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Some aspects of population dynamics of Indian River shad, *Gudusia chapra* in the greater Jessore region, Southeast Bangladesh

Md. Sherazul Islam[1*], Kakoly Khanam[1], Nafisa Islam[2]

[1]*Department of Fisheries and Marine Bioscience, Jessore University of Science and Technology, Jessore-7408, Bangladesh*

[2]*Department of Biosciences, Graduate School of Science and Technology, Shizuoka University, Japan*

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Abstract

The Indian river shad *Gudusia chapra* is an important small indigenous food fish in Bangladesh. The study of the population dynamics particularly length-weight relationship of any fishes forms an important base for fish biology. The statistical relationship between these two parameters has great significance with regard to their morphology, biology, nutrition, condition and growth rate. In the present study, population demography, size-class distribution, length-weight relationship and sexual distribution of *G. chapra* were analyzed from greater Jessore region, Southeast Bangladesh. A total of 166 individuals were sampled during May to December, 2015 from twelve markets of four sub-districts of Jessore. The maximum length and weight measured 160.02 mm and 31.56 g respectively. The average total length and body weight were 103.63±21.86 mm and11.03±5.80 g respectively and most species was belonging to the size class of 71-130 mm. The size class distribution of the species varied monthly but similar pattern exhibited in both sexes and seasons. The length-weight relationships were Log W= 4.071+2.516 Log L for combined sexes, Log W= 4.137+2.545 Log L for male, Log W=3.931+2.450 Log L for female, Log W=3.929+2.450 Log L in monsoon and Log W= 4.801+2.884 Log L during winter season respectively. The total length and body weight relationship was linear and fish exhibits negative allometric growth as the b<3. The overall sex ratio showed significant differences from the expected value 1:1 (male: female = 1:1.81, $\chi 2$ =13.88, p<0.001) and females were dominance over the males throughout the study period.

* **Corresponding Author:** Md. Sherazul Islam ✉ tuhinkk@yahoo.com

Introduction

The Indian river shad *Gudusia chapra* (Hamilton-Buchanan, 1822) is a small indigenous fish species of Bangladesh. This species is widely distributed in the natural waters of Asia throughout the Indian sub-continent including Bangladesh, India, Pakistan, Nepal, Bhutan, Sri-Lanka, Myanmar, and Afghanistan (Talwar and Jhingran, 1991; Froese and Pauly, 2009).

The species found mostly in wetlands, derelict water bodies, lakes, ponds, ditches, inundated fields and closed water impoundments (Rahman and Haque, 2006; Mondal and Kaviraj, 2010).

The species represents an important fishery in the artisanal fisheries of the Indian sub-continent and is an important source of livelihood for many of the subsistence and artisanal fisher folks (Talwar and Jhingran, 1991; Jayaram, 1999; Daniels, 2002).

In Bangladesh, *G. chapra*is one of the important small indigenous fish species reported as both an important food source and a crucial source of micronutrients essential in preventing malnutrition and vitamin and mineral deficiencies in the rural communities, particularly among women and children (Thilsted *et al.*, 1997; Thilsted, 2003).

However, in the recent years population of the fish has alarmingly declined in the rivers and other reservoirs and its production has been restricted to impoundments water bodies like ponds, inundated fields etc. (Rahman, 1989; Alam *et al.*, 2002; Rahman and Haque, 2006).

The study of the length-weight relationship of fishes forms an important base for fish biology.

The statistical relationship between these two parameters has great significance with regard to their morphology, biology, nutrition, condition and growth rate. Further, this relationship is useful in differentiating small taxonomic units, as variations may occur within populations of different localities (Le Cren, 1951).

In addition, the size-class distribution has great importance in fish culture and fisheries management. Sex ratio also is an indicator of population behaviour (Panthulu, 1961). An understanding of the sex ratio of a fish in different months and seasons is essential for obtaining information on seasonal segregation of the sexes and also their differential growth. Several studies have already been conducted on *G. chapra* in other countries like, morphology, meristic and non-meristic characters from Agra, India (Chondar, 1975 and 1976), length-weight relationship from the Betwa (Yamuna River tributary) and Gomti (Ganga River tributary) rivers, India (Sani *et al.*,2010) and age and growth from Pakisthan (Narejo *et al.*, 2000).

