INNSPUB

Journal of Biodiversity and Environmental Sciences (JBES)
ISSN: 2220-6663 (Print) 2222-3045 (Online)
Vol. 10, No. 3, p. 123-133, 2017
http://www.innspub.net

RESEARCH PAPER OPEN ACCESS

Length-weight relationship and condition factor of 13 fish species collected from the Atrai and Brahmaputra rivers, Bangladesh

Md. Rashidul Islam*[1], Md. Golam Azom[2], Md. Faridullah[3], Md. Mamun[2]

[1]*Department of Fisheries Biology and Genetics, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh*

[2]*Faculty of Fisheries, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh*

[3]*Department of Fisheries Technology, Hajee Mohammad Danesh Science and Technology University, Dinajpur, Bangladesh*

Article published on March 23, 2017

Key words: Length-weight relationships, Growth pattern, Well-being, Stream fishes

Abstract

Length-weight relationship (LWR) and condition factors (CFs) are imperative tools to discern the relative health condition of fishes. Using seine net, a total of 432 individuals (13 species) were collected from the Atari (Dinajpur) and Brahmaputra (Kurigram) Rivers of Bangladesh from January to June 2016. In LWR, isometric growth ($b \approx 3.0$) were found for *Amblypharyngodon mola*, *Lepidocephalichthys guntea* and *Xenentodon cancila*, positive allometric growth ($b < 3.0$) were only recorded for *Devario devario* but another 9 fishes showed negative allometric growth ($b > 3.0$). No significant differences ($p < 0.05$) were scrutinized between observed body weight (BW) and standard body weight (BW_s). But statistical differences ($p < 0.05$) were evaluated among the values of CF_f (0.17±0.02-1.50±0.07) but not for BW_r (99.77±1.87-101.80±3.29). Using the values of CF_f and BW_r, analysis of similarities (ANOSIM, $p < 0.05$) revealed that distances were recorded among fishes especially with *X. cancila*. Based on CF_f and BW_r values, *X. cancila* showed poor health condition and separated (stress < 0.01) from other fishes. *A. mola*, *D. devario*, *Pethia ticto* and *Nandus nandus* showed extended body shape ($0.010 < a_{3.0} > 0.014$) with more adaptability in these rivers than those of others. This is the first record for *C. nama*, *D. devario* and *Parambasis ranga* not recorded in Fish Base that would be the basis for upcoming research.

***Corresponding Author:** Md. Rashidul Islam ✉ mrislam_fbg@hstu.ac.bd

Introduction

Amblypharyngodon mola (Hamilton, 1822), *Chanda nama* (Hamilton, 1822), *Devario devario* (Hamilton, 1822), *Eutropiichthys vacha* (Hamilton, 1822), *Heteropneustes fossilis* (Bloch, 1794), *Glossogobius giuris* (Hamilton, 1822), *Lepidocephalichthys guntea* (Hamilton, 1822), *Macrognathus pancalus* (Hamilton, 1822), *Mystus tengara* (Hamilton, 1822), *Pethia ticto* (Hamilton, 1822), *Parambasis ranga* (Hamilton, 1822), *Nandus nandus* (Hamilton, 1822) and *Xenentodon cancila* (Hamilton, 1822) are known as small indigenous fishes out of which *P. ticto* is catalogued as vulnerable and *N. nandus* as near threatened species in Bangladesh (IUCN Bangladesh, 2016). These small fishes serve as a major source of proteins, vitamins and minerals for pregnant and lactating women including infants and rural community where *A. mola* is comparatively richer in protein, vitamin A, iron and calcium than other species (Bogard *et al.,* 2015). Recently, freshwater biodiversity is always facing in devastation owing to excess fishing pressure, pollution and development activities disturbing the life cycle of aquatic biota and accelerating the rate of loss of indigenous fishes (Stoddard *et al.,* 2006). Equally, this paper report on the length-weight relationships (LWRs) of these fishes because LWR is a useful tool for altering lengths into biomass, deciding health condition, feeding and reproductive studies (Koutrakis and Tsikliras, 2003) of fishes used in stock assessment and biomass estimation from inadequate number of individuals (Simon *et al.,* 2009). Besides, indices of condition factors (CFs) are commonly used in fisheries science to assess the well-being, reproduction and survival (Didenko *et al.,* 2004; Richter, 2007) and to compare relative health status of fishes (Froese, 2006).

To the best of our knowledge, this is the first scientific report on LWRs (*C. nama*, *D. devario* and *P. ranga*) and CFs (except for *C. nama*, *P. ticto* and *N. nandus*). If there were a number of research works on LWRs and CFs but very few scientific data were noted on this issues attributing the Atrai and Brahmaputra Rivers in Bangladesh. Therefore, a study was accomplished to determine the length-weight relationship (LWR) and condition factors (CFs) for some selected small indigenous fishes obtained from these rivers that would be the basis for further studies.

Materials and methods

Study area and duration

An experiment was conducted in the Atrai (25.924° N 88.724° E) and Brahmaputra (25.705° N 89.745° E) Rivers in Bangladesh where 13 fish species (Table 1) were caught monthly (by fishermen) using seine net (15 × 3.5 m^2, mesh size 4 mm) from January to June 2016. The collected fishes were identified in the field observing their external morphology (Rahman, 2005). Then, identified and sorted species were immediately (within 1.5 hours) transported to laboratory using ice box. After taking all measurements, fishes were preserved with 10% formaldehyde solution.

