CHAPTER - 3

LENGTH- WEIGHT RELATIONSHIP AND CONDITION FACTOR

3.1. INTRODUCTION

The Indian Tiger prawn *P. monodon* (Fabricius, 1798), commonly known as “Jumbo Tiger Prawn” in the Indo-Pacific region (Rao, 2013) is the largest species among the penaeid prawns. It is known as Bagda chingdi in West Bengal. It has a wide distribution in the Indian waters. Along the east coast, it forms a substantial component of the shrimp landings from the sea and the estuaries. Its occurrence has been observed from all the maritime states of the country (Mohamed, 1970). However, between Cuddalore and the Sunderbans, along the east coast it supports a commercial fishery (Rao, 2013). Length-weight relationship (LWR) is very important in fishery biology and stock assessment of aquatic species (Gulland, 1983; Enin, 1994; Stergou and Moutopoulos, 2001). It is also useful for estimating growth rates, age structure and other aspect of fish and shrimp population dynamics (Tsonumani et al., 2006). It is important in fishery management for comparison of growth studies (Moutopoulos and Stergou, 2002; Hossain et al., 2006). Length weight relationship compares the life histories of aquatic species between the regions and differences between separate units of stocks from the same species (Petrakis and Stergou, 1995; King, 2007). For monitoring the feeding intensity and growth rates in fish, the index widely used is the condition factor (Ndimele et al., 2010). Condition factor is used as an index to assess the status of the aquatic ecosystem in which the fish lives, primarily as increased weight denotes an abundance of food organisms which in turn indicates a favourable environment. Condition factor is strongly influenced by both biotic and abiotic ecological conditions (Anene, 2005). Several researches have studied the length weight relationship of *P. monodon* from Chilika lake of Odisha (Rao, 1967), Kakinada coast of Andhra Pradesh (Lalitadevi, 1987) and Buguna Creek of Nigeria (Yakub and Ansa, 2007). The present study is to provide information on the length weight relationship and condition factor of *P. monodon* from Digha Coast, India.

3.2. REVIEW OF LITERATURE

Hall (1962) estimated the weight length relationship of *P. monodon*. Rao (1967) estimated the total length – total weight relationship of *P. monodon* sampled from the landings of Chilka Lake. Rao (1993) along the east coast estimated the length and weight relationship of *P. monodon*. Mayavu et al. (2005) studied the length weight relationship of normal and loose-shell disease affected *P. monodon* and found the relationship to be significantly different between normal and affected animals. Piratheepa et al. (2013) studied the length-weight relationship of *P. monodon* (Fabricius, 1798) from the Kakkaithevu coastal waters in the Northern part of Sri Lanka. Gopalkrishnan et al. (2013) studied the length – weight relationships and condition factors of wild, cultured, and loose – shell affected *P. monodon*. Yakub and Ansa (2007) reported positive allometric growth pattern in both *Penaeus notialis* and *P. monodon* sampled from the Buguma Creek. As the length – weight relationship of a species is influenced and varies according to locality and season, differences were observed in the values of the co-efficient of length and weight and on the slope of the regression relation (Medina – Reyha, 2001; Prasad, 2001).

In fish, negative allometric growth signifies that the weight increases at a rate lesser than the cube of the body length (Adeyemi et al., 2009). Fish condition factor and length-weight relationship parameters are influenced by many factors such as sex, age, state of maturity, size, state of stomach fullness, sampling methods and sample sizes and environmental conditions (Ama-Abasi, 2007; Yem et at., 2007; Adeyemi et al., 2009).

For comparing the condition or fatness or wellbeing of a fish, the condition factor is widely used in fisheries science. It implies that heavier fish of a particular length are in a better physiological condition compared to others (Bagenal and Tesch, 1978). For monitoring the feeding intensity and growth rates in fish, the index widely used is the condition factor (Ndimele et al., 2010). Condition factor is used as an index to assess the status of the aquatic ecosystem in which the fish lives, primarily as increased weight denotes an abundance of food organisms which in turn indicates a favourable environment. Condition factor is strongly influenced by both biotic and abiotic ecological conditions (Anene, 2005).Condition factors of different tropical fish species were investigated and reported (Rickter, 1973; Alfred-Ockiya and Njoku, 1995; Abowei and Davies, 2009; Abowei, 2010). Condition factor is used to measure feeding intensity and growth (Anene, 2005). Higher condition factor denotes higher weight gain per unit length of fish, which indirectly indicates high feeding intensity. Condition factor has an influence on the reproductive cycle in fish (Welcome, 1979) and is observed to decrease with an increase in length of the fish (Fagade, 1979). Comparative condition factor of two penaeid shrimps; *P. notialis* (pink shrimp) and *P. monodon* were studied in a coastal state, Lagos, Southwest Nigeria. For *P. monodon*, higher values of condition factor were observed implying that they were in good physiological condition (Ajani et al., 2013).

