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Trophic state of the reservoir influences the allometric coefficient and condition factor of Giant Freshwater Prawn (*Macrobrachium rosenbergii*) cultured in perennial reservoirs of Sri Lanka

R.G. Sanuja[1], U.A.D. Jayasinghe[2], P.L.N. Lakshman[3], and K.H.M. Ashoka Deepananda[1] *

[1]*Department of Fisheries and Aquaculture, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Matara 81000, Sri Lanka, R.G. Sanuja, ORCID: https://orcid.org/0000-0003-3111-3190, K.H.M. Ashoka, ORCID: https://orcid.org/0000-0002-2866-1906*

[2]*Department of Limnology and Water Technology, Faculty of Fisheries and Marine Sciences & Technology, University of Ruhuna, Matara 81000, Sri Lanka, U.A.D. Jayasinghe, ORCID: https://orcid.org/0000-0002-7528-7718*

[3]*Department of Food Science & Technology, Faculty of Agriculture, University of Ruhuna, Kamburupitiya 81100, Sri Lanka, P.L.N. Lakshman, ORCID: https://orcid.org/0000-0002-1002-6664*

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Corresponding author: ashoka@fish.ruh.ac.lk

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ABSTRACT

Giant Freshwater Prawn (*Macrobrachium rosenbergii*) is an essential crustacean species in culture-based fisheries of Sri Lanka. Studying the morphometric characteristics and empirical models in fishing and aquaculture is highly beneficial; thus, it is the most accurate way of analyzing growth patterns. The present study aimed to establish the length-weight relationship and compute the relative condition factor for the *M. rosenbergii* cultured in trophically different perennial reservoirs in Sri Lanka, considering the trophic status of the reservoirs. The allometric coefficient and condition factor of *M. rosenbergii* concerning the trophic state of the reservoir were empirically ascertained from the samples collected from twenty-five dry-zone perennial reservoirs of Sri Lanka. Carlson's Trophic State Index (TSI) was calculated based on the chlorophyll-a content. The allometric coefficient and relative condition factor were computed using the total length and weight of the *M. rosenbergii*. The TSI ranging between 44.09±0.47 and 65.15±0.24 differed significantly ($p<0.05$). Sexual dimorphism in the growth of males over the female *M. rosenbergii* was ascertained with the aid of allometric coefficient (b value) 3.2306 (positive allometric growth) and 2.9534 (negative allometric growth), respectively. In eutrophic perennial reservoirs, Giant Freshwater Prawns showed the highest allometric coefficient in both sexes. There was a positive correlation between the allometric coefficient and TSI among males, $r(23)=0.7210$, $p<0.001$, and combined sexes, $r(23)=0.7900$, $p<0.001$, respectively. The results of the present study revealed that the trophic state of the reservoir influences the allometric coefficient and condition factor of *M. rosenbergii* cultured in perennial reservoirs of Sri Lanka.

Keywords: Culture-based fisheries; dry zone reservoirs; trophic state index; total length & weight; mesotrophic; eutrophic

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INTRODUCTION

Perennial reservoirs in Sri Lanka are primarily being utilized for irrigation and hydropower generation and secondarily for culture-based fisheries (CBF) to harness the natural productivity of the reservoirs, increase the fish supplies at an affordable price for rural communities as a source of animal protein, and provide additional income for the rural populace to reduce poverty (Jones et al., 2021). In CBF, the reservoirs are conventionally stocked mainly with exotic finfish species (Jayasinghe et al., 2006; Deepananda et al., 2014). Giant Freshwater Prawn (GFP), *Macrobrachium rosenbergii*, one of the biggest natantians in the world (Kunda et al., 2008), live in tropical freshwater and brackish water environments, as its larval development must take place in water with low salinity (12-16 ppt) (New, 2002). Adult male GFP can reach a total length (from the tip of the rostrum to the tip of the telson) of about 320mm, and females can reach about 250mm (New, 2002). Since 2007, the introduction of GFP to perennial reservoirs of Sri Lanka has enhanced the economic and societal benefits of the rural communities due to high rearing and marketing potential. Consequently, GFP has become one of the most economically essential crustaceans used in the CBF of Sri Lanka (Farook et al., 2018).

Studying the growth characteristics of any wild or aquaculture commodity is important in fisheries and aquaculture (Sampaio and Valenti, 1996). The length-weight relationship is a vital tool in fisheries science to describe the growth pattern of wild stocks and cultured species by manifesting a mathematical relationship between the two variables, facilitating the conversion of one variable to another, to describe the growth of the species and, determining the variations in the growth rate of the species under different environmental conditions (Lalrinsanga et al., 2012). Also, studying the morphometric characteristics and mathematical models in fisheries and aquaculture is highly beneficial since it is the most accurate way of analyzing growth data (Hopkins, 1992). Condition factor (K) helps estimate the condition, robustness, or degree of well-being or fitness of the populations inhabiting different localities, reflecting the interaction between biotic and abiotic factors in the physiological condition of the fish (Lalrinsanga et al., 2013). Several studies have been conducted on the length-weight relationship of *M. rosenbergii* inhabiting different regions of the world (Sampaio and Valenti, 1996; Kunda et al., 2008; Lalrinsanga et al., 2012; Lalrinsanga et al., 2013; Indargo et al., 2021). However, empirical studies on the length-weight relationship of *M. rosenbergii* inhabiting Sri Lanka reservoirs are scarcer.

Carlson's Trophic State Index, which can be calculated using chlorophyll-a content, is essential to surveying a waterbody (Pavluk and Bij, 2013). Five types of trophic statuses can be identified in aquatic ecosystems: oligotrophic, mesotrophic, eutrophic, hyper-eutrophic,

Table 1. Classification of trophic statuses in aquatic ecosystems.

