



Length-weight relationship and relative condition factor (KN) of *Monopterusuchia* (HAMILTON) in Meghalaya, India

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Abstract

The Length-Weight Relationship (LWR) and relative condition factor (Kn) of Mud eel (*Monopterusuchia*) from three different areas of Meghalaya were studied. The data was analyzed using the formula: $W=aL^b$. The values of regression co-efficient 'b' indicate a positive allometric growth pattern of the fish due to higher proficiency in feeding. The values of correlation co-efficient proved to be highly significant. It also exhibits a high degree of positive correlation between the length and weight of the species. The values of relative condition factor 'Kn' indicate a good well-being of the fish. High relative condition factor (Kn) value proved that condition factor increased with increasing length and weight of the species. The results revealed a healthy habitat conditions. The Length-Weight Relationship and relative condition factor showed that the growth of *Monopterusuchia* from three different areas of Meghalaya is quite satisfactory.

Keywords: length-weight, relative condition factor, *monopterusuchia*, mud eel, allometric, correlation

Introduction

Mud eel (*Monopterusuchia*) is fresh water air breathing, swamp dwelling fish. It belongs to the family Synbranchidae of the order Synbranchiformes. Locally known as *Khabseiñ* in Khasi language in Meghalaya and considered as a nutritious as well as a valued remedy in oriental medicine. The species is commonly available in the fresh water of Bangladesh, Pakistan, Northern and North-East India and Nepal [1]. The habitat of this species is fresh and salty water as they are mainly found in shallow well vegetated water and mud. They often spend their daytime hiding under stones and mud as they have a burrowing habit [2]. The population has been declined to a great extent due to various environmental and anthropogenic factors. According to [3], the status of *Monopterusuchia* in India is endangered. In future *Monopterusuchia* can be a potential candidate for artificial culture in ponds, so it is important to study its Length-Weight Relationship and relative condition factor to understand the condition for captive culture and breeding. At present no published information is available on the study of *Monopterusuchia* from Meghalaya. The present investigations were carried out to ascertain Length-Weight Relationship (LWR) and Relative Condition Factor (Kn) of this species.

The Length-Weight Relationship (LWR) and Fulton's condition factor (K) are two main parameters used in fishery research and have been closely related since they were first proposed [4]. The Length-Weight Relationship is the relationship between weight and length for a given species, and can be used to estimate the growth pattern. [5] Also reported that 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. Basic information

on such as parameters that relate weight to length of fish is of great importance in studies on the evaluation of fish stocks [6] and fisheries biology [7]. Length-Weight Relationship (LWR) 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, based on the assumption that heavier fish of a given length are in better condition [8]. According to [9], Knowledge of Length-Weight Relationships (LWR) is an important tool for the adequate management of any fish species which have been applied in the assessment of fish stocks and populations. Length-Weight Relationship (LWR) data of fishes are useful for biologists in fishery assessment and proper management of their population and it is also a very important tool in fisheries assessment [10, 11, 12]. Length-Weight Relationship studies in fishes are being done with a view to establish the relationship between length and weight for enabling the interconversions of these variables as required in setting up of yield equations for estimating population strength [13]. The study (LWR) of fishes are important in fisheries and fish biology because they allow the estimation of the average weight of the fish of a given length group by establishing a mathematical relation between them [14, 15]. Like any other morphometric characters, the Length-Weight Relationship can be used as a character for the differentiation of taxonomic units and the relationship changes with the various developmental events in life such as metamorphosis, growth and onset of maturity [16]. Besides this, LWR can also be used in setting yield equations for estimating the number of fish landed and comparing the population in space and time [17].

Allometric growth is the change in the organisms in relation to proportional changes in body size. Allometric growth was reported in *Ompok bimaculatus* by [18] and in *Nibeamaculata*

collected from Mandapam by [19]. [20] Revealed the allometric growth in *Ctenopharyngodon idella* grown under the agro-climatic zone of Himachal Pradesh. [21] Also reported an allometric growth in *Rasbora daniconius*. [22] Studied the Length-Weight Relationship in nine species of fishes from the Ologe lagoon Nigeria and reported the allometric growth of most species. Growth is said to be positive allometric when the weight of an organism increases more than length ($b > 3$) and negative allometric when length increases more than weight ($b < 3$) [23]. [24] Also revealed that species like *P. fasciata*, *M. marginatus* and *C. apogon* showed a positive allometric growth with $b > 3.0$. Similarly, [25] also reported positive allometric growth in *Macragnathus aral*. [26] Observed the higher proficiencies in feeding, availability of food and other associated factors for positive allometric growth in different fishes. Moreover, [27] also reported that the slope $b = 3.51$ values indicated a positive allometric growth in case of *P. argenteus*. Moreover, [28] revealed that the positive allometric growth was observed in longer length group and negative allometric growth was in shorter length group. The parameters of WLRs indicate allometric growth of skipjack tuna [4] and these parameters are affected by many ecological and individual factors [29]. Similarly, [30, 31, 32, 33] have reported allometric growth for various species of molluscs.