Data collection and measurements

Total length (TL) was measured with a vernier caliper to the nearest 0.1 cm for each fresh individual. Observed body weights (BW) were taken with a digital balance (HD-602ND, MEGA, Japan) to the nearest 0.1 g. LWRs were estimated through logarithmic transformation of the linear regression equation as log BW = log a + b log TL of the power function ($BW = aTL^b$), where BW is the body weight (g), TL total length (cm) of fishes, a intercept and b slope of regression curve. The log-log plots for LWRs were exploited to eliminate the outliers (Froese, 2006). The degrees of association between variables were computed by coefficient of determination (r^2) at 95% confidence limits. To check significant differences in the values of b from 3, t-test was accomplished according to equation stated by Sokal and Rohlf (1987) as $t_s = (b-3)/SE_b$, where t_s is the t-test value, b slope and SE_b standard error of b. The statistical significance ($p < 0.05$) of the isometric exponent (b) was analysed. A dissimilarity between obtained values of t_s-test and critical values certified the decision of b values statistically and their enclosure in isometric (b = 3) or positive allometric (b > 3) or negative allometric (b < 3) growth (Islam and Mia, 2016).

Besides, condition factors (CFs) were measured to recognize the health condition of these fishes from this river where Fulton's condition factor calculated as $CF_f = (BW \times 100)/TL^3$ (Fulton, 1904) and relative body weight as $BW_r = (BW/aTL^b) \times 100$ (Froese, 2006). Where, BW is observed body weight (g), TL total length (cm) while a and b are the regression parameters previously estimated from LWRs by Islam and Mia (2016). According to Froese (2006), form factor ($a_{3.0}$) was estimated through an equation as $a_{3.0} = 10^{\log a - S(b-3)}$, where a and b from LWRs as regression parameters while slope, S = -1.358 reported by Froese (2006) used to estimate $a_{3.0}$ by plotting $\log_{10}$ a vs. b because of little information on LWRs for these species.

Data analysis

The observed body weight (BW) of a fish specimen was compared to standard body weight ($BW_s = aTL^b$) through student's t-test to know the significance variations ($p < 0.05$) between them. One-way analysis of variance (ANOVA) and similarities (ANOSIM, based on Euclidean method) were tested to notice dissimilarities ($p < 0.05$) among fishes based on CF_f and BW_r values, respectively. After logarithmic transform of CF_f and BW_r values, two-dimensional nMDS (nonmetric multidimensional scaling) based on Euclidean's similarity index was taken to observe the seclusion among fishes. All statistical tests were done using PAST (Paleontological statistics, version 3.10) software and Microsoft Office Excel, 2013.

Results and discussion

Length-weight relationship and growth pattern

A total of 432 specimens belonging to 13 fish species were captured from two rivers namely the Atrai and Brahmaputra in Bangladesh. Based on linear regressions with coefficient of determination, $0.992 > r^2 > 0.827$ ($p < 0.05$), estimated parameters and descriptive statistics for LWRs are represented in Table 1 with their log TL vs. log BW scattered plots in Fig. 1. In LWRs, b values ($2.999 < b < 3.060 \approx 3.0$) from 3 fishes *A. mola*, *L. guntea* and *X. cancila* were correlated ($t_s = 1.47$, $p > 0.05$) to isometric point exhibiting isometric growth ($b = 3.0$) and perfect body shape. In contrary, b values of 10 fish species were significantly different ($t_s = 5.65$, $p < 0.05$) from isometric value ($b = 3.0$) through one sample t-test showing allometric growth ($2.515 < b < 3.120$) i.e. *C. nama, E. vacha, H. fossilis, G. giuris, M. pancalus, M. tengara, P. ticto, P. ranga* and *N. nandus* exhibited negative allometric growth but only *D. devario* showed positive allometric growth.

Table 1. Descriptive statistics and LWRs parameters (see figure 1) for thirteen fishes in the Atrai and Brahmaputra River, Bangladesh.

Species	S	n	Total length (cm)		Body weight (g)		a*	b	95% of confidence limits		Bayesian limits (Froese *et al.* 2014)		Growth type	r²
			Min.	Max.	Min.	Max.			a*	b	a*	b		
A. mola	A	46	4.40	6.20	0.82	2.41	0.009	3.060	0.005-0.015	2.715-3.406	0.005-0.015	3.03-3.31	IS	0.879
C. nama	B	43	4.00	7.40	0.60	3.45	0.012	2.869	0.009-0.016	2.692-3.048	0.008-0.052	2.79-3.23	NA	0.963
D. devario	A	30	5.00	7.10	1.35	4.11	0.010	3.120	0.004-0.026	2.585-3.656	0.003-0.017	2.85-3.23	A+	0.836
E. vacha	A	14	6.60	18.50	2.47	42.82	0.011	2.829	0.007-0.017	2.649-3.009	0.005-0.008	2.90-3.06	NA	0.990
H. fossilis	A	24	7.51	13.71	2.70	16.42	0.008	2.862	0.004-0.018	2.568-3.158	0.002-0.010	2.89-3.35	NA	0.948
G. giuris	B	49	5.50	9.70	1.40	7.50	0.016	2.682	0.009-0.031	2.374-2.990	0.007-0.010	3.01-3.11	NA	0.867
L. guntea	A	30	6.20	8.70	2.05	5.87	0.009	3.014	0.006-0.013	2.798-3.231	0.004-0.013	3.00-3.34	IS	0.967
M. pancalus	A	20	8.70	12.60	2.30	9.27	0.006	2.842	0.002-0.018	2.369-3.315	0.004-0.007	2.84-3.18	NA	0.899
M. tengra	B	39	6.50	11.20	3.00	15.00	0.030	2.515	0.013-0.068	2.132-2.899	0.004-0.022	2.83-3.21	NA	0.827
P. ticto[1]	A	33	4.91	6.52	1.57	3.78	0.017	2.875	0.010-0.030	2.544-3.207	0.009-0.030	2.83-3.15	NA	0.910
P. ranga	B	16	3.20	6.10	0.56	2.80	0.030	2.525	0.007-0.055	2.156-2.894	0.008-0.51	2.79-3.23	NA	0.939
N. nandus	B	25	7.00	14.00	4.00	36.0	0.016	2.924	0.007-0.037	2.544-3.305	0.004-0.029	2.83-3.27	NA	0.917
X. cancila	A	63	9.30	18.10	1.14	7.85	0.002	2.999	0.001-0.003	2.816-3.183	0.001-0.002	2.97-3.31	IS	0.946

