Length-Weight, Length-Length Relationship of the Spiny Eel, *Macrognathus pancalus* (Hamilton 1822) sampled from Ganges and Brahmaputra river basins, India

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Abstract

The freshwater spiny eel, *Macrognathus pancalus* is an inland water teleost fish commonly known as barred or striped spiny eel found in Asia. The sampling areas were selected which are spatially and geographically different and characterized by different environmental conditions in order to elucidation of ecotype. A total 345 specimens were collected from the sampling sites during January 2008 to December 2010. The weight of *M. pancalus* in the present study nearly the cube of its length in all cases as the values of regression coefficient 'b' were found to be close to 3. The length weight relationship indicated the isometric growth in all the samples of striped spiny eel collected from different environmental condition. The coefficient of regression 'b' were more in the riverine population (3.17±0.08) as compared to the populations of a large lake i.e. Beel (2.85±0.13). The coefficient of determination, (r^2) in all the cases was highly significant ($p < 0.001$). The relative condition factor (Kn) were also calculated and the average of condition factor in riverine and beel populations of spiny eel were found to be 0.50±0.09, and 0.47±0.05, respectively. The length-length relationship was highly correlated ($r^2 = 0.99$ at $P<0.0001$) for all the individuals of both habitats. A significant size difference was also noted between the river basin populations of *M.pancalus*. In the present study the length-weight, length-length relationship of *M.pancalus* in two different river basins was compared.

Keywords: *Macrognathus pancalus,* Length-weight relation, Condition factor

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Introduction

The freshwater spiny eel, *Macrognathus pancalus* is an inland water teleost fish commonly known as barred or striped spiny eel found in Asia (Suresh et al., 2006). The species is distributed in India and its neighbouring countries such as Nepal (Froese and Pauly, 2006), Pakistan, Sri Lanka, Bangladesh and Myanmar (Talwar and Jhingran, 1991). The species is known to occur in estuaries and freshwater habitats such as beels (wetland or a string of beels is indicative of their being the remains of a great river that deserted its channel), ponds, lakes and rivers (Talwarar and Jhingran, 1991).The fish is commercially important and palatable as a table fish. The demand of larger sized spiny eels always exceeds the supply in India and abroad, and it fetches a good price (INR 60-80per kg) when sold alive particularly in northern, eastern and north-eastern parts of India where people relish alive and less bony fish (Suresh et al., 2006). The smaller size of this species has an ornamental value as an indigenous aquarium fish and is being exported to America, Europe and other Asian countries (Sugunan et al., 2002; Tripathi, 2004). The fish is generally caught using line and trap methods because of its bottom dwelling habits besides cast and drag nets. The bottom–set traps are exclusively used to catch this fish in wetland area (Gorgon beel) in Assam from where the sample was collected for this study. The population of this species is showing the sign of dwindling because of its reckless exploitation from the natural resources in the absence of its cultivation. It is included under least concern category in IUCN (Vishwanath, 2010). The investigations on various aspects of its biology are carried out by many workers such as Swarup et al. (1972) on sexual dimorphism, Karim and Hussain (1972) on maturity and fecundity, Srivastava (1975) on unusual development of the caudal fin, Serajuddin and Ali(2005) on food and feeding habits and Suresh et al.(2006) on biology. Sikder and Das (1980) carried out work on skin structure while Talwar and Jhingran (1991) described the taxonomy and distribution of the species. Dutta (1989,1990), Serajuddin and Mustafa (1994) and Serajuddin et al. (1998) investigated the food and feeding habits of a closely related species, *Mastacembelus armatus*. Serajuddin (2004) also reported the intra specific diversity of *M. armatus*.

The study on length- weight relationship is still scanty for most tropical and sub-tropical fish species. (Martine-Smith, 1996; Harrison, 2001; Ecoutin et al., 2005; Hossain et al., 2009 a&b). The biology of this species was also studied by Suresh et al. (2006) from the Ganga river basin at North 24 Parganas district of West Bengal. The length-weight relationship would be helpful in calculating the total weight of fish, measuring changes in robustness or health of the population and comparing the condition of the populations. The length-length (LLR_s) relationships are useful in the standardization of length type when data are summarized (Froese, 1998).In the present study the length-weight, length-length relationship of two different river basins was compared.