3.3. MATERIALS AND METHODS:

3.3.1. Length - weight relationship:

Fisheries researchers and managers use the relationship between length and weight of a fish for two main purposes (Le Cren, 1951). Firstly, from the length of a fish, the relationship is used to predict the weight. When the length frequency of a sample is available, the relationship is particularly useful for computing the biomass of that sample of fish. Secondly, to identify the relative condition or robustness of the population, this relationship is used for comparing the present parameter estimates to the average parameters for the region, parameter estimates from previous years or parameter estimates among groups of fish. A total of 633 samples of *P. monodon* were collected randomly from the trawl landings at Digha

(West Bengal) fishing harbors for the period during January 2011 to December 2013. Total length (mm) and wet body weight (grams) were measured. Carapace length represents an important morphometric measurement in crustaceans and the relation between carapace length and total length signifies the growth and health of the shrimp. Carapace length (mm), from the tip of the rostrum to the end of the carapace, was measured. Length - weight relationship was estimated separately for both sexes as $W = aL^b$ (Le Cren, 1951). Analysis of Covariance or ANACOVA was employed to ascertain the significant differences in the slopes of the regression lines for males and females (Snedecor and Cochran, 1967). Least-square method was used to estimate the parameters 'a' and 'b' from the logarithmically transformed data, and determination coefficient (r^2) was used to calculate the degree of association between the weight-length variables. For the parameters 'a' and 'b', the statistical significance level of r^2 and 95% confidence limits were estimated. If the length increases in equal proportions with body weight for constant specific gravity, the fish is said to exhibit isometric growth. For isometric growth, the value of regression co-efficient is 3 and if the values are greater than or lesser than 3, it indicates allometric growth. If the regression co-efficient is greater than 3 it indicates positive allometry and if it is less than 3 it indicates negative allometry. The null hypothesis of the isometric growth was tested by t – test (Snedecor and Cochran, 1967), which is being done to find out whether the 'b'values for males, females and sex pooled are significantly different from 3, using the formula [$t=b-3/Sb$], where b= regression coefficient and Sb= Standard error of 'b'.

3.3.2. Condition factor (K)

Depending on their body shape the exact relationship between length and weight of fish differs among various species. Within species, it varies based on the condition (robustness) of individual fish. Condition factor is a measure of growth and food availability. However in fisheries, conditions are variable and dynamic. Within the same sample, individual fishes vary considerably and both annually and seasonally, the average condition of each population changes. Sex and gonadal development of fish are other important parameter influencing the relationship. The Fulton's condition factor (K) determines the physical and environmental condition of fish or shrimp (Le Cren, 1951). It is used for comparing the condition, fatness or well-being of fish or shrimp. The condition factor (K) for *P. monodon* was calculated using the following equation, K =100 W/L^3 (Gayanilo and Pauly, 1997), where K= condition factor, W= weight of fish (gm) and L= length of fish (cm). Condition factor was estimated separately for the sexes for each month for the three year study period. The significance of condition factor was tested by ANOVA.

3.4. RESULTS

The total numbers of *P. monodon* examined were 633; of them, 391 were females and 242 were males during January 2011to December 2013.

3.4.1. Total length - total weight relationship:

The regression equation for length - weight relationship of *P. monodon*; males, females and pooled was as follows:

Male: Log W = -1.115568777 + 2.40925 logL (r = 0.88214)

Female: Log W = -1.0369821 + 2.38872 logL (r = 0.920514)

Pooled Log W = -1.340527 + 2.60916 Log L(r=0.925811)

Length - weight relationship revealed the exponent ranging from 2.245 to 2.572 for males, 2.287 to 2.489 for females and 2.525 to 2.692 for pooled sexes, respectively. Growth exhibited negative allometry in all the sexes with significant differences ($b<3$, $p<0.05$). The scatter diagrams for the total length - weight relationship for males and females are illustrated (Figures 3.5 and 3.6 and Table 3.2 and 3.5).

3.4. 2. Carapace length-weight relationship

The regression equations for the carapace length-weight relationship for males, females and pooled were calculated as under:

Males: Log W= 0.92698 + 1.28763 Log CL (r = 0.661846)

Females: Log W = 0.68519 + 1.673308 Log CL (r = 0.865155)

Pooled: Log W= 0.56873+ 1.7918036 Log CL (r = 0.86533)

The scatter diagrams for the carapace length - weight relationship for males and females are illustrated (Figures 3.1 and 3.2 and Table 3.3 and 3.6).

3.4.3. Carapace length –total length relationship:

The carapace length - total length relationship of *P. monodon* for males, females and pooled were calculated as below:

Male: Log TL= 0.910448+0.452938 log CL (r =0.63583)

Female: Log TL= 0.727943+0.692095 log CL (r=0.92858)

Pooled: Log TL= 0.750318+0.663744 log CL (r=0.90330)

The scatter diagrams for the carapace length - total length relationship for males and females are illustrated (Figures 3.3 and 3.4 and Table 3.4 and 3.7).

3.4.4. Condition factor (K):

The month-wise condition factor (K) of *P. monodon* (242 males and 391 females) from Digha of Bay of Bengal is presented (Figures 3.7 and Table 3.8 and 3.9). The present study results reveal significant differences (p<0.05) in condition factor between males and females. The highest average condition factor of 1.5±0.54 was observed in June for males and 1.65±0.05 in January for females and lowest of 1.2 ±0.49 in March for males and 1.4±0.55 in the months of February, March, August and September for females.