n, number of individuals; a*, anti-log a; a, intercept; b, slope; r^2, coefficient of determination; A+, positive allometric; IS, isometric; [1], endangered species.

The values of b from LWRs for 8 fishes were within the Bayesian limits (Froese *et al.,* 2014) while 5 fishes were out of this range (Table 1) but these fishes were between the expected range 2.5 to 3.5 (Froese, 2006). Estimated b values in LWRs were 3.36-3.51 for *A. mola* and 2.77-2.91 for *E. vacha* (Hossain *et al.,* 2009), 2.79 for *C. nama* (Hossain *et al.,* 2012a), 2.887-3.291 for *G. giuris* (Islam and Mollah, 2012), 3.026 for *M. pancalus* (Hossain *et al.,* 2006), 2.80 for *M. tengara* (Hossain *et al.,* 2016), 2.71-3.04 for *N. nandus* (Hossain *et al.,* 2013), and 3.220 for *X. cancila* (Subba *et al.,* 2012), respectively. This variation in slope (b) may be due to time and space (Bagenal and Tesch, 1978).

Table 2. Condition factors for thirteen fishes in the Atrai and Brahmaputra River, Bangladesh.

Species	Source	n	Fulton's condition factor CF_f = (BW × 100)/TL^3				Relative body weight BW_r = (BW /aTL^b) × 100				Foam Factor
			Min.	Max.	Mean±SE	t_s	Min.	Max.	Mean±SE	t_s	($a_{3.0}$)
A. mola	A	46	0.67	1.10	0.94±0.01	-4.63*	70.90	117.26	100.55±1.30	0.42	0.010
C. nama	B	43	0.77	1.16	0.94±0.01	-4.74*	83.44	126.17	100.62±1.32	0.46	0.008
D. devario	A	30	0.99	1.54	1.24±0.02	10.37*	80.24	124.29	101.16±1.90	0.61	0.014
E. vacha	A	14	0.65	0.86	0.73±0.02	-16.68*	88.91	111.97	99.77±1.87	-0.13	0.007
H. fossilis	A	24	0.51	0.77	0.61±0.01	-31.74*	85.54	130.82	101.26±2.06	0.61	0.006
G. giuris	B	49	0.47	1.17	0.85±0.02	-8.39*	55.20	132.84	101.13±1.92	0.59	0.006
L. guntea	A	30	0.78	0.99	0.90±0.01	-11.02*	86.83	111.31	100.31±1.04	0.30	0.009
M. pancalus	A	20	0.34	0.50	0.40±0.01	-68.80*	84.76	127.69	101.60±2.16	0.74	0.004
M. tengra	B	39	0.81	1.48	1.04±0.03	1.45	80.99	134.98	101.26±2.46	0.51	0.007
P. ticto[1]	A	33	1.25	1.66	1.39±0.02	23.95*	89.82	121.51	100.39±1.17	0.33	0.012
P. ranga	B	16	1.16	1.84	1.45±0.06	6.75*	75.68	130.60	101.05±3.24	0.33	0.007
N. nandus	B	25	1.16	1.87	1.39±0.05	8.59*	83.98	134.37	101.80±3.29	0.55	0.013
X. cancila	A	63	0.12	0.21	0.17±0.02	-409.99*	76.54	127.35	102.84±1.44	1.41	0.002

A, Atrai River; B, Brahmaputra River; n, number of specimen; BW, observed body weight; TL, total length; Min, minimum; Max, maximum; SE, standard error; *, at 5% level of significance; [1], endangered species.

The divergences may also be due to minimum individuals examined, range and type of length used, stomach fullness, spatiotemporal variation, sex, sexual maturity, spawning and physiology of fishes, lack of covering all size of classes or excess of juveniles which were not considered in this study (Le Cren, 1951; Ozaydin *et al.,* 2007; Cherif *et al.,* 2008; Khan and Sabah, 2013). No significant variations ($0.03 < t_s > 0.28$, $p > 0.05$) were found between BW and BW_s indicating good option to forecast the quite accurate body weight for species supported by Abobi (2015) for nine freshwater fishes in Ghana.

Table 3. Spearman rank correlation coefficient (r_s) for condition factors (Fulton's condition factor and relative body weight) with lengths (cm) and body weights (g) of thirteen fishes in the Atrai and Brahmaputra River, Bangladesh.