Trophic status	TSI	Chlorophyll-a (µg/L)	Attributes
Oligotrophic	0-40	0-2.6	Clearwater
Mesotrophic	41-50	2.7-7.3	Moderately clear water
Eutrophic	51-70	7.4-56	Blue-green algae dominate; algal scums and aquatic plants
Hyper-eutrophic	71-80	57-155	Light limited productivity; dense algae and macrophytes
Dystrophic	>80	>155	Organic and inorganic sedimentation; high oxygen depletion

and dystrophic (Table 1). The trophic state of Sri Lankan perennial reservoirs is primarily varied according to the biomass of phytoplankton, which directly influences nutrient content in the water (Deepananda and Macusi, 2012).

Therefore, the present study was undertaken to establish the length weight relationship and compute the relative condition factor for the *M. rosenbergii* cultured in trophically different perennial reservoirs in Sri Lanka, considering the trophic status of the reservoirs.

MATERIALS AND METHODS

The present study was conducted in twenty-five perennial reservoirs of Sri Lanka, located in Anuradhapura, Puttalam, Hambantota, and Monaragala districts (Figure 1), over six months from October 2019 to March 2020. Table 2 summarizes the details of each reservoir. To analyze the chlorophyll-a content of the study reservoirs, 150mL of water was filtered through GF/C filters (1.2 µm; 47 mmØ), and the filters were stored in acid-free, lightproof vials in ice and then transported to the laboratory. Then, filter papers were macerated in 80% acetone, and absorption values of the acetone extraction were measured at 750nm and 664nm before acidification and 750nm and 665nm after acidification, using a spectrophotometer (Jenway 6405UV/VIS) (Carlson and Simpson, 1996). The productivity of the reservoir water body, indicated as Carlson's Trophic State Index (TSI), was calculated based on chlorophyll-a (Chl-a) content using the following equation (Carlson and Simpson, 1996).

Table 2. Details of the studied perennial reservoirs of Sri Lanka.

District	Reservoir	Code	GPS Coordinates	
			N	E
Anuradhapura	Nachchaduwa	A1	8°14'57.61"	80°28'55.37"
	Mahakanadarawa	A2	8°23'42.65"	80°33'07.84"
	Mahawilachchiya	A3	8°28'05.04"	80°11'46.78"
	Angamuwa	A4	8°10'27.49"	80°13'17.35"
Puttalam	Thabbowa	P1	8°04'00.34"	79°57'23.48"
	Mahauswewa	P2	7°55'37.36"	80°05'47.61"
	Saliyawewa	P3	8°10'06.55"	80°05'38.89"
	Pahariya	P4	8°07'31.67"	79°59'46.04"
	Kottukachchiya	P5	7°55'39.29"	79°56'40.39"
Hambantota	Ridiyagama	H1	6°12'15.17"	80°59'03.64"
	Weerawila	H2	6°17'13.30"	81°13'57.39"
	Muruthawela	H3	6°12'54.85"	80°43'27.13"
	Yodhawewa	H4	6°16'14.46"	81°18'51.85"
	Bandagiriya	H5	6°15'19.40"	81°08'20.14"
	Udukiriwala	H6	6°09'20.52"	80°45'28.05"
	Pahala Andara	H7	6°19'07.43"	81°06'46.82"
Monaragala	Muthukandiya	M1	6°58'46.58"	81°30'07.66"
	Kiriibbanwewa	M2	6°22'33.46"	80°58'13.66"
	Urusita	M3	6°19'55.17"	80°55'59.56"
	Handapanagala	M4	6°39'56.88"	81°09'07.00"
	Hambegamuwa	M5	6°32'33.69"	80°57'19.19"
	Buduruwagala	M6	6°41'15.59"	81°05'06.03"
	Habaralu	M7	6°24'10.23"	80°55'09.67"
	Mahawewa	M8	6°27'29.93"	81°00'40.03"
	Sugaladevi	M9	7°01'15.77"	81°35'28.14"

