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Research Article

Morphometric Measurements and Sexual Dimorphism of Barramundi *Lates calcarifer* (Bloch, 1790) from the Coastal Rivers Adjoining Bay of Bengal

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Abstract

Background and Objective: Barramundi *Lates calcarifer* is one of the commercially most important fish species due to its consumer preference and high market demand. However, indiscriminate exploitation and anthropogenic activities have impacted the species abundance in the coastal rivers of Bangladesh. A comparative study was carried out to illustrate the sexual dimorphism in terms of Sex Ratio (SR), Length-Weight Relationships (LWRs), condition factor (K_F) and relative weight (W_R) of *Lates calcarifer*. **Materials and Methods:** Altogether 204 individuals were collected ranging from 15.00-40.10 cm in total length and 47.00-478.00 g in weight from the four rivers, for investigation over a period of one year from June, 2014 to May, 2015. Student t-test, Mann-Whitney U-test, Wilcoxon signed rank test and Principal Component Analysis (PCA) were performed by SPSS v. 16. **Results:** The result showed that the sex ratio, body weight and condition factor did not reveal significant variation between the males and females of *Lates calcarifer*. The LWRs for males (Log a = -3.493, b = 2.694) and females (Log a = -3.120, b = 2.577) indicated negative allometric growth for both sexes. **Conclusion:** Very little studies have been carried out on these parameters of *Lates calcarifer* and this study would be considered the comprehensive report on morphometric measurements and their sexual dimorphism of *Lates calcarifer* inhabiting in the coastal rivers of Bangladesh along with its wide geographical distribution.

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INTRODUCTION

Lates calcarifer, commonly known as Asian sea bass and Barramundi, is a large euryhaline species found in the freshwater, brackish and coastal environment in Taiwan, Papua New Guinea and northern Australia[1]. This species is also abundantly available in Bangladesh, India, Pakistan, Myanmar, Thailand[2] and identified as a potential candidate for aquaculture[3]. In many countries, including Bangladesh the culture techniques and seed production technologies of this species are yet to develop[4]. Furthermore, the wild stock of *Lates calcarifer* is facing increasing pressure to fulfill the demand of table size fish and on the other hand, natural fry and fingerlings are indiscriminately exploited by fishermen for stocking in the farming condition[5]. Thus, the natural stock of this important fishery in Bangladesh is gradually diminishing[6]. However, some factors including anthropogenic activities, intense tourism, pollution and even global changing consequences have changed the coastal waters and ecosystems of Bangladesh significantly over the years[6-11].

Sexual dimorphism based on Length-weight Relationships (LWRs), condition factor, form factor and relative growth of fish is crucial to diagnose the general well-being of the fish population in a particular area[12-15]. Condition factor, a quantitative parameter, is being calculated from length-weight data and indicates the life cycle of fish species, the population success in terms of present and future by its influence on growth and reproduction and therefore contributes to the adequate management of these species[12]. Similarly, sex ratio and size structure provide fundamental information to assess the potentiality of reproduction and estimate the populations stock size[11,16]. Despite some available reports on LWRs and condition factor on barramundi in brackish water tide-fed ponds[2] or in open sea floating cages[4] in Indian waters, sexual dimorphism studies of *Lates calcarifer* have never been undertaken before in its wide geographical locations. Thus, the current investigation was aimed to evaluate morphometric measurements and sexual dimorphism based on Sex Ratio (SR), length-weight (LWRs), condition factor (K_F) and relative weight (W_R) of *Lates calcarifer* in the rivers adjoining Bay of Bengal, Bangladesh.

MATERIALS AND METHODS

Specimen collection and preparation: Fish specimen were procured monthly from the four coastal rivers; Baleswar, Bishkhali, Burishwar and Andermanik positioned in the southern coastal region of Bangladesh during June, 2014 to May, 2015 (Fig. 1). The collected specimens were kept in ice for preservation and fixation with 10% buffered formalin were performed to keep the fish safe and undamaged from any deterioration until arriving at the laboratory. All morphometric features were measured following the method as given by Siddik *et al.*[6]. The identification of sexes was done through the visual inspection of morphometric characteristics and gonads[17].

Descriptive statistics: The LWRs were estimated by growth equation model given by Ricker[18]: $BW = a \times TL^b$, which was converted logarithmic form[19] as:

$$Log\ BW = Log\ a + b\ Log\ TL$$

Where:
BW = Body weight
SL = Standard length
a = Intercept
b = Slope

A t-test was used to identify significant variation between b and isometric growth (b = 3)[20].