In Bangladesh, also have done several studies like, growth and reproduction of *G. chapra* from river Brahmaputra, northeast Bangladesh (Ahmed *et al.*, 2007), length-weight and length-length relationship from the Ganges, northwestern Bangladesh (Hossain *et al.*, 2009) and the population biology from old Brahmaputra river, northeast Bangladesh (Ahamed *et al.*, 2014). But there is no details study on the population dynamics of *G. chapra* from south-eastern part of Bangladesh. Therefore, the present study first time describes the population demography, size-class distribution, length-weight relationship and sexual distribution in order to provide the much-needed information for the sustainable management of this species in the region.

Materials and methods

Sample collection and preservation

Samples were collected from three fish market in each of the four districts namely Jessore, Narail, Jhinaidah and Magura of greater Jessore area (Fig. 1). The study was conducted for eight months from May to December, 2015. Immediately after collection, the fishes were stored in ice box with sufficient ice and then brought back to laboratory of Fisheries and Marine Bioscience department of Jessore University of Science and Technology. The further morphometric measurement and analysis such as length-weight relationship, size-class distribution and sex ratio were carried out in the same laboratory of the department.

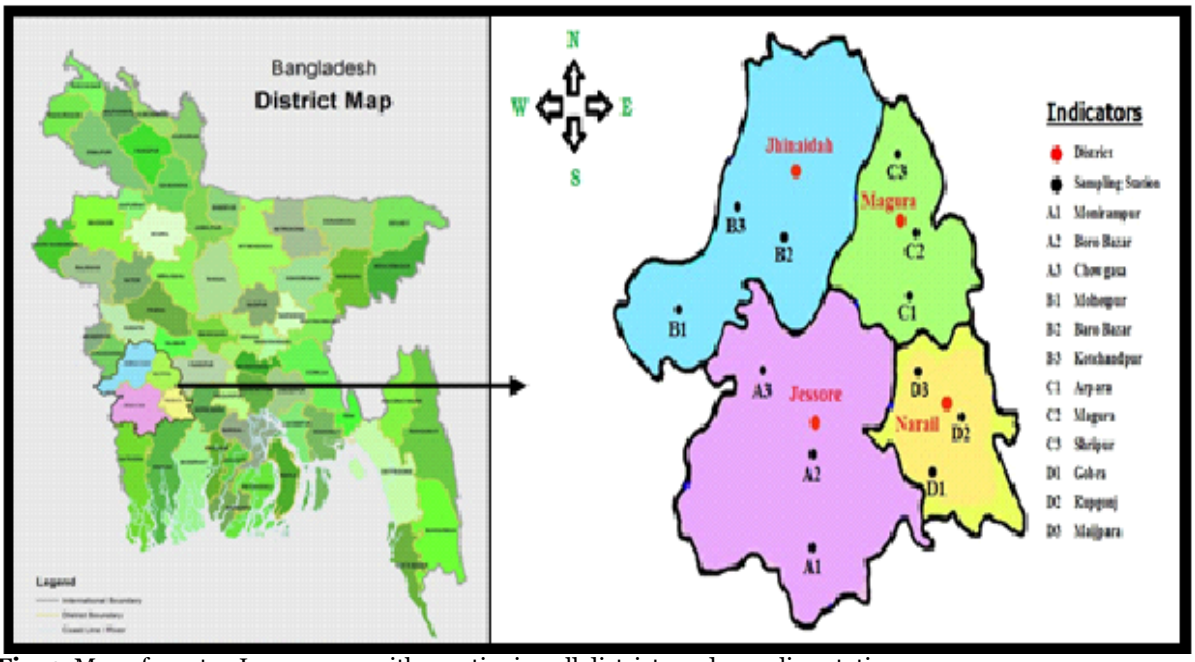

Fig. 1. Map of greater Jessore area with mentioning all districts and sampling stations.