The 'Kn' value is a physiological indicator of general well being of any fish living in a given environment [34, 35]. [36] Also reported that the monthly fluctuations in 'Kn' value are due to an increase in the body weight either due to tissues growth or egg mass development. Generally 'Kn' value greater than 1 indicates better condition of fish [37]. The high value of 'Kn' is a special feature recorded for the species *Nandus nandus* as reported by [26]. The well-being or 'Condition' or 'fatness' of fish determined by Kn-factor, is an index to monitor feeding intensity and growth rate [38] is based on hypothesis that heavier fish for a given length are in better condition and high value of 'Kn' for fishes are heavy for its length, while with low 'Kn' are lighter [39]. In any natural aqua-habitat, the value of relative condition factor 'Kn' also determines the well-being of fish [40]. The relative condition factor is more effective estimate of variations of food supply, sexual condition etc of any fish [37]. Therefore, the Length-Weight Relationship (LWR) of this species from Meghalaya was undertaken to find out the variations, if any, and growth pattern from three climatically different habitats viz. East Khasi Hills, Garo Hills and Ri-Bhoi District of Meghalaya.

Materials and methods

Fish samples were collected monthly from January 2016 to August 2017 from three different areas viz East Khasi Hills, Garo Hills and Ri-Bhoi District. A total of fifty (50) specimens from each of the three areas were analyzed. Length and weight of the fish were measured in centimeter and gram respectively.

Length-Weight Relationship was estimated by the equation:

$$W = aL^b \text{ [37]}$$

Which was further expressed logarithmically as:

$$\text{Log } W = \text{Log } a + b \text{ Log } L$$

Where, W= weight of the fish in grams, L= length of the fish in centimeter, a= constant, b= regression coefficient. The parameters 'a' and 'b' were determined empirically. The correlation coefficient 'r', standard deviation (SD) between total length and body weight were calculated with the help of Microsoft Office Excel.

For Relative Condition Factor (Kn), the equation used is:

$$Kn = W/w$$

Where, W= observed weight of fish in grams and w= calculated weight for the observed length (in grams).

The correlation co-efficient 'r' was found out by using the formula:

$$r = \frac{\sum XY - n\bar{X}\bar{Y}}{\sqrt{(\sum X^2 - n\bar{X}^2)(\sum Y^2 - n\bar{Y}^2)}}$$

The correlation coefficient 'r' shows a very high degree of correlation between length and weight. A strong or high Correlation Co-efficient 'r' value (near one) means that the two variables have a strong relationship with each other. The closer the 'r' value to +1 or -1, the more closely the two variables are related with each other. If the Correlation Coefficient 'r' value is positive, this means that as one variable gets larger the other variable also gets larger.

Results

A total of fifty (50) specimens from each of the three areas were analyzed in this study. The results obtained for Length-Weight Relationship and Relative Condition Factor were shown in Table-1 and Table-2 and the pie-charts were shown in Fig-1 and Fig-2 respectively.

Table 1: Length-Weight Relationship of *Monopterus cuchia*

Areas	Number of Fish Examined	Mean Length (cm) ±SD	Mean Weight (gm) ±SD	a	b	R
Ri-Bhoi	50	64.32±3.57	357±16.93	2.03	3.8	0.82
East Khasi Hills	50	74.65±4.52	625.2±18.71	2.53	3.7	0.90
Garo Hills	50	63.91±4.53	242.9±23.73	-1.05	3.9	0.80

b=slope of regression, r= correlation coefficient, *significance at 5% level

Table 2: Relative Condition Factor and Chi-Square Test for both Length and Weight of the species

Areas	Number of Fish Examined	Relative condition Factor (Kn)	χ² Test For Length	χ² Test For Weight
Ri-Bhoi	50	1.00	9.74	39.35
East Khasi Hills	50	1.00	13.44	27.46
Garo Hills	50	1.02	15.76	113.60