3.5. DISCUSSION

Length and weight relationship are very important in the fishery biology and stock assessment of aquatic species. The present study gives the information on the length and weight relationship of *P.monodon*. The length- weight relationship in the present study agrees with the finding of Gopalakrishnan et al.(2013) who observed the length - weight relationship of *P. monodon* from wild shrimps as log W = −1.444 + 2.485 logL (r^2 = 0.91). Rao (1993) from east coast observed the relationship for males as Log W =-5.3399 + 3.1032 log L and for females as log W =-4.8953 + 2.9022 log L. The negative allometric growth observed in both sexes indicated that larger collected samples are more elongated. Yakubu and Ansa (2007) have reported positive allometric pattern of growth in Buguma Creek. As the length – weight relationship of a species is influenced and varies according to locality and season differences were observed in the growth pattern in the present study (Medina – Reyha, 2001; Prasad, 2001).

Negative allometric growth indicated that the weight increases at a slower rate than the body length. Several factors such as sex, age, stage of maturity, food availability, fishing ground and environmental factor have impact on growth (Ama-Abasi, 2007).

Mean condition factor ‘K’ of *P.monodon* was greater than 1 indicative of the fact that they were in good physiological condition (Ajani et al.,2013).The mean condition factor in the present study was 1.65, which could be evidence to the presence of either gravid females or good food availability, similar to that reported by Andem et al. (2013). This high condition factor could either be caused due to the weight increase as a result of the presence of fully matured gonads or due to increased feeding intensity or uptake.

Plate 3.1. Weight measurement of *P. monodon*

Plate 3.2. Separating of *P. monodon* from other species

Figure 3.1.Carapace length – weight relationship of female *P.monodon* collected from Digha coast during January 2011 to December 2013.

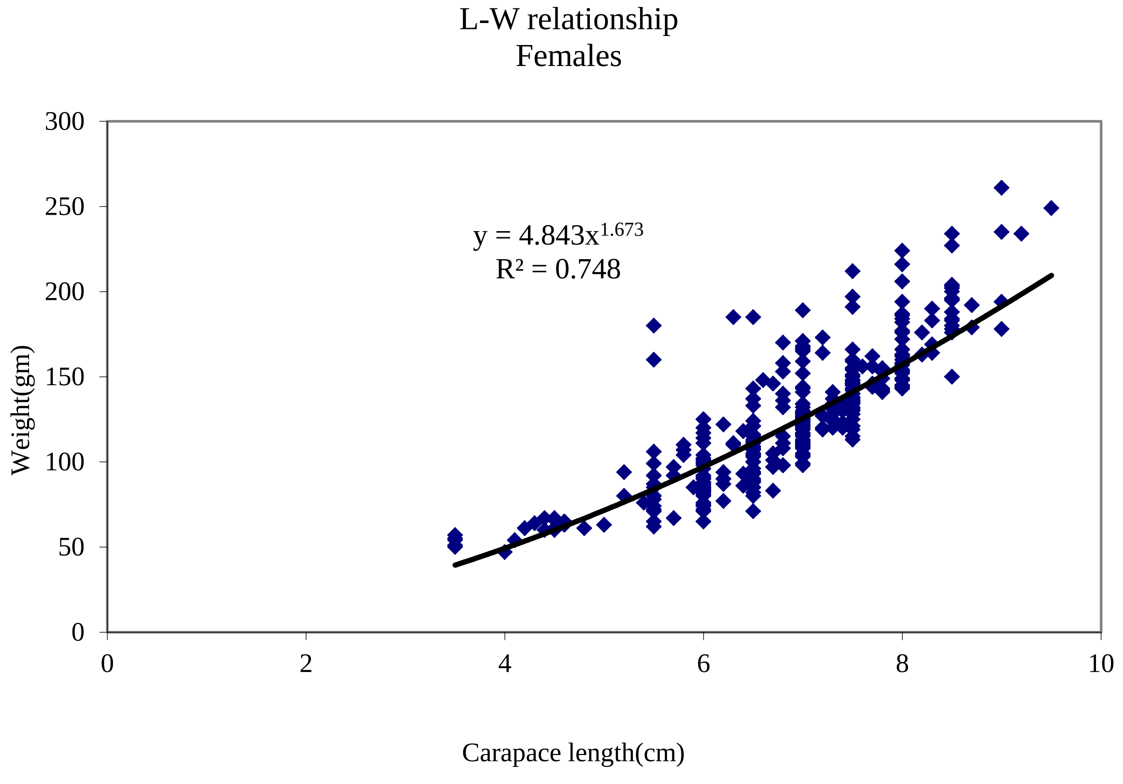

Figure 3.2.Carapace length – weight relationship of male *P. monodon* collected from Digha coast during January 2011 to December 2013.