Sex determination and sex ratio

Fishes were sexed as male and female observing the genital pore and gonads with naked eye.

Then the overall sex ratio, month and season-wise sex ratio were calculated. Chi-square test was made to find out the sex ratio for the difference, if any, from hypothetical ratio 1:1 (Hoda, 1986).

Morphometric measurement and analysis

The collected specimens were confirmed according to the morphometric characteristics followed by Encyclopaedia of Flora and Fauna; Freshwater Fishes (Ahmed *et al.*, 2009). In the laboratory; each individual fish was measured for the total length (TL) to the nearest millimetre by using a slide callipers' (Electronic digital calliper) and for the body weight (BW) recorded to the nearest grams by using an electric balance (A & D company, Model: EK 1200i; Made in Japan).

The collected specimens were classified into different size class according to 20 mm intervals. The samples of the months June to October considered as monsoon while November and December considered as winter season. The size-class distribution was also analyzed regarding to their sexes and seasons.

Length-weight relationship

The length-weight relationship of the collected specimens was estimated by the allometric formula (Ricker, 1975),

$\text{Log } W = \text{Log } a + b \text{ Log } TL.$

Where W is dependent variables (i.e., total body weight in g) and L in independent variables (i.e., total length in mm), a is the intercept of the regression and b is the regression coefficient (slope). Values of the exponent b provide information on fish growth. When b values = 3, indicate the isometric growth. When the value of $b>3$ indicate the positive allometric growth and $b<3$ indicate the negative allometric growth. The length-weight relationship was analysed based on the sexes and seasons.

Results

Population demography

The average value of total length, body weight, maximum and minimum size of *G. chapra* are presented in Table 1.

The maximum and minimum length of all individuals recorded 160.02 mm and 52.14 mm with the mean value 103.63±21.86 mm while weight were 31.56 g and 1.46 g with mean value 11.03±5.80 g.

Table 1. Population demography of *G. chapra* collected from different fish market in Jessore region.

	Max* length (mm)	Min* length (mm)	Average length ± SD*	Max weight (g)	Mini weight (g)	Average weight ± SD*
All individuals	160.02	52.14	103.63±21.86	31.56	1.46	11.03±5.80
All male	127.48	57.00	92.42±17.06	16.54	1.78	7.95±3.86
All female	160.02	52.14	109.69±21.83	31.56	1.46	12.72±6.01
M* all	160.02	52.14	103.32±20.86	29.36	1.46	11.03±5.33
M* male	127.48	57.00	94.29±18.12	16.54	3.14	8.67±4.04
M* female	160.02	52.14	106.36±20.99	29.36	1.46	11.87±5.50
W* all	147.00	60.50	97.69±17.69	31.56	1.78	9.69±5.22
W* male	121.00	60.50	90.05±15.70	16.30	1.78	7.34±3.61
W* female	147.00	73.52	106.87±15.79	31.56	3.88	12.55±5.66

M*= Monsoon, W*= Winter, SD*= Standard deviation, *Max=Maximum, *Min=Minimum.

The average value of length and weight for male and female were 92.42±17.06 mm and 7.95±3.86 g respectively. The larger individual was female and average size of female was larger than male in both seasons.

Size-class distribution

The length of *G. chapra* is divided into six classes at 20 intervals which are presented in the Fig. 2 for its size group. In case of both sexes, the highest (30%) numbers of individuals were under the size class 91-110 mm. Males were dominated in small size-group particularly in the size-class 71-90. The larger individuals were below 2% of the population.

Table 2. Regression parameters for length-weight relationship of *G. chapra* from Southeast Bangladesh.

