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Dimensional relationships of *Fenneropenaeus merguiensis* (de Man,1888) banana prawn, from Mumbai waters

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ABSTRACT

Dimensional relationships of various morphometric characters were established for the Banana prawn, *Fenneropenaeus merguiensis* (de Man,1888) from Mumbai waters. A total of 467 males ranging in size from 48-171 mm and weighing from 0.550 – 38.934 g and 579 females ranging in size from 54-237 mm and weighing from 0.739-107.998 g were used for the relationships. The relationship was calculated for various parameters such as Total length with total weight, tail weight, carapace length & rostrum length and similarly for carapace length with total weight, rostrum length and total weight with tail weight and meat weight. The coefficient of correlation (r^2) for various parameters is ranging between 0.73 to 0.99 indicating high degree of relationship. The total length–total weight relationships are different and therefore, it is necessary to use separate expressions for the males and females. It was also observed that length and weight relationship of males and females increases more than the cube.

Key words: Dimensional relationship, *Fenneropenaeus merguiensis*, morphometric characters, length weight relationship

INTRODUCTION

Morphometric characters are of great importance in classification studies for distinguishing various taxonomic groups, species and the races within the species. However, in closely resembling species and particularly in juvenile phases, such characters are invariably not distinguishable. In order to avoid such difficulties morphometric analysis of different body parts are generally practiced by fish taxonomists. In morphometric studies, measurements of different body part are taken and their proportions and relations are expressed in the form of numerical or mathematical expressions. Such morphometric expressions are widely used to study races or subpopulations (Marr, 1955). During growth of an animal all the body parts do not grow proportionately and their relations may change during their life span. Yet, such changes are species specific and therefore they are extremely important in population dynamics.

The size of an organism can be measured in terms of length, height, width or weight. In the case of fishes, total length and standard length are the generally used dimensions for noting the body size. But, in case of crustaceans in the absence of permanent hard-part and due to the periodic molting of the exoskeleton, it is difficult to note their size. In spite of this, length of a crustacean is noted as total length, carapace length or carapace width (in crabs). The penaeid prawns have a long pointed rostrum which some times break while fishing and handling, therefore most of the researcher use carapace length as the standard unit of length. Though, it is imperative to take the carapace length as a standard length for the size, measuring it by Vernier calipers is cumbersome in the field. Moreover being small, carapace length has very limited range, and a slightest error in measurement can lead to distortion. Therefore, it is easier and safer to measure the total length in case of prawns as the standard length unit of size.

The relationships between various body parts are easier to express mathematically for conversions. The expressions may take linear form, when one body part (variable) increases in the same proportion with other. In exponential form one variable may change disproportionately in relation to other and generally expressed by a power function.

Among the various relationships used in fisheries biology, the most widely used one is the relation between length and weight. This relationship is very useful for conversion of one to other, if one is known. For stock assessment studies length-weight relationship of commercially important organisms is of eminent importance, since size is noted as length while yield is estimated in terms of weight. A deviation in the mathematical expression of length and weight with previously established relationship may indicate the taxonomic differences or condition of fish such as spawning stress and the ecological condition of the surrounding area. According to Le Cren (1951) length and weight of a species of fish are closely related to each other and can be expressed mathematically. Accordingly, length is a linear dimension and weight is a measure of volume, hence they are related by a cube form. For expressing the length weight relationship Le Cren (1951) gave a mathematical expression : $W = a^* L^b$, Where 'a' is a constant while 'b' is an exponent and the value of 'b' generally lies close to 3 but it may vary from 2.5 to 4.0 (Hile, 1936). From a simple regression analysis between length and weight it is difficult to find out the exponent 'b'. Therefore, the values of length and weight are transformed into logarithms and a linear regression is performed to get 'a' and 'b' values.