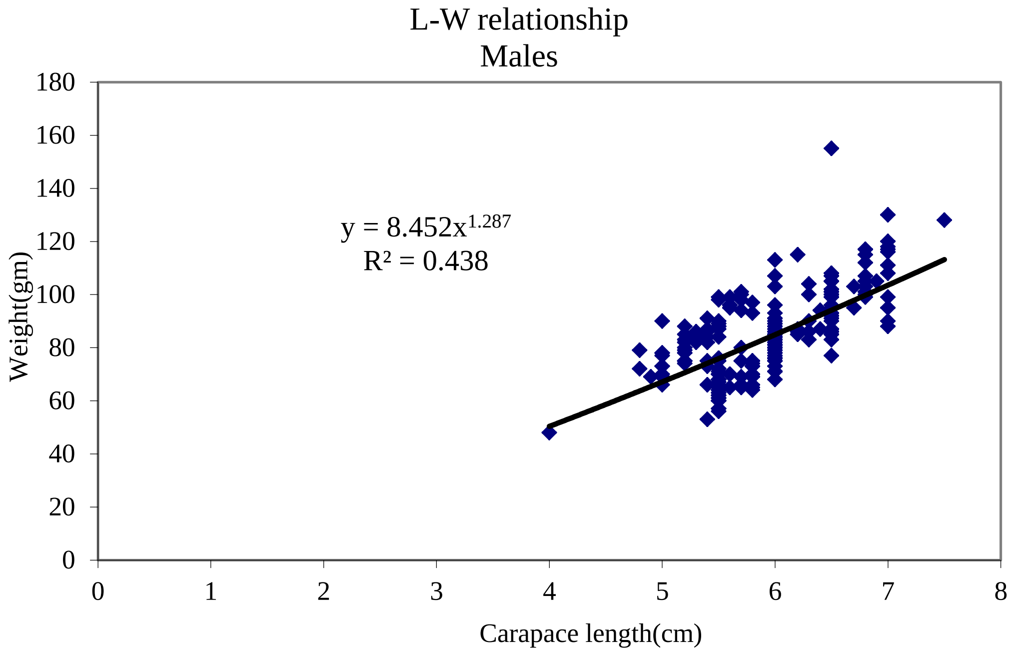

Figure 3.3.Carapace length - total length relationship of female *P. monodon* collected from Digha coast during January 2011 to December 2013.

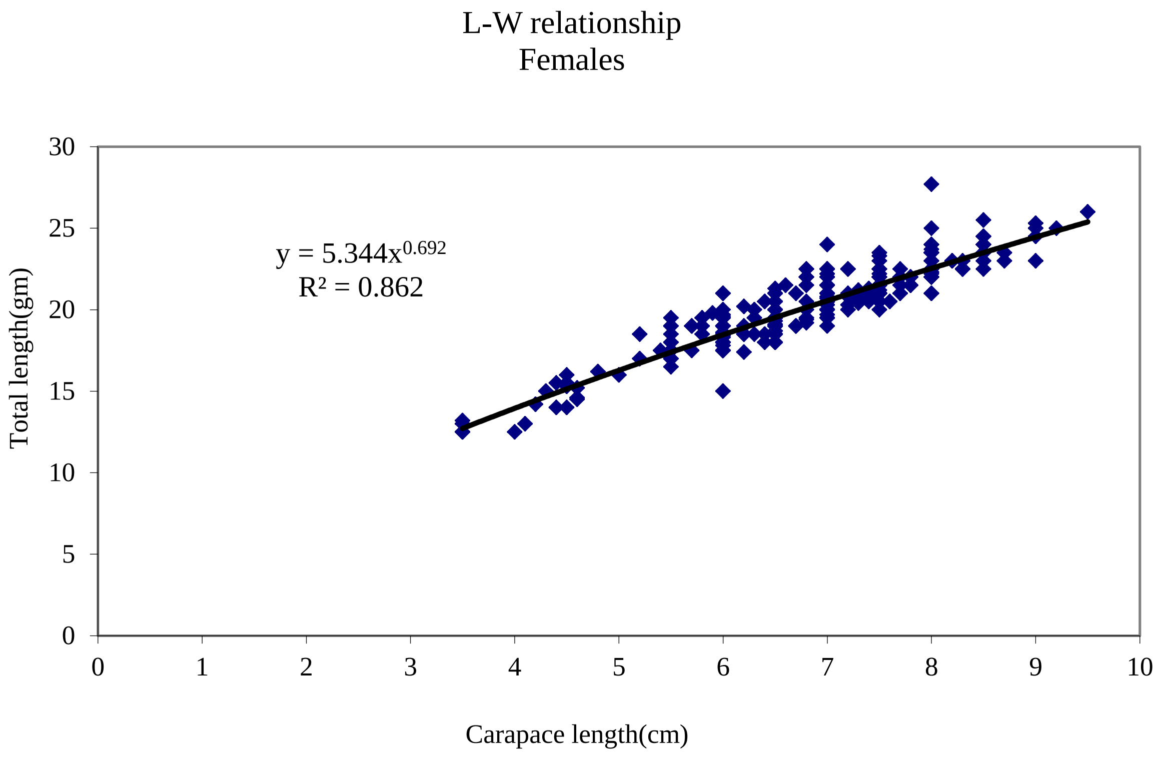

Figure 3.4.Carapace length - total length relationship of male *P. monodon* collected from Digha coast during January 2011 to December 2013.