Sex/ Season	Regression equation	a	b	R^2
Both sexes	Log W= –4.071+2.516 Log L	4.071	2.516	0.911
Male	Log W= –4.137+2.545 Log L	4.137	2.545	0.921
Female	Log W= –3.931+2.450 Log L	3.931	2.450	0.886
Monsoon	Log W= –3.929+2.450 Log L	3.929	2.450	0.889
Winter	Log W= -4.801+2.884 Log L	4.801	2.884	0.957

In the present study, samples were collected mostly in two seasons, namely monsoon and winter. In monsoon, a total of 96 individuals were encountered and showed that the largest male and female were 127.48 mm and 160.02 mm while in winter, among 60individuals the largest male and female were 121mm and 147 mm respectively. In both seasons, most male individuals were under the size group 71-90 mm. The highest female individuals (44%) were smaller group size (91-110 mm) in winter rather than the monsoon. In monsoon, the largest size group (32%) of female reported in size-class 111-130 mm (Fig. 3).

Month wise size class distribution of *G. chapra*is presented in Fig. 4. Different size group noticed in different months. The smallest group (50-70 mm) recorded in the month of June-July and November-December which may indicate twice recruitment of the species in a year. In addition, larger individuals did not notice after the month of September.

Length-weight relationship

The parameter of length-weight relationship (LWR) along with regression coefficient (R2) of G. chapra is presented in Table 2. The LWR in the present study was analysed according to their sexes and seasons. *G. chapra* showed a positive linear relationship between total length and body weight in combined sexes, in male and female and in both seasons (Fig. 5). The value of b in *G. chapra* was less than 3.0 in all aspects of calculation (Table 2) indicating negative allometric growth.

Sexual distribution

The sexual distribution of *G. chapra* regarding different months and seasons are presented in Table 3 and 4. Female were dominated throughout the sampling period except in the month of December (Table 3).

Table 3. Sex ratio of *G. chapra* in different months collected from different markets in Jessore region.

Month	No. fish	Male	Female	%Male	%Female	Male: Female	X^2 *df*=1	Remark
May	10	1	9	10	90	1.0:9.0	6.40	S*
June	56	17	39	30	70	1.0:2.3	8.64	S**
July	20	3	17	15	85	1.0:5.6	9.80	S**
Aug.	10	2	8	20	80	1.0:4.0	3.60	S
Sep.	5	2	3	40	60	1.0:1.5	0.20	NS
Oct.	5	1	4	20	80	1.0:4.0	1.80	NS
Nov.	30	13	17	43	57	1.0:1.3	0.54	NS
Dec.	30	20	10	67	33	1.0:0.4	3.34	NS
Total	166	59	107	5.54	64.46	1.0:1.81	13.88	S**

NS= Non-Significant, S*= Significant (P< 0.05), S**= Significant (P< .001).

The significant female dominancy noticed during May to July. It is showed that the males were comparatively higher in number in the winter season (55%) while the females were significantly (P<0 .001) higher in monsoon season (74%) (Table 4).

Table 4. Sex ratio of *G. chapra* in different season collected from Jessore region.

Season	No. of fish	M	F	% M	%F	M:F	X^2 (*df*=1)	Remark
Monsoon	96	25	71	26	74	1.0:2.84	22.04	S*
Winter	60	33	27	55	45	1.0:0.82	0.60	NS

NS= Non-Significant, S*= Significant (P<0 .001).

Discussion

Population demography

The maximum and minimum sizes recorded in the present study were almost similar compare to others who reported from the country. In the present study, it was recorded smallest one is 52.14 mm and largest one was 160.02 mm while 30 mm and 137 standard length (SL) by Ahmed *et al.* (2007), 30 mm and 134 mm SL by Hossain *et al.* (2009) and 31 mm and 137 mm SL reported by Ahamed *et al.* (2014).

The SL and TL usually differ by 25 mm. Though the similar length pattern showed in the present study compare to others, in case of weight it was different. Like, maximum weight recorded 31.56 g while the maximum individual weight was 44.54 g in case of Ahmed *et al.* (2007). It was also noticed that females were larger in size than male which also supported by Ahmed *et al.* (2007) and Ahamed *et al.* (2014).

Size-class distribution

The monthly size-class distributions showed that more than one size groups were found to be present in several months. This type of distribution is also noticed by Ahmed *et al.* (2007) and Ahamed *et al.* (2014) from northeast Bangladesh.