The well-being of individual was estimated by Fulton condition factor given by Fulton[21] as:

$$K_F = BW \times 100 / SL^3$$

Where:
BW = Body weight
SL = Standard length

and the factor 100 is used to bring K_F close to unity. Moreover, relative weight (W_R) for each individual was also calculated by the formula given by Froese[16] as:

$$W_R = \frac{W}{W_S} \times 100$$

where, W is the weight of a particular individual and W_S is the predicted standard weight for the same individual as calculated by $W_S = a \times L^b$, where the a and b values are obtained from the length-weight relationships. A student t-test was applied to reveal significance variation in the value of b from expected cube law in order to find out either isometric or allometric growth. All statistical calculation such as student t-test, Mann-Whitney U-test, Wilcoxon signed rank test and Principle Component Analysis (PCA) were performed by SPSS v. 16 at 5% (p<0.05).
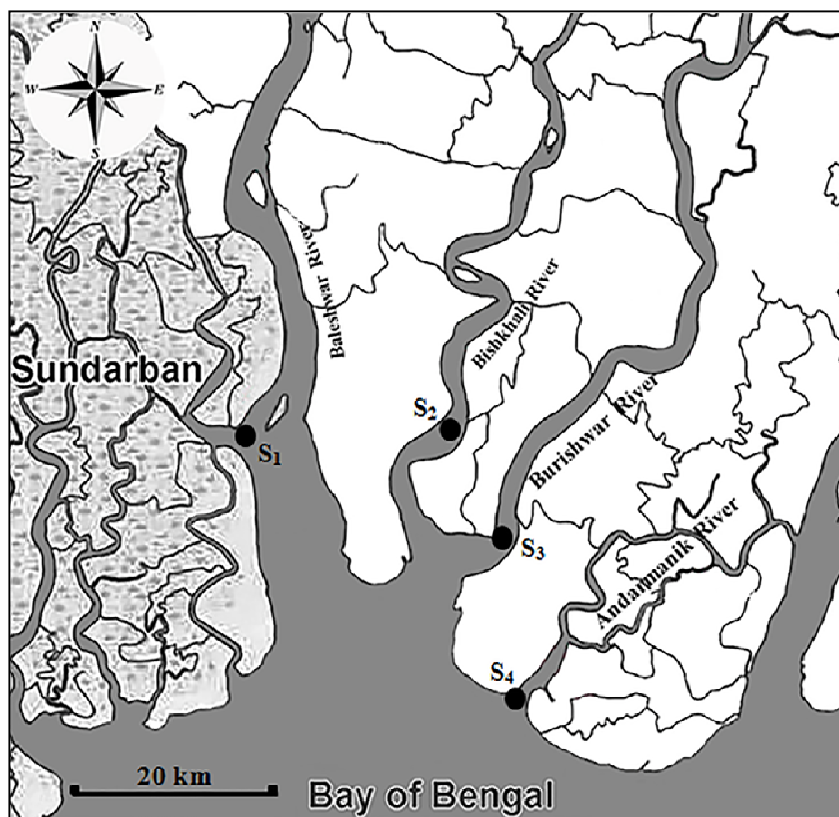
Fig. 1: Sampling sites of *Lates calcarifer* from the four coastal rivers adjoining the Bay of Bengal, southern Bangladesh

RESULTS

Altogether 204 individual were analyzed to demonstrate the sexual dimorphism of *Lates calcarifer* in the present study and the results showed that females have a higher mean value compared to males in all examined morphometric measurements. Descriptive statistics including mean, lengths and body weights range, Standard Deviation (SD), 95% Confidence Limit (CL) for both sexes are given in Table 1.

The size composition of males and females of *Lates calcarifer* is represented in Fig. 2 which clearly revealed that females were predominant during the study period. Among total samples for this study, males represent 49% and females 51% (male = 98; female = 106; male: female = 1: 1.05) (Table 2) which showed that the overall sex ratio remained within the expected sex ratio of 1:1 (df = 1, χ^2 = 0.34, p>0.05). The TL reliant sex ratio of *Lates calcarifer* depicted that males and females were prevailing in the 15.00-30.99 TL groups (Table 2).