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Materials and methods

The sampling areas were selected which are spatially and geographically different and characterized by different environmental conditions in order to elucidation of ecotype. A total of 225 specimens (size range 10.10-18.50 cm) from Gomti river at Lucknow (27° N 81° E).River Gomti is a major tributary of Ganga in northern India, the river originates from a natural lake in a forested area (elevation of about 200m, North latitude 28° 34ˈN and east longitude 80° 07ˈE near Pilibhit town in Uttar Pradesh about 50 km south of the Himalayan foothills. The river flowing a approximate distance of 730 km before merging with Ganga river near Varanasi (Sarkar et al., 2010). While on the other hand 120 samples (size range 9.10-15.30 cm) were collected from the Gorgon beel (35 km^2) of Bagta village of Assam (26° 5´ N 34° E) by line and trap methods. The channels of beels are a part of river Brahmaputra river basins due to flooding and other causes. The samples were collected in both the sites during January 2008 to December 2010. Both the sampling sites are approximately 2000 km far away from each other through geographical barriers; there is no connection between these water bodies. These samples were brought to the laboratory. The fishes were measured to nearest 1mm in a fish measuring board, and weighed to the nearest 0.1g in an electronic balance. The specimens were sectioned and observed macroscopically by examination of gonads in order to determine their sex. The fishes were divided into male, female and overall of male and female. The data was transformed into log-log transformation. The transformed data of length-weight and length-length relationship was estimated by the method of least squares as used by Ricker (1973): $W = {}_aTL^b$, where ‘W’ is weight in g, ‘L’ is total length in cm and ‘a’ is intercept of regression line while ‘b’ is slope indicating the growth rate (Beverton and Holt, 1996). For practical purpose this relationship is usually expressed in its logarithmic form (LeCren, 1951) as:

$$\text{LogW} = \text{Log } a + b \text{ Log L} \quad \text{and}$$
$$\text{LogTL} = \text{Log } a + b \text{ Log SL}$$

The b value for each form was tested by t-test to verify if it was significantly different from the isometric growth (b=3) (Sokal and Rohlf, 1981). The Fulton condition factor was calculated by using the following formula as:

$$K = W \times 100 / L^3$$

Fulton condition factor K with W = is the whole wet weight in g and L=is the standard length in cm and the factor 100 is used to bring K close to unity. The total length was log transformed before the subjection of length frequency distribution in order to compare their size structure. The t-test (unpaired) was used in order to compare the size difference between the populations. The coefficient of determination (r^2>0.95) was estimated in order to indicate the quality of the linear regression. All the statistical analysis was done with the help of software (Graph pad prism 4).

Results

The lograthmic regression equation of length-weight relationship of 345 individuals of *M. pancalus*, which were caught from the Ganges and Brahmaputra river basins, was calculated and given in the table 1 with Fig 1.

Table 1: Logarithmic regression equation of weight on total length of *M. pancalus*

Source	Logarithmic regression Equation	Sample size	Correlation Coefficient (r)
Gurgon Beel			
Male (♂)	LogW=2.28±0.17Log L-1.68±0.17	51	0.88
Female(♀)	LogW=2.59±0.22Log L-1.93±0.24	69	0.82
Combined	LogW=2.85±0.13Log L-2.24±0.14	120	0.90
River Gomti			
Male (♂)	LogW=3.16±0.23Log L-2.62±0.26	43	0.91
Female (♀)	LogW=3.14±0.09Log L -2.58±0.10	182	0.93
Combined	LogW=3.17±0.08Log L-2.61±0.09	225	0.94