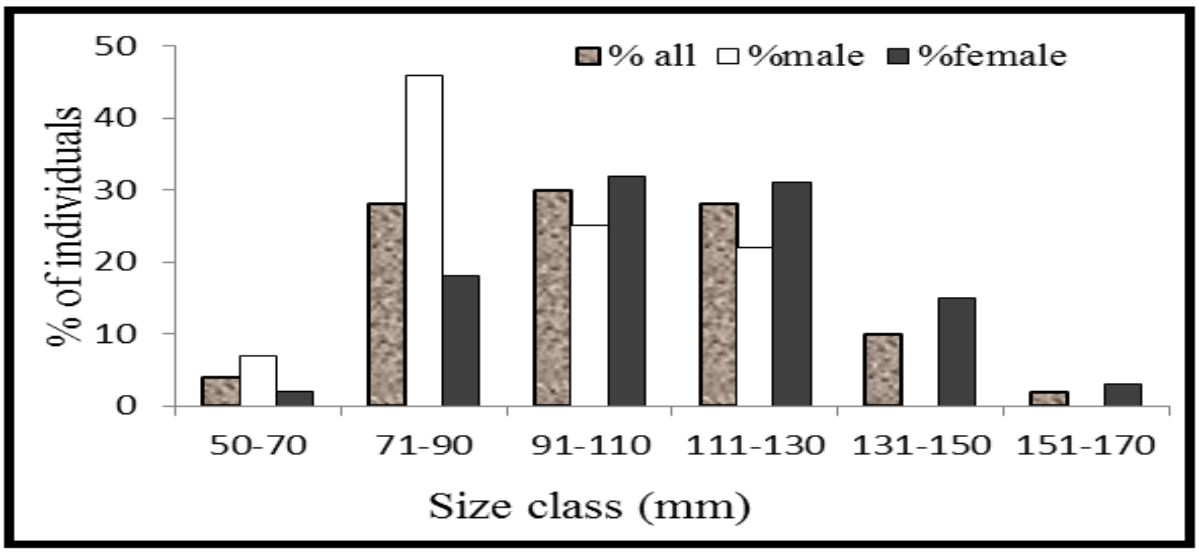

Fig. 2. Size-class distribution of *G. chapra* collected from different fish market in greater Jessore region.

The present study showed that most of the specimens (30%) were belongs to 71-130 mm size group. No fishes were found below 50 mm and the larger group of individuals constituted minimum number (2%) of the population. The similar pattern also noticed by Ahamed *et al.* (2014). They recoded most individuals within 50-80 mm SL and small number of individuals encountered which length was 120 mm SL.In the sex-wise size-class distribution revealed that most of the male (46%) and females (32%) individuals were under size-class 71-90 mm and 91-110 mm respectively. Thus a size predominance of female over male of the present fish indicated common feature for this group of fish, with female size consistently exceeding that of male throughout the study period.