In an ideal situation as length increases the weight also increases proportionately. Such growth is called isometric growth, but this is rarely met with. A preliminary scatter of the observed lengths and weight shows that as the size increases the variability in weights gets amplified; so also when data are log transformed for linear regression method, the estimate of the constant (a) is biased (Haynes *et al.*, 1995). Therefore, allometric growth model given by Quinn and Deriso (1999) with multiplicative error structure is followed for precision: $W = a L^b e^{\varepsilon}$, Where, parameters 'a' and 'b' are the constant (condition factor) and the exponent respectively. 'ε' is the random error term with mean 0 and variance σ^2. In order to estimate the parameters by linear regression, the data are log transformed by considering the expression: $\log W = \log a + b \log L + \varepsilon$. The main consideration in fitting the allometric model is that correct error structure is chosen and that the resultant fit of the model to the data should not indicate any lack of fit. The method tacitly assumes multiplicative error model $W = a.L^b.\varepsilon$, where 'ε' is random error factor and the estimate of 'a' by the linear regression is biased. Therefore to compensate, the biased 'a' value is corrected.

For commercially important prawns, relationships between carapace length-total length, total length-total weight and total weight-tail weight are required to compare them from different sources since information on catch statistics is recorded in various units (Rao, 1988) such as number of tails per pound of weight or per kg. The fish processing industry requires the conversion of one unit into another, *i.e.* total weight into meat weight or tail weight. In juvenile phase of some species of prawns the rostrum is longer in relation to the carapace or total length; as a result body size (total length) of the prawn is deceptively longer than the actual. Therefore, relations between rostrum length, carapace length and total length are necessary for conversions. Since length of rostrum in relation to size (carapace or total length) decreases it is necessary to understand whether such decline is uniform or inconsistent. Achuthankutty (1988) calculated separate length-weight relationship for both juveniles and adults.

Many workers have reported length-weight relationship of penaeid prawn from Indian waters (George, 1959; Rajyalakshmi 1961; Subrahmanyam, 1963; Rao, 1967; Kunju, 1967; Thomas, 1975; Sukumaran and Rajan, 1981; Lalithadevi, 1986 & 1987; Sukumaran *et al*., 1993). Ramamurthy and Manickraja (1978) reported dimensional relationship between tail and total length, total and carapace length for *M. dobsoni*, *M. affinis* and *Parapeneopsis stylifera*. Nandakumar (1998) studied dimensional relationships of *M. monoceros* from Cochin waters. Farmar (1986) gave morphometric relationships for *P. semisulcatus*, *M. affinis* and *Parapeneopsis stylifera* from Kuwaiti waters, Bishara (1976) gave separate length-weight relationship for male and female penaeid prawns from Egyptian water.

In the case of *F. merguiensis*, Achuthankutty and Parulekar (1986) studied carapace length - total weight relationship separately for juveniles and adults from Goa waters while, Pillai *et al.* (1991) reported length-weight relationship for the species from Orissa coast. Bhadra and Biradar (2000) worked out the relationship for the same species from trawl catch of Mumbai waters. Along with *Penaeus semisulcatus* and *P. latisulcatus*, Roongratri and Laitim (1992) reported the carapace length and total weight relationship of *F. merguiensis* from east coast of the Gulf of Thailand. Aujimangkul *et al.* (2003) studied the carapace length and total weight relationship from the Wain estuary, Thailand.

MATERIALS AND METHODS

F. merguiensis has distinct juvenile phase in inshore brackish waters and creeks, while adults are found in the sea from nearshore to offshore waters. The juveniles were rarely found in the trawlers, therefore, it was necessary to collect samples from different areas and fishing gears, so that dimensional relationships could be investigated from both the phases and most of the size ranges.

Random samples of the species were collected from different gears, from January 2015 to December 2015. From the trawlers operated at New Ferry Wharf and Harnai samples were collected at monthly interval, excepting in the month of July when fishing was totally closed due to fishing ban on monsoon trawling. Samples were also brought from Khamde village from barrier nets twice a month. The samples were preserved in 5% formalin and brought to the laboratory for further analysis. The prawns were sorted sex-wise and measured from tip of the rostrum to end of telson to the nearest millimetre for total length. Carapace length was taken from the orbital notch to the posterior mid dorsal margin and for rostrum from orbital notch to the pointed tip of the rostrum by means of a divider. The specimens were blotted on a dry cloth and then weighed on an electronic balance (with 0.001 g accuracy) for their total weight. Tail weight was taken after removing the head (cephalothorax) from the tail (abdomen) and the meat weight was the tail weight after removing the exoskeleton over the abdomen.

