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Length-weight relationships and condition factor of giant freshwater prawn, *Macrobrachium rosenbergii* (De Man, 1879) in five perennial reservoirs in Northern Province, Sri Lanka

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Abstract
Present study was mainly investigated length-weight relationships and condition factor of *M. rosenbergii* stocked in two large (Vavunikulam, Muthayankattu) and three small (Puthumurippu, Kalmadu, Muhathankulam) perennial reservoirs in Northern Province of Sri Lanka as culture-based fisheries. Randomly selected 300 *Macrobrachium rosenbergii* caught by multi mesh gillnets between January to December 2017 were analyzed. Non-linear regression analysis was conducted for total length (L) and body weight (W) of *M. rosenbergii* as power function $W= aL^b$. Fulton's condition factor (*K*) was calculated by using the formula: $K = (W * 100)/L^3$. One-way ANOVA and Tukey comparison was conducted for significance of condition factor among reservoirs. Allometric growth coefficient (*b*) ranged between 2.1295 – 4.2068. Highest *b* value was observed in both Kalmadu (*b*=4.2068) and Puthumurippu (*b*=4.1132), while the lowest from Vavunikulam (*b*=2.1295). Mean condition factor (*K* value) of *M. rosenbergii* ranged from 1.3928 – 1.9505 and overall *K* value was 1.6130. *K* values were higher in Puthumurippu (1.9505) and lower in Vavunikulam (1.3928). Smaller reservoirs had higher condition factor values than larger perennial tanks and *M. rosenbergii* were in a good health condition in these five reservoirs.

Keywords: *Macrobrachium rosenbergii*, length-weight relationships, condition factor, culture-based fisheries, perennial reservoirs

Introduction
Giant freshwater prawn *Macrobrachium rosenbergii* is the largest species in family Palaemonidae and is the most commercially important cultured species in the world [1]. To develop freshwater prawn industry in Sri Lanka, National Aquaculture Development Authority (NAQDA) collaborated with public and private stakeholders and launched a stocking program in perennial and seasonal tanks in Northern Province of Sri Lanka. Length-weight relationships of fish or crustacean is vital in fisheries and aquaculture, to observe growth pattern in wild stocks and cultured species and to determine variations in growth rate of a specific species in different environmental conditions [2]. A study of morphometric measurements and mathematical models in aquaculture are beneficial due to analysis of growth pattern for culture management, which limits the cost for culture [3].
Condition factor (*K*) revels the interactions between biotic and abiotic factors in the physiological condition of the fish which reflects the overall welfare of the animal [3], but not the qualitative characteristics (protein, lipid, carbohydrates) of the body [4]. Condition factor is allied to a complex interaction of endogenous such as physiological, metabolic, hormonal and genetic processes [5] and exogenous factors such as temperature, photoperiod, rainfall, availability and quality of feeds, salinity and population density [6]. Information on condition factor (*K*) can be fundamental to aqua-culturist which provides general information of the cultured environmental condition suitability for the particular species [7].
Present study mainly investigated length-weight relationship and condition factor of *M. rosenbergii* stocked in five perennial reservoirs under extensive culture and explored the differences of the allometric growth coefficient (*b* value) of the length-weight relationship among the five reservoirs.

This knowledge may be useful to aqua-culturists and fisheries managers for the establishment of culture-based fisheries in reservoirs using *M. rosenbergii* under extensive culture. *M. rosenbergii* was introduced for the first time in all the five selected reservoirs and this study is the first study of its kind and on *M. rosenbergii* in these reservoirs.

Materials and Methods

This study was conducted in two large (Vavunikulam, Muthayankattu) and three small (Puthumurippu, Kalmadu, Muhathankulam) perennial reservoirs (Fig. 1) in Northern Province of Sri Lanka. Samples of *M. rosenbergii* were randomly selected between January to December 2017, by multi-mesh gillnets (88.9 mm, 101.6 mm, 114.3 mm 127 mm, 152.4 mm and 177.8 mm, knot to knot). All these gill nets were set by local fishermen in the evening around 4.00 p.m. to 6.00 p.m. and collected on next day morning between 5.00 a.m. and 9.00 a.m. in almost all the areas of reservoirs. All the measurements were taken at the landing site immediately after landing. Individuals with missing or damaged appendages and soft-shell prawns were excluded from analyzes. In total 300 individuals were examined.