Species	n	Fulton's condition factor (CF_f)			Relative body weight (BW_r)		
		TL-CF_f	BW-CF_f	BW_s-CF_f	TL-BW_r	BW-BW_r	BW_s-BW_r
A. mola	A	ns	0.43**	ns	ns	0.37*	ns
C. nama	B	ns	ns	ns	ns	ns	ns
D. devario	A	ns	0.44*	ns	ns	0.40*	ns
E. vacha	A	ns	ns	ns	ns	ns	ns
H. fossilis	A	ns	ns	ns	ns	ns	ns
G. giuris	B	-0.33*	ns	-0.33*	ns	0.31*	ns
L. guntea	A	ns	ns	ns	ns	ns	ns
M. pancalus	A	ns	ns	ns	ns	ns	ns
M. tengra	B	-0.44**	ns	-0.44**	ns	0.45**	ns
P. ticto[1]	A	ns	ns	ns	ns	ns	ns
P. ranga	B	-0.61**	ns	-0.61**	ns	ns	ns
N. nandus	B	ns	ns	ns	ns	ns	ns
X. cancila	A	ns	0.29*	ns	ns	0.29*	ns

A, Atrai River; B, Brahmaputra River; n, number of specimen; TL, total length; BW, observed body weight; BW_s, standard body weight; ns, not significant ($p > 0.05$); *, at 5% level of significance; **, at 1% level of significance; [1], endangered species.

Condition and form factors

A sign of overall fish condition was employed to compare length and body weight with the assessment of overall fitness and outputs of a particular specimen or individual (Rypel and Richter, 2008). Fulton's condition factor (CF_f) which is free from regression parameters (a and b) involving length and weight data of fishes were used to know their physical fitness. Descriptive information of condition factors are shown in Table 2 where Fulton's (CF_f > 0.17±0.02) condition factor was significantly assorted (F = 387.70, $p < 0.05$) among species.

Table 4. Based on the Euclidean method one-way ANOSIM (uncorrected significant) of Fulton's condition factor (CF_f) and relative body weight (BW_r) among thirteen fishes in the Atrai and Brahmaputra Rivers, Bangladesh.

Species	Source	Overall R-value of CF_f = 0.74 (above the diagonal) / BW_r = 0.02 (below the diagonal)												
		A. mola A	*C. nama* B	*D. deveario* A	*E. vacha* A	*H. fossilis* A	*G. giuris* B	*L. guntea* A	*M. puncalus* A	*M. tengra* B	*P. ticto* A	*P. ranga* B	*N. nandus* B	*X. cancila* A
A. mola	A	-	ns	0.73	0.72	0.93	0.13	ns	0.99	0.09	0.98	0.89	0.82	1.00
C. nama	B	ns	-	0.73	0.68	0.95	0.09	ns	0.99	0.08	0.98	0.88	0.81	1.00
D. devario	A	ns	ns	-	0.96	0.99	0.79	0.85	1.00	0.30	0.21	0.25	0.08	1.00
E. vacha	A	ns	ns	ns	-	0.51	0.19	0.77	0.99	0.46	0.99	0.83	0.85	1.00
H. fossilis	A	ns	ns	ns	ns	-	0.63	0.97	0.91	0.78	1.00	0.96	0.96	1.00
G. giuris	B	ns	ns	ns	ns	ns	-	ns	0.92	0.18	0.97	0.88	0.84	0.99
L. guntea	A	ns	ns	ns	ns	ns	ns	-	1.00	0.10	0.99	0.87	0.82	1.00
M. pancalus	A	ns	ns	ns	ns	ns	ns	ns	-	0.96	1.00	0.97	0.99	0.99
M. tengra	B	0.11	0.08	ns	ns	ns	0.05	0.07	ns	-	0.63	0.53	0.41	0.99
P. ticto[1]	A	ns	ns	0.04	ns	ns	ns	ns	ns	0.08	-	0.43	0.24	1.00
P. ranga	B	ns	ns	ns	ns	ns	ns	0.14	ns	ns	0.13	-	ns	0.99
N. nandus	B	0.23	0.20	0.09	ns	0.06	0.10	0.24	ns	ns	0.23	ns	-	1.00
X. cancila	A	ns	ns	ns	ns	ns	ns	ns	ns	0.11	ns	ns	0.19	-

A, Atrai River; B, Brahmaputra River; ns, not significant ($p > 0.05$); [1], endangered species.

The calculated values of CF_f were significantly ($p < 0.05$) higher ($23.95 < t_s > 6.75$) than 1 (constant) in *D. devario, P. ticto, P. ranga* and *N. nandus* but statistically lower ($p < 0.05$) in *A. mola, C. nama, E. vacha, H. fossilis, G. giuris, L. guntea, M. pancalus* and *X. cancila* ($-409.99 < t_s > -4.63$). No significant difference was observed in *M. tengara* ($t_s = 1.45$, $p < 0.05$).

According to Barnham and Baxter (1998), a fish was meager and elongated with lean body (CF_f = 1.0), sound health (CF_f = 1.20) and healthy body (CF_f = 1.40). In this experiment, *D. devario, M. tengara, P. ticto, P. ranga* and *N. nandus* (CF_f > 1.04±0.03) were in good body shape but rest of the fishes collected from both rivers were poor, thin and elongated body form where the differences may be due to food loads and sexual maturity (Gupta *et al.,* 2011).

Relative body weight (BW_r) was used to recognize the prey availability, food abundance and gonad maturation of fishes (Anderson and Neumann, 1996).

In BW_r, no significant differences were found within ($-0.13 < t_s > 1.41$, $p > 0.05$) and between ($t_s = 1.78$, $p < 0.05$) fish species except *X. cancila* from 100 where this fish showed significant variation ($t_s = 2.41$, $p < 0.05$) from other species. If BW_r values of a fish were below 100 pointed to minimum prey or maximum predator availability and vice-versa (Froese, 2006; Rypel and Richter, 2008).