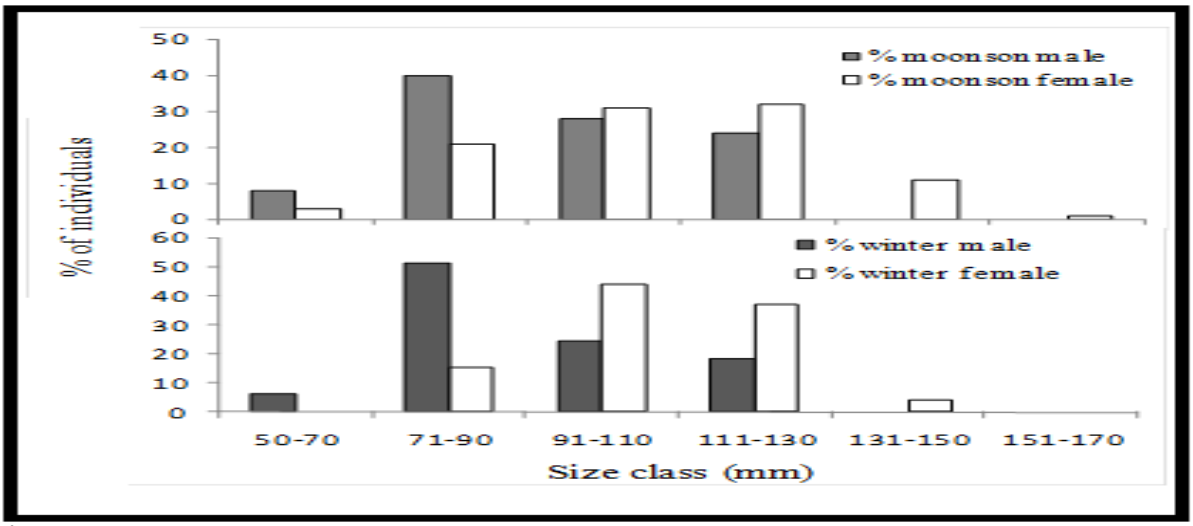

Fig. 3. Size-class distribution of male and female *G. chapra* in monsoon and winter seasoncollected from different fish market in greater Jessore region.

Length-weight relationship

A highly significant length-weight relationship was found in respect to total length of *G.chapra* where R^2 =0.911 which is close to the findings of Vinci *et al.* (2005) who reported the value of R^2 =0.917. The stronger relationship noticed from other water bodies of Bangladesh like R^2 =0.958 from the Ganges, northwest Bangladesh (Hossain *et al.*, 2009) and R^2 =0.986 from old Brahmaputra river, northeast Bangladesh (Ahamed *et al.*, 2014). However, the

present relationship indicates the weight of fish is directly related with the length of the species which was stronger in male (R^2 =0.921) rather than female (R^2 =0.886). While Ahamed *et al.* (2014) noticed a bit stronger relationship in female (R^2 =0.989) than male (R^2 =0.980). This variation may be due to different geographical location. But no variation noticed regarding different seasons.

