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FLESH YIELD AND PHENOTYPIC RELATIONSHIP BETWEEN DIFFERENT ECONOMICALLY IMPORTANT TRAITS OF MUD CRAB (*Scylla serrata,* Forskål 1775)

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Abstract

Phenotypic relationships of flesh yield with total weight; carapace width; carapace length and carapace height of mud crab (Scylla serrata, Forskål 1775) were estimated from a sample of 60 individuals having size range of 4.80-10.2 cm in carapace width and 42.72-196.71 g in total weight. Data were recorded and analyzed for total weight (Twt), flesh weight (Fwt), carapace length (CL), carapace width (CW) and carapace height (CH). The mean condition factor (K) of the samples was computed as 22.5 suggesting that the sample of mud crab were in good condition having normal shape. The average flesh yield or weight was calculated as 38.42 ± 10.52 respectively. There was no significant variation ($p \geq 0.05$) in condition factor between male and female mud crab. Most of the true traits were strongly and positively correlated ($r > 0.6$) with one another. Both bivariate and multivariate regression analysis were done to estimate the regression coefficient between the traits and to find out the best fitted model. Bivariate linear regression coefficient of flesh yield on Twt; CW; CL and CH were 0.39; 7.88; 10.5 and 18 respectively. In case of multivariate regression analysis of Fwt, the best fitted model gave the equation as Fwt = -29.2 +9.93 CW -10.2 CL +13.8 CH.

Keywords: Mud crab, *Scylla serrata,* fillet %, dress-out weight, phenotypic correlation

1. INTRODUCTION

Scylla serrata (mud crab) locally known as *Jati kakra* or *haba kakra* occur abundantly in the whole coastal region of the Bangladesh particularly in the estuaries, tidal rivers of the Sundarbans mangrove swamps and vast coastal 'ghers' or shrimp polders (Khan and Alam, 1991). The mud crab is globally distributed in the Indo-West-Pacific region from Hawaii, Southern Japan, Taiwan and the Philippines to Australia, Red Sea and East and South Africa (Motoh, 1979 and Macintosh *et al.*, 2002). In Bangladesh the annual production of crab is estimated to be more than 10,000 tons (Zafar and Siddique, 2000). Considering the increasing demand of mud crab in the local and international markets, it has been gaining popularity among the coastal communities in greater Khulna and Chittagong regions (Azam *et al.*, 1998).

As the crab is a good source of protein then it can be contribute in our protein deficiency. The nutritional quality of crab protein is more favourable than meat of mutton, chicken, duck and fish (Newcombe, 1944). Mud crabs are rich in high protein and fat content. It has high demand in international market due to its delicious taste. Its price is also lucrative. Culture of Mud crab has not yet been developed in Bangladesh, though it has a great potential as a cultivable species. Only fattening is being practiced in our country. It can be a good source of protein and currency through artificial

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breeding and culture of the species. In artificial breeding and selection program, choosing the best quality and healthy parents is a major concern. For selection of the parents for next generation, some traits are economically important such as higher weight, length, fillet percentage and dress-out percentage. Though fillet percentage and dress-out percentage are the most important and targeted traits, it can not be measured without killing the fish. Thus it is a problem to directly estimate fillet percentage and dress-out percentage. The alternative way is to use the correlation between other traits that can be measured easily such as length, weight, body depth etc. For this reason, it is very important to know the relationships between different traits.

Many works have been conducted on the relationships between different traits, especially length-weight by (Khan and Alam, 1991; Ali *et al.,* 2004; Zafar *et al.,* 2006; Ikhwanuddina *et al.,* 2011) but no publications on meat weight and other important economic traits are available. That is why the present investigation was carried out on the phenotypic relationship between some economically important traits of mud crab *Scylla serrata*.

Major objectives of the study were to estimate correlation among different traits (Total weight, meat weight, meat weight%, carapace meat weight%, chilate meat weight%, carapace width, carapace length and carapace height); to estimate bivariate relationship among different traits; to estimate multivariate relationship among different traits and to find out the best-fitted model that express the relationships between the traits with high accuracy.

