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Original Article

Length-weight relationships and growth pattern of *Macrobrachium malcolmsonii* (H. Milne-Edwards, 1844) from the river Old Brahmaputra, Bangladesh

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Abstract
Study of biological parameters of a species is important for its sustainable management. The length-weight relationships and growth patterns of *Macrobrachium malcolmsonii* (H. Milne-Edwards, 1844), collected from the river Old Brahmaputra in Bangladesh, were determined in this study based on 359 specimens (carapace length, CL: 11–90 mm; body weight, BW: 0.2–54.4 g) including 308 male and 351 female individuals. For both sexes, intercepts, slopes, and coefficients of determinations of regression analyses between CL and BW varied monthly. The lowest values of intercept (–11.51 and –11.65 for male and female respectively) was recorded in October whereas the highest values were recorded in January for male (–7.01) and March for female (–8.26 for female). The minimum coefficient of determination was 0.784 (for male) and 0.801 (for female) whereas the maximum coefficient of determination was recorded 0.971 (for male) and 0.970 (for female). For male, the *b* value at 95% Cl revealed that the growth in March, June, July, September and February were isometric and in April, May, October, November and January were allometric. Whereas for female, the growth in March, April, June, July, November, January and February were isometric and was allometric in May, September and October.

Keywords: LWR; *Macrobrachium malcolmsonii*; monsoon river prawn; Old Brahmaputra

1 | INTRODUCTION

Fisheries sector represents one of the most productive dynamic sectors in Bangladesh. This sector contributes 3.5% to the GDP, 1.5% to the export earnings and it supports the livelihood of about 1.5 million professional fishermen (DoF 2019). The crustacean fishery, primarily prawns or shrimps and crabs, forms an important part of this sector in the country (Paul and Vogl 2011; Rahman *et al.* 2020). There are 24 freshwater prawn species and 36 species of marine shrimp (DoF 2019). Shrimp or prawn are being cultured in 258681 ha coastal farms (locally known as 'ghers') (DoF 2019). In 2017–18, a total of 48847 metric tons of shrimps were produced of which about 53% were from aquaculture farms (DoF 2019). Shrimp and prawn are the important export commodities of Bangladesh. In 2017–18, 36168 metric tons of frozen shrimps were exported to foreign markets from Bangladesh (DoF 2019). The dominant species of shrimps produced in Bangladesh, from both aquaculture and harvest from the wild, are *Penaeus monodon*, *Macrobrachium*

rosenbergii, *Macrobrachium malcolmsonii*, *Metapenaeus monoceros* and *Penaeus indicus*.

The freshwater monsoon river prawn *M. malcolmsonii* (H. Milne-Edwards, 1844) is widely distributed throughout the Indian subcontinent. This prawn species has potentials for aquaculture in freshwater habitats. This large and fast-growing prawn commonly occurs in the rivers of Bangladesh, India, and Pakistan, including the Ganges, Mahnanda, Hooghly, and Brahmaputra river systems (Kanaujia 2003; Prasad 2005).

Different properties of its biology such as length-length relationships, length-weight relationships (LWRs), condition factors, sex ratios, growth parameters etc. could provide important information for the sustainable fishery of the species (Alam *et al.* 2012; Chaki *et al.* 2013). Despite wide availability, this species of prawn has received less attention from the researchers (but see Shafi and Quddus 1975; Hossain and Rafik 1981). Therefore, the aim of this study was to establish LWRs and determine growth patterns of *M. malcolmsonii* population collected from the Old Brahmaputra River in Bangladesh.

2 | METHODOLOGY

2.1 Study area

The specimens of *M. malcolmsonii* population were collected from the Old Brahmaputra River of Bangladesh, near Bangladesh Agricultural University, Mymensingh. A large number commercially important species in this river are targeted by both small and large scale fishermen throughout the year. The river is also believed to be an important spawning and feeding ground for many prawn and fish species of Bangladesh.