In the present study following relations were investigated for male and female prawns separately. Total length – total weight, total length – tail weight, total length – carapace length, total length – rostrum length, carapace length – total weight, carapace length – rostrum length, total weight – tail weight, total weight – meat weight. Among the above relations total length – carapace length, total length – rostrum length, carapace length – rostrum length, total weight – tail weight, total weight – meat weight relation were linear therefore, they are expressed as: 'y = a+ b*x'. Other relations such as total length – total weight, total length – tail weight and carapace length – total weight showed exponential relationship i.e., by taking their logarithmic values they were converted into linearised form. Separate relationships for length and weight of juveniles and adults of the species within the sexes and between the sexes were also carried out. The juveniles were considered from the minimum recorded length to the size at maturity (Lm) *i.e.* for males up to 123 mm and for females up to 132 mm. Prawns above the size at maturity were considered as adults.

In order to find out differences between various relationships of the two sexes, regression coefficients were tested by 't' test using statistical method given by Zar (1999). The analysis was used to find the differences between juveniles and adults of the two sexes. Similarly, differences in relationships between juvenile and adult males and juvenile and adult females of the species were also tested.

RESULTS AND DISCUSSION

A total of 467 males ranging in size from 48-171 mm and weighing from 0.550 – 38.934 g and 579 females ranging in size from 54-237 mm and weighing from 0.739-107.998 g were used for the relationships. The mathematical expressions of the morphometric relationships obtained by linear, logarithmic and power function were tested for their goodness of fit by correlation coefficient (r^2) and given in Table 1.

1. *Relationship between total length and carapace length:*

The carapace length of males ranged from 8.5 to 39.5 mm and that of females from 9.5 to 63.5 mm.

Males: The best relationship between total length and carapace length for male was found to be a power function (Table 1) and it can be expressed as:

$CL = 0.0819 \times TL^{1.189}$ (r^2= 0.9886)

Females: The relationship between total length and carapace length for female was found to be power function (Table 1) and it can be expressed as:

$CL = 0.0589 \times TL^{1.262}$ (r^2= 0.9915)

Comparison of regression lines between males and females showed significant difference at 5 % level (p= 2.959 $^{-31}$). The relationship between the sexes suggests that for a given total length, carapace size of a female is longer than males. Conversely, for a given carapace length, the total length of a male is longer than female.

2. *Relationship between total length and total weight:*

The relationship between total length and total weight was found to be curvilinear and therefore the lengths and weights were transformed into logarithms. The relationship between the transformed values showed linear relationship. Since relationship between total length and total weight is extremely important in the yield model of Beverton and Holt (1957) and the length based virtual population analysis of Jones (1984), it was rigorously tested by various statistical analyses. Initial scatter of total length (independent variable) and total weight (dependent variable) showed curvilinear relation, hence they were transformed into logarithms and using multiplicative error structure model parameters 'a' and 'b' were estimated. The relationships for the two sexes are expressed as:

Males: $\text{Log } TW = -6.096 + 3.4299 \times \text{Log } TL \times e$ (r^2= 0.9925) or the simplified version of the equation as: $TW = 0.00000080 \times TL^{3.4299} \times e$

Females: $\text{Log } TW = -6.1566 + 3.4615 \times \text{Log } TL \times e$ (r^2= 0.9944) or the simplified version of the equation as: $TW = 0.00000070 \times TL^{3.4615} \times e$

The details of the regression statistics are given in Table 2. The biased value of 'a' on account of log transformation was corrected by using the expression:

$$\text{Antilog } \frac{(a + S^2)}{2} \text{ .... (1)}$$

Where, 'S^2 'is an estimate of variance of deviation from the regression.

The corrected value of 'a' was 0.000000822 for male and 0.000000702 for female prawns. However, the variance (for male = 0.0016 and for female =0.0014) of regression is very small and the number of independent observations (degrees of freedom) is large therefore, corrected value of 'a' was almost the same as previously estimated. In order to test the equality of 'b' with cube, 't' test was followed by Null hypothesis.

H_0: b = 3.

