. and Mathialagan, R. (2014). Food and feeding habit and length-weight relationship of the Asian Striped Catfish *Mystus vitattus* (Bloch, 1794) (Siluriformes: Bagridae) in the Vadavar River, Lower Anicut, Tamil Nadu. Indian J. Sci., 8(20): 55-64.

Vinci, G.K.; Suresh, V.R. and Bandyopadhyaya, M.K. (2005). Biology of *Gudusia chapra* (Hamilton-Buchanan) from a floodplain wetland in West Bengal. Indian J. Fish., 52(1): 73-79.

WHO/UNEP and GEMS. (1989). Global Freshwater Quality. Alden Press, Oxford.