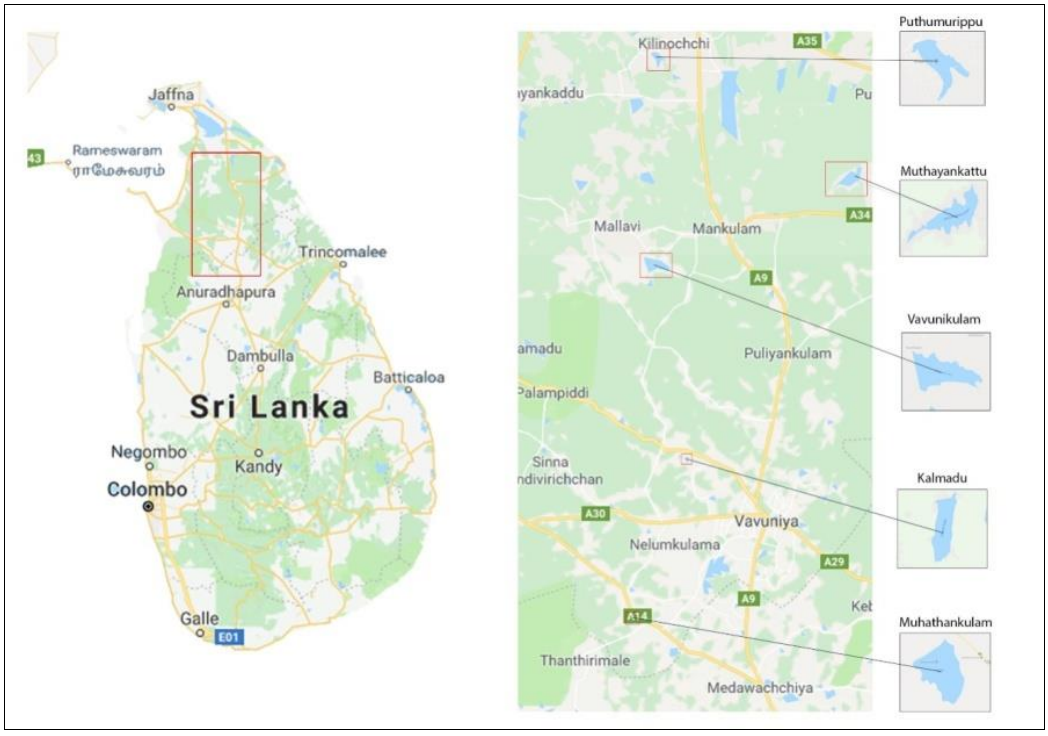

Fig 1: Locations of selected reservoirs

Nonlinear regression analysis was conducted for total length (L) and body weight (W) of *M. rosenbergii* caught from five reservoirs. Length-weight relationships are typically described as power function $W = aL^b$ [8] where Y is the dependent variable (total body weight) and X is the independent variable (Total length-the length from tip of the antennule's plate to end of the telson), *a* is the intercept and *b* is the allometric growth coefficient. The coefficient of determination (R^2) was used as the index of strength of the linear association. Fulton's condition factor (CF) was calculated by using the following formula: $CF = (W * 100)/L^3$ [9, 10] where W is the weight of the prawn (g) and L is the total length of the prawn (cm). A t-test was conducted for significance of condition factor and *b* value of the reservoirs. One-way ANOVA and Tukey comparison was conducted for significance of condition factor among reservoirs and types of reservoirs. All statistical procedures were performed using Microsoft Excel 2016 and Minitab 17 statistical software.