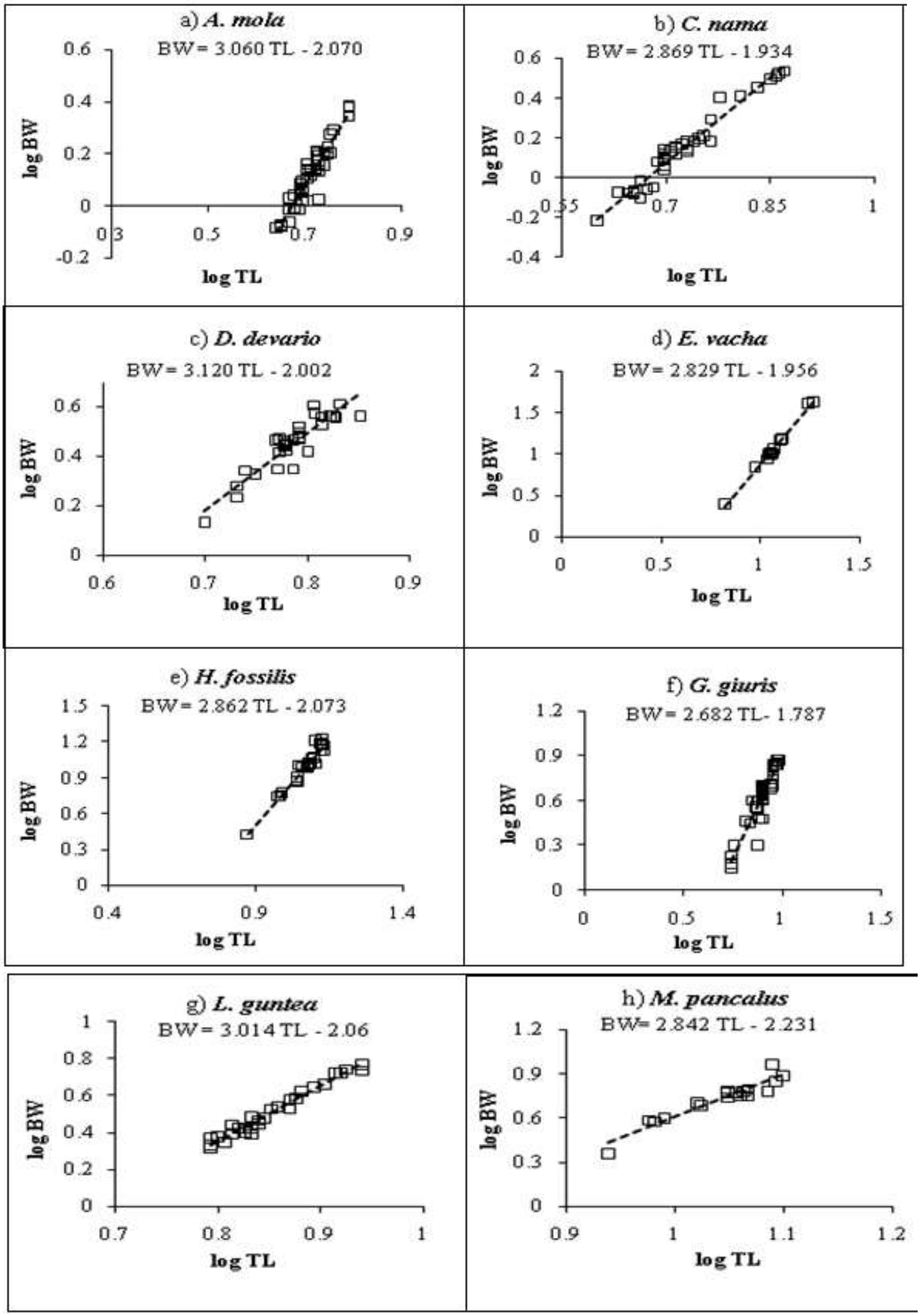

Fig. 1. Linear relationships between total length (TL) and body weight (BW) of fishes (a-h).