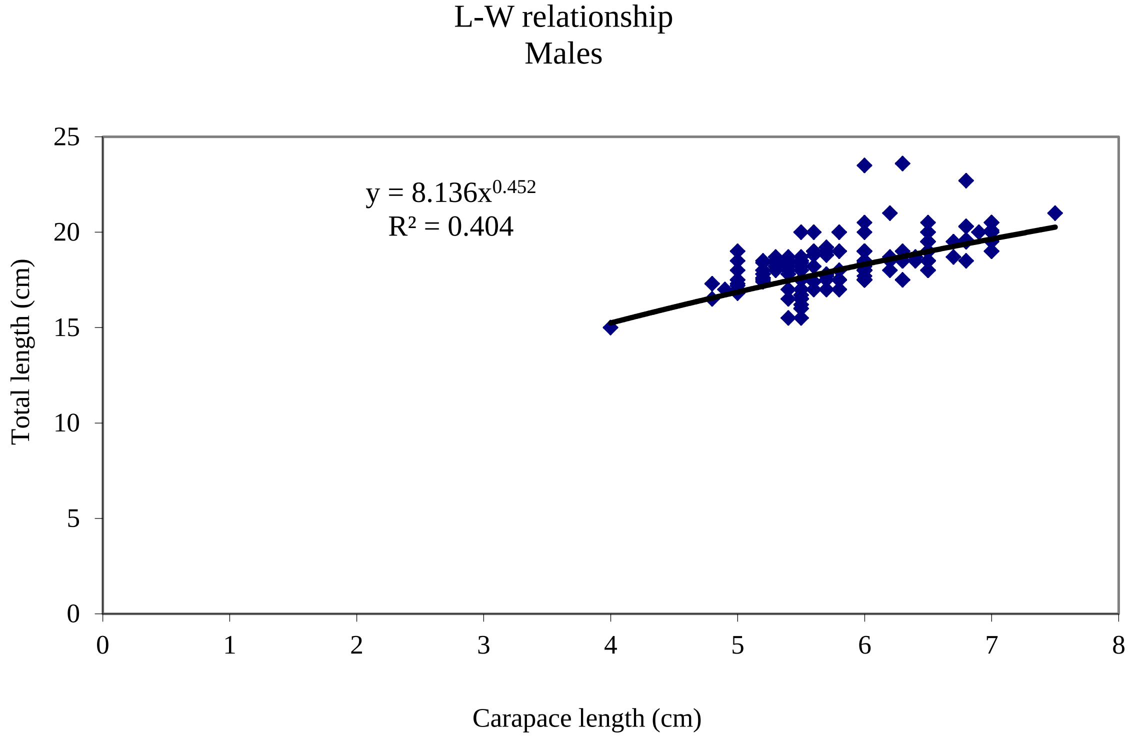

Figure 3.5.Total length - weight relationship of female *P. monodon* collected from Digha coast during January 2011 to December 2013.