Results

Allometric growth coefficient (*b*) of the total length-weight relationships estimated in the present study (Table 1) ranged between 2.1295 – 4.2068 and overall *b* value was 2.5315. Highest *b* value was observed in both Kalmadu (*b*=4.2068) and Puthumurippu (*b*=4.1132), while the lowest from Vavunikulam (*b*=2.1295) and Muhathankulam (*b*=2.5315). A statistical difference was not observed (*P*=0.575) between mean *b* value in reservoirs and but there was a significant difference (*P*=0.006) between the mean value of *b* in two reservoir types.

Table 1: Summary of sample size (N), mean total length (L), mean body weight (W), length-weight relationship and their parameters (*a,b*) and mean condition factor (K) of *M. rosenbergii* in Vavunikulam (R1), Muthayankattu (R2), Puthumurippu (R3), Kalmadu (R4), Muhathankulam (R5) and all five reservoirs (All).

Reservoirs	N	L	W	*A*	*B*	R^2	Relationship	*K*
R1	60	29.7	368	0.2627	2.1295	0.718	$W=0.2627(L)^{2.1295}$	1.3928
R2	60	28.0	377	0.0099	3.1546	0.8489	$W=0.0099(L)^{3.1546}$	1.6668
R3	60	23.8	279	0.0006	4.1132	0.8966	$W=0.0006(L)^{4.1132}$	1.9505
R4	60	24.0	251	0.0004	4.2068	0.9591	$W=0.0004(L)^{4.2068}$	1.7124
R5	60	24.4	248	0.0013	3.7775	0.9353	$W=0.0013(L)^{3.7775}$	1.6167
All	300	26.3	303	0.0729	2.5315	0.7896	$W=0.0729(L)^{2.5315}$	1.6130

Present study reveals that mean *K* value of *M. rosenbergii* of selected five perennial reservoirs (Table 1) under extensive culture ranged from 1.3928 – 1.9505 and overall *K*-value was 1.6130. *K*-values were highest in Puthumurippu (1.9505) and lowest in Vavunikulam (1.3928). The *P*-value of one-way ANOVA for the condition factor (*K* value) of *M. rosenbergii* was less than 0.05 (P=0.000) with a r^2 value of 34.48%. This result indicated that the mean differences between the condition factor of *M. rosenbergii* of the reservoirs are statistically significant. Tukey comparison indicated that the confidence interval for the difference between the means of Vavunikulam and Puthumurippu significantly differed from Muthayankattu, Kalmadu and Muhathankulam. Meanwhile, a statistical difference was not observed in condition factor among Muthayankattu, Kalmadu and Muhathankulam. Condition factor of *M. rosenbergii* in type of reservoirs also significantly different (P < 0.001) and the smaller reservoirs had higher condition factor than larger reservoirs.