2.2 Sampling

Prawn specimens were collected once in a month from March 2012 to February 2013 except August and December in 2012 due to unavoidable reasons with the help of the professional fishermen in the river (Table 1). The fresh specimens were immediately chilled in ice on site, and preserved with 10% buffered formalin upon arrival of the laboratory at Bangladesh Agricultural University.

2.3 Length and weight measurements

The water from body surface of each prawn was removed with the help of tissue paper. The specimens were kept in room temperature for further drying. Carapace length (CL) was measured in mm from the base of the eye stalk to the posterior end by using digital slide calipers. The body weight (BW) of an individual prawn was recorded using an electronic balance in g with 0.01 g accuracy.

2.4 Sex determination

Significant differences existed between the male and female prawns. Mature males were considerably larger than females and the second walking leg is much thicker. Mature males could be easily recognised by their longer and stronger chelipeds with larger spines than in case of females. Male possess appendix masculina, a spinous process adjacent to the appendix interna on the endopod of the second pleopod. Mature females have proportionally small body size as well as head and claw. The cephalothorax is also proportionally larger in the male than female while abdomen is narrower in the female. The genital pores of the male are between the bases of the fifth walking leg. The female's genital pores situated at the base of the third walking legs. The pleura of the abdomen are lower and broader in the brood chamber in which the eggs are carried between laying and hatching. A ripe ovigerous female can easily be identified because the ovaries can be seen as large orange-colored mass occupying a large portion of the cephalothorax.

TABLE 1 Description of *Macrobrachium malcolmsonii* specimens collected from the Old Brahmaputra River in different sampling months.

Months	Male			Female		
	n	CL (mm)	BW (g)	*n*	CL (mm)	BW (g)
Mar 2012	60	26–69	0.2–42.8	17	19–52	1–18
Apr	24	15–62	0.3–36.1	17	13–48	0.3–12.8
May	20	16–74	0.3–54.4	33	19–51	0.4–15.1
Jun	25	11–71	0.2–40.7	51	13–62	0.3–23.9
Jul	04	14–17	0.3–0.5	50	13–64	0.3–34.9
Sep	07	20–90	0.6–39.0	46	16–80	0.4–31.2
Oct	17	18–66	0.4–36.8	49	17–55	0.3–21.4
Nov	62	16–57	1.3–20.5	29	17–63	0.6–31.9
Jan 2013	56	15–80	0.8–34.3	44	23–76	1.1–30.9
Feb	33	30–61	2.6–31.2	15	18–57	1.2–23.4

2.5 Length-weight relationship

Algebraically cubic relationship exists between CL and BW of aquatic crustacean species. The relationship was expressed as $BW = aCL^b$, where BW is body weight (g), CL is the carapace length (CL, mm), *a* is the intercept of the regression and *b* the regression coefficient or the slope.

2.6 Growth pattern assignment

The growth patterns of monthly prawn samples were determined on the basis of *b* value in the equation $BW = aCL^b$. If the *b* value is equal to 3, the sample growth was isometric; if not, the growth was allometric. The confidence interval (CI) of *b* value at 95% CI for the population of the LWR equation revealed the growth pattern of the population in a specific month.

3 | RESULTS

Out of total of 659 prawn individuals, 308 were male and 351 were female representing a sex ratio of 1:0.83 (M:F). The CL and BW of male ranged from 11 to 90 mm and from 0.2 to 54.4 g respectively (Table 1). The CL and BW of female varied from 13 to 80 mm and from 4.3 to 34.9 g

respectively (Table 1).

3.1 LWRs for male population

The LWRs of male population are shown in Table 2 and Figure 1. The values of intercept of the linear relationships varied among monthly samples. The lowest value was –11.51 (estimated in October 2012) and the highest value (–7.01) was obtained in January 2013. The values of *a* in the power curve equation was 0.00009. The *b* values of LWRs also varied monthly and ranged from 2.37 to 3.61 (Table 2). The coefficient of determination (r^2) ranged from 0.784 to 0.971. The lowest and highest value of r^2 was in March and June 2012 respectively (Table 2). The study estimated high value of coefficient of determination in all months (all $r^2 \geq 0.784$) which explained that the change of BW was very high with the change of CL.