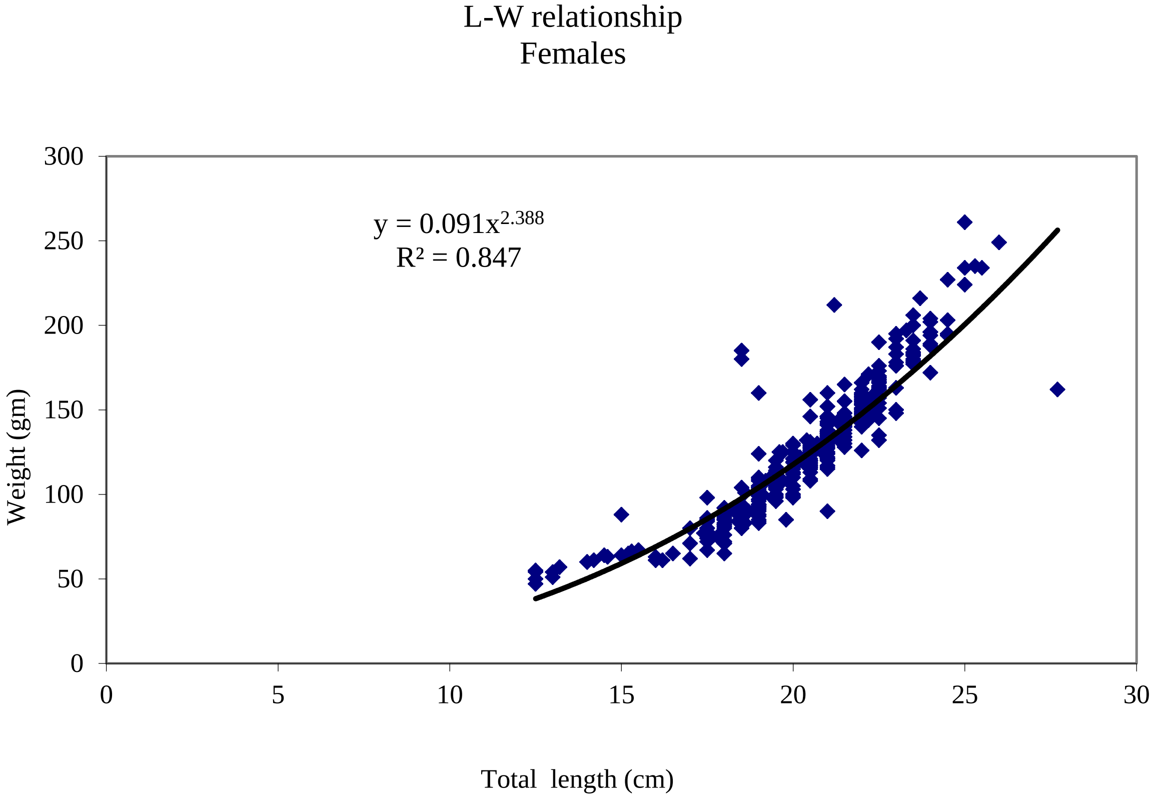

Figure 3.6.Total length - weight relationship of male of *P*. *monodon* collected from Digha coast during January 2011 to December 2013.

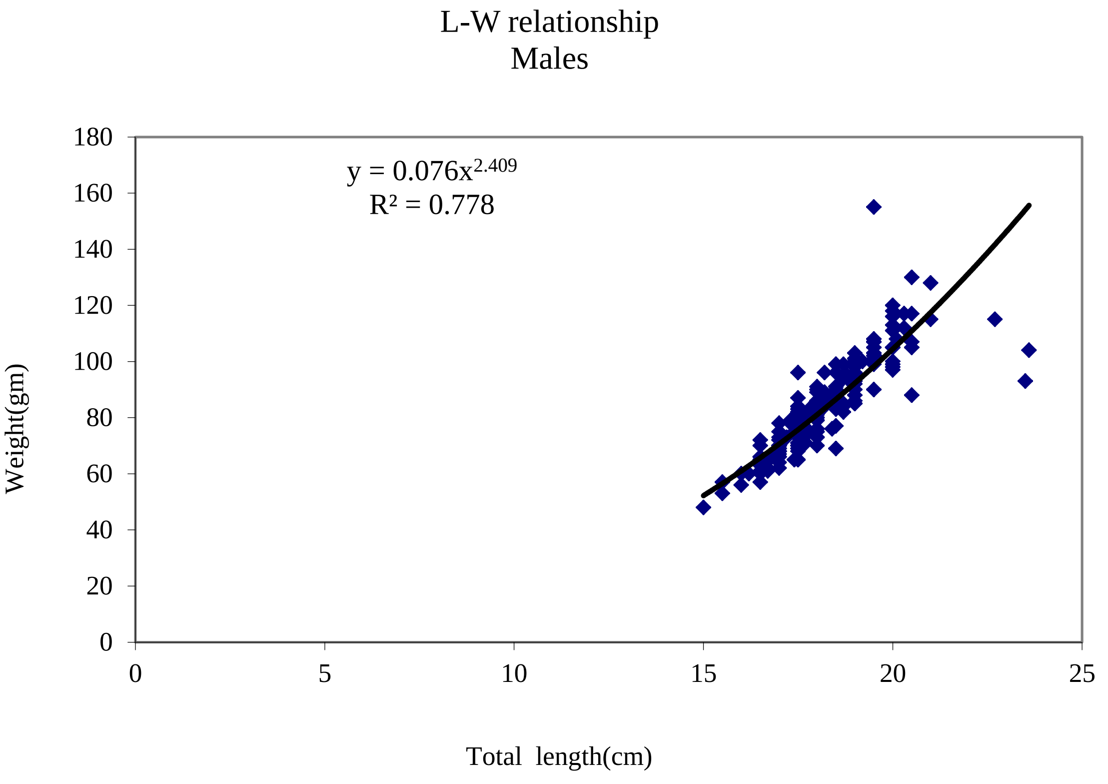

Figure 3.7. Average condition factor of *P. monodon* collected from Digha coast during January 2011 to December 2013.

