



Mathematical Analysis of Morphometric Attributes Effects on Body Weight of Three-Month-Old Lates Calcarifer

YANG Rui^{1,2}, ZHAO Wang^{1,2}, YU Gang^{1,2}, MA Zhenhua^{1,2*}

¹Sanya Tropical Fisheries Research Institute, Sanya 572018, China.

²Tropical Fisheries Research and Development Center, South China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Sanya 572018, China.

***Corresponding Author:** MA Zhenhua, Tropical Fisheries Research and Development Center, South China Sea Fisheries Research Institute, Chinese Academy of Fishery Sciences, Sanya 572018, China.

Abstract: The relationship between morphometric attributes and body weight of *Lates calcarifer* was analyzed using body weight (Y) and 20 morphometric attributes (x1-x20) from three-month-old *L. calcarifer*. The results show that significant positive correlation between morphometric attributes and body weight, and all the correlation coefficients reach extremely significant level ($P < 0.01$). The path analysis reveal that x16 display the highest positive direct effect (0.635) to body weight, and follow by x4, x2, x7 and x9, x1 affect body weight indirectly by x16, x4, x2 and x7; The analysis results of determination coefficients show that the total decision coefficient of six morphological attributes to body weight is find to be 0.976, and indicating those morphological attributes are the main factor to body weight; The multiple regression equation is established by multiple regression analysis. The study shows that the regression equation can be applied to the breeding of *L. calcarifer*.

Keywords: *Lates calcarifer*; Morphometric attributes; Body weight; Path analysis; Multiple regression analysis.

1. INTRODUCTION

Lates calcarifer is also known as Asian seabass or 'Barramundi' or giant sea perch, and it is an important euryhaline carnivorous fish. It can be cultured in both brackish and freshwater ponds as well as in cages (Shanmugaarasu, Kathiresan, Ilanchelian & Rajendran, 2018). Such as *Lates calcarifer* is increasingly significant tropical aquaculture species of the Indo-Pacific region and has been cultured for over 30 years in Southeast Asia (Yue, Li, Chao, Chou & Orban, 2002). And now *Lates calcarifer* is also an important commercial fish in China, especially the southeast coast. At present, the research on *Lates calcarifer* was mainly focused on cultivation, nutrition, immunity, physiology, disease, genetics and so on (ATHAUDA & ANDERSON, 2014; DOMINGOS, ZENGER & ERRY, 2015; Lin, Yan, Rui-rong, Yang & Xue-peng, 2015; RANJAN, PRASAD & VANI, 2014; TRUJILLO-GONZÁLEZ, JOHNSON L & CONSTANTINOIU, 2015). However, the relationship between morphometric attributes and body weight is one of the basic characteristics for its thoroughbred breeding but rarely reported. Multivariate analysis is one of the main ways to determine the relationship between morphological traits, and it has been widely used in aquatic breeding, for example *Pelodiscus sinensis* (Fengfan, Wei, Xinping & Jian, 2015), *Exopalaemon carinicauda* (Chengsong, Fuhua & Jianhai, 2013), *Orithyia sinica* (Shou-Min, Ren-Jie & Ling-Xu, 2015), *Synodus macrops* (Jiayu, Wenqi, Yangjie, Qinyu & Jian, 2013), *Pinctada fucata* and so on (Caigang, Baosuo & Dongling, 2015).

In this study, the relationship between morphological traits and body weight of 3-month-old *Lates calcarifer* was analyzed by multiple regression analysis. In the first place first the main influencing traits of body weight were found by correlation analysis and path analysis. Finally the regression equation of 3-month-old *Lates calcarifer* was established.

2. MATERIALS AND METHODS

2.1. Materials

A total of 150 individuals of three-month-old Lates calcarifer selected from over 20000 F1 individuals randomly in Tropical Fisheries Research and Development Center in Sanya China. And all the individuals were cultured in fiberglass (Model : GBL-TK20-10, specification : $\Phi 200 \times 100\text{cm}$) of this center with a density of about 150 fish/ m³ with a daily exchange rate of 200% tank volume. The temperature was maintained from 25 °C to 32°C, salinity was maintained at 30±5‰, the range of pH was 7.5~8.5 and the DO \geq 5mg/L. The individuals were fed twice a day at 8:30 and 17:30 by pellets of common marine fish feed.