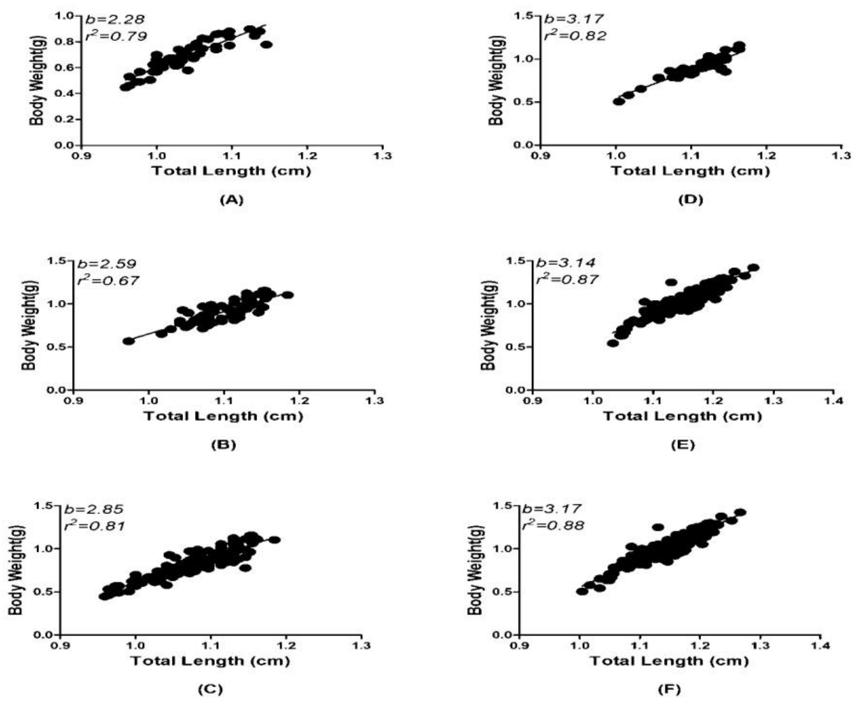

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Figure 1: Logarithmic linear relationships fitted to the estimated body weight of *M.pancalus* of Brahmaputra river basins(Left A.,B.,C) and Ganges river basins(Right D.,E.,F). Top to bottom, Male (A.,D), Female(B.,E) and overall(C.,E).

The average size of the population of Brahmaputra river basin (11.88±0.13 cm) was as compared to the population of Ganges river basin (13.88±0.11 cm). The t-test showed (t=11.97 df=343 at $P<0.05$) a significant difference in the size of the populations of *M.pancalus* in both the river basins respectively. The length frequency distribution of *M.pancalus* was given in fig 3.The exponent b often has a value close to three but varies between 2 and 4 (Tesch, 1971).The coefficient of correlation (r^2) in all the cases were highly significant ($P< 0.001$). The weight of *M. pancalus* in the population of Ganges river basin (Gomti river) was equal to the cube of its length (b=3.17±0.08) as compared to the population of Brahmaputra river basin (Gurgoon beel) of Assam (b=2.85±0.13). The regression coefficient b (3.16±0.23) of male population of Ganges river basin was positively allometric while the regression coefficient b (2.28±0.16) of male population of Brahmaputra river basin was negatively allometric. The regression coefficient b (3.17±0.09) of female population of Ganges river basin was also positively allometric as compared to the regression coefficient b (2.59±0.22) of female population of Brahmaputra river basin was also negatively allometric. The linear regression and associated statistical parameters of length-weight are given in the Table 2.

Table 2, Statistics and parameters of linear regression relationship of body weight and total length of freshwater spiny eel (*M. pancalus*).

Source	**Intercept(a)**	**Regression coefficient(b)**	**Size Range(cm)**	**Coefficientof Determination(r^2)**	**P value**	**Remark**
Gurgon Beel						
Male(♂)	-1.68±0.17	2.28±0.17	9.1-14.0	0.79	<0.0001	S
Female(♀)	-1.93±0.24	2.59±0.22	9.4-15.30	0.67	<0.0001	S
Combined	-2.24±0.14	2.85±0.13	9.10-15.30	0.81	<0.0001	S
River Gomti						
Male(♂)	-2.62±0.26	3.17±0.23	10.10-14.60	0.82	<0.0001	S
Female(♀)	-2.58±0.10	3.14±0.09	10.80-18.50	0.87	<0.0001	S
Combined	-2.61±0.09	3.17±0.08	10.10-18.50	0.88	<0.0001	S

The significance of variation was calculated in the value of b from expected cube law was tested by a student t - test in order to find out to their either isometric or allometric growth. The value of t – test were for the males (t=-4.23, df=49, p≤

0.01), females (t= -1.86, df= 67, p≤ 0.1), and for the combined form (t=-1.15, df =118, p≤ 0.1) of the Brahmaputra river basin population respectively. These all the values of t-test are not significant because the tabulated value is higher than the calculated value. On the other hand in the population of *M. pancalus* in Ganges river basin also shows a highly significant values in the combined form (t=2.13, df= 223, p≤ 0.05), while the values of males (t=0.69, df= 41, p≤ 0.1), females (t=1.55, df= 180, p≤ 0.1) are not significant which indicates that fishes shows the isometric growth instead of allometric growth. The rate of increase in weight in relation to length was slightly higher in the fish collected from Ganges river basin (b= 3.17±0.08) as compared to the fishes collected from Brahmaputra river basin (b=2.85±0.13). The coefficient of determination value of both habitats indicates that the length-weight relationship of Ganges river basin was more correlated (88%) as compared to the Brahmaputra river basins (81%) in the populations of *M.pancalus.* The relationship between the total length and standard length were highly correlated. The logarithmic regression equation of total length and standard length was given in the table 3 with fig 2.