The detailed information regarding sample size, regression parameters (a, b) and their range in 95% confidence intervals, coefficients of determination (r^2) for length-weight relationships are presented in Table 3. The coefficient of correlation (r^2) was highly significant (p<0.001) in all cases with high r^2 values (>0.9). The calculated allometric coefficient b based on various body dimension was significantly different from 3 (t-test: <3.0, p<0.01), indicating negative allometric growth for both sexes. T-test values for males (t = -3.36, df = 96, p$\leq$0.01) and females (t = 3.45, df = 104, p$\leq$0.01), clearly indicated negative allometric growth for both sexes instead of isometric growth. The ANCOVA revealed significant differences between genders for the intercepts a and slopes b of the regression lines (ANOVA, p<0.05). Principal Component Analysis (PCA) was applied to analyze the sexual dimorphism based on morphometric measurement indicated that there was an intermingling relationship found between the sexes during the study period (Fig. 3).

The condition factor (K_F) of *Lates calcarifer* were estimated for each 6 cm length group by using body weight (Fig. 4). The K_F values in males ranged from 0.88-1.47 and 0.68-1.60 in females (Table 4), which did not show significant variation between sexes according to Mann-Whitney U-test. The W_R value for male and female *Lates calcarifer* ranging
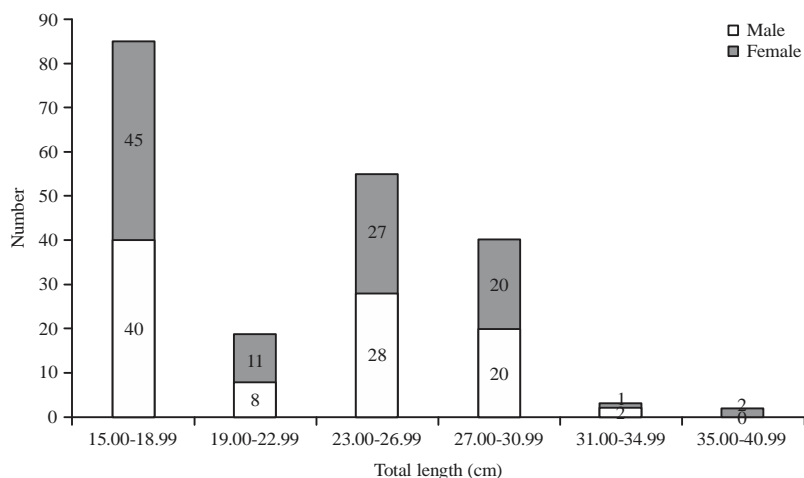
Fig. 2: Number of individuals represented by total length class group during the study period

Table 1: The descriptive statistics of barramundi *Lates calcarifer* sampled from coastal rivers adjoining the Bay of Bengal, Bangladesh

		Sex	
Morphometric measurements		Male (♂) (99)	Female (♀) (105)
Total length (cm)	Min	15.00	15.30
	Max	34.40	40.10
	Mean±SD	22.21±5.24	22.22±5.62
	95% CL	21.16-23.27	21.14-23.30
Standard length (cm)	Min	9.70	10.00
	Max	26.40	35.60
	Mean±SD	17.17±4.95	17.26±5.32
	95% CL	16.17-18.16	16.23-18.28
Body weight (g)	Min	42.00	47.00
	Max	426.00	478.00
	Mean±SD	146.16±89.08	147.50±96.33
	95% CL	128.30-164.02	128.94-166.05

Min: Minimum, Max: Maximum, CL: Confidence level, SD: Standard deviation

Table 2: length class, number of male and female and sex ratio of *Lates calcarifer* from the coastal rivers, southern Bangladesh

				Ratio			
Length class (TL, cm)	Total	Males	Females	Male	Female	χ^2	Significance
15.00-16.99	54	28	26	1	0.93	0.07	ns
17.00-18.99	31	12	19	1	1.58	1.58	ns
19.00-20.99	8	2	6	1	3.00	2.00	ns
21.00-22.99	11	6	5	1	0.83	0.10	ns
23.00-24.99	26	13	13	1	1	0.00	ns
25.00-26.99	29	15	14	1	0.93	0.04	ns
27.00-28.99	22	12	10	1	0.83	0.18	ns
29.00-30.99	18	8	10	1	1.25	0.22	ns
31.00-32.99	1	1	0	1	-	1.00	ns
33.00-34.99	2	1	1	1	1	0.00	ns
35.00-36.99	0	0	0	-	-	-	-
37.00-38.99	0	0	0	-	-	-	-
39.00-40.99	2	0	2	-	-	0.00	ns
Overall	204	98	106	1	1.08	0.34	ns

ns: Not significant

from 100.4-109.8 and 101.9-109.7, respectively did not highlight significant variation (Table 4). The Wilcoxon signed rank test presented that the W_R (actual median = 104.31 for males and 106.30 for females) did not deviate from 100 for males and females in this study, indicating the dwelling ambience of *Lates calcarifer* was still in good condition.