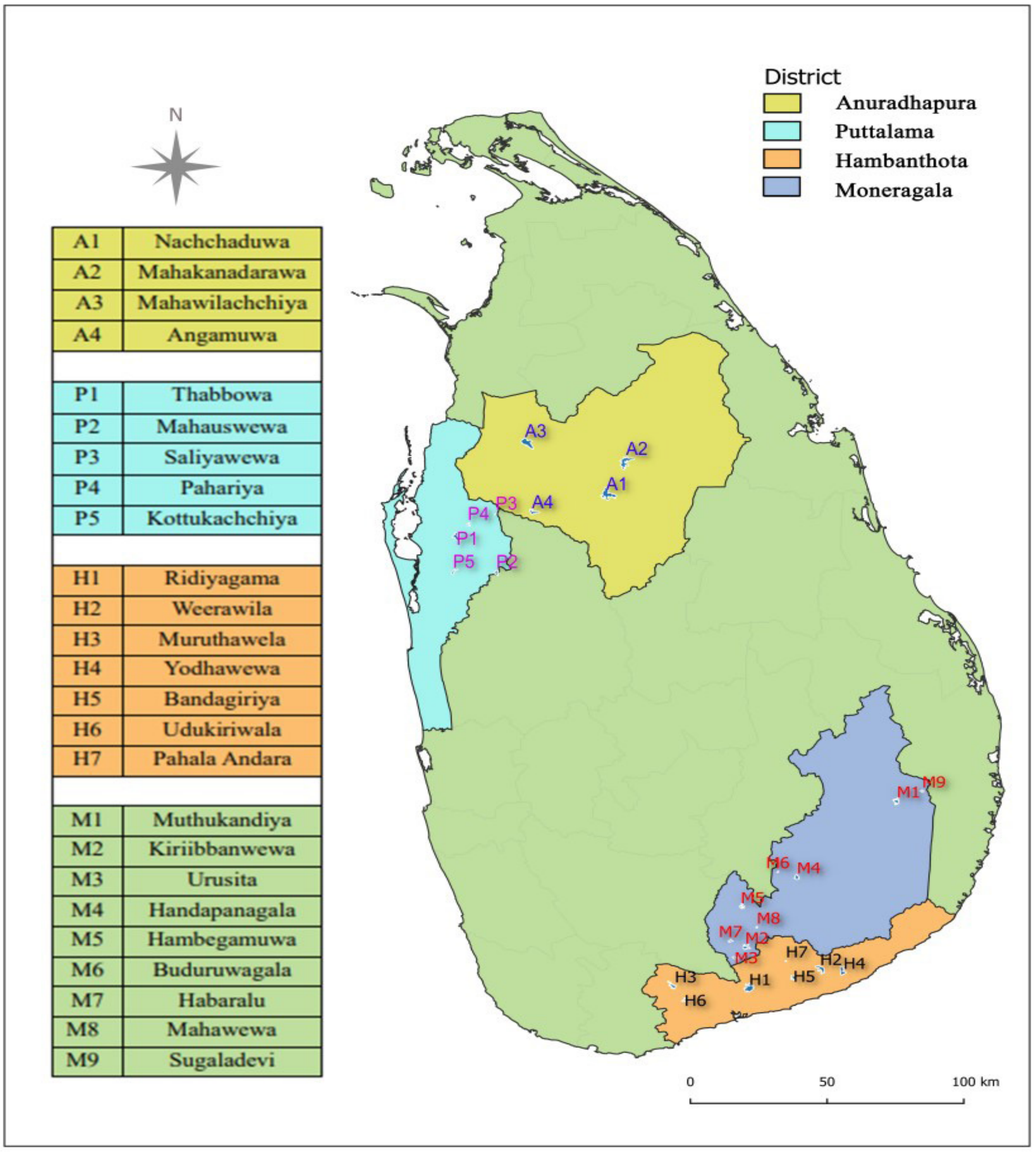

Figure 1. Map of Sri Lanka showing the study reservoirs.

TSI (Chl-a) = 9.81 ln Chlorophyll-a (mg/m^3) + 30.6 Computed TSI was used to categorize the waterbody into five groups: oligotrophy (<30), mesotrophy (30-40), eutrophy (50-60), hyper-eutrophy (60-70), and dystrophy (>70).

Twelve intact and hard shell GFP specimens (06 blue claw males and 06 females) were collected from the local fishers at each reservoir and stored in polystyrene boxes within the ice layers and then transported to the Fish Post-Harvest Technology Research Laboratory of the Department of Fisheries and Aquaculture, University of Ruhuna, Sri Lanka. Total length (TL), the length from the tip of the antennule's plate to the end of the telson of the GFP, was measured using a standard measuring board with 01mm accuracy. The total wet weight (TW) of the respective specimen was taken using top load balance (Type 3600, Mettler, Switzerland), having an accuracy of 1.0g. A total of 300 GFP specimens were studied for this analysis.

The power equation $W=aL^b$ (Le Cren, 1951) was employed to calculate the parameters *a* and *b*, where W is the total wet weight (g), L is the total length (mm), *a* is the coefficient of the length-weight relationship, and *b* is the exponent describing the rate of variation in weight in respect to length. Following Le Cren (1951), the power equation was transformed into base 10 logarithms in estimating parameters using linear regression and expressed as:

$$\log(W) = \log(a) + b\log(L)$$

Where *a* is the initial growth constant and *b* is the allometric coefficient/growth exponent. The values of *a* and *b* were determined empirically.

The ideal value of *b* is 3, representing an isometric growth (balanced growth). When *b* is unequal to 3, it is considered allometric growth (unbalanced growth). When *b* is less than 3, GFP becomes slimmer with increasing length, and growth was considered negative allometric. When *b* is greater than 3, GFP becomes heavier, showing positive allometric growth, reflecting the optimum condition for growth. The standard error of *b* was also computed to calculate the 95% confidence interval (CI 95%) using the equation CI = b± ($1.96*SE_b$). Student t-test was employed with the aid of the equation $t_s=(b-3)/SE_b$ to compare the *b* value with the hypothesis of isometric growth. The values of $p<0.05$ were considered statistically significant and included in the allometric growth range (negative and positive allometric). The relationship between the variables was computed by determining the correlation coefficient (R^2).

The degree of well-being, robustness, or fitness of the GFP stocks at each reservoir was evaluated by computing the relative conditions factor (Kn) Le Cren (1951) suggested. The equation $Kn = W/aL^b$ was employed in this context, where *a* and *b* are the exponential form of the intercept and slope, respectively, in the logarithmic length-weight relationship.