Table 3, Logarithmic regression equation of length -length relationship of *M.pancalus*

Source	Logarithmic regression Equation	Sample size	Correlation Coefficient (r)
Gurgon Beel			
Male (♂)	LogTL=1.01±0.01Log SL-0.04±0.01	51	0.99
Female(♀)	LogTL=1.01±0.01Log SL-0.05±0.01	69	0.99
Combined	LogTL=1.02±0.01Log SL-0.05±0.01	120	0.99
River Gomti			
Male (♂)	LogTL=1.02±0.01Log SL-0.06±0.01	43	0.99
Female (♀)	LogTL=1.01±0.01Log SL-0.04±0.01	182	0.99
Combined	LogTL=0.99±0.02Log SL-0.02± 0.02	225	0.93

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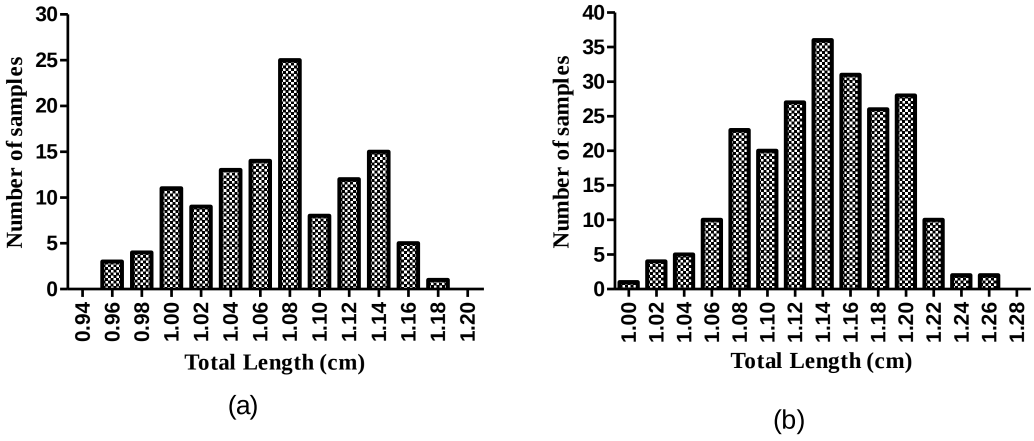

Figure 3: Total length (log) frequency distribution of the population of *M.pancalus* (a) Brahmputra river basin (b)Ganges river basin.

The value of intercept (a) was -0.04±0.01 and regression coefficient (b) was 1.01±0.01 of male populations of *M.pancalus* of Brahmaputra river basins. The male fishes of Brahmaputra river basins at Assam region are highly correlated in their length-length relationship (r^2=0.99) at p<0.0001. In females these (a) is -0.05±0.01, and (b) was 1.01±0.01 and coefficient of determination was r^2 =0.99 at p< 0.0001. The overall form also shows a strong correlation between the lengths which was determined r^2 =0.99, and intercept, slope are -0.05±0.01, 1.02±0.01 respectively in populations of *M. pancalus* of Brahmaputra river basins at Assam. The length-length relationship was also highly significant in the population of Ganges river basin, the value of intercept (a) for males was -0.06±0.01, and the value of regression coefficient (b) was 1.02±0.01 with coefficient of determination (r^2) was 0.99 at p< 0.0001. The length-length relationship for females were also highly significant at p< 0.0001 with coefficient of determination (r^2) was 0.99 and the calculated value of intercept (a) was -0.04±0.01, the regression coefficient (b) was 1.01±0.01. The length-length relationship of the overall population of Ganges river basin was highly significant at p<0.0001, with coefficient of determination (r^2) was 0.93 with the value of intercept (a) was -0.02±0.02 and the regression coefficient's (b) value was 0.99±0.02. The linear regression and associated statistical parameters of total length with standard length are given in the Table 4.

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Table 4, Statistics and parameters of linear regression relationship of total length and Standard length of freshwater spiny eel (*M. pancalus*).

Source	**Intercept(a)**	**Regression coefficient(b)**	**Coefficient of Determination(r^2)**	**P value**
Gurgon Beel				
Male(♂)	-0.04±0.01	1.01±0.01	0.99	<0.0001
Female(♀)	-0.05±0.01	1.01±0.01	0.99	<0.0001
Combined	-0.05±0.01	1.02±0.01	0.99	<0.0001
River Gomti				
Male(♂)	-0.06±0.01	1.02±0.01	0.99	<0.0001
Female(♀)	-0.04±0.01	1.01±0.01	0.99	<0.0001
Combined	-0.02± 0.02	0.99±0.02	0.93	<0.0001