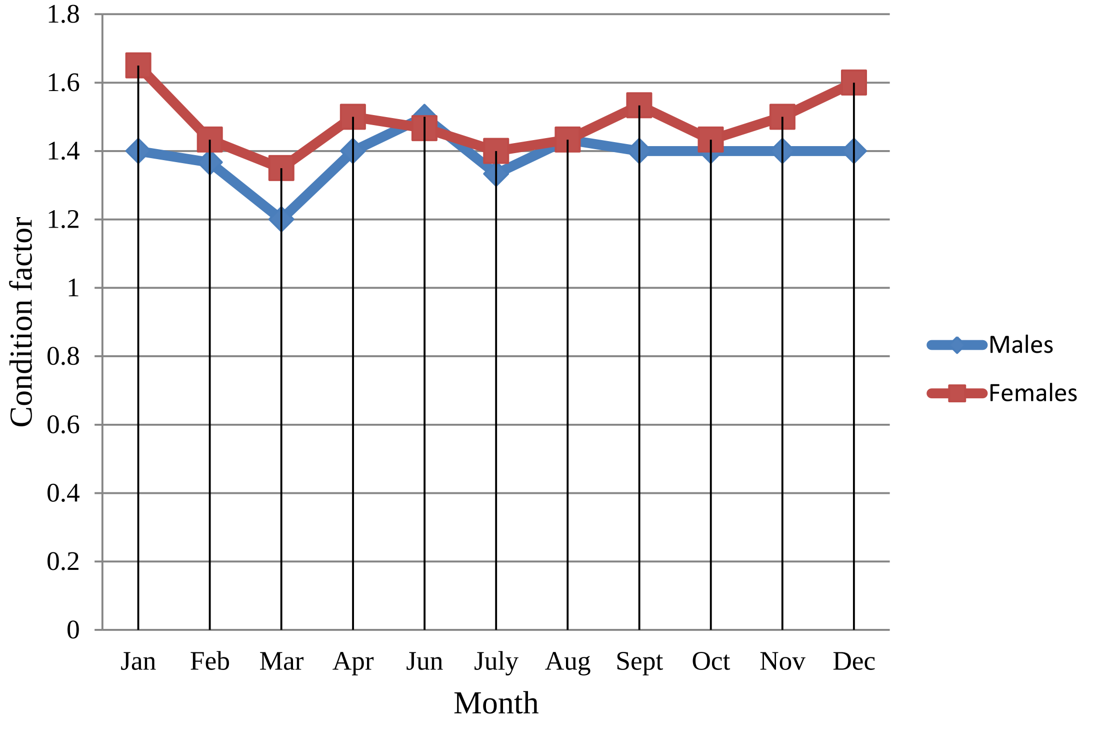

Table 3.1. Length and weight of *P. monodon* collected from Digha coast during January 2011 to December 2013.

	Carapace Length (cm)	Total Length (cm)	Total Weight (g)
Maximum	9.5±0.04	27.7±0.9	261±1.48
Minimum	3.5 ±0.04	12.5±0.9	47±1.48

Table 3.2.Total length and weight relationship of *P. monodon* collected from Digha coast during January 2011 to December 2013.

Sex	Total length - weight relationship	n	Logarithmic transformation	r	a	b
Male	$W = 0.076636L^{2.409251}$	242	LogW=-1.1155687+2.40925 logL	0.8821	0.0766	2.40
Female	$W = 0.091837\ L^{2.388728}$	391	LogW=-1.0369821+2.38872 logL	0.9205	0.0918	2.38
Pooled	$W = 0.045366\ L^{2.611231}$	633	LogW= -1.340527+2.60916 Log L	0.9258	0.0454	2.61

L=Length

W=Weight

r= Correlation coefficient

a= Intercept Coefficient

b= Coefficient of X i.e. slope

n=Sample number

Table 3.3.Carapace length and weight relationship of *P. monodon* collected from Digha coast during January 2011 to December 2013.

Sex	Carapace length -weight relation ship	n	Logarithmic transformation	r	a	b
Male	$W=8.452484CL^{1.28763}$	242	LogW=-0.92698+ 1.28763 Log CL	0.6618	8.452	1.29
Female	$W=4.843879CL^{1.793293}$	391	LogW=-0.68519+ 1.673308 Log CL	0.8651	4.843	1.67
Pooled	$W=3.693949CL^{1.793293}$	633	LogW=-0.56873+1.7918036 Log CL	0.8653	3.693	1.79

CL=Carapace length

W=Weight

r= Correlation coefficient

a= Intercept Coefficient

b= Coefficient of X i.e. slope

n=Sample number

Table 3.4.Carapace length and total length relationship of *P. monodon* collected from Digha coast during January 2011 to December 2013.

Sex	Carapace length - total length relationship	n	Logarithmic transformation	r	a	b
Male	$TL=8.13669CL^{0.4529}$	242	Log TL= -0.910448+0.452938 log CL	0.636	8.137	0.45
Female	$TL=5.34494\ CL^{0.6921}$	391	Log TL= -0.727943+0.692095 log CL	0.929	5.345	0.69
Pooled	$TL=5.62754\ CL^{0.6637}$	633	Log TL= -0.750318+0.663744 log CL	0.903	5.628	0.66

CL=Carapace length

TL=Total length

r=Correlation coefficient

a= Intercept Coefficient

b= Coefficient of X i.e. slope

n=Sample number

Table 3.5.Comparison of the regression lines of total length - total weight relationship between sexes of *P. monodon* collected from Digha coast during January 2011 to December 2013.