$t = |b - 3| \div S_b$ ....(2)

Where,

$S_b^2 = S^2 \div (\Sigma x^2 - ((\Sigma x)^2 \div n))$ ....(I)

$S_b = \sqrt{S_b^2}$ ....(II)

S^2 'is an estimate of variance of deviations from regression, Σx^2 is sum of squares of independent variable, Σx is sum of independent variables and 'n' is the total number of specimens observed.

It was found that the table value of 't' with 466 degrees of freedom for the males and 578 degrees of freedom for the females was 1.965 at 5 % significance level for both the sexes. The resultant 't' values (31.01 for males and 42.18 for females) are greater than the table values at 5 % and 1 % levels of significance. Hence, null hypothesis (H_0) was rejected. The value of $|t|$ was significant at p= 2.25^{-115} for male and p=1.44^{-178} for females. Therefore, it was concluded that there was a significant difference between the value of 'b' and cube (*i.e.* $b \neq 3$) and it may be stated that the weight of both males and females increases more than the cube.

To find out the difference between the relationships of males and females, slopes and elevations of the regression lines were compared statistically. The details of the analysis are given in Table 3. It was observed that the slopes of the regression lines were not significantly different (p= 0.08) but the elevations were significantly different (p= 0.007) at 5% level. It was concluded that the total length–total weight relationships are different and therefore, it is necessary to use separate expressions for the males and females.

Table 1. Correlation coefficients for relationships between different morphometric characters of male and female prawns of *F. merguiensis*

Relationship	Sex	r^2			
		Linear	**Logarithmic**	**Power**	**Exponential**
Total length – Carapace length	M	0.9824	0.9473	**0.9886**	0.9776
	F	0.9846	0.9295	**0.9915**	0.9787
Total Length –Total weight	M	**0.9925**	0.9900	-	-
	F	**0.9941**	0.9915	-	-
Total length – Tail weight	M	**0.9929**	0.9921		
	F	**0.9941**	0.9930		
Carapace length – Rostrum length	M	0.692	0.7535	**0.7569**	0.6757
	F	0.7675	0.8300	**0.8357**	0.7446
Carapace length – Total weight	M	**0.9889**	0.9870	-	-
	F	**0.9914**	0.9904	-	-
Total length – Rostrum length	M	0.7290	0.7707	**0.7778**	0.7171
	F	0.8157	0.8476	**0.8591**	0.8019
Total weight – Tail weight	M	0.9968	0.8578	**0.9988**	0.8430
	F	0.9920	0.7981	**0.9972**	0.7530
Total weight – Meat weight	M	0.9947	0.8547	**0.9979**	0.8401
	F	0.9844	0.7852	**0.9958**	0.7494

Figures in bold indicate the best relationships.

Table 2. Statistical parameters for testing the cube law between total length and total weight.

	Male	Female
Log a ± 1 SE	– 6.09603 ± 0.02903	– 6.1566 ± 0.02312
95% CI for ‘a’	(– 6.15307,– 6.03899)	(– 6.20039,– 6.10725)
‘b’ ± 1 SE	3. 4299 ± 0.01386	3. 4615 ± 0.01108
95% CI for ‘b’	(3.4027, 3.4572)	(3.4403, 3.4827)
a = Antilog (â)	0.00000080	0.00000070
95% CI for â	(0.000000703, 0.00000091)	(0.00000063, 0.00000077)
n	467	578
σ	0.012	0.0013
r^2	0.9925	0.9944
‘t' test result	$t_{(467,0.05)}$ = 31.01	$t_{(578,0.05)}$ = 42.18

Table 3. Statistical parameters for testing the cube law between carapace length and total weight.