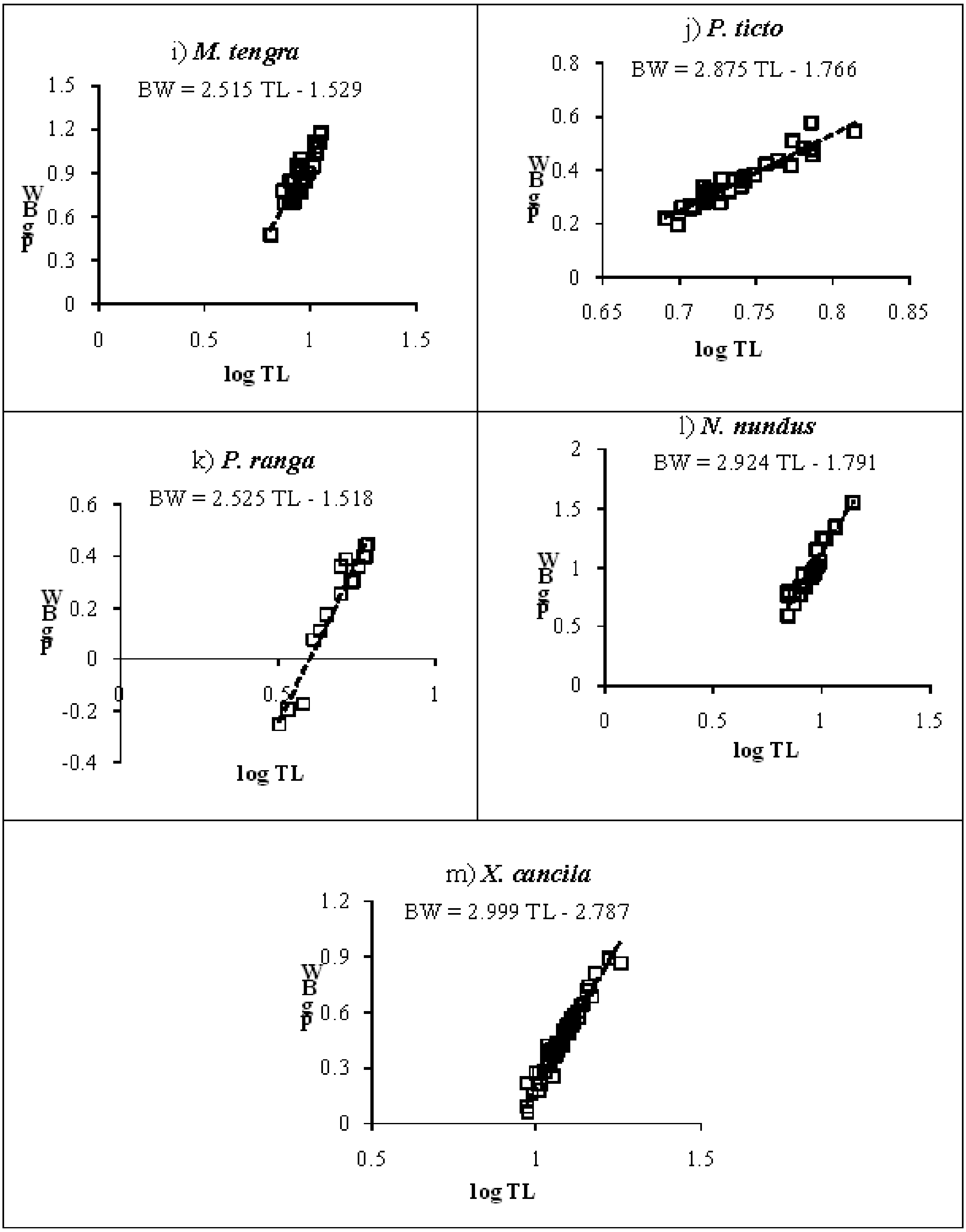

Fig. 1. (Continued) Linear relationships between total length (TL) and body weight (BW) of fishes (i-m).

The values of BW_r for all fishes were very close to 100 proposing good relation with food organisms and predators representing good aquatic ecosystem in the Atrai and Brahmaputra Rivers where water quality parameters were less dependable to decrease fish abundance than other factors such as overfishing and territory division (Mijkherjee *et al.,* 2002). So, the abundance of these small indigenous fishes are decreasing day by day from this river may be due to overfishing and alteration of ecological parameters (Mijkherjee *et al.,* 2002) instead of hydrological factors.

In these rivers, nine fishes were within expected range (0.00775-0.00906) of $a_{3.0}$ representing elongated body shape while *A. mola*, *D. devario*, *P. ticto* and *N. nandus* showed extended body height supported by the findings of Froese (2006).

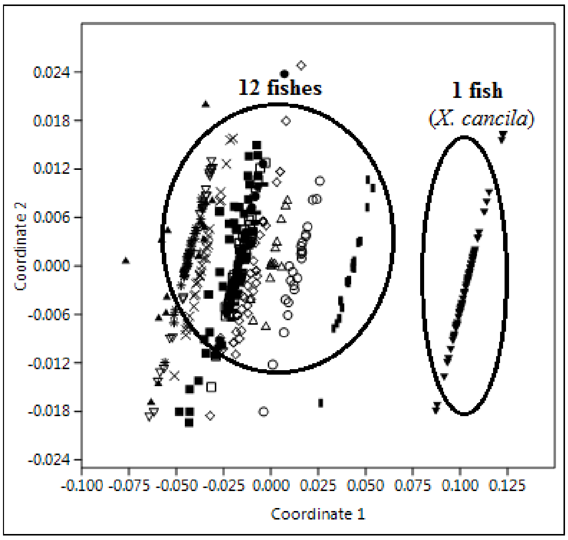

Fig. 2. A two dimensional nMDS ordination of CF_f and BW_r among fishes where *X. cancila* was isolated from another 12 fishes stressing < 0.01 in the Atrai and Brahmaputra Rivers of Bangladesh.

Form factor ($a_{3.0}$) was also used to differentiate body shape of a fish or population from other. More or less similar body form ($a_{3.0}$) was reported for *C. nama, P. ticto*, *N. nandus* in Bangladesh by Hossain *et al.* (2012b) and Hossain *et al.* (2013).

In a spearman rank test (r_s) given in Table 3 where CF_f was significantly ($p < 0.01$ or < 0.05) correlated with TL and BW_s for *G. giuris*, *M. tengara* and *P. ranga* while *BW* for *A. mola*, *D. devario* and *X. cancila* but not for another fishes. Besides, BW_r was also significantly ($p < 0.01$ or < 0.05) associated with BW for *A. mola*, *D. devario*, *G. giuris*, *M. tengara* and *X. cancila* but not for another 9 fishes. No previous reports are found to compare with these relationships but more or less similar findings were detected on different freshwater fishes in Bangladesh (Hossain *et al.,* 2012b) rather than different species and geographical area.