3.2 LWRs for female population

The results of natural log-log LWRs of female population are shown in Table 2 and Figure 1. The values of intercept of the linear relationships varied among monthly samples. The lowest value (–11.65) was estimated in October whereas the highest value (–8.26) was obtained in March. The *b* values of LWRs also varied monthly and it ranged from 2.75 to 3.66 (Table 2). The lowest and highest values of *b* were recorded in October and March respectively. The r^2 ranged from 0.801 to 0.970 (Table 2). The study estimated high value of coefficient of determination in all months (all $r^2 \geq 0.801$; Table 2).

TABLE 2 Parameters of the log-log length-weight relationships of male *Macrobrachium malcomsoni* population and growth pattern in different sampling months. *t*, value from t table; seln*a* , standard error of intercept; se*b*, standard error of slope; *CI*, confidence interval; r^2, coefficient of determination.

Month	Sex	*n*	Intercept ln*a*	Slope *b*	r^2	± t*se_{lna}	± t*se_b	*CI* of *b* at 95%	Growth inference
Mar 2012	M	60	–9.18	3.016	0.784	1.012	0.262	2.75–3.27	Isometric
	F	17	–8.266	2.758	0.801	2.001	0.568	2.18–3.32	Isometric
	Pooled	77	–8.856	2.930	0.776	0.707	0.186	2.74–3.12	Isometric
Apr	M	24	–10.27	3.326	0.868	0.809	0.216	3.10–3.55	Allometric
	F	17	–8.877	2.953	0..808	1.927	0.530	2.42–3.48	Isometric
	Pooled	41	–9.764	3.192	0.820	0.851	0.230	2.96–3.42	Isometric
May	M	20	–10.90	3.454	0.915	0.507	0.135	3.31–3.58	Allometric
	F	33	–10.696	3.427	0.958	0.544	0.158	3.26–3.58	Allometric
	Pooled	53	–10.659	3.405	0.880	0.352	0.098	3.30–3.50	Allometric
Jun	M	25	–9.92	3.184	0.971	0.719	0.224	2.95–3.41	Isometric
	F	51	–8.904	2.952	0.877	0.434	0.123	2.82–3.07	Isometric
	Pooled	76	–9.430	3.077	0.880	0.411	0.121	2.95–3.19	Isometric
Jul	M	04	–8.80	3.12	0.831	1.193	0.412	2.85–3.45	Isometric
	F	50	–8.692	2.919	0.914	0.301	0.085	2.83–3.01	Isometric
	Pooled	54	–8.759	2.935	0.919	0.292	0.084	2.85–3.02	Isometric
Sep	M	07	–8.92	2.808	0.869	0.958	0.232	2.57–3.04	Isometric
	F	46	–8.985	2.850	0.972	0.311	0.092	2.75–2.94	Allometric
	Pooled	53	–8.894	2.819	0.955	0.266	0.076	2.74–2.89	Allometric
Oct	M	17	–11.51	3.616	0.852	0.954	0.257	3.35–3.87	Allometric
	F	49	–11.654	3.667	0.918	0.559	0.162	3.50–3.83	Allometric
	Pooled	66	–11.636	3.662	0.868	0.486	0.138	3.52–3.80	Allometric
Nov	M	62	–7.76	2.612	0.835	1.117	0.312	2.29–2.92	Allometric
	F	29	–9.862	3.182	0.839	0.748	0.210	2.96–3.39	Isometric
	Pooled	91	–8.650	2.855	0.834	0.775	0.217	2.63–3.07	Isometric
Jan 2013	M	56	–7.01	2.371	0.886	0.806	0.228	2.14–2.60	Allometric
	F	44	–8.897	2.869	0.920	0.566	0.151	2.71–3.02	Isometric
	Pooled	100	–7.934	2.624	0.913	0.507	0.140	2.48–2.76	Allometric
Feb	M	33	–10.34	3.348	0.791	1.657	0.436	2.90–3.78	Isometric
	F	15	–8.285	2.760	0.864	1.906	0.537	2.21–3.31	Isometric
	Pooled	48	–9.439	3.106	0.804	1.021	0.275	2.82–3.38	Isometric
Generalised	M	308	–9.33	3.043	0.940	0.312	0.085	2.95–3.12	Isometric
	F	351	–9.374	3.043	0.960	0.235	0.067	2.97–3.11	Isometric
	Pooled	659	–9.377	3.051	0.952	0.187	0.052	2.99–3.10	Isometric