From the above table it was found out that 'b' value was observed to be different from all the three areas. Moreover, the growth of the fish is positive allometric. This means that the fish grows faster in weight than in length and it also grows stouter with the increase in length. Correlation coefficient 'r' value showed a good relationship between two parameters. Moreover, the mean Relative Condition Factor 'Kn' was found to be 1.00 suggesting the wellbeing of the fish. Since

the calculated value of Chi-square test for the length of the species is less than the tabulated value, it is not significant and the null hypothesis may be accepted at 5% level of significance. From Fig-1, 51% of the total weight of the fish was observed in East Khasi Hills which is more as compared to Ri-Bhoi (29%) and Garo Hills (20%). Since the weight is more relevant in East Khasi Hills, this may be due to some environmental factors, availability of food or better water quality with optimum pH level as compared to Ri-Bhoi and Garo Hills. Moreover, the highest length was also observed in East Khasi Hills which is highly correlated with its weight and the similar being observed in Ri-Bhoi and Garo Hills. Since the length is more in East Khasi Hills, then it is following the similar trend with its weight. In general, the overall percentage of the Length and Weight from all the three areas was found to be high in East Khasi Hills District.

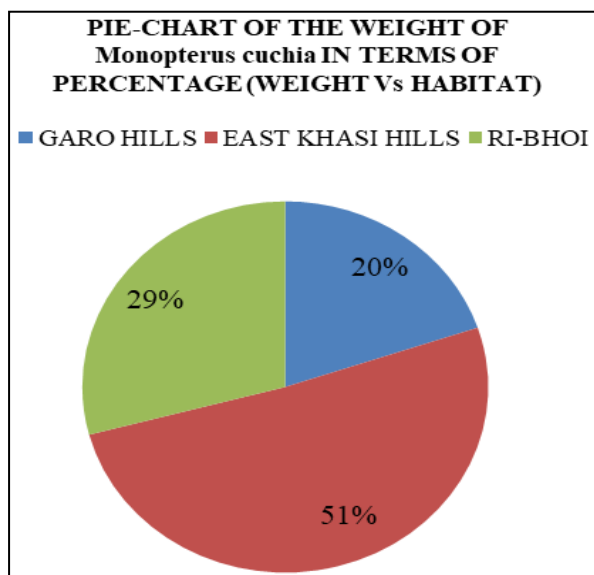


Fig 1: Pie- chart showing Weight versus Habitat of the specimens collected.

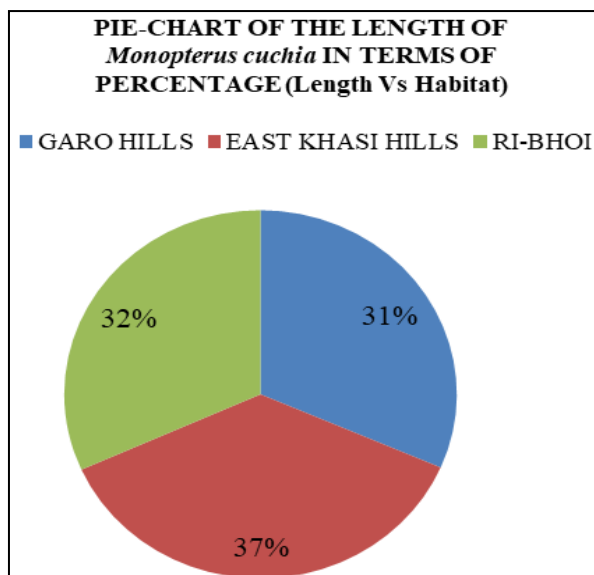


Fig 2: Pie-chart showing Length versus Habitat of the specimens collected.