Similarities and dissimilarities in fishes

Furthermore, analysis of similarity (ANOSIM) represented significant distinctions ($0.08 < R < 1.0$, $p < 0.01$) among CF_f values of most fishes while no variations were observed among BW_r values except some fishes ($0.05 < R < 0.24$, $p < 0.01$) given in Table 4.

In case of CF_f, maximum variation ($R > 0.99$, $p < 0.001$) was found for *X. cancila* with other fishes but lowest ($R > 0.08$, $p < 0.01$) was record between *C. nama* and *M. tengara*. Based on BW_r values, highest deviation ($R < 0.24$) recorded between *N. nandus* and *L. guntea* while lowest ($R > 0.05$) found between *G. giuris* and *M. tengara*.

A significant difference ($R = 0.072$, $p < 0.05$) was observed among morphometric data of *Acanthocybium solandri* (Zischke *et al.,* 2013) which was different with present findings may be due to different taxa and area. A two-dimensional ordination of nMDS based on the values of CF_f and BW_r proposed that *X. cancila* was isolated from other 12 fishes stressing as < 0.01 (Fig. 2).

The variation among fishes may be due to external morphology controlled by a number of ecological and genetic factors (Cadrin, 2000) that were not considered in this study.

The potential factors that would also have abilities to alter the values of LWRs and CFs were not measured but need to grip through future assessments.

Conclusion

The basic information on LWRs and CFs of thirteen small indigenous fishes from the Atrai and Brahmaputra Rivers would be necessary dataset for future studies. In this river, *D. devario*, *P. ticto* and *N. nandus* showed good health condition and extended body shape with more adaptability in the Atrai and Brahmaputra rivers than others. Moreover, there was a good relationship between prey and predator representing proper habitats for growth and breeding of these fishes. So, a sustainable fisheries resource management system would be developed to conserve these small fishes from their declining and extinction.

Acknowledgements

The authors are gratified to fishermen and students of the department of Fisheries Biology & Genetics (HSTU) collecting specimens and assessing the measurement data.

References

Abobi SM. 2015. Weight-length models and relative condition factors of nine (9) freshwater fish species from the Yapei Stretch of the White Volta, Ghana. Elixir Applied Zoology **79**, 30427-30431.

Anderson RO, Neumann RM. 1996. Length, weight and associated structure indices. In: Fisheries Techniques. 2nd Ed. American Fisheries Society.

Bagenal TB, Tesch FW. 1978. Age and growth. In: Methods for Assessment of Fish Production in Fresh Waters. 3rd Ed. New York: USA Blackwell Science Publications, 101-136.

Barnham C, Baxter A. 1998. Condition factor 'K' for Salmonid fish. Fisheries Notes, 1-3.

Bogard JR, Thilsted SH, Marks GC, Wahab MA, Hossain MAR, Jakobsen J, Stangoulis J. 2015. Nutrient composition of important fish species in Bangladesh and potential contribution to recommended nutrient intakes. Journal of Food Composition and Analysis **42**, 120-133. http://dx.doi.org/10.1016/j.jfca.2015.03.002

Cadrin SX. 2000. Advances in morphometric identification of fishery stocks. Reviews in Fish Biology and Fisheries **10**, 91-112. http://dx.doi.org/10.1023/A:1008939104413

Cherif M, Zarrad R, Gharbi H, Missaoui H, Jarboui O. 2008. Length-weight relationships for 11 fish species from the Gulf of Tunis (SW Mediterranean Sea, Tunisia). Pan-American Journal of Aquatic Sciences **3**, 1-5.

Didenko AV, Bonar SA, Matter WJ. 2004. Standard weight (*W*s) equations for four rare desert fishes. North American Journal of Fisheries Management **24**, 697-703. http://dx.doi.org/10.1577/M02-119.1

Froese R, Thorson JT, Reyes Jr, RB. 2014. A Bayesian approach for estimating length-weight relationships in fishes. Journal of Applied Ichthyology **30**, 78-85. http://dx.doi.org/10.1111/jai.12299

Froese R. 2006. Cube law, condition factor and weight-length relationships: History, meta-analysis and recommendations. Journal of Applied Ichthyology **22**, 241-253. http://dx.doi.org/10.1111/j.1439-0426.2006.00805.x

Fulton TW. 1904. The rate of growth of fishes. Twenty-second Annual Report, Part III. Fisheries Board of Scotland, Edinburgh, 141-241.

Gupta BK, Sarkar UK, Bhardwaj SK, Pal A. 2011. Condition factor, length-weight and length-weight relationships of an endangered fish *Ompok pabda* (Hamilton, 1822) (Silurifomes: Siluridae) from the River Gomti, a tributary of the River Ganga, India. Journal of Applied Ichthyology **27**, 962-964. http://dx.doi.org/10.1111/j.1439-0426.2010.01625.x

Hossain MY, Ahmed ZF, Leunda PM, Islam AKMR, Jasmine S, Oscoz J, Miranda R, Ohtomi J. 2006. Length-weight and length-length relationships of some small indigenous fish species from the Mathabhanga river, southwestern Bangladesh. Journal of Applied Ichthyology **22,** 301-303. http://dx.doi.org/10.1111/j.1439-0426.2006.00801.x

Hossain MY, Hossen MA, Pramanik MNU, Sharmin S, Nawer F, Naser SMA, Bahkali AH, Elgorban AM. 2016. Length-weight and length-length relationships of five *Mystus* species from the Ganges and Rupsha rivers, Bangladesh. Journal of Applied Ichthyology **32**, 994-997. http://dx.doi.org/10.1111/jai.13135

