ISSN: 2347-5129
(ICV-Poland) Impact Value: 5.62
(GIF) Impact Factor: 0.352
IJFAS 2015; 3(1): 419-422

www.fisheriesjournal.com
Received: 15-07-2015
Accepted: 16-08-2015

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Length – Weight relationship and condition factor of *Neolissochilus hexagonolepis* (McClelland) in Meghalaya, India: A comparative study

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Abstract
The Length-Weight Relationship and Condition Factor of *Neolissochilus hexagonolepis*, collected from three different rivers of Meghalaya were studied. The data was analyzed using the formula, $W = aL^b$. The values of 'b' indicate a wide variation of growth pattern of the fish in different rivers of the state. The values of 'r' proved to be highly significant. The value of Condition Factor indicates a good well-being of the fish. The result also reveals healthy condition of the habitat.

Keywords: Length-weight, Condition factor, *hexagonolepis*, Growth pattern.

1. Introduction
Meghalaya, the important hill state of North-Eastern India lies between $25^0 1'$N and $26^0 5'$N latitude and $92^0 52'$E longitude which is crisscrossed with various rivers of different size and length. However, it has been observed that the population structure of different indigenous fish has been declined in the rivers of the state over the years. One such important fish species is *Neolissochilus hexagonolepis*.
Chocolate Mahseer, *N. hexagonolepis* locally known as 'Khasaw' is an icon in the water bodies of Meghalaya. Besides its importance as food fish and sport fish, it also plays an important role in eco-tourism of the North-Eastern region of the country in general and Meghalaya in particular.
Growth of a fish is defined as the change in size with reference to time and weight is expressed as a function of length [1]. Knowledge of Length-Weight Relationship (LWR) is of prime importance in fishery biology as it serves several practical purposes. Firstly, it provides a mathematical relationship between the two variables i.e. length and weight of a particular species of fish, so that the unknown variable can be easily calculated from the known variable. The values are important for estimation of number of fish landed at a particular time and comparison of fish species caught from various places at similar or different time [2]. It also allow to estimate the productivity and biomass of a fish population [3] determining the condition factor of fish making a morphological comparison between species and populations. Also, we can get information about the type of fish growth (whether isometric or allometric) by means of LWR [4].
Secondly, a published report on LWR is important for the studies of biology, population and management of species and their fisheries [4, 5]. Besides, it provides information on growth, gonadal development and general condition of the fish. Therefore, it is useful for comparison of body forms as general well-being of different populations of particular species [4]. The LWR in fish is significantly important in terms of fishery ecology and stock management [6] and essential for stabilizing taxonomic characters of the species [7]. Finally, the LWR, is a wide application in delineating the growth patterns during their developmental pathways, in measuring the yield of fish from water masses, etc. [8]
The Condition Factor (K) is used in order to compare the 'condition', 'fatness' or well-being of fish [9] and it is based on the hypothesis that heavier fish of a given length are in better condition than lighter fish of same length from the same population [10]. It is universal that growth of fishes or any other animal increases with the increase in body weight. Thus, it can be said that length and weight are co-related [11]. The LWR parameters and Condition factor have been found very useful to evaluate the well-being of populations, their biology for scientific management of fisheries in stock assessment [12]. It is also important to note that the

Physio-chemical parameters of water influence vertical and horizontal migrations of fishes in aquatic ecosystem, their distribution and feeding pattern [13]. The number of samples studied, also plays a very crucial role in the LWR [14].

Several workers have worked on studying the length-weight relationship and Condition factor of different fish species. The values of 'a' and 'b' differs not only between different species but also within the same species depending on sex, stage of maturity and food habits and habitat [15,16]. The fishes normally do not retain same shape of the body throughout their life span and the relationship may depart from the Cube law [17]. This is due to seasonal fluctuation in environmental parameters, physiological condition of the fish at the time of collection, gonadal developmental and nutritive condition of the environment of the fishes. The correct interpretation of the parameters resulting from the length-weight relationships of the species will disclose information that is useful to the study of fishing biology and management [18]. The 'b' value in the LWR of fish can be used as an indicator of food intake and growth pattern and may differ according to such biotic and abiotic factors [19]. In terms of growth, a value of 'b' close to three indicates that the fish grows isometrically and other values indicate allometric growth [20]. As the values of 'b' increases, the size of the fish also increases because the fish usually grows proportionally in all directions. However, the changes in fish weight in general are usually greater than the changes in its length. The body shape of the fish, also, tends to change as the length increases [2].

The fish, *N. hexagonolepis* is categorized as threatened species. Therefore it is utmost important to increase the population through artificial propagation and conservation of natural stock. Hence it is necessary to know the general health conditions of this fish species in the rivers of the State. Hence, the present study aims at providing information on the LWR and Condition Factor of different population of *N. hexagonolepis* from different rivers of Meghalaya.

2. Materials and Methods

The samples were collected by netting from January 2013 to June 2014 from three different rivers. The collected specimen were transported and reared in the ponds of the hatchery complex of Department of Fishery Science at Shillong. A total of 40 specimens from each of the three rivers were examined. The length and weight of the fish were measured in millimetre and gram, respectively.

The data were computed for LWR using the equation,

$$W = aL^b$$

Where, W = weight in grams, L = total length in mm, a = constant, b = regression coefficient. The parameters 'a' and 'b' were determined empirically.

The logarithmic form of the equation is given as

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

The coefficient of correlation (r) was calculated by standard statistical formula.

For Condition factor (K), the equation used is,

$$K = (W \times 10^5)/L^3$$

Where, W= weight of the fish (in grams), L = total length of the fish (in mm)

Number 10^5 = a factor bringing the condition factor near to unity.

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

$$Kn = W/w$$

Where, W= observed weight of the fish (in grams);

w = calculated weight for the observed length (in grams).

The high values of correlation coefficient 'r' (near one) for each equation depicts high precision of the relationship [21].

3. Results

The results obtained for LWR and Condition Factor of *N. hexagonolepis* were shown in table.1 and table.2, respectively.

Table 1: Length-Weight Relationship of *N. hexagonolepis*

Sampling site	No. of fish examined	Mean Length (mm) ±SD	Mean Weight (gm) ± SD	a	b	r	Chi square test
Amlayee river	40	244.49 ± 21.77	294.33 ± 41.90	-2.53	2.59	0.85	9.51
Khri river	40	169.5 ± 33.57	81 ± 38.07	-2.20	1.10	0.971	
Umran river	40	214.5 ± 23.92	142 ± 39.95	-2.25	1.50	0.81	

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

Table 2: For Condition Factor of *N. hexagonolepis*

Sampling site	No. of fish examined	Condition Factor (K)	Relative Condition Factor (Kn)
Amlayee river	40	2.19	1.