2.2. Measurement Methods

In this study, morphometric indexes were measured by using a digital vernier caliper (Hangzhou) accurate to 0.01 mm and an electronic balance which the precision is 0.01g. The morphometric indexes including body weight(y); body length(x1); body width(x2); head length(x3); stem length(x4); body height(x5); eye diameter(x6); eye distance(x7); snout length(x8); the caudal peduncle height(x9); the caudal peduncle length(x10); the distance of the origin of the first dorsal fin to the end of the second dorsal fin(x11) ; the distance of the origin of the first dorsal fin to the base of pectoral fin(x12); the distance of the origin of the first dorsal fin to the base of pelvic fin(x13); the distance of the origin of the first dorsal fin to the origin of anal fin(x14); the distance of the end of the origin of anal fin to the second dorsal fin(x15); the distance of the base of pectoral fin to the end of the second dorsal fin(x16); the distance of the base of pelvic fin to the end of the second dorsal fin(x17) ; the distance of the origin of anal fin to the base of pelvic fin(x18); the origin of the anal fin to the base of the pectoral fin(x19); the base of the pectoral fin to the base of pelvic fin(x20).

2.3. Analysis

Statistical analyses were performed with SPSS 19.0 software(SPSS Inc., Chicago, USA). The descriptive statistical results of each trait were obtained in the first place, and then the direct and indirect effects of morphological traits and the body weight were determined by correlation analysis and path analysis. Finally, multiple regression equation of 3-month-old L. calcarifer is established by multiple regression analysis.

3. RESULTS

3.1. The Descriptive Statistic Of Morphometric Attributes Of Three-Month-Old L. Calcarifer

In this study, the descriptive statistic of morphometric attributes of three-month-old L. calcarifer were showed in Tab.1. The body weight three-month-old L. calcarifer was between 13.17 and 93.46 g, while the average was 30.18 g. The highest value of body length was 86.95 mm and lowest was 167.90mm, their average was 113.52 mm. The highest CVs of all measured traits was body weight (43.81%), it indicated that the body weight had a large selection potential in the traits of 3-month-old L. calcarifer.

Table1. The descriptive statistic of morphometric attributes of three-month-old L. calcarifer

Traits	Mean	SD	SE	Kurtosis	Skewness	CV%
y/g	30.18	13.22	1.08	4.53	1.65	43.81
x ₁ /mm	113.52	16.46	1.34	0.28	0.56	14.50
x ₂ /mm	14.79	2.27	0.18	0.82	0.69	15.31
x ₃ /mm	37.32	5.46	0.45	0.53	0.62	14.62
x ₄ /mm	45.97	7.12	0.58	1.27	0.78	15.48
x ₅ /mm	34.88	4.69	0.38	-0.30	0.34	13.44
x ₆ /mm	6.70	0.56	0.05	0.46	0.17	8.43
x ₇ /mm	12.04	1.28	0.10	1.48	1.03	10.63
x ₈ /mm	6.55	0.99	0.08	1.08	0.56	15.13
x ₉ /mm	17.77	2.83	0.23	0.46	0.51	15.92

x_{10}/mm	26.80	4.43	0.36	0.74	0.67	16.52
x_{11}/mm	44.10	6.81	0.56	1.52	0.88	15.43
x_{12}/mm	25.21	3.64	0.30	-0.21	0.42	14.43
x_{13}/mm	36.09	4.98	0.41	-0.24	0.38	13.80
x_{14}/mm	47.87	6.94	0.57	0.84	0.70	14.50
x_{15}/mm	24.06	3.57	0.29	1.37	0.76	14.84
x_{16}/mm	55.31	8.61	0.70	0.79	0.76	15.57
x_{17}/mm	57.10	9.75	0.80	5.18	-0.49	17.07
x_{18}/mm	44.06	7.10	0.58	0.59	0.63	16.12
x_{19}/mm	47.09	7.50	0.61	0.85	0.71	15.93
x_{20}/mm	12.81	1.89	0.15	0.86	0.56	14.74

3.2. Correlation Coefficients Among Morphometric Attributes Of Three-Month-Old L. Calcarifer

The correlation between the morphological traits of the of three-month-old *L. calcarifer* was highly significant (Tab.2). The correlation coefficients of x_5 and x_{13} was the largest (0.984), however, x_6 and x_8 was on the contrary the numerical value was only 0.565. It also showed another message that, the largest contribution to body weight of three-month-old L. calcarifer was x_{16} (0.968) , and the second was x_{11} (0.957) , the last was x_6 (0.713).