Hossain MY, Jasmine S, Ibrahim AHM, Ahmed ZF, Rahman MM, Ohtomi J. 2009. Length-weight and length-length relationships of 10 small fish species from the Ganges, Bangladesh. Journal of Applied Ichthyology **25,** 117-119. http://dx.doi.org/10.1111/j.1439-0426.2008.01168.x

Hossain MY, Rahman MM, Ahamed F, Ahmed ZF, Ohtomi J. 2013. Length-weight and length-length relationships and form factor of three threatened fishes from the Ganges river (NW Bangladesh). Journal of Applied Ichthyology **30**, 221-224. http://dx.doi.org/10.1111/jai.12251

Hossain MY, Rahman MM, Fulanda B, Jewel MAS, Ahamed F, Ohtomi J. 2012a. Length-weight and length-length relationships of five threatened fish species from the Jamuna (Brahmaputra river tributary) River, northern Bangladesh. Journal of Applied Ichthyology **28**, 275-277. http://dx.doi.org/10.1111/j.1439-0426.2011.01900.x

Hossain MY, Rahman MR, Jewel MAS, Ahmed ZF, Ahamed F, Fulanda B, Abdallah EM, Ohtomi J. 2012b. Conditions- and form-factor of the five threatened fishes from the Jamuna (Brahmaputra river Distributary) River, northern Bangladesh. Sains Malaysiana **41,** 671-678.

Islam MR, Mia MJ. 2016. Length-weight and length-length relationships of five fish species in the Atrai River, Dinajpur, Bangladesh. Journal of Applied Ichthyology **32,** 1371-1373. http://dx.doi.org/10.1111/jai.13210

Islam MR, Mollah MFA. 2012. Morphological observation and PG-induced breeding of *Glossogobius giuris* (Hamilton, 1822). Journal of Science and Technology **11,** 171-180.

IUCN Bangladesh. 2016. Upgrading species red list of Bangladesh. The IUCN red list of threatened species. Species list available at www.iucnredlistbd.org.

Khan MA, Sabah. 2013. Length-weight and length-length relationships for five fish species from Kashmir Valley. Journal of Applied Ichthyology **29**, 283-284. http://dx.doi.org/10.1111/j.1439-0426.2012.02061.x

Koutrakis ET, Tsikliras AC. 2003. Length-weight relationships of fishes from three northern Aegean estuarine systems (Greece). Journal of Applied Ichthyology **19**, 258-260. http://dx.doi.org/10.1046/j.14390426.2003.00456.x

Le Cren ED. 1951. The length-weight relationships and seasonal cycle in gonad weight and condition in the perch (*Perca fluviatilis*). Journal of Animal Ecology **20,** 201-219. http://dx.doi.org/10.2307/1540

Mijkherjee M, Praharaj A, Das S. 2002. Conservation of endangered fish stocks through artificial propagation and larval rearing technique in West Bengal, India. Aquaculture Asia 2, 8-11.

Ozaydin O, Uckun D, Akalin S, Leblebici S, Tosunoglu Z. 2007. Length-weight relationships of fishes captured from Izmir Bay, Central Aegean Sea. Journal of Applied Ichthyology **23,** 695-696. http://dx.doi.org/10.1111/j.1439-0426.2007.00853.x

Rahman AKA. 2005. Freshwater fishes of Bangladesh. 2nd Ed. Zoological Society of Bangladesh, Department of Zoology, University of Dhaka, Dhaka-1000, 364.

Richter TJ. 2007. Development and evaluation of standard weight equations for bridge-lip suckers and large-scale suckers. North American Journal of Fisheries Management **27**, 936-939. http://dx.doi.org/10.1577/M06-087.1

Rypel AL, Richter TJ. 2008. Empirical percentile standard weight equation for the black tail red horse. North American Journal of Fisheries Management **28,** 1843-1846. http://dx.doi.org/10.1577/M07-193.1

Simon KD, Bakar Y, Samat A, Zaidi CC, Aziz A, Mazlan AG. 2009. Population growth, trophic level and reproductive biology of two congeneric archer fishes (*Toxotes chatareus*, Hamilton 1822 and *Toxotes jaculatrix*, Pallas 1767) inhabiting Malaysian coastal waters. Journal of Zhejiang University Science B **10,** 902-911. http://dx.doi.org/10.1631/jzus.B0920173

Sokal RR, Rohlf FJ. 1987. Introduction to Biostatistics. 2nd Ed. New York: Freeman Publication.

Stoddard JL, Larsen DP, Hakins CP, Johnson RK, Norris RH. 2006. Setting expectations for the ecological conditions of streams: The concept of reference condition. Ecological Applications **16,** 1267-1276.
http://dx.doi.org/10.1890/10510761(2006)016[1267:SEFTEC]2.0.CO;2

Subba BR, Mehta SN, Adhikaree S. 2012. Length-weight and length-length relationships in freshwater garfish *Xenentodon cancila* (Ham.) from Muriyadhar, Sunsari, Nepal. Journal of Natural History Museum **26,** 10-14.

Zischke MT, Griffiths SP, Tibbetts IR, Lester RJG. 2013. Stock identification of wahoo (*Acanthocybium solandri*) in the Pacific and Indian Oceans using morphometrics and parasites. ICES Journal of Marine Science **70**, 164-172.
http://dx.doi.org/10.1093/icesjms/fss164