Table 3: Estimated parameters of length –weight relationship based on various body dimensions of barramundi *Lates calcarifer* from the coastal rivers, southern Bangladesh

Sex	Equation	a±SE	95% CL of a	b±SE	95% CL of b	r^2	GT
Male (♂) (98)	$BW = a \times TL^b$	0.030±0.09	0.025-0.037	2.694±0.03	2.634-2.755	0.988	A-
	$BW = a \times SL^b$	0.398±0.18	0.278-0.578	2.040±0.06	1.913-2.166	0.914	A-
Female (♀) (106)	$BW = a \times TL^b$	0.044±0.11	0.036-0.055	2.577±0.04	2.507-2.646	0.981	A-
	$BW = a \times SL^b$	0.362±0.11	0.290-0.452	2.072±0.04	1.993-2.151	0.963	A-

a: Intercept, b: Slope, SE: Standard error, r^2: Coefficient of determination, GT: Growth type, A-: Negative allometry growth

Table 4: Fulton condition factor (K_F) and relative weight (W_R) of male and female of *Lates calcarifer* from the coastal rivers, southern Bangladesh

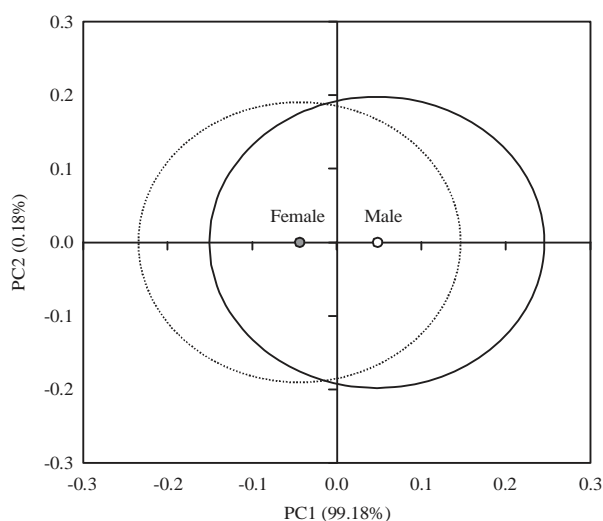|		Sex	
Measurements		Male (♂)	Female (♀)
Fulton condition factor (K_F)	Min	0.88	0.68
	Max	1.47	1.60
	Mean±SD	1.20±0.12	1.21±0.16
	95% CL	1.17-1.22	1.18-1.24
Relative weight (W_R)	Min	100.41	101.90
	Max	109.75	109.70
	Mean±SD	105.20±2.95	105.90±2.50
	95% CL	103.09-107.30	104.30-107.60

Fig. 3: Scatterplot of the placement of males and females individual on PC1 and PC2 of *Lates calcarifer* from the coastal rivers, southern Bangladesh
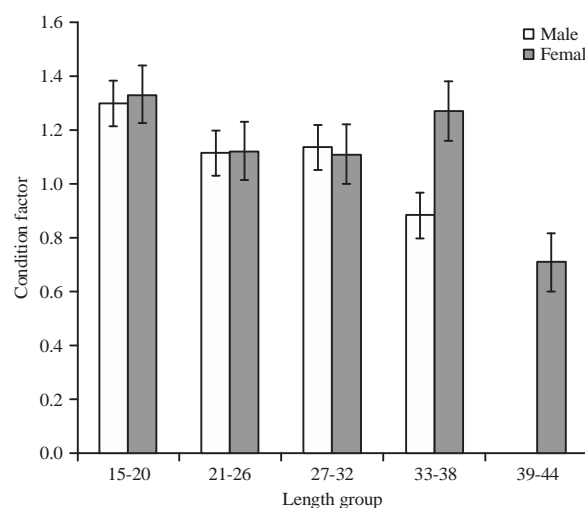

Fig. 4: Mean condition factors of male and female of *Lates calcarifer* per 6 cm length groups from the coastal rivers, southern Bangladesh

DISCUSSION

The maximum size of *Lates calcarifer* in the current study was 40.10 cm which was markedly smaller than 200 cm reported by Huda *et al.*[22]. The present study recorded 478 g as the maximum weight, much less than 1536 g reported by Karna *et al.*[23] in Chilika Lagoon, India. A large number of individuals of numerous body sizes were collected by using different fishing gear but it was impossible to catch out of the given range during the sampling period, which may be due to their presence or the selectivity of the fishing gear.