2. MATERIALS AND METHODS

2.1 Sample collection and preparation

Scylla serrata species was selected for this study. The species was identified by using the taxonomic guide by Keenan *et al*. (1998). The morphological characteristics used to determine the species identity of *Scylla serrata* from USGS Non-indigenous Aquatic Species Database written by Perry (2006). Mud crab (*Scylla serrata*) Samples were randomly collected from local fishermen at the market place Rupsha Bazar, Jorakol Bazar and Puratan Shandhya Bazar) of Khulna metropolitan area. A total 60 specimen of *Scylla serrata* were collected for this study. Live sample are brought to the Physiology laboratory of Fisheries and Marine Resource Technology Discipline, Khulna University. The samples were kept in fresh condition without icing or freezing. Live crabs are aggressive and very difficult to work with. That is why it was fixed with 10% Formaldehyde for 5 minutes in order to anesthesia. The crabs were separated by sex based on the shape of the abdomen. The female crab has a wider and more globular abdomen while the male crab has a narrow and straight abdomen (Poovachiranon, 1991). A total of 60 mud crabs were measured and used to determine phenotypic traits. From the total crabs sampled, 33 male and 27 female crabs of various sizes measured to determine the carapace width (CW) and meat weight (Mwt) relationship.

2.2 Data recording and measurement

Crab size was measured using the carapace width (CW), or the distance between the tips of the ninth antero-lateral spines of the carapace. The carapace width was measured to the nearest 0.05cm with Vernier caliper. Different weights of the crabs were measured to the nearest gram using a digital electronic balance (Model No. AND GF-300) with sensitivity to 0.005 g. Carapace weight (Cwt), chilate weight (Clwt), Walking legs weight (LW) was measured separately by cut out them with surgical scissor. Total meat weight (Mwt) was measured by calculating with carapace meat weight (CMwt), chilate weight (Chwt), chilate meat weight (ChMwt), walking leg weight (Lwt) and walking leg meat weight (LMwt). To measure the meat weight of carapace, chilate and walking legs of *Scylla serrata* firstly, weight of different parts were measured. Then meats of different parts are removed by hammering in mortar and the carapace shell weight (CSwt); chilate shell weight (ChSwt) and walking leg shell weight (LSwt) were measured. The differences of these two weights are meat weights. To measure CMwt firstly the weight of carapace are measured excluding the inner organ (gonad, gill, brain etc.) and upper shell of the carapace. Then meats are removed from carapace with hammering in mortar. Lower carapace shell weights (CSwt) are measured and the differences of these two weights are

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carapace meat weight. Meat weight percentage was calculated as:(the weight of meat / total weight) x100.

2.3 Data analysis and model setting

All the data were analyzed by using microsoft excel 2007 and statistical software Minitab-15. Condition factor of the fish was measured by the following formula, K=(W/L^3)×100 (Williams, 2000). Where: w = the weight of the crab in grams and L = carapace width in centimeters. The relationship between carapace width (L) and body weight (W) was calculated by using Le-Cren, (1951) equation, $W=aL^b$ Where, W = the weight of the crab in grams and L = the carapace width of the crab in centimeters. Values of W were calculated from the logarithmic (base 10) equivalent, log *W*=log a+a log *L* (Schneider, *et al*. 2000). For model setting, bivariate regression model and multiple regression models were used to estimate the relationships between different traits: The model were assumed as:

$$Y=a+ b_1X_1+ b_2X_2+ b_3X_3+ \dots\dots\dots\dots + b_nX_n$$

Where, a = constant or intercept; b = regression coefficient or the slope of the regression curve;Y= Response variable; X = predictor variables as X_1, X_2, X_3……..X_n.

3. RESULTS AND DISCUSSION

3.1 Descriptive statistics

This study was carried out with a total of 60 mud crabs (33 male and 27 female). The descriptive statistics of all traits are shown in the table 1. In the present study, the mean total weight and meat weight of the samples found as 82.41 ± 36.3 g (range 42.72 - 196.71 g) and 31.66 ± 16.31 g (range14.20 - 89.58 g). The mean carapace meat weight and chilate meat weight were 14.8 ± 7.14 g and 11.86 ± 7.13. The mean meat weight % was 38.42 ± 10.52. The mean carapace meat % and chilate meat % were 17.75 ± 2.35 and 14.34 ± 3.76 respectively.