Table2. Correlation coefficients among morphometric attributes of three-month-old *L. calcarifer*

Traits	y	x_1	x_2	x_3	x_4	x_5	x_6	x_7	x_8	x_9	x_{10}	x_{11}	x_{12}	x_{13}	x_{14}	x_{15}	x_{16}	x_{17}	x_{18}	x_{19}
x_1	0.950**																			
x_2	0.937**	0.906**																		
x_3	0.916**	0.961**	0.869**																	
x_4	0.931**	0.932**	0.878**	0.874**																
x_5	0.943**	0.958**	0.924**	0.932**	0.911**															
x_6	0.713**	0.764**	0.643**	0.770**	0.712**	0.724**														
x_7	0.940**	0.925**	0.892**	0.895**	0.885**	0.898**	0.720**													
x_8	0.757**	0.799**	0.713**	0.843**	0.774**	0.780**	0.565**	0.705**												
x_9	0.879**	0.882**	0.839**	0.866**	0.865**	0.906**	0.688**	0.817**	0.786**											
x_{10}	0.877**	0.884**	0.858**	0.838**	0.788**	0.873**	0.687**	0.857**	0.632**	0.830**										
x_{11}	0.957**	0.959**	0.907**	0.927**	0.903**	0.939**	0.722**	0.924**	0.726**	0.846**	0.879**									
x_{12}	0.902**	0.945**	0.877**	0.917**	0.897**	0.949**	0.731**	0.869**	0.761**	0.866**	0.841**	0.871**								
x_{13}	0.935**	0.964**	0.908**	0.942**	0.909**	0.984**	0.747**	0.889**	0.806**	0.906**	0.866**	0.921**	0.969**							
x_{14}	0.954**	0.962**	0.904**	0.938**	0.947**	0.956**	0.737**	0.913**	0.778**	0.882**	0.822**	0.972**	0.903**	0.943**						
x_{15}	0.944**	0.938**	0.914**	0.893**	0.865**	0.949**	0.705**	0.902**	0.698**	0.847**	0.929**	0.953**	0.894**	0.933**	0.919**					
x_{16}	0.968**	0.979**	0.921**	0.934**	0.932**	0.963**	0.748**	0.934**	0.733**	0.869**	0.901**	0.975**	0.942**	0.960**	0.965**	0.963**				
x_{17}	0.887**	0.909**	0.855**	0.888**	0.839**	0.912**	0.692**	0.862**	0.701**	0.809**	0.832**	0.909**	0.869**	0.912**	0.901**	0.903**	0.916**			

x_{18}	0.92 6**	0.94 4**	0.87 7**	0.91 6**	0.94 7**	0.92 9**	0.76 2**	0.88 5**	0.77 3**	0.86 7**	0.78 9**	0.92 7**	0.90 6**	0.93 7**	0.97 0**	0.87 3**	0.94 8**	0.88 1**		
x_{19}	0.94 8**	0.95 9**	0.89 9**	0.91 8**	0.96 4**	0.94 2**	0.74 6**	0.91 5**	0.74 8**	0.86 7**	0.81 3**	0.94 4**	0.92 4**	0.93 8**	0.98 1**	0.89 8**	0.97 1**	0.88 0**	0.98 1**	
x_{20}	0.89 9**	0.88 8**	0.87 8**	0.83 6**	0.86 8**	0.92 7**	0.63 1**	0.85 3**	0.70 3**	0.83 6**	0.83 1**	0.88 5**	0.83 8**	0.90 7**	0.89 3**	0.90 4**	0.90 4**	0.84 1**	0.85 0**	0.89 1**

Note: * represents significant correlation ($P < 0.05$), ** represents highly significant correlation ($P < 0.01$).

3.3. Path Analysis of Morphological Attributes to Body Weight of Three-Month-Old *L. Calcarifer*

The path analysis of morphological attributes to body weight of three-month-old *L. calcarifer* were showed in Table 3. To remove all the no significant correlation variables except x_1 , x_2 , x_4 , x_7 , x_9 and x_{16} after significant difference testing of the path coefficients. According to the composition of the correlation coefficient, the correlation coefficient between morphological traits and body weight is decomposed into two parts: direct effect and indirect effect. In addition to x_{16} , the direct effects of morphological traits on body weight were less than indirect effects. The direct effect of x_{16} on the body weight of three-month-old *L. calcarifer* was the highest(0.635), which reached the significant level, it indicated that the direct effect of x_{16} on body weight was the largest. The direct effect of x_1 on body weight is negative, indicating that x_1 has a negative effect on body weight; however it produced a large indirect effect through x_{16} , with a total indirect effect of 1.277.

Table3. Path analysis of morphological attributes to body weight of three-month-old *L. calcarifer*

Traitss	Correlation coefficient	Direct	Indirect						
			Σ	x_1	x_2	x_4	x_7	x_9	x_{16}
x_1	0.950	-0.327**	1.277	-	0.183	0.203	0.182	0.087	0.622
x_2	0.937	0.202**	0.739	-0.296	-	0.191	0.176	0.083	0.585
x_4	0.931	0.218**	0.724	-0.305	0.177	-	0.174	0.086	0.592
x_7	0.940	0.197**	0.745	-0.302	0.180	0.193	-	0.081	0.593
x_9	0.879	0.099*	0.782	-0.288	0.169	0.189	0.161	-	0.552
x_{16}	0.968	0.635*	0.339	-0.320	0.186	0.203	0.184	0.086	-

Note: * represents significant correlation ($P < 0.05$), ** represents highly significant correlation ($P < 0.01$).