	Male	Female
Log a ± 1 SE	– 2.9303 ± 0.0197	– 2.7615 ± 0.01529
95 % CI for Log ‘a’	(– 2.9691,– 2.8915)	(– 2.7915,– 2.7315)
b ± 1 SE	2.8635 ± 0.014043	2.7274 ± 0.01036
95% CI for’ b’	(2.8360, 2.8912)	(2.7071, 2.7478)
a = Antilog (Log â)	0.001173	0.001732
95% CI for ‘a’	(0.0014588, 0.0012847)	(0.001616, 0.001856)
n	467	578
σ	0.0017	0.0019
r^2	0.9889	0.9917
‘t' test result	$t_{(467,0.05)}$ = 9.71	$t_{(578,0.05)}$ = 26.30

Table 3. Regression parameters of the morphometric relationships for males and females.

	sex	Independent variable Range	Dependent variable Range	No. of Specimens	Regression coefficients	Corrected 'a'	r 2	sex
					a	b	a'	
TL-CL	M	48-171	8.5-39.5 mm	467	-4.6540	0.2425	-	0.97
	F	54-237	9.5-63.5 mm	579	-7.9400	0.2700	-	0.98
TL-TW	M	48-171	0.550-38.934	467	-6.0859	3.4251	0.00000082	0.99
	F	54-237	0.739-107.998	579	-6.1538	3.4600	0.00000070	0.99
TL-Tail Wt	M	48-171	0.372-26.649	467	-6.2477	3.4297	0.0000006	0.99
	F	54-237	0.528-65.113	579	-6.1730	3.3900	0.0000007	0.99
CL-RL	M	8.5-39.5 mm	11-26	467	13.3868	0.2761	-	0.69
	F	9.5-63.5 mm	13-29	579	14.2780	0.2440	-	0.76
CL-TW	M	8.5-39.5 mm	0.550-38.934	467	-2.9153	2.8536	0.00121942	0.98
	F	9.5-63.5 mm	0.739-107.998	579	-2.7600	2.7262	0.0017418	0.99
TL-Rost LT	M	48-171	11-26	467	11.7755	0.0695	-	0.73
	F	54-237	13-29	579	11.9670	0.0697	-	0.81
TW-Tail wt	M	0.550-38.934	0.372-26.649	467	0.1365	0.6948	-	1.00
	F	0.739-107.998	0.528-65.113	579	0.8440	0.6360	-	0.99
TW-meat wt	M	0.550-38.934	0.304-23.133	467	0.0105	0.6026	-	0.99
	F	0.739-107.998	0.41-58.851	579	0.5950	0.5316	-	0.99

3. *Relationship between total length and tail weight:* The relation also followed the curvilinear pattern and relationships expressed as:

Males: $\text{Log TLW} = -6.2567 + 3.4340 \times \text{Log TW} \times e$ (r^2= 0.9929) or the simplified version of the equation as: $TW = 0.00000057 \times TL^{3.4340} \times e$

Females: $\text{Log TLW} = -6.1814 + 3.395 \times \text{Log TL} \times e$ (r^2= 0.9946) and the simplified version of the equation as: $TW = 0.0000066 \times TL^{3.395} \times e$.

It was observed that differences between the relationships of the two sexes were significantly different for both the sexes (p=0.02) at 5 % level.

4. *Relationship between carapace length and rostrum length:* Since carapace and rostrum are recorded as sizes, the expected relationship between them is simple linear function. However, the best relation judged from the correlation coefficient was the power function (Table 1) for both the sexes.

Males: $CL = 6.6623 \times RL^{0.3484}$ (r^2= 0.7569).
Females: $CL = 6.8050 \times RL^{0.3439}$ (r^2= 0.8357).

Such relationship indicated that as size of carapace increases the length of rostrum declines by power function. Comparison between the two sexes showed no significant difference at 5 % level (p= 0.0021). It was noticed that size of rostrum in relation to carapace was longer in juvenile prawns than in adult prawns until 20 mm carapace length is reached. The size of rostrum however, stagnated with further increase in size towards adulthood. In order to understand this change, the relation between carapace length and rostrum length was investigated in juvenile and adult prawns separately. Since the two sexes exhibited different other morphometric relations the carapace length and rostrum length relations were analysed separately for the males and females and shown in Fig 1a and Fig 1b respectively. It is seen that in the case of males the slope of the line for juveniles is 0.5075 and for the adults 0.1533. Similarly, in females the slope is 0.4729 and 0.1639 for juveniles and adults respectively. The difference in the slopes is by a factor of 3.3 in the males and 2.9 in females, which explicitly indicated that the rostrum was not only longer in relation to carapace length, but also among the sexes with males having longer rostrum. It is interesting to note that at this size, the sub-adults of the species leave the estuarine habitat and migrate towards the open sea. Therefore, size of the rostrum must be having an adaptive role. The longer rostrum in small sized prawns may be an organ of defense against the predators and it becomes redundant later on when the prawns grow to larger adult size.