In the present study, the sex ratio of *Lates calcarifer* was 1:1.08 which demonstrated slightly female predominance over male but not departing from the expected sex ratio of 1:1. Sex ratio may be attributed by one or a combination of the factors: (1) Biased sex determination, (2) Adaptation of the population and reproductive behavior, (3) Divergent sexual behavior, (4) Environmental condition, (5) Food availability and (6) Growth rate and longevity of a species[24,25]. However, which factors that influence the fluctuation of male-female sex ratio was not clear in the presented study.

The value of (b) obtained from the regression analysis on the basis of various body dimensions for both sexes was significantly differed from 3.0 but did not exceed the expected limit of 2.0-3.5 as reported in various studies for most fishes[26,27]. Karna *et al.*[23] estimated the (b) values 2.683 for male, 2.613 for female and 2.663 for the combined gender of *Lates calcarifer* in Chilika Lagoon, India. The samples collected for the present study mostly from the estuary and maximum samples were juvenile and pre-adult according to size. The regression coefficient (b) generally remains static at 3.0 for an ideal fish and variation from 3.0 is uncommon in adult fishes suggested by Beverton and Holt[28]. It is recognized that fluctuations of exponent (b) can be affected by a set of factors: ecological conditions of the habits or physiological variation of animals or both[19]; feeding frequency, development of gonad and growth phase, behavior and water flow[22]; number of specimens examined, preservation technique, seasonal variation, sex, degree of stomach fullness and differences in the observed length ranges of the specimens caught[29-32].

Condition factor calculated from length-weight is an index widely used to assess the condition of the aquatic ecosystem[33]. According to population dynamics studies, the high values of condition factor shows the satisfactory conditions of environment such as auspicious habitat and the ample number of prey, while values below the optimum detect the less satisfactory condition of the environment[34]. Le Cren[19] stated K_F value above 1 denotes general wellbeing of the fish whereas values below 1.0 indicate the opposite condition. The mean value of K_F was 1.20 for male and 1.21 for female which means fish were thriving well in this environment. The results revealed that Fulton's condition factor didn't show significant variation (ANOVA, p>0.05) between females and-males. The mean condition factor was higher for females compared to males. These results show a tendency for the female to be grown faster and reached older ages compared to male and also might be attributed due variation in metabolism and oxygen consumption between sexes.

Relative weight (W_R), on the other hand, is an important factor useful for making the comparison of the condition of populations and species. Rypel and Richter[35] reported that the estimated value of W_R beneath 100 for an individual, size group or population suggesting the poor availability of prey or affluent density of predator; whereas values higher than 100 indicate the surplus number of prey or low predator density. The calculated value of relative weight (W_R) was very close to 100 indicates that the habitats are yet congenial for this species with available food and prey. During this study, there was no significant deviation of mean value of W_R for both sexes from the expected value of 100, indicating the habitat was still in balance condition with the availability of food despite the presence of predators[36] and might recommend that the water quality of the coastal rivers is yet congenial for fisheries.

Although fish specimens were collected over an extended period of time, the seasonal and anthropogenic effect influencing sex ratio, allometric coefficient, condition factor and relative weight of fish was not considered for the study. Therefore, further study should be warranted in relation to several factors such as seasonal, anthropogenic and environmental effects on the morphometric variability and sexual dimorphism of *Lates calcarifer.*

CONCLUSION

The results showed the existence of sexual dimorphism in *Lates calcarifer* based on sex ratio, length-weight relationships, condition factor and relative growth, yet these variations were not significant (p>0.05).

SIGNIFICANCE STATEMENT

The study provides some basic biological aspects of male and female barramundi *Lates calcarifer* in Bangladeshi waters which would be beneficial for fishery scientists and conservationists to take appropriate plan for the management of *Lates calcarifer* fishery sustainably and conservation of this species inhabiting in the coastal rivers of Bangladesh.

ACKNOWLEDGMENT

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