3.4. Coefficient of Determination of Morphological Attributes to Body Weight of Three-Month-Old *L. Calcarifer*

In this study, the coefficient of determination of morphological attributes to body weight of three-month-old *L. calcarifer* were showed in Table.4. The results showed that, the sum of the direct decision coefficient and the indirect decision coefficient is 0.976. The results indicated that x_1 , x_2 , x_4 , x_7 , x_9 and x_{16} were the important traits affecting the body weight of three-month-old *L. calcarifer*, and other traits had little effect on body weight. Table.4 also demonstrated that the impact of these six traits on the body weight there are differences. x_{16} most directly determined.

Table4. Coefficient of determination of morphological attributes to body weight of three-month-old *L. calcarifer*

Traits	x_1	x_2	x_4	x_7	x_9	x_{16}	Σ
x_1	0.107	-0.120	-0.133	-0.119	-0.057	-0.407	0.976
x_2		0.041	0.077	0.071	0.034	0.236	
x_4			0.048	0.076	0.037	0.258	
x_7				0.039	0.032	0.234	
x_9					0.010	0.109	
x_{16}						0.403	

3.5. Construction of Multiple Regression Equation

The multiple regression equation of morphological attributes to body weight of three-month-old *L. calcarifer* is established by multiple regression analysis, it is:

$$y = -64.974 + 1.273x_2 + 0.238x_4 + 2.205x_7 + 0.401x_9 + 0.573x_{16}$$

In the equation, y is body weight, x_2 is body width; x_4 is stem length; x_7 is eye distance; x_9 is the caudal peduncle height; x_{16} is the distance of the base of pectoral fin to the end of the second dorsal fin. The variance analysis showed that the regression relation of the multiple regression equation is extremely significant ($F=705.995$, $P=0.000<0.01$, $R^2=0.961$). The partial regression coefficient of 5 morphological attributes (x_2 , x_4 , x_7 , x_9 and x_{16}) to body weight of three-month-old *L. calcarifer* are either significant or extremely significant.

4. DISCUSSION AND CONCLUSION

In the reported study of fish path analysis, it has been found that the fish breeding attributes are not the same. This difference is related to the species of fish, gender (An & Qingheng, 2012), aquaculture density (Limin, Barry, Chao & Liping), and the morphological attributes selected by the researchers. It has been choosed that the length of the body (body length, body width, body height, head length, body length and tail length, etc.), eye index (eye diameter, eye distance, etc.) in the study of fish path analysis, and the attributes related to fins are rare. The attributes related to fins (x_{11} - x_{20}) were added on the basis of the commonly used indexes (x_1 - x_{10}) in the study, the results of path analysis showed that the largest direct path coefficient of body weight were the fish fin index (x_{16}). The regression analysis showed that the total decision coefficient was 0.976, indicating that the fish fin correlation index could also be used as the morphological attributes affecting the body weight. Zhou Shaofeng found that the total length, body length, body height and head length of red spot grouper (*E. akaara*) body mass of the total coefficient of determination was 0.924 (Shao-feng, Wei-qing & Rui-fa, 2015); and the range of values for other study was 0.784-0.967. However, the correlation index of the study was higher than the above results, it indicated that the fins was also one of the main traits to construct multiple regression equation of *L. calcarifer*.

Research has also shown that morphological traits affecting the body weight of fish may be related to the growth stage. The results of the study on the relationship between morphological traits and body weight of *Paralichthys olivaceus* at 20-40 days showed that the main trait that affected body weight at 20 days of age was body height while at other stages the major influencing factor was body length (Xue-hong, Bao-ming, Huan-li & Xiao-lan, 2014). The most important morphological traits that affected the body weight of early *Pseudosciaena crocea* were body height and body length, while full length was important in addition to these two factors in the medium term (Xian-de, Ming-yi, Zhi-yong & Guang-tai, 2010). Body length or body height was the main traits that affected the body weight of *Liza haematocheila* at different times. In the study of path analysis of shellfish, including *Scapharca subcrenata* Lischke, *Chlamys nobilis* and so on were also confirmed that the traits affect their body weight at different stages were always different. In this study X_2 , X_4 , X_7 , X_9 and X_{16} were related to body weight of three-month-old *Lates calcarifer* closely. However, the relationship between morphological traits and body weight in other stages will be further research and exploration.

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