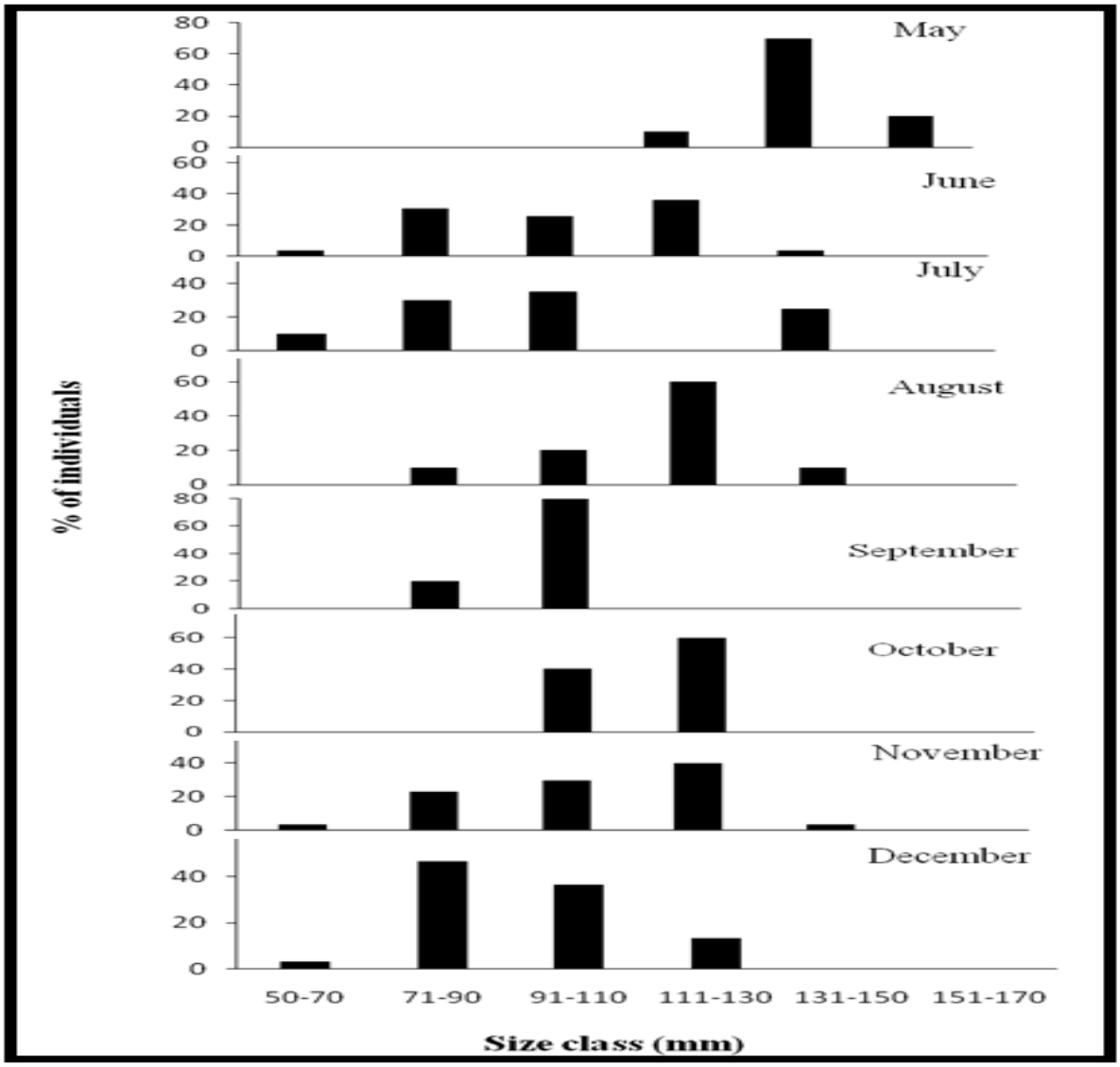

Fig. 4. Month wise size class distribution of *G. chapra* collected from different fish market in greater Jessore region.

According to Hile (1936) the values of regression coefficient (b) usually fluctuate between 2.5 and 4.0 and in the majority of cases the value was not equal to 3. For a fish, which maintains its shape throughout its life, the value of regression coefficient (b) will be 3 (Varghese, 1961; Talwar, 1962). This value may change with locality, sex and maturity (Le Cren, 1951) besides environmental conditions. Under these circumstances the value other than 3 indicated allometric growth. In the present study, the value of b in *G. chapra* was less than 3 which indicated negative allometric growth in respect to all individuals, males, females and seasons. Similar findings in *G. chapra* were reported by Ahamed *et al.* (2014) from north-eastern Bangladesh where the negative allometric growth was evident. Ahmed *et al.* (2007) also reported negative allometric growth in the same fish from the Mymensingh, Bangladesh with b value 2.97 (male) and 2.82 (female). However, Hossain *et al.* (2009) recorded positive allometric growth in *G.*

chapra with the value of b= 3.11 from Ganges river, north-western Bangladesh. The differences in b values can be attributed to the combination of one or more factors including habitat, area, stomach fullness, gonadal condition, health and preservation methods (Hossain *et al.*, 2011) which were not accounted in this study.