In par with Indarjo et al., (2021), the computed relative condition factor was used to categorize the body shape of GFP into five groups: very thin (Kn=0.01-0.05), thin/slender (Kn=0.510.99), ideal/proportional (Kn=1.00), fat/plump (Kn=1.01-1.50), and very fat (Kn>1.50). The relative condition factor, which is one or close to one or more, was denoted the better robustness in GFP. All the parameters were computed separately for male and female GFP, and pooled data (male and female) were used to assess the same for combined sexes. All the descriptive statistics were computed using the Minitab Statistics Package (Version 20). Microsoft Excel 2016 was employed to calculate LWR in power and regression functions, and condition factors were used to perform the Student t-test and determine the correlation coefficient (R^2). All the data is presented as mean±SD. To compare the means among the 25 study reservoirs, the non-normality of the collected chlorophyll-a data was reduced using log natural (ln) transformation before the one-way ANOVA, Turkey's Honestly Significant Difference (HSD) post-hoc test. Pearson correlation coefficient and simple linear regression were used to predict the *b* value using the TSI value. The analyzed data were aptly presented.

RESULTS AND DISCUSSION

Chlorophyll-a content and trophic state index (TSI) of Carlson (1977), helped elucidate the status of studied perennial reservoirs, either mesotrophy or eutrophy. The TSI indicates the nutritional level of the reservoirs, which is a key influencing factor affecting the growth and yield of GFP in Sri Lankan reservoirs (Jones et al., 2021). Computed TSI for the 25 reservoirs indicated that most reservoirs (56%, n=14) were mesotrophic, and the rest (44%, n=11) were eutrophic. Descriptive statistics of Chlorophyll-a contents and TSI values of the reservoirs are summarized in Table 3. A parametric one-way ANOVA test revealed that there was a significant difference in TSI among study perennial reservoirs ($F(24,149)=34.80$, $p<0.001$).

Table 3. Chlorophyll-a content and Trophic State Index (TSI) of the study reservoirs in Sri Lanka

Reservoir	Code	Chlorophyll-a content (µg/L)		Trophic state index (Chl-a) (%)		Trophic status
		Mean±SD	Min-max	Mean±SD	Min-max	
Nachchaduwa	A1	6.76±1.16	5.24-8.60	49.22±1.66defg	46.85-51.71	Mesotrophy
Mahakanadarawa	A2	5.90±1.02	4.26-6.88	47.88±1.81efghi	44.82-49.52	Mesotrophy
Mahawilachchiya	A3	6.49±1.43	5.04-8.62	48.75±2.12defgh	46.47-51.73	Mesotrophy
Angamuwa	A4	4.95±0.82	4.21-6.27	46.19±1.58ghij	44.70-48.61	Mesotrophy
Thabbowa	P1	4.57±1.22	3.49-6.74	45.25±2.43hij	42.86-49.32	Mesotrophy
Mahauswewa	P2	8.04±1.22	6.01-9.45	50.95±1.58cde	48.19-52.63	Eutrophy
Saliyawewa	P3	5.10±1.20	3.45-6.52	46.34±2.42ghij	42.75-48.99	Mesotrophy
Pahariya	P4	6.03±0.87	5.09-7.21	48.13±1.41efghi	46.56-49.98	Mesotrophy
Kottukachchiya	P5	4.36±1.16	3.06-6.25	44.75±2.54ij	41.57-48.58	Mesotrophy
Ridiyagama	H1	10.88±0.29	10.45-11.25	54.01±0.26bc	53.62-54.34	Eutrophy
Weerawila	H2	13.06±0.37	12.45-13.56	55.80±0.28b	55.34-56.18	Eutrophy
Muruthawela	H3	8.27±0.49	7.56-8.90	51.31±0.59cde	50.44-52.05	Eutrophy
Yodhawewa	H4	13.40±0.42	12.57-13.70	56.06±0.31b	55.43-56.28	Eutrophy
Bandagiriya	H5	33.87±0.81	32.58-34.80	65.15±0.24a	64.78-65.42	Eutrophy
Udukiriwala	H6	8.09±0.11	7.95-8.24	51.11±0.13cde	50.94-51.29	Eutrophy
Pahala Andara	H7	9.40±0.49	8.70-10.00	52.57±0.51bcd	51.82-53.19	Eutrophy
Muthukandiya	M1	7.83±2.12	4.23-10.06	50.42±3.10cdef	44.75-53.25	Eutrophy
Kiriibbanwewa	M2	6.18±2.04	3.87-8.46	47.99±3.38efghi	43.88-51.55	Mesotrophy
Urusita	M3	5.73±1.51	3.48-7.85	47.41±2.76efghij	42.83-50.81	Mesotrophy
Handapanagala	M4	4.75±0.80	3.81-6.03	45.77±1.64ghij	43.72-48.23	Mesotrophy
Hambegamuwa	M5	4.66±1.26	3.14-6.57	45.40±2.61hij	41.82-49.07	Mesotrophy
Buduruwagala	M6	8.02±0.25	7.56-8.23	51.02±0.31cde	50.44-51.28	Eutrophy
Habaralu	M7	5.16±0.70	4.23-.11	46.62±1.33fghij	44.75-48.36	Mesotrophy
Mahawewa	M8	11.14±0.49	10.30-11.70	54.24±0.44bc	53.48-54.73	Eutrophy
Sugaladevi	M9	3.96±0.19	3.69-4.11	44.09±0.47j	43.41-44.47	Mesotrophy

The findings agree that reservoir environments support culture-based fishery as an alternative livelihood for the rural populace (Nissanka and Amarasinghe, 2000; Jayasinghe et al., 2006) and the GFP as a popular commodity in the culture-based fishery. Even though several studies (Rao, 1967; Nagamine and Knight, 1980; Hossain et al., 1987; Sampaio and Valenti, 1996; Kurup et al., 2000; Thanh et al., 2009; Lalrinsanga et al., 2012; Lalrinsanga et al., 2013; Ming et al., 2016; Indarjo et al., 2021) have been conducted on length-weight relationship and condition factor of *M. rosenbergii* under natural and captive environments, empirical studies on the relationship of the length-weight and the condition factor with the trophic state of the reservoir and the size of the living environment of *M. rosenbergii* are scarcer. The present findings help elucidate the size and growth of the GFP with the aid of algal biomass of the perennial reservoirs of Sri Lanka, which is used for culture-based fisheries successfully. Also, the present findings help in predicting the yield of the reservoir.