Table 4. Estimates of dimensional relationships by various researchers for *P.merguiensis*.

Name of the researcher	Study area	Year	Sex	Relationship	a	b
Achuthankutty and Parulekar	Goa,India	1988	Juvenile males	Total length - total weight, Logarithmic	-2.62	3.39
			Adult males	-"-	-2.79	3.58
			Juvenile females	Total length - total weight, Logarithmic	-2.71	3.49
			Adult females	-"-	-2.74	3.53
Pillai *et al.*	Orissa, India	1991	Female	Total length - total weight, Logarithmic	-4.6612	2.8239
Roongratri and Laitim	Gulf of Thailand	1992	Male	Carapace length - total weight	0.000689	3.070830
			Female	-"-	0.001126	2.002313
Bhadra and Birader	Mumbai, India	2000	Male	Total length - total weight, Logarithmic	-5.0523	3.065
			Female	-"-	-5.2132	3.0262
Aujimangkul *et.al.*	Thailand	2003	Combined	Carapace length - total weight	-5.2442	2.2554

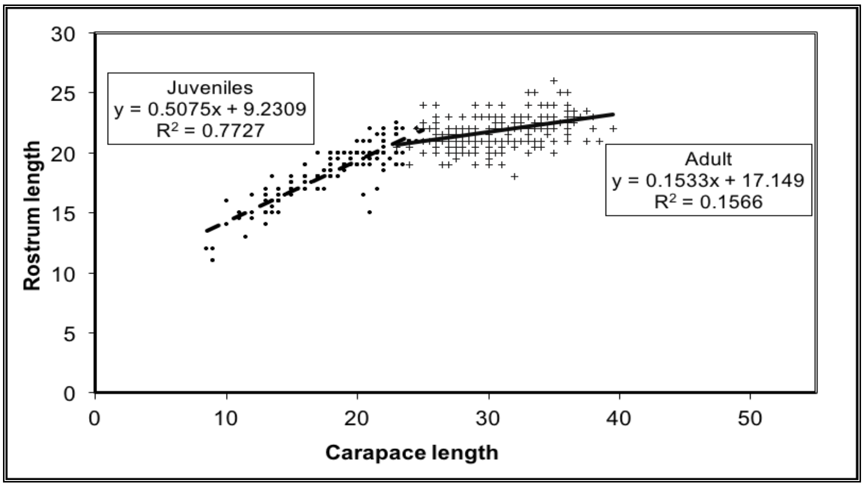

Fig. 1a Carapace and rostrum length relationships of males for juveniles (spots) and adults (+ sign)

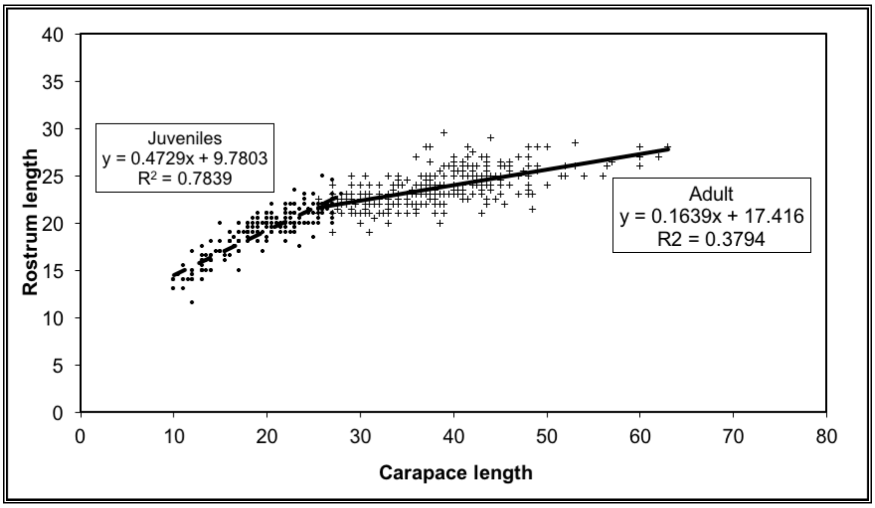

Fig. 1b Carapace and rostrum length relationships of females for juveniles (spots) and adults (+ sign).