Table 1. Mean ± standard deviation and range of the traits of *Scylla serrata*

Traits	Mean ± Std. Deviation	Minimum	Maximum
Total Weight (g)	82.41 ± 36.3	42.72	196.71
Meat Weight (g)	31.66 ± 16.13	14.20	89.58
Meat Weight %	38.42 ± 10.52	28.30	91.77
Carapace Weight (g)	50.47 ± 21.74	22.24	102.33
Carapace Meat Weight (g)	14.8 ± 7.14	6.91	38.87
Carapace Meat Weight %	17.75 ± 2.35	13.08	24.58
Chilate Weight (g)	20.61 ± 13.02	8.75	86.88
Chilate Meat Weight (g)	11.86 ± 7.13	4.46	43.88
Chilate Meat Weight %	14.34 ± 3.76	5.29	24.50
Carapace Width (cm)	7.21 ± 1.31	4.80	10.20
Carapace Length (cm)	5 ± 0.96	3.40	7.20
Carapace Height (cm)	2.91 ± 0.56	2.10	4.50

3.2 Correlation between traits

Phenotypic correlations among important traits are shown in the table 2. It is evident from the table that all the true traits were positively correlated in which some traits were strongly correlated ($r > 0.6$) with one another. The correlations of meat weight %, carapace meat weight % and chilate meat weight % with other traits were low, because these were calculated traits which are independent of the size and weight of the crab.

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Table 2. Correlation matrix between different traits of *Scylla serrata.*

Traits	TWt	MWt	MWt %	CMWt %	ChMWt %	CH	CL	CW
TWt	1	0.87	-0.001	0.21	0.03	0.78	0.82	0.81
MWt	0.87	1	0.47	0.2	0.12	0.62	0.63	0.64
MWt %	-0.001	0.47	1	0.08	0.13	-0.06	-0.13	-0.11
CMWt %	0.21	0.2	0.08	1	-0.46	0.22	0.32	0.33
ChMWt %	0.04	0.12	0.13	-0.46	1	-0.07	-0.12	-0.09
CL	0.82	0.63	-0.13	0.32	-0.12	0.93	1	0.97
CW	0.84	0.64	-0.11	0.33	-0.09	0.88	0.97	1
CH	0.78	0.63	-0.06	0.22	-0.06	1	0.93	0.88

Correlation is significant at the 0.01 level.
TWt= Total Weight (g); MWt= Meat Weight (g); MWt %= Meat Weight %; CMWt %= Carapace Meat Weight %; CMW %= Chilate Meat Weight %; CH= Carapace Height (cm); CL= Carapace Length (cm) and CW= Carapace Width (cm).

3.3 Bivariate relationship of traits

Bivariate relationship of total weight and meat weight with other traits are shown in Table 3. The fitted regression line (logarithmic) of total weight and meat weight as functions of other traits are presented in Fig. 1-11. The logarithmic regression coefficient "b" has a value almost equal to 2.0. The regression equation of total weight (TWt) on carapace width (CW) was logTWt = 0.32 + 1.8 logCW (r^2 = 0.68).The relationship between carapace width and body weight were estimated by Ali *et al*., (2004) as W= -128.25+4.06 CW, logW=-3.73+3.06 logCW for male and W= -89.59+2.387 CW, logW= -1.6035+1.8928 logCW for female. These findings are supporting the present study. Model 1 shows that the arithmetic regression coefficient (b) of total weight as a function of carapace meat weight is about 5, which means that each 1 g increase in carapace meat will lead to 5 g increase in total weight. Similarly, Model 2 shows 1g increase of chilate meat weight will lead to about 4 g increase of total weight. Model 3 shows 1cm increase of carapace width will lead to about 23 g increase of total weight. Mohapatra *et al*.(2010) found 27 g increase of total weight with the increase of 1 cm of carapace width. Model 4 shows 1cm increase of carapace length will lead to about 31 g increase of meat weight. Model 5 shows 1cm increase of carapace height will lead to about 50 g increase of total weight.