Discussion

This study provides new information on the Length-Weight Relationship of *Monopterus cuchia* in Meghalaya. Length-Weight Relationship revealed 'b' values (regression coefficient) of 3.8 (Ri-Bhoi), 3.7 (East Khasi Hills) and 3.9 (Garo Hills) respectively. The result indicates a positive allometric growth pattern of the fish. Across species median, $b=3.03$ is significantly larger than 3.0, thus indicating a tendency towards slightly positive-allometric growth (increase in relative body thickness or plumpness) in most fishes [4]. [8] Used the term 'allometric growth' for values other than $b=3$. He stated that if $b>3$, the fish becomes "heavier for its length" as it grows larger.' [41, 42] They observed that the value of regression coefficient (b) usually lies between 2.5 and 4.0. [8] Also presented a variation of the relative condition factor as 'allometric condition factor' for comparing individual fish. He also reported that the value of 'b' might be between 2.0 and 4.0. However, a variation in 'b' value may occur due to different environmental factors. [4] Also reported that if $b > 3$, then large specimens has increased in height or width more than in length, either as the result of a notable ontogenetic change in body shape with size, which is rare, or because most large specimens in the sample were thicker than small specimens, which is common. Moreover, [41] observed that 'b' value more than 3 (i.e. $b > 3.0$) indicates an increase in condition or increase in height or width with increase in length. Values of the exponent 'b' provide information on fish growth. When $b=3$, increase in weight is isometric. When the value of b is other than 3, weight increase is allometric, (positive allometric if $b>3$, negative allometric if $b<3$) [43]. In this study, the LWR of *Monopterus cuchia* showed a positive allometric growth (3.8, 3.7 and 3.9) from all the three areas. The present results are with conformity with the above findings and showed a positive allometric growth for the three different places from where fish specimens are collected. Similarly, [44, 45, 46] they also attained similar results. [47] Also reported that the regression coefficient for the LWR and relative condition factor of Peacock Eel (*Macroglythys aral*) in indicates positive allometry. The positive allometry shown by the fish may be due to higher proficiency in feeding [48, 49, 50] and better environmental condition for survival for the species. [51, 52, 53, 54, 26] also observed the effect of availability of food and other associated factors responsible for positive allometric growth. [22] Studied the Length-Weight Relationship in nine species of fishes from the Ologe lagoon Nigeria and reported that most of the species shows an allometric growth. The variation in the regression coefficient for the same species could be attributed to the difference in sampling, sample size or length ranges [55]. Moreover, morphological changes due to age also cause substantial changes in the exponent of length on weight [56].

The differences in the regression coefficient can be due to the ecological features of the selected areas. Positive allometric growth implies that the species becomes relatively stouter or deeper bodied as it increase in length and it is also indicated by $b>3.0$. Since the regression coefficient (b value) in case of *Monopterus cuchia* was more than three (i.e. $b>3$), this indicates that LWR deviates from maintaining the Cube law and at the same time it exhibit positive allometric growth pattern of the species. The greater the regression coefficient

($b > 3$) suggests that the specimens have increased in width more than in length. The results of the present study are very similar to the above findings and it is almost in the same range as reported by [41, 42, 37, 8].

In the present investigation, it was found out that the correlation coefficient 'r' values were 0.82 (Ri-Bhoi), 0.9 (East Khasi Hills) and 0.8 (Garo Hills) respectively. This indicates that the growth performance of the fish are found high since the correlation coefficient 'r' value exhibits a high degree of positive correlation between the length and weight of the species. Moreover, the correlation coefficient (r value) calculated indicated a high correlation between the length and weight and at the same time it also proved to be highly significant. [57] Also reported that the correlation coefficient "r" value of 0.9 indicating a high correlation coefficient. [58] Also revealed that the correlation coefficient (r) was found to be 0.9865 which showed a good relationship between the two parameters. Similarly [59] reported that the correlation coefficient (r) for length and weight relationships is high for all fish species which indicates that the length increases with increase in weight of the fish. Moreover, the value of correlation coefficient 'r' proved to be highly significant as reported by [60, 61]. The value of $r > 0.8$ regardless of sex and season represent a strong relationship between length and weight and indicate whether the relationship was significant or not [62]. Since the results of the present study are similar to the above findings, therefore the correlation coefficient 'r' value in case of *Monopterusuchia* showed a good relationship between the length and weight of the species.