3.3 Growth pattern inference

In males, the 95% CI of *b* values in March, June, July, September and February were more than 3, and therefore, the growth of those months were isometric. In the remaining months, the growth pattern was allometric (Table 2).

In females, the CI of *b* values in March, April, June, July, November, January and February were more than 3, represented an isometric growth. In the remaining months, the pattern was allometric (Table 2).

For pooled data, the 95% CI of *b* values in March, April, June, July, November and February were more than 3 which indicated an isometric growth. In the remaining months, the growth pattern was allometric (Table 5).

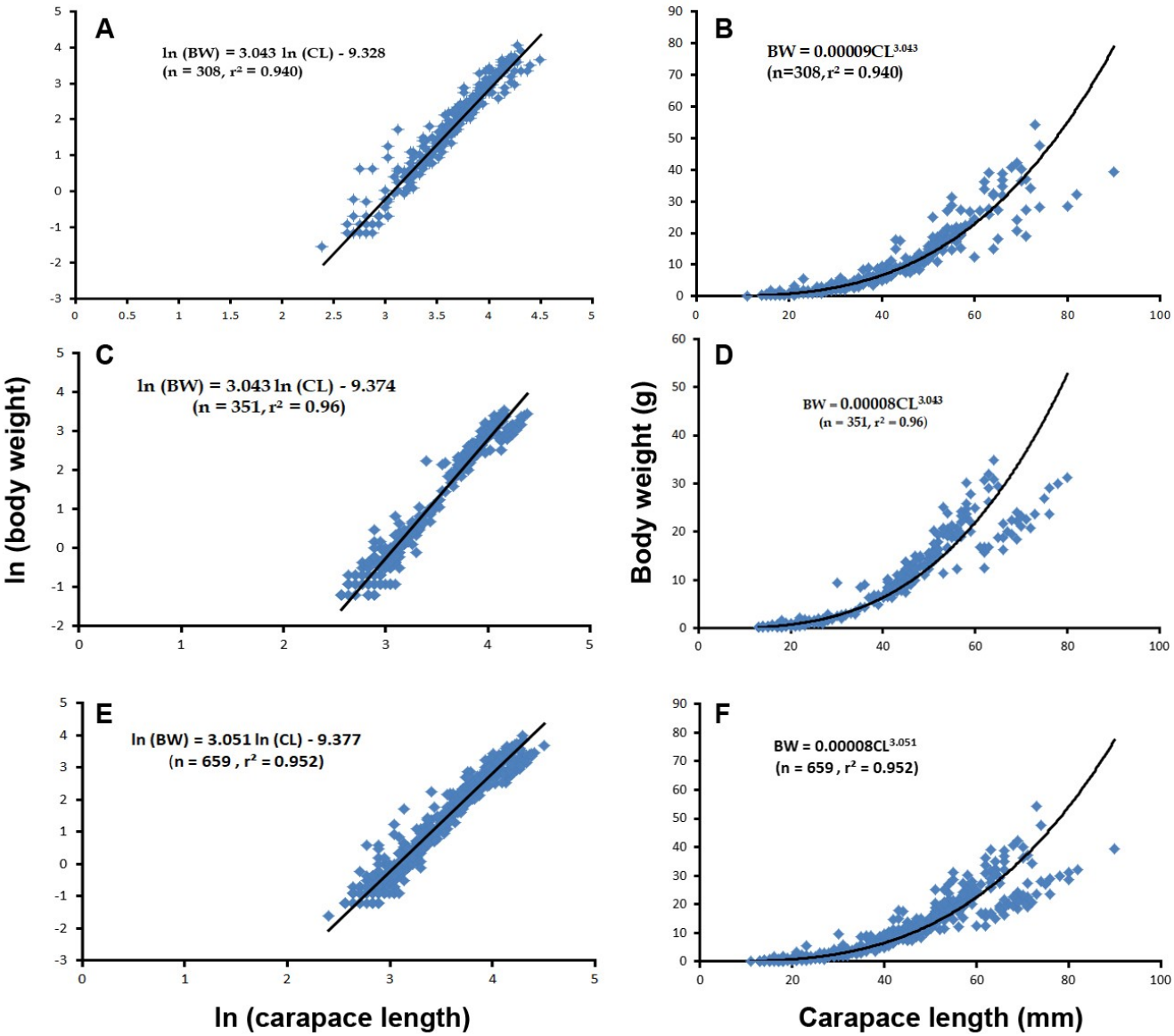

FIGURE 1 Generalized body weight and the carapace length of the male (A and B), female (C and D) and pooled (E and F) *Macrobrachium malcolmsonii*.

4 | DISCUSSION

Studies on the biometrics of *Macrobrachium malcolmsonii* in Bangladesh is insufficient. This study provides descriptions of LWRs, sex ratio and growth patterns of this freshwater prawn species, based on a reasonable sample size (*n* = 659 individuals). The sex ratio of male to female was 1 : 0.83. The generalized log-log and power curve relationships between BW and the CL of male *M. malcolmsonii* were ln (BW) = 3.043 ln (CL) – 9.328 and BW = 0.00009 CL 3.04 respectively. The generalized log-log and power curve relationships between BW and the CL of female *M. malcolmsonii* were ln (BW) = 3.043 ln (CL) –

9.374 and BW = 0.00008 CL 3.043 respectively. The generalized log-log and power curve relationships between BW and the CL of pooled *M. malcolmsonii* were ln (BW) = 3.051 ln (CL) – 9.377 and BW = 0.00008 CL 3.051 respectively. The generalized coefficient of determination (r^2) values for male, female and combined were 0.940, 0.960 and 0.952 respectively which is highly correlated.