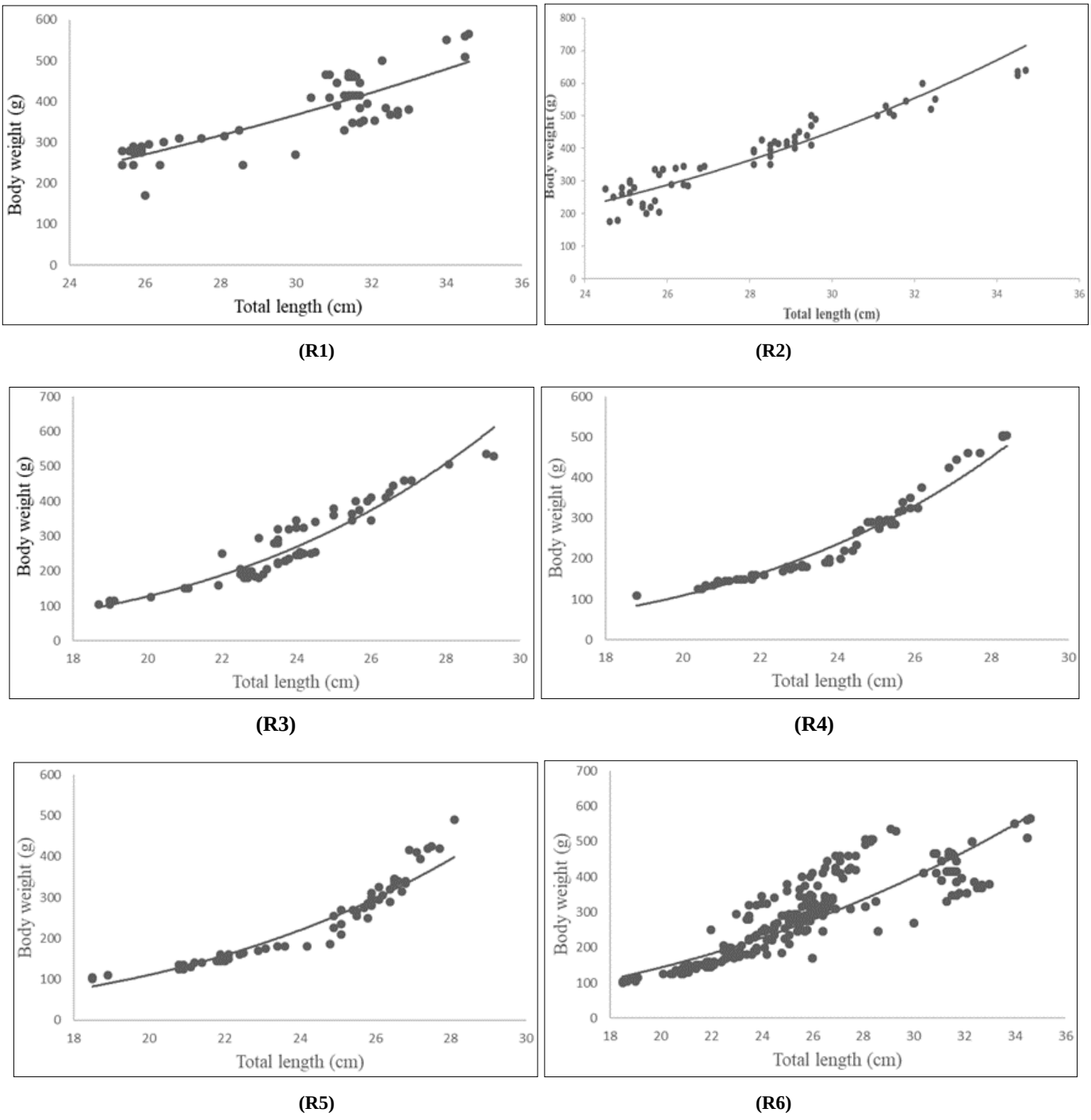

Fig 2: Length-weight relationship for *M. rosenbergii*at Vavunikulam (R1), Muthayankattu (R2), Puthumurippu (R3), Kalmadu (R4), Muhathankulam (R5) and All five reservoirs (R6)

Discussion

Length– weight relationships has been widely applied for wild and culture of *Macrobrachium* species [2, 11]. Hence, total length is used to determine the length-weight relationship in the present study. In length-weight relationships, if *b*=3, fish or prawn grows either isometrically or allometrically [8, 10]. Ricker (1975) [8] mentioned that allometric growth can be either positive (*b*>3) or negative (*b*<3) and fish may thinner if *b* value is less than 3 and may fleshy when *b* is greater than 3. Present study recorded the positive allometric growth (*b*-value