Table 3. Bivariate Relationship of total weight and meat weight with other traits

Models	Respons e variable	Predictor variable	r^2	a	b (± se)*	Regression equation
Model 1	Twt	CMwt	0.91	10.4	4.86(±0.19)*	Twt= 10.4 +4.86 CMWt
Model 2		ChMwt	0.70	31.8	4.26(±0.36)*	Twt= 31.8 +4.26ChMWt
Model 3		CW	0.66	-79.9	22.5(±2.11)*	Twt = -79.9 +22.5 CW
Model 4		CL	0.67	- 71.8	30.8(±2.85)*	Twt= -71.8+ 30.8 CL
Model 5		CH	0.60	-63.9	50.2(±5.36)*	Twt = -63.9 +50.2 CH
Model 6	Mwt	Twt	0.76	-0.34	0.39(±0.02)*	Mwt= -0.34 +0.388 TWt
Model 7		CMwt	0.70	3.63	1.89(±0.16)*	Mw= 3.63 +1.89 CMWt
Model 8		ChMwt	0.64	10.3	1.8±(0.18)*	Mwt= 10.3 +1.8 ChMWt
Model 9		CW	0.41	-25.2	7.88(±1.24)*	Mwt = -25.2 + 7.88 CW
Model 10		CL	0.39	-20.8	10.5(±1.72)*	Mwt = -20.8 + 10.5 CL
Model 11		CH	0.39	-20.9	18(±2.94)*	Mwt = -20.9 + 18.1 CH
*p<0.05						

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Table 4. Multivariate Relationship of total weight and meat weight with other traits

Models	Response Variable	Predictor Variable	r^2	a	b	Fitted regression equation
Model 12	Meat Weight	Carapace width	0.44	-29.2	9.93*	Mwt = -29.2+9.93 CW-10.2CL +13.8CH
		Carapace length			-10.2*	
		Carapace Height			13.8*	
Model 13	Total Weight	Carapace width	0.68	- 80.8	11.8*	Twt= - 80.8 + 11.8CW +9CL +11.3 CH
		Carapace length			9*	
		Carapace Height			11.3*	
*p<0.05						

Model 6, 7 and 8 shows 1g increase of total weight, carapace meat weight and chilate meat weight will lead to about 0.39 g, 1.89 g and 1.8 g increase of meat weight. Model 9, 10 and 11 shows 1 cm increase of carapace width, carapace length and carapace height will lead to about 8g, 11g and 18g increase of meat weight.

The arithmetic and logarithmic graphs of total weight and meat weight with other traits are given below.

3.4 Multivariate relationship of total weight and fillet weight with other traits

In broad sense bivariate relationship can show the specific result. In narrow sense multivariate relationship can provide more specific result than the bivariate relationship. Multivariate relationship of total weight and meat weight with other traits are shown in Table 4.Table 4 shows that the best fitted model for the relationship measure is relation with meat weight with combined to carapace width, carapace length and carapace height. And the total weight also combined to carapace width, carapace length and carapace height.So the best fitted model for meat weight and total weight are:

Meat Weight = - 29.2 +9.93 Carapace Width -10.2 Carapace Length +13.8 Carapace Height.
Total Weight = - 80.8 +11.8 Carapace Width +9.0 Carapace Length +11.3 Carapace Height.

3.5 Condition factor

Condition factor "K" was found to remain constant with increasing the carapace width or total weight. The condition factor was found 22.43 in male and female combination. For male and female it was 22.37 and 22.5 respectively. This is shows that all the med crab had normal shape. Ali *et al.* (2004) described the biology of mud crab and found value of condition factor was 24.65. This is almost similar with the condition factor of this study.

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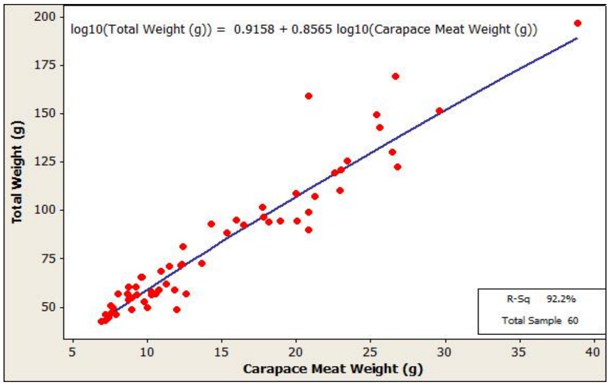