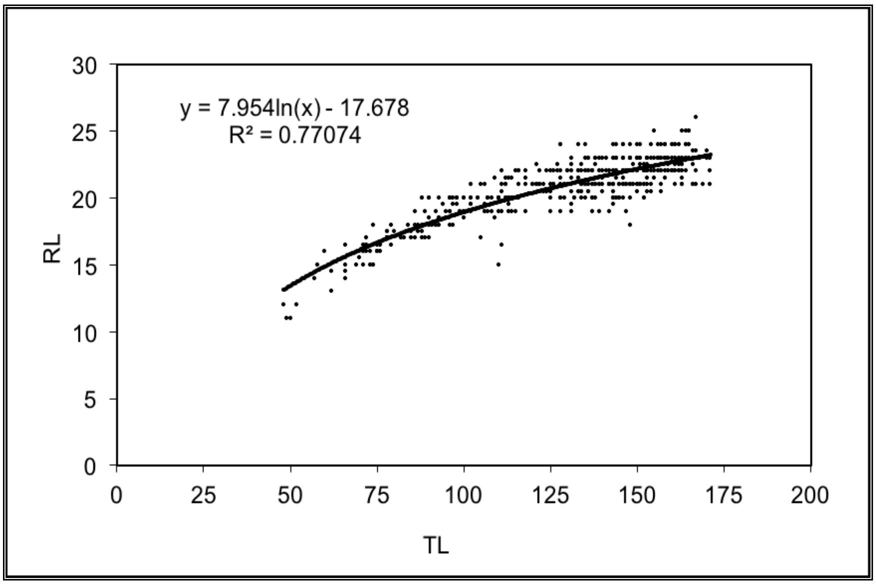

Fig. 2a Total and rostrum length relationships of males.

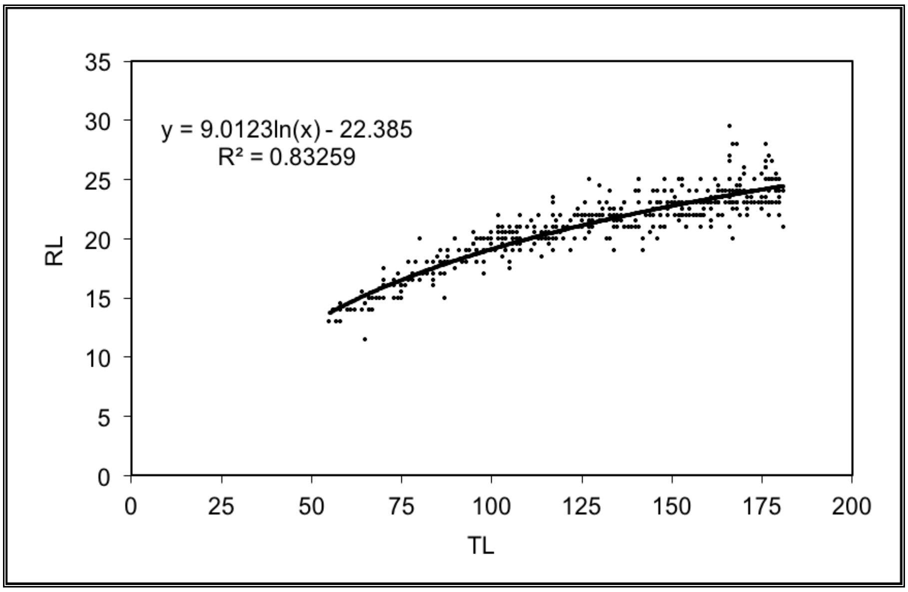

Fig. 2b Total and rostrum length relationships of females.