Length-weight relationship & condition factor of total GFP sample

The allometric coefficient (b) of all male GFP (n=150) collected from 25 reservoirs showed positive allometric growth. Albeit female GFP collected from the reservoirs showed negative allometric growth. However, combined sexes of GFP from the study reservoirs showed positive allometric growth following the male GFP (Figure 2 & Table 4). The computed relative condition factor (Kn) ranged from 0.97 to 1.25, indicating distinct body shapes amongst male and female GFP and combined GFP sexes in 25 different reservoirs (Table 5).

The present study's findings, in line with Lalrinsanga et al. (2012), report positive allometric growth in combined sexes of 300 GFP collected from 25 reservoirs, mainly due to the growth rate of males. This reveals that perennial reservoirs of Sri Lanka are ideal for GFP culture-based fisheries that provide a higher yield by highly grown prawns that attract the export market. However, considering the female GFP overall growth, it obtained

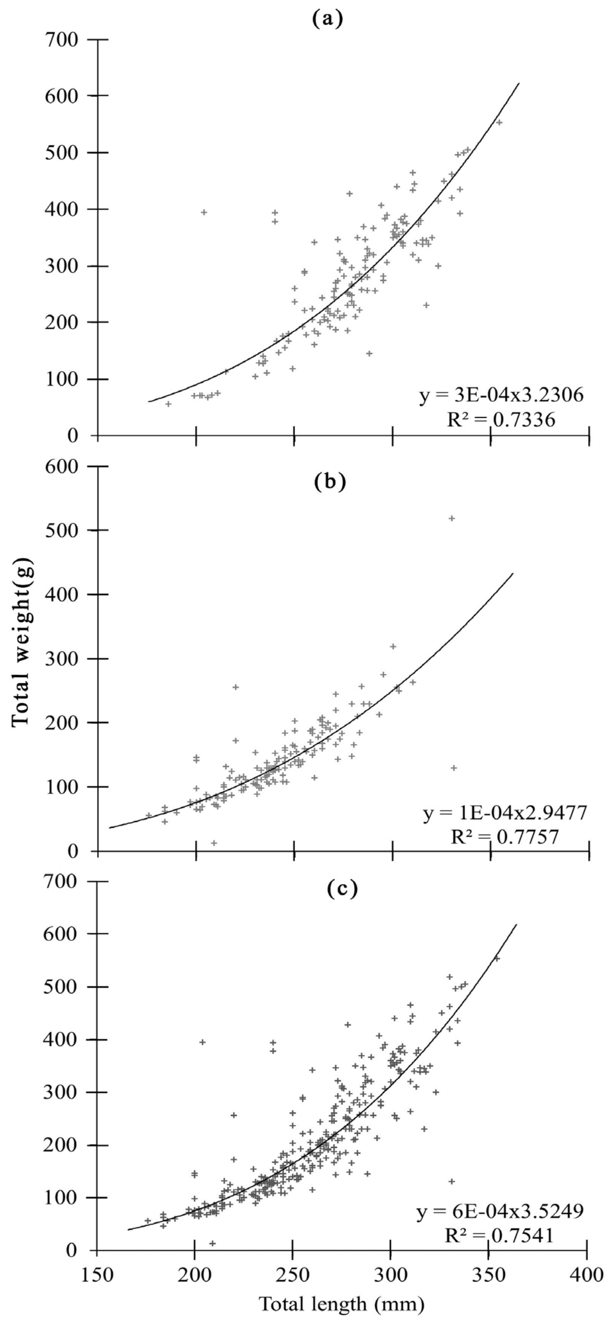

Figure 2. Length-weight relationship of male (a), female (b), and combined sexes (c) of GFP samples

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negative allometric growth. The results argue that energy acquisition for producing eggs in female GFP might be the possible reason for the difference in the development of female GFP.

Sexual dimorphism in the growth of males over the female *Macrobrachium rosenbergii* has been documented in several studies (Nagamine and Knight, 1980; Thanh et al., 2009; Lalrinsanga et al., 2012; Indarjo et al., 2021). The present findings align with those studies, and the length and weight of male GFP are significantly higher than the females, directly affecting the length and weight relationship of the GFP in the study reservoirs. Also, the findings are on par with several other studies in which the total length and total weight of the *M. rosenbergii* have been used in obtaininga length-weight relationship (Sampaio and Valenti, 1996; Kunda et al., 2008; Lalrinsanga et al., 2012; Lalrinsanga etal., 2013; Indargo et al., 2021). Length-weight relationship has broadly been applied for wild and cultured *M. rosenbergii* in ascertaining allometric coefficient (b) values (Rao, 1967; Nagamine and Knight, 1980; Hossain et al., 1987; Sampaio and Valenti, 1996; Kurup et al., 2000; Thanh et al., 2009; Lalrinsanga et al., 2012; Lalrinsanga et al., 2013; Ming et al., 2016; Indarjo et al., 2021).