Fig. 1. Linear regression of logTwt vs logCMwt

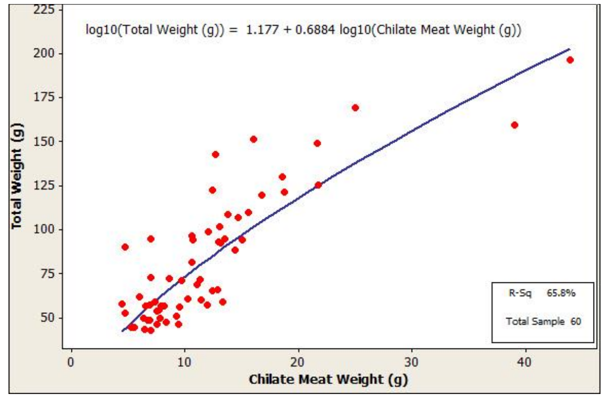

Fig. 2. Linear regression of logTwt vs logChMwt

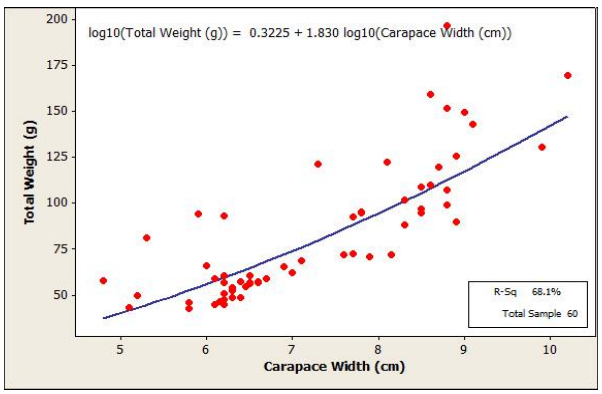

Fig. 3. Linear regression of logTwt vs logCW

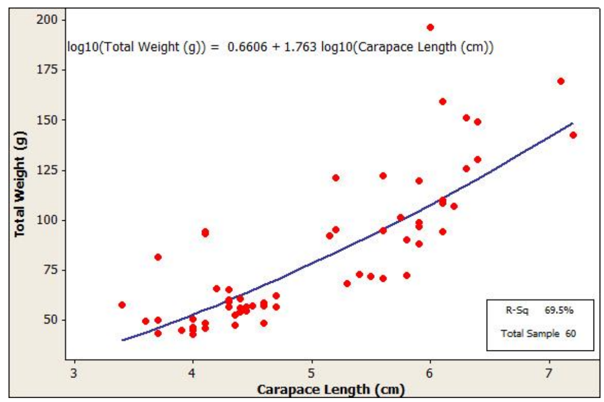

Fig. 4. Linear regression of logTwt vs logCL

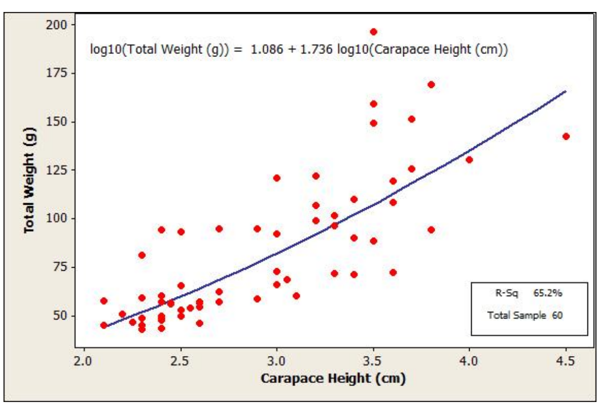

Fig. 5. Linear regression of logTwt vs logCH

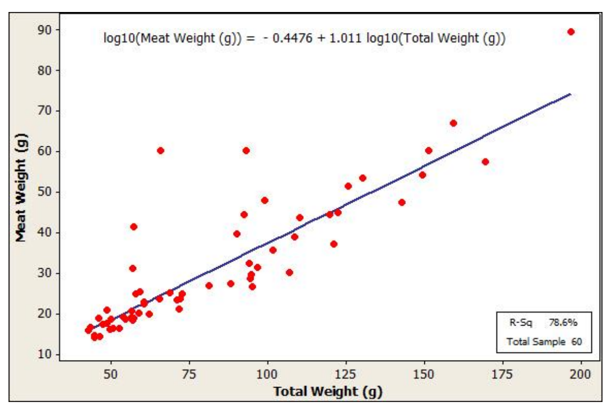

Fig. 6. Linear regression of logMwt vs logTwt

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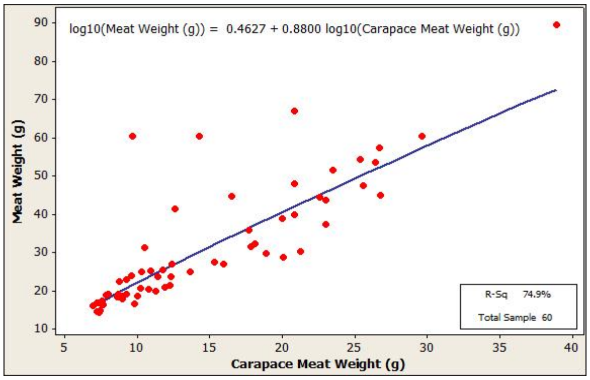