5. *Relationship between carapace length and total weight:*

The carapace length and total weight showed curvilinear relationship which on log transformation gave linear expression as:

Males: Log TW = –2.93032 + 2.8635 × Log CL × e (r^2= 0.9889) or the simplified version of the equation as: TW = 0.00117 × $CL^{2.8635}$ × e

Females: Log TW = –2.7615+ 2.7274 × Log TL × e (r^2= 0.9917) or the simplified version of the equation as: TW = 0.00173 × $CL^{2.7274}$ × e

The details of the regression statistics are given in Table 3. The biased value of 'a' on account of logarithmic transformation was corrected by using the equation 1. The corrected value of 'a' was 0.001176362 for males and 0.00173566 for females. However, the variance (for males = 0.0017 and for females =0.0020) of the regression is very small therefore, the corrected values of 'a' were almost the same. In order to test the equality of the value of 'b' with the cube, Null hypothesis was tested as given in equation 2. It was found that 'b' value was significantly different from 3 (p=1.981^{-20} for males and p=3.8928^{-94} for females). Comparison of the regression lines of both the sexes for slope ('b') was significantly different at 5% level (p=5.89^{-14}), therefore the relation between carapace length and total weight should be separate for the two sexes.

6. *Relationship between total length and rostrum length*:

The relationship between total length and rostrum length for both males and females expressed power relation (Table 1).

Males: RL = 2.6808 × $TL^{0.4222}$ (r^2= 0.7778).

Females: RL = 2.4721 × $TL^{0.4419}$ (r^2= 0.8591).

This relationship shows (Fig 2a & 2b for male and female respectively) that the rate of increase of size of rostrum increases as the total length increases in smaller prawns (juveniles) but declines in higher sizes (adults). It was also observed that difference between the regressions of the two sexes was not significant for the slopes (p=0.99) but comparison between the two elevations was significantly different at 5% level (p= 0.0053).

7. *Relationship between total weight and tail weight:*

The relation between total weight and tail weight followed the power expression for both the sexes.

Males: TLW = 0.7039 × $TW^{1.0001}$ (r^2= 0.9987).

Females: TLW = 0.7214 × $TW^{0.9796}$ (r^2=0.9982).

It was observed that the relationships between two sexes were significantly different at 5 % level (p= 1.146^{36}).

8. *Relationship between total weight and meat weight:*

The relation between total weight and meat weight for male and female was found to be power function (Table 1) and it can be expressed:

Males: MW = 0.5662 × $TW^{0.1.021}$ (r^2= 0.9979).

Females: MW = 0.5911 × $TW^{0.9836}$ (r^2=0.9963).

Comparison between the male and female regression lines showed significant difference at 5 % level (p= 1.621^{-40}).

9. *Relationship between total length and total weight of juveniles and adults:*

The relationships between total length and total weight of both the juveniles and adults were curvilinear and therefore lengths and weights were log transformed. The transformed values showed linear relationships.

Juveniles: The relationship for juvenile males is expressed mathematically by: Log TW = –5.9074 + 3.3322 × Log TL × e (r^2= 0.98) or the simplified version of the equation as: TW = 0.00000124 × $TL^{3.3322}$ × e**.** The relationship for females is expressed mathematically by: Log TW = –5.8756 + 3.3172 × Log TL × e (r^2= 0.99) or the simplified version of the equation as: TW = 0.00000133 × $TL^{3.3172}$ × e

Adults: The relationship for juvenile males expressed mathematically by: Log TW = –6.1820 + 3.4704 × Log TL × e (r^2= 0.96) or the simplified version of the equation as: TW = 0.00000066 × $TL^{3.4704}$ × e**.** The relationship for females expressed mathematically by: Log TW = –6.1451 + 3.4577 × Log TL × e (r^2= 0.97) or the simplified version of the equation as: TW = 0.00000133 × $TL^{3.3172}$ × e

Total length and total weight relationships for juveniles and adults of the species within and between the sexes showed that the relationships between juvenile males and females as well as adult males and females are not significantly different at 5 % level, but those between juvenile males and adult males and juvenile females and adult females are significantly different at 5 % level.

The sex-wise relationships between various morphometric characters and their regression parameters and correlation coefficient (r^2) irrespective of size are given in Table 3. The relationships obtained by other workers are also given in Table 4.

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