The calculated b value of *Macrobrachium rosenbergii* in the present study ranged between 2.6593 and 3.5540, which agrees with the values documented in previous studies, which report negative allometric, isometric or positive allometric growths in natural environments. In this context, studies reported by Rao, 1967 in India (3.1935-positive allometric growth), Hossain et al., (1987) in Bangladesh (3.4011-positive allometric growth), Lalrinsanga et al., (2012) in India (3.3893-positive allometric growth), Lalrinsanga et al. (2013) in India (3.4369-positive allometric growth) and Indarjo et al., (2021) in Indonesia (0.7509-3.1960-negative to positive allometric growth) are significant. In addition, under culture environment studies, by Sampaio and Valenti (1996) in Brazil (3.43-positive allometric growth), Ming et al., (2016) (3.1205-positive allometric growth) and Kunda et al., (2008) reported 3.075-isometric growth in GFP sampled from rice fields in Bangladesh are noteworthy.

Ricker (1973) has documented that negative allometric growth could be shown when the allometric coefficient is less than 3, and fish may become thinner, and positive allometric growth could be observed when b>3, where fish may become fat/plump. Kurup et al., (2000) have reported that generally, in shellfishes that maintain dimensional equality, the weight increment is proportional to the cube of the length increment or isometric growth, while having slope value (b) of less than 3 shows a negative allometric growth indicating that the shellfish becomes slender when it increases in length. In contrast, a slope value greater than 3 or positive allometric growth indicates shellfish exhibit stoutness. In line with those findings, most of the combined sexes of GFP inhabiting Sri Lankan reservoirs are in positive allometric growth, showing fat/plump bodies.

The condition varies with environmental factors, sex, life stages, and time (Le Cren, 1951). Thus, we computed the relative condition factor to assess the condition of *Macrobrachium rosenbergii* at the harvestable stage. The calculated relative condition factor that ranges from 0.95 to 1.32 in study reservoirs elucidates that the GFP is in good condition in the reservoirs. Thus, the present findings indicate that the study reservoirs are well-supported and suitable for culturing *Macrobrachium rosenbergii* successfully, and the Sri Lankan reservoirs are ideal for GFP culture-based fisheries. Kunda et al. (2008) have computed 1.0013 for the relative condition factor of *Macrobrachium rosenbergii* cultured in rice fields, which elucidates that the environment

Table 4. Parameters of length-weight relationship and growth pattern in male, female, and combined sexes of *Macrobrachium rosenbergii* collected from 25 studied perennial reservoirs, Sri Lanka (Ns: sample size; a: intercept; b: allometric coefficient/slope; SE(b): standard error of slope; CI: confidence interval; R^2: coefficient of determination; I: isometric; A+: positive allometric; A-: negative allometric).

Sex	N_S	Total length (cm)		Total weight (g)		Equation parameters							Growth type
		Mean ± SD	Min-max	Mean ± SD	Min-max	a	b	SE(b)	t-test	p-value	95% CI of b	R^2	
Male	150	27.84 ±3.17	18.60 -35.40	279.54 ±103.12	55.73 -553.68	0.0003	3.2306	0.1603	1.4384	<0.001	2.9312 -3.5648	0.7336	A+
Female	150	24.10 ±2.98	17.60 -33.10	141.27 ±60.75	45.91 -519.00	0.0001	2.9534	0.1097	2.1005	0.0365	2.3088 -3.1409	0.7757	A-
Combined	300	25.97 ±3.60	17.60 -35.40	210.40 ±109.24	45.91 -553.68	0.0006	3.5249	0.1097	4.7812	<0.001	3.3088 -3.7409	0.7541	A+

Table 5. Relative condition factor (Kn) and body shape of male, female, and combined sexes of GFP collected from 25 different perennial reservoirs of Sri Lanka (Ns- sample size).

Sex	N_S	Kn		Body shape
		Mean±SD	Min-max	
Male	150	1.25±0.41	0.61-1.64	Fat/plump
Female	150	0.97±0.23	0.14-1.40	Thin/slender
Combined	300	1.11±0.36	0.14-1.64	Fat/plump

enhances the excellent condition in GFP. Furthermore, Indarjo et al., (2021) have reported the 0.5-1.5 relative condition factor for *Macrobrachium rosenbergii* inhabiting estuarine systems in North Kalimantan, Indonesia and, concerning the Kn of the GFP, the variation in body shape of Indonesian and Sri Lankan GFP are indistinguishable. Most of the GFP belong to body shapes that are slender, ideal, or fat compared to a low abundance of very thin and very fat body shapes.

Length-weight relationship and condition factor in trophically different reservoirs

The allometric coefficient (b) of male GFP collected from mesotrophic and eutrophic reservoirs showed negative allometric and positive allometric growth, respectively. Albeit female GFP collected from the mesotrophic and eutrophic reservoirs showed negative allometric and isometric growth. However, combined sexes of GFP collected from eutrophic and mesotrophic reservoirs showed positive allometric growth (Table 6 and Figure 3). The computed relative condition factor (Kn) ranged from 0.95 to 1.32 indicating indistinguishable body shapes separately amongst male and female GFP as well as amongst combined sexes of GFP in two trophically different reservoirs (Table 7) of the study reservoirs (n=25), male GFP collected from mesotrophic reservoirs (n=14) showed negative allometric growth, while, positive allometric growth was obtained by male GFP collected from eutrophic reservoirs. Female GFP collected from mesotrophic reservoirs showed negative allometric growth. In contrast, those collected from eutrophic reservoirs showed isometric growth, emphasizing that an increase in algal biomass and nutrient level in the reservoir may be the significant factor that affects the growth of both male and female GFP. Therefore, the allometric coefficient in combined sexes of GFP inhabiting the reservoirs of both trophic states showed positive allometric growth.