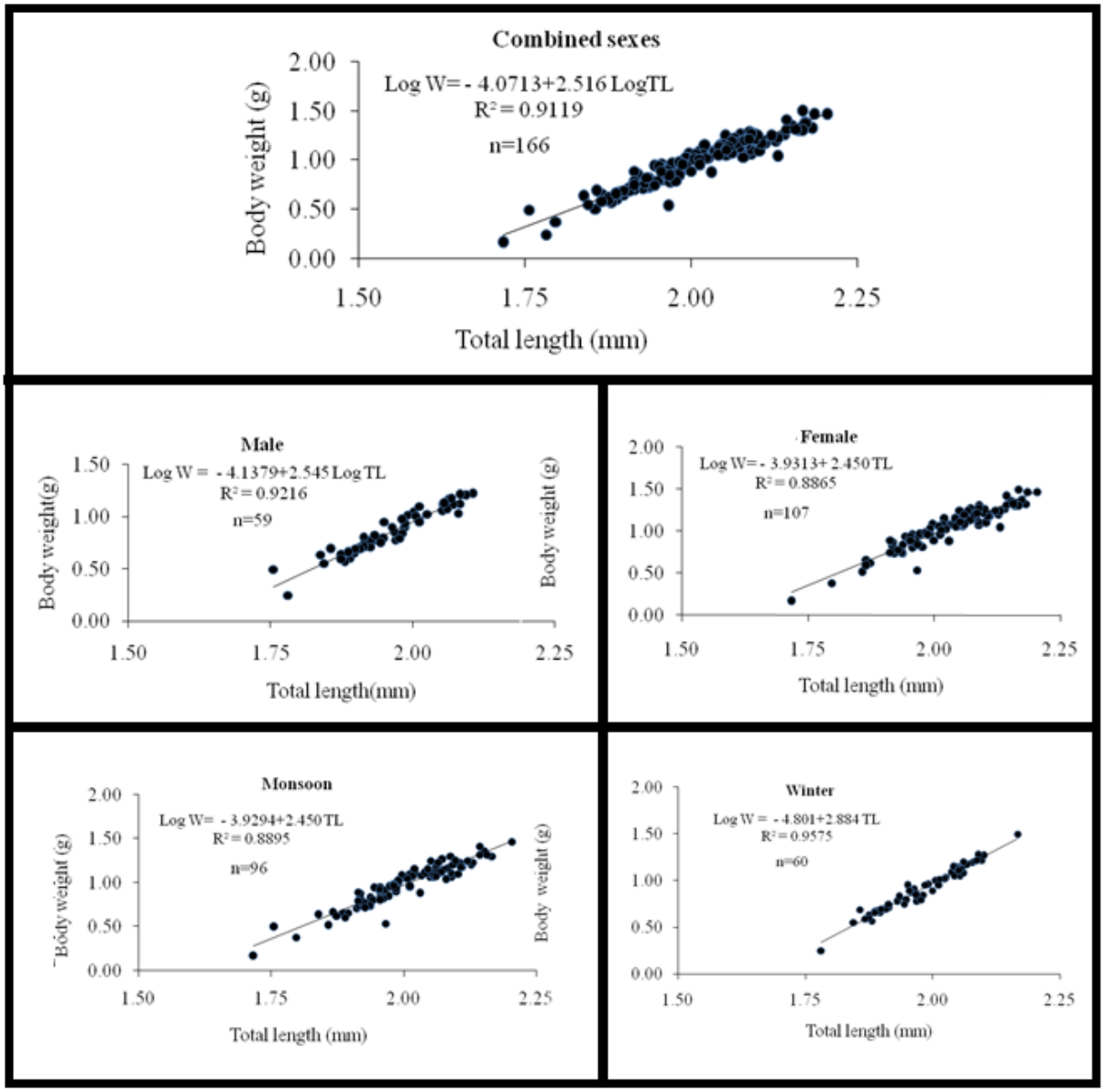

Fig. 5. Length-weight relationship of combined sexes, different sexes and seasons of *G. chapra* in Jessore region of Bangladesh.

Sex ratio

In the present study, the sex ratio significantly departed from the expected 1:1 ratio and female showed significantly dominance over males throughout the study period except the month of December. Dominance of females over males in *G. chapra* was also reported by Mondal and Kabiraj (2010) from two floodplain lakes of India. However, different sex distribution pattern noticed of the fish such as male dominancy from the old Brahmaputra river, northeast Bangladesh (Ahamed *et al.*, 2014) while no variation observed by Ahmed *et al.* (2007) from Brahmaputra river, northeast Bangladesh. In addition, it was showed that females were significantly dominant in monsoon season while Ahamed *et al.* (2014) noticed male dominancy in

June and August. It was not clear which factors might be responsible in the fluctuation of male-female sex ratio in different season. However, sex ratio variations may be attributed to reproduction, growth and longevity of a species (Oh *et al.*, 2002; Chilari *et al.*, 2005).

Conclusion

The population demography, growth pattern, sex and size distribution revealed the similar genetic population exhibits all over the country. Thus, the findings could be useful to develop management strategy in the locality as well as for the country.

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