Fig. 7. Linear regression of logMwt vs logCMwt

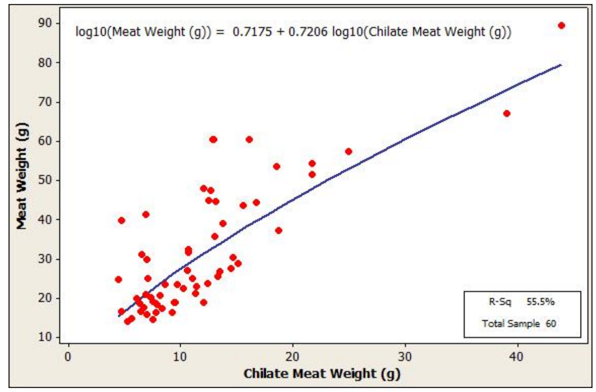

Fig. 8. Linear regression of logMwt vs logChMwt

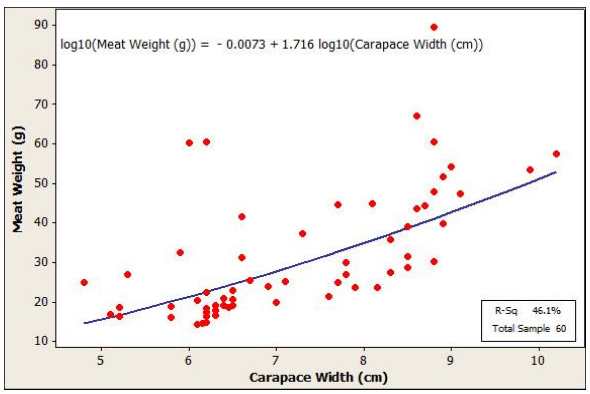

Fig. 9. Linear regression of logMwt vs logCW

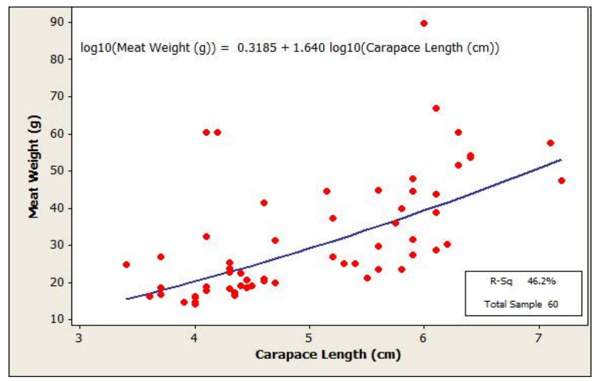

Fig. 10. Linear regression of logMwt vs logCL

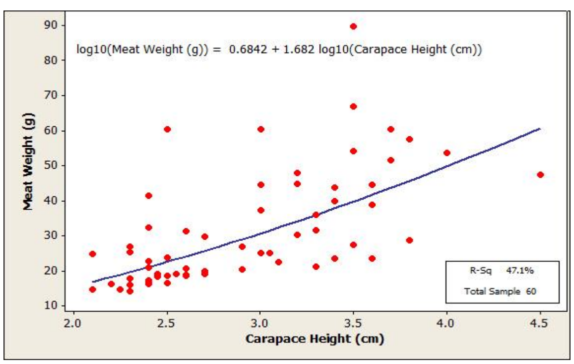

Fig. 11. Linear regression of logMwt vs logCH

4. CONCLUSION

For more accuracy and reliable prediction on the measurement of different traits, more intensive research with large sample size with respect to sex, size and seasons are needed. However, the information of this work will definitely contribute to further research on this species in general, and particularly to artificial breeding, selective breeding and making breeding values for index selection of Scylla *serrata.*

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