The computed relative condition factor (Kn) of the GFP in two trophically different reservoirs reveals that male prawns of the reservoirs have a fat body shape, affirming that the GFP in the study reservoirs is in normal and healthy conditions. Also, the Kn values of the combined sexes of GFP in reservoirs belonging to two different trophic statuses exhibit fat body shapes, while the female GFP shows thin/slender body shapes. This is particularly significant in culture-based fisheries because fat-shaped individuals are crucial in increasing production. None of the GFP specimens exhibit Kn >1.5, implying a very fat body shape, as recorded in a previous study (Indarjo et al., 2021). Kunda et al. (2008) have also revealed that *Macrobrachium rosenbergii* culture in rice fields in Bangladesh reached a 1.080 relative condition factor, suggesting good conditions for GFP culture in rice fields.

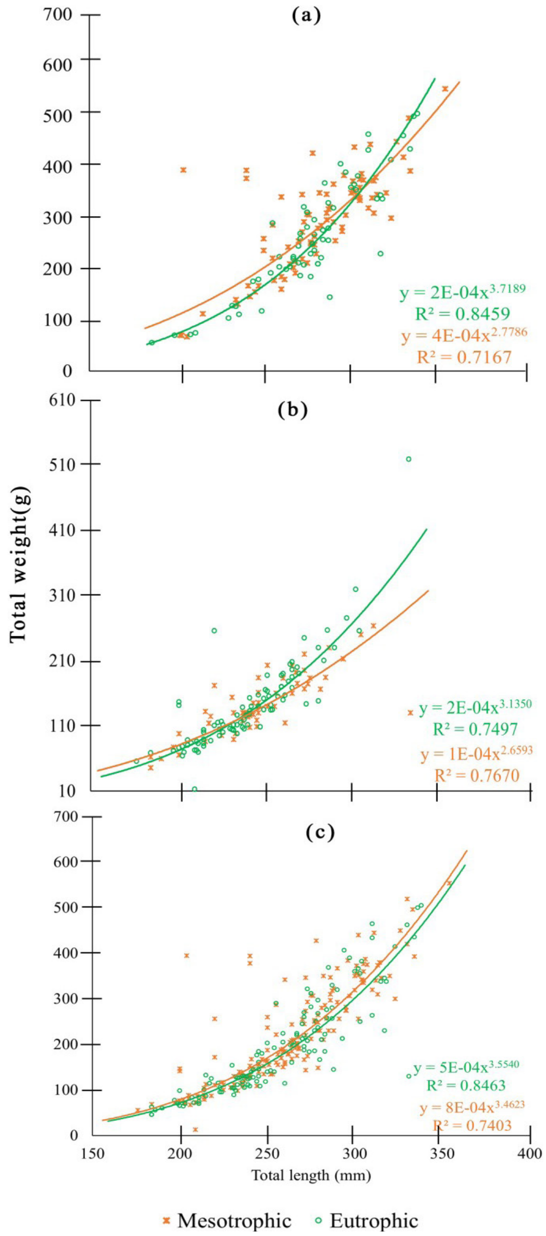

Figure 3. Length-weight relationship of male (a), female (b), and combined sexes (c) of GFP collected from mesotrophic and eutrophic reservoirs.

Table 6. Parameters of length-weight relationship and growth pattern in male, female, and combined sexes of *M. rosenbergii* collected from mesotrophic and eutrophic perennial reservoirs in Sri Lanka (NR: number of reservoirs; Ns: sample size; a: intercept; b: allometric coefficient/slope; SE(b): standard error of slope; CI: confidence interval; R^2: coefficient of determination; I: isometric; A+: positive allometric; A-: negative allometric).

Category of TSI	N_R	Sex	N_S	Total length (cm)		Total weight (g)		Equation parameters							Growth type
				Mean ± SD	Min-max	Mean ± SD	Min-max	a	b	SE(b)	t-test	p-value	95% CI of b	R^2	
Mesotrophy	14	Male	84	28.01 ±3.14	20.20 -35.40	283.26 ±95.23	70.50 -553.68	0.0004	2.7786	0.1669	1.3262	<0.001	2.9007 -3.5604	0.7167	A-
		Female	84	24.39 ±2.91	17.60 -33.00	149.59 ±67.48	55.80 -519.00	0.0006	2.6593	0.1935	-1.7600	<0.001	202725 -3.0461	0.7497	A-
		Com bined	16 8	26.02 ±3.44	17.60 -35.40	212.42 ±106.64	55.80 -553.68	0.0008	3.4623	0.1669	2.7690	0.0062	3.1326 -3.7919	0.7403	A+
Eutrophy	11	Male	66	27.33 ±3.12	18.60 -33.80	246.38 ±99.70	55.73 -435.40	0.0002	3.7189	0.1983	3.3544	0.0013	3.3225 -4.1152	0.8459	A+
		Female	66	23.54 ±2.72	18.4 0-33.10	126.06 ±43.68	45.91 -230.03	0.0005	3.1350	0.2622	0.5147	0.6080	2.6132 -3.5655	0.7670	I
		Com bined	13 2	25.44 ±3.48	18.40 -33.80	187.14 ±97.23	45.91 -435.40	0.0005	3.5540	0.1328	4.1712	<0.001	3.2913 -3.8168	0.8463	A+

Table 7. Relative condition factor (Kn) and body shape of male, female, and combined sexes of GFP collected from trophically different perennial reservoirs of Sri Lanka (N_R-number of reservoirs; N_s- sample size).