The Relative Condition Factor (Kn) value is a physiological indicator of general wellbeing of any fish living in a given environment [34, 35]. Moreover, the relative condition factor is an index to monitor feeding intensity, well-being and growth rate of the fish [38]. Relative Condition Factor (Kn) is of great significance for understanding the nutritional and biological cycle of a fish. It is also important to the fishery industry to predict the suitable length and time suited to harvest a particular species. Relative condition factor (Kn) was found to be high during the monsoon months (spawning period) from April -June reflecting the maturity of the fish and the highest Kn values were found in smaller sized fishes [61]. Similar reports were also reported for *Cirrhina mrigala* by [63]. The 'Kn' value of *Nandus nandus* showed a better condition of the experimental fish. The high value of 'Kn' (greater than 1) is a special feature recorded in the present study of the species [26]. The high value of 'Kn' for fishes are heavy for its length, while with low 'Kn' are lighter [39]. However, the condition factor (K) and relative condition factor (Kn) in the free living stage of *Channa aurantimaculata* clearly indicate that the general wellbeing and the status of maturity and growth are favourably good [64]. High relative condition factor (Kn) value in both the species suggests that condition factor increased with increasing length and weight of the fish [65]. However, 'Kn' value greater than 1 ($Kn > 1$) indicates better condition of fish [37]. [61] Also revealed that the values of 'Kn' showed fluctuations in all sized groups. [58] Also reported that value of $Kn > 1$ implies that food was not limiting in the rivers. If the weight increases more rapidly than the cube of the length, 'Kn' would increase with increase in length. When the weight increases less than the cube of the length, 'Kn' would tend to

decrease with the growth of the fish. The highest values of 'Kn' reflect that fish is towards maturity and the sudden decline of 'Kn' value might be due to first maturity of fish [59]. [66] Also revealed that the LWR of *Monopterusuchia* were found significantly at 0.1% level and the Kn value was found to be high during monsoon months (spawning period) from April-June reflecting the maturity of the fish. Higher values of 'Kn' in a particular period seem to be the preparation for reproductive activity [67]. The Relative Condition factor ($Kn > 1$) is due to an increase in body weight either due to tissue growth or egg mass development [68]. The value of relative condition factor ($Kn > 1$) show good general condition of the fish [40]. LWR and relative condition factor (Kn) also gives various information like well-being of fish in relation to habitat, its status of stock variation, assessment of growth rate, appearance of first maturity and time of spawning [37].

Hence, in the present study 'Kn' value of *Monopterusuchia* from all three areas was found to be 1 ($Kn = 1.0$) indicating the suitability of water body for good fish growth in different length range and this implies that food was not limiting in these selected areas. The value of $Kn > 1$ indicates the wellbeing of the fish to be good. The present study showed that the relative condition factor (Kn) is the same from three different habitats and the mean value of relative condition factor (Kn) for all cases is within the optimal range of 1.0 determining the healthy well-being of fish. Relative condition factor more than one means that the fish weighs more than expected for its length.

The value of Chi-square test for the Length of *Monopterusuchia* from all three habitats was found to be 9.74, 13.44 and 15.76 respectively. In this study, the hypothesis H_0 was set up such that the length of the species does not depend on the location. Since the value of the calculated Chi-square ($X^2_{cal} = 9.74, 13.44$ and 15.76) is less than the tabulated value ($X^2_{tab} = 62$), it is not significant and the null hypothesis may be accepted at 5% level of significance. Hence this concludes that the length of the fishes does not depend on the area. Moreover, the value of the Chi-square test for the Weight of *Monopterusuchia* from Nongpoh, Shella and Baghmara was found to be 39.35, 27.46 and 113.6 respectively. Since the calculated value of this species from Nongpoh and Shella is less than the tabulated value, the null hypothesis may be accepted at 5% level of significance. But since the calculated Chi-square value of *Monopterusuchia* from Baghmara i.e. $X^2_{cal} = 113.6$ is more than the tabulated value ($X^2_{tab} = 62$), it is significant and the null hypothesis may not be accepted at 5% level of significance.

Conclusion

Total lengths and body weights of *Monopterusuchia* were recorded during the experimental period and measured in centimeter and gram respectively. Length-Weight Relationship was studied to know the wellbeing and growth pattern of the fish. Slope ($b = 3.8, 3.7$ and 3.9) indicated allometric growth and the correlation coefficient more than 0.8 indicated a high degree of correlation between total length and body weight in the sample and its positive value showed that the slope is positive. Moreover, Relative Condition factor ($Kn = 1.0$) indicated the wellbeing of the fish during the study period. The Length-Weight Relationship and Relative

Condition Factor show that the growth of *Monopterusuchia* is quite satisfactory. Finally, the LWR and Relative Condition Factor will provide useful information for fisheries Management and fish population dynamic studies.

Acknowledgement

Financial support from the Department of Fisheries, Government of Meghalaya, India are duly acknowledged. Support of Dr. Ashit B. Chakra borty, Associate Professor, Department of Statistics, St. Anthony's College, Shillong in statistical analysis are gratefully acknowledged.

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