> 3.0) except Vavunikulam major reservoir. Therefore, in the reservoirs that showed allometric growth the increase in the weight of *M. rosenbergii* was higher than the increase in the length. Similar findings have been reported elsewhere (Table 2). In an earthen pond culture of 0.02 ha in Brazil, Sampaio and Valenti (1996) [2] also observed a higher *b* value of 3.43 with a density of 1.5 prawns/m^2. A similar study in Orissa, India was conducted by Lalrinsanga *et al*. (2012) [4], who reported a higher *b* value of 3.5932. Similarly, Ming *et al*. (2016) [12] observed a *b*-value of 3.1205 even in high density pond culture for *M. rosenbergii* and Kunda *et al*. (2008) [11] reported isometric growth (*b* = 3.075) of *M. rosenbergii* in rice field with a coefficient of determination (R^2) of 0.99, indicating rapid growth of the species. Growth pattern of prawns generally follows a sigmoidal pattern and may vary in different life stages [4]. "Leapfrog" growth pattern was observed by Karplus *et al*. (1991) [13] for *M. rosenbergii* and the relationship between length and weight at different life stages could be described in different biological regression equations (Table 2).

Table 2: Length-weight relationship of *M. rosenbergii* reported in previous studies.

Length-Weight Relationship	*B*	r^2	References
$W=7.222*10^{-5}L^{3.19346}$	3.19346	0.99013	Rao (1967) [14]
$W=0.00303L^{3.4011}$	3.4011	0.96	Hossain *et al*. (1987) [15]
$W=1.21*10^{-6}L^{3.43}$	3.43	-	Sampaio and Valenti (1996) [2]
$W=0.008875L^{3.075}$	3.075	0.99	Kunda *et al*. (2008) [11]
$W=0.087694L^{3.3893}$	3.3893	0.9478	Lalrinsanga *et al*. (2012) [4]
$W=5*10^{-6}(TL)^{3.1205}$	3.1205	0.9935	Ming *et al*. (2016) [12]

Fulton's condition factor (*K*), is widely used in aquaculture and fisheries studies to determine the degree of robustness of fish and crustaceans. *K*=1 is the baseline between slender and robust condition of the organism and *K*>1 indicates the fish or crustacea is in a better condition of robustness of the organism [3, 7, 5]. Present study reveals that the mean *K* value of *M. rosenbergii* of selected five perennial reservoirs (Table 1) under extensive culture ranged between 1.3928 – 1.9505. Other studies present a slightly lower mean *K* value. Kunda *et al.* (2008) [11] in their study of prawns grown in rice fields found *K* values ranging between 0.97-1.17. Meanwhile, Lalrinsanga *et al*. (2012) [4] reported a *K* value of 0.79-1.14 in pond culture. In a similar study conducted by Ming *et al*. (2016) [12], in high density earthen ponds, reported *K* values between 0.7-1.05. The low R^2 value (34.48%) reveals that this model generates non-specific predictions. This may be due to the small size of the groups and/or the different types of male morphotypes of *M. rosenbergii*.

Hartnoll (1982) [16] observed growth of organisms depended on intrinsic (genetics) and extrinsic (environmental) factors, which act in ontogenetic development while exogenous factors temperature and feed availability strongly influence growth rate of freshwater prawns. Intraspecific and interspecific competition for food space and interaction among animals may occur due to higher population densities which severely affect the growth of prawns even in nutrient rich environments due to high energy expenditure by competition stress [13, 17]. Sampaio and Valenti (1996) [2] reported that when population density increased from 4 prawn/m^2 to 12 prawn/m^2 there was a higher reduction in mean maximum asymptotic length and specific growth rate. *M. rosenbergii* shows territorial behavior [1] and the higher energy expenditure due to the aggressive or social behavior for a territory and its defense at higher densities may gradually reduce the growth rate and aggression among competitors, stress is intense even when food is abundant [13] which may the reason at Vavunikulam showed the low *b*-value (2.1295), due to higher stocking density and low water level at the reservoir.

Conclusion

In the present study four of the five reservoirs showed positive allometric growth with a b-value greater than 3.0. In addition, condition factor value was high in all the five reservoirs and this value ranged from 1.3928 to 1.9505 with the mean value of 1.6130 (K>1). The findings indicate that *M. rosenbergii* was rapidly growing in the four reservoirs while all the reservoirs were in good health condition for growth. Furthermore, both minor and medium reservoirs had comparatively higher K values than major perennial reservoirs, which delineates that they are better habitats for growth.

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