The values for Fulton's condition factor (K) were also calculated for overall, males and females of both the groups of different populations of *M. pancalus.* The average values of condition factor were found to be 0.50±0.09, 0.47±0.05 in the populations of *M. pancalus* collected from Ganges river basin and Brahmaputra river basins respectively. The condition factor for the males was found to be 0.47±0.08 and 0.46±0.05, of Ganges river basin and Brahmaputra river basins respectively. The condition factor for the females was found to be 0.53±0.09 and 0.47±0.05, of Ganges and Brahmaputra river basins respectively. The environmental conditions of both the stations are differ to each other such as in Ganges basin the weather follows extreme hot and cold conditions and the humidity is more only in the rainy season. However in the Brahmaputra river basins weather conditions adequate in all the seasons and water is slightly alkaline as compared to Ganges river basin water which is more alkaline.

Discussion

The regression equations and the values of coefficient of correlation (r) of the samples collected from river and beel are suggestive of a close relationship between length and weight in *M. pancalus*. But the fish follow the cube law strictly, and the weight increase was a rate of the cube of its length in all the samples collected from spatially and geographically different places characterized by different environmental conditions. The departure from the cube law is within the expected range of 2.0 – 3.5 as reported by various workers such as Bagenal and Tesch (1978), Koutrakis and Tsikliras (2003) and

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Froese (2006) for most fishes. The value of 'b' in all the populations of *M. pancalus* in the present study is not significantly different from 3.0, indicating the fish grow isometrically. The values close to 3.0 indicate isometric growth in general and despite the many variations in fish forms between species (Tesch, 1971). However, Hossain et al. (2006) reported the isometric growth (b=3.026) in the same species collected from river Mathabhanga a tributary of river Padma in Bangladesh. The other workers such as Narejo et al. (2003) and Serajuddin (2005) reported low value of 'b' in the closely related species, *Mastacembelus armatus*. The rate of increase in weight in relation to length was slightly higher in the fish collected from river (b= 3.17) as compared to those collected from beels, it may be due to ecological factors particularly high dissolved oxygen concentration, circulation of water and forage organisms to the fish. The present findings is similar to those of Mustafa (1978) who reported variation in length-weight relationship associated with habitat differences in *Esomus danricus*, and emphasized that fishes living in running water show rapid growth compared to those which inhabit stagnant water. Tesch (1971) also reported that the length-weight relationship in fishes can be affected by habitat and area besides other factors such as seasonal effect, degree of stomach fullness, gonad maturity, sex, health, preservation techniques and differences in the observed length ranges of the specimens. The length-length and length-weight relationship were also studied in *Boops boops* of Izmir bay of turkey Kara et al. (2008). The length-length relationship was also in a dynamic pattern with highly significant coefficient of determination. Simon and Mazalan (2008), also studied the length-weight and length-length relationship of archer (*T. chatareus, T. jaculatrix*) and pufferfish (*L. wheeleri* , *L. sceleratus*) from the Malaysian estuaries. They found positive allometry in archer fish, but in case of pufferfish they found negative isometry in pufferfish. Kumolu-Johnson and Ndimel (2011) studied the length-weight relationship in nine species of fishes from the Ologe lagoon Nigeria and reported the allometric growth of most species. A highly significant correlation was obtained in the length-length relationship of fishes indicates that lengths are intimated to each other in a proportionally which provides a strength between the length-length relationship .Nowak (2009) also observed the negative value of intercept in *Leuciscus leuciscus*, *Phoxinus phoxinus*, *Salmo trutta* of Dniester River drainage of Poland. Froese 2006 also pointed out the concept of isometric and allometric growth of fishes whenever the value of slope (b) deviates its standard value of 3 in his review. Weight- length relationships are used for estimating the weight corresponding to a given length, and condition factors are used for comparing the 'condition', 'fatness', or 'well-being' of fish (Tesch, 1968). Carlander (1969) reviewed the relative condition factor (Kn) of LeCren (1951) and concluded that "while the relative condition factor is useful in certain studies, it is not suitable for comparisons among populations". So the Fulton's condition factor (K) was used in the present study. The highest condition factor in the individuals of *M. pancalus* of river suggested their better condition in these environments because of the availability of their forage items. The decline of K in very large fish may be because of inadequate feeding or empty stomach. These comparative attributes of length-weight and length frequency distribution provides new insights in the size structure of *M. pancalus* in relation to environmental plasticity or genetic differentiation. However further investigations by common garden experiments on variations of life history traits including length-weight and size structure in relation to environmental conditions or genetic differentiations of populations are needed to establish beyond doubt whether these parameters are plastic or genetically governed.

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