We recorded the maximum CL of *M. malcolmsonii* as 90 mm in the sampling site, Old Brahmaputra River. The maximum weight for this prawn (54.4 g) in our study was lower than the maximum weight observed (65.0 g) in Meghna and Sitalakhya rivers of Bangladesh (Shafi and Quddus 1975). In a tropical reservoir (Wyra) in India, Khan *et al.* (2009) estimated the asymptotic length of *M. malcolmsonii* as 20.30 mm TL. However, in our study this figure was 11 – 90 mm CL which may be quite similar as direct comparisons is not possible due to differences in the measurement units considered.

We did not record *M. malcolmsonii* above 54.4 g during the sampling period, which may be due to the absence of larger sized individuals in the population or fishing bias towards nursery habitats. Studies confirm that the growth rate in prawns varied between sexes and usually higher in males (Mossolin and Bueno 2003; Fransozo *et al.* 2004). The calculated *b* values based on the CL–BW relationship was 3.043 for males and 3.043 for females, which were within the limit (2.5 – 3.5) reported by Froese (2006) for most finfish and shellfishes. Hence, despite the presence of divergent prawn forms among species, *b* is close to 3.0, indicating that prawns generally grow isometrically (Tesch 1971). However, various factors can affect the LWR in prawn which may include habitat type, area, season, stomach fullness, gonad maturity, gender, health, preservation technique, and length ranges of collected specimens (Tesch 1971). In this study, most of these factors were not considered which may be examined in the future studies.

5 | CONCLUSIONS

This study provides an important baseline study on the length-weight relationships of the *M. malcolmsonii* from Bangladesh, particularly from the riverine system of the country. The outcomes of the study are believed to be helpful for developing the management strategies and regulations for the species.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHORS' CONTRIBUTION

DP study design, field sampling, laboratory work, data analysis; **MTK** data analysis, visualisation and manuscript preparation; **MTP** data analysis, visualisation and manuscript preparation; **SMH** research supervision; **ZFA** research supervision.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request to the corresponding author.

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