Category of TSI	NR	Sex	NS	Kn		Body shape
				Mean±SD	Min-max	
Mesotrophy	14	Male	84	1.32±0.49	0.77-1.65	Fat/plump
		Female	84	0.98±0.25	0.14-1.40	Thin/slender
		Combined	168	1.16±0.42	0.14-1.65	Fat/plump
Eutrophy	11	Male	66	1.17±0.24	0.61-1.75	Fat/plump
		Female	66	0.95±0.19	0.36-1.62	Thin/slender
		Combined	132	1.05±0.24	0.36-1.75	Fat/plump

Relationship between TSI and b value of GFP

A Pearson correlation coefficient was computed to assess the linear relationship between the Trophic state index (TSI) of the study perennial reservoirs and the allometric coefficient (b value) of collected GFP samples from the reservoirs as male, female, and combined sexes that indicated separately indicated. A positive correlation between the two variables among the male, r(23) =0.7210, p<0.001: female, r(23)= 0.018, p =0.934: and combined sexes, r(23)=0.7900, p<0.001. Simple linear regression was employed to test if the trophic state index significantly predicted the allometric coefficient of the male and combined sexes. GFP showed that the fitted regression model was b value =1.48+0.04*(TSI value) for male GFP. The overall regression was statistically significant (R^2=0.7860, p<0.001), and the fitted regression model was b value =2.36+0.02*(TSI value) for combined sexes GFP. Also, the overall regression was statistically significant (R^2=0.7362, p<0.001).

It was found that there was no correlation between the above two variables in female GFP. Therefore, simple linear regression cannot be used to predict the b value of female GFP using the computed TSI of the perennial reservoir (Figure 4). The initial finding of the relationship between the TSI of the perennial reservoir and the b value might be helpful in the field of predicting the allometric coefficient for the male and combined sexes of GFP. Thus, the findings indicate that the selected perennial reservoirs in Sri Lanka support GFP culture-based fisheries.

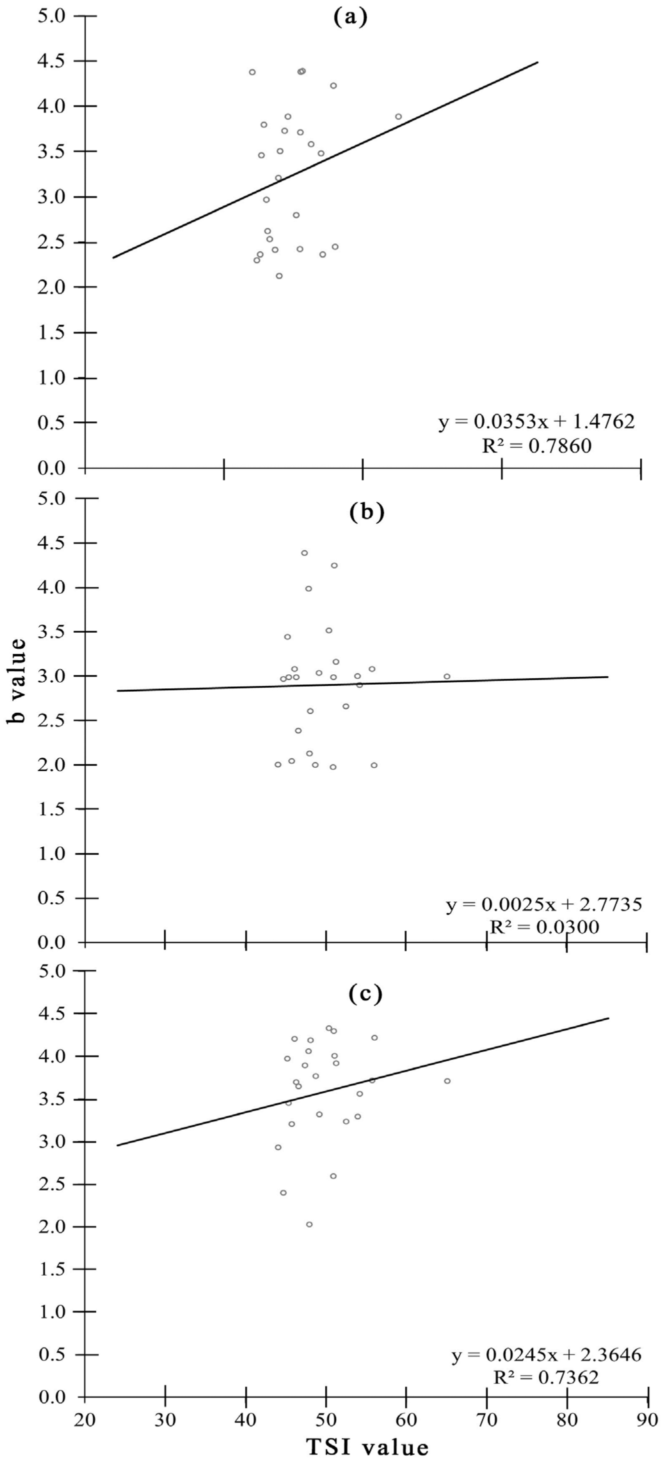

Figure 4. Graphical illustration of the simple linear regression between TSI and b value of male (a), female (b), and combined sexes (c) of GFP

CONCLUSION

The present findings confirm that the allometric coefficient and condition factor of *Macrobrachium rosenbergii* depends on the trophic status of reservoirs. It reveals that the highest allometric coefficient is computed for eutrophic perennial reservoirs. The present findings help accept the postulated hypothesis that the allometric coefficient and condition factor of GFP varies with the trophic state of the inhabitant reservoir, where GFP is stocked for the development of CBF. The results showed the potential of selecting suitable marketable size GFP from the stocked reservoirs, overcoming the insufficient supply for the consumer demand. The present findings might apply to CBF, which is GFP-dependent in the rest of the world.

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