						Deviations from regression				
Source	**d.f.**	**ssx**	**ssy**	**spxy**	**Reg. coef**	**d.f.**	**S.S.**	**M.S**	**F**	**Prob**
Within										
Males	241	1.0734	8.00725	2.5863	2.409	240	1.776	0.007		
Indeterminates	390	5.7850	38.9566	13.818	2.388	389	5.946	0.015		
						629	**7.722**	**0.012**		
Pooled W	631	6.8585	46.9638	16.405	2.391	630	7.723	0.012		
						1	**0.000**	**0.000**	**0.031**	**0.860**
Between B										
W+B	632	8.4083	66.8451	21.956		631	9.512			
		Between adjusted means				**1**	**1.789**	**1.789**	**145.97**	

Note: If Prob <0.05 then significant at 5% level
If Prob<0.01 then significant at 1% level

d.f.= Degree of freedom
Ssx= Sums of Squares of x
Ssy= Sums of Squares of y
S.S=Sums Squares
M.S=Mean Squares

Table 3.6. Comparison of the regression lines of the Carapace length - total weight relationship between sexes of *P. monodon* collected from Digha coast during January 2011 to December 2013.

						Deviations from regression				
Source	**d.f.**	**ssx**	**ssy**	**spxy**	**Reg. coef**	**d.f.**	**S.S.**	**M.S**	**F**	**Prob**
Within										
Males	241	2.11550	8.0072	2.7239	1.287	240	4.499	0.018		
Indeterminates	390	10.4139	38.956	17.425	1.673	389	9.797	0.025		
						629	**14.29**	**0.022**		
Pooled W	631	12.5295	46.963	20.149	1.608	630	14.55	0.023		
						1	**0.261**	**0.261**	**11.31**	**0.00081**
Between B										
W+B	632	15.5760	66.845	27.932		631	16.75			
		Between adjusted means				**1**	**2.194**	**2.194**	**94.97**	

Note: If Prob <0.05 then significant at 5% level
If Prob<0.01 then significanrt at 1% level

d.f .= Degree of freedom

Ssx= Sums of Squares of x

Ssy= Sums of Squares of y

S.S=Sums Squares

M.S=Mean Squares

Table 3.7. Comparison of the regression lines of the Carapace length - total length relationship between sexes of *P. monodon* collected from Digha coast during January 2011 to December 2013.

						Deviations from regression				
Source	**d.f.**	**ssx**	**ssy**	**spxy**	**Reg. coef**	**d.f.**	**S.S.**	**M.S**	**F**	**Prob**
Within										
Males	241	2.1155	1.07349	0.9581	0.452	240	0.639	0.00		
Indeterminates	390	10.414	5.78508	7.2074	0.692	389	0.796	0.00		
						629	**1.436**	**0.00**		
Pooled W	631	12.529	6.85858	8.1656	0.651	630	1.536	0.00		
		Difference between slopes				**1**	**0.100**	**0.10**	**41.22**	**0.00000**
Between B										
W+B	632	15.576	8.40830	10.338		631	1.546			
		Between adjusted means				**1**	**0.009**	**0.00**	**3.799**	**0.05170**

Note: If Prob <0.05 then significant at 5% level

If Prob<0.01 then significanrt at 1% level

d.f.=Degree of freedom

Ssx= Sums of Squares of x

Ssy= Sums of Squares of y

S.S=Sums Squares

M.S=Mean Squares

Table 3.8.Female condition factor (Mean ±SE) of *P. monodon* collected from Digha coast during January 2011 to December 2013.

Month	2011	2012	2013	Mean
January	1.6±0.04	1.7±0.01		1.65±0.05
February	1.4±0.05	1.5±0.03	1.4±0.01	1.4±0.03
March	1.3±0.07	1.4±0.02		1.4±0.55
April		1.5±0.03		1.5±0.03
June	1.6 ±0.08	1.4±0.02	1.4±0.01	1.5±0.07
July	1.4±0.04	1.4±0.02	1.4±0.04	1.4±0.01
August	1.5±0.03	1.4±0.03	1.4±0.02	1.4±0.03
September	1.6±0.08	1.4±0.02	1.6±0.12	1.5±0.07
October	1.4±0.01	1.5±0.02	1.4±0.03	1.4±0.03
November	1.4±0.01	1.5±0.05	1.6±0.04	1.5±0.06
December	1.6±0.01	1.4±0.02	1.8±0.13	1.6±0.12

Table 3.9.Male condition factor (Mean ±SE) of *P. monodon* collected from Digha coast during January 2011 to December 2013.

Month	2011	2012	2013	Mean
January	1.4±0.02	1.4±0.02		1.4±0.57
February	1.3±0.03	1.4±0.02	1.4±0.03	1.4±0.03
March	1.1±0.10	1.3±0.03		1.2±0.49
April		1.4±0.03		1.4±0.03
June	1.8±0.19	1.3±0.05	1.4±0.03	1.5±0.54
July	1.3±0.12	1.4±0.04	1.3±0.02	1.3±0.45
August	1.5±0.05	1.4±0.03	1.4±0.03	1.4±0.48
September	1.4±0.04	1.4±0.01	1.4±0.03	1.4±0.47
October	1.4±0.04	1.4±0.02	1.4±0.02	1.4±0.47
November	1.4±0.06	1.4±0.03	1.4±0.01	1.4±0.47
December	1.4±0.03	1.4±0.03	1.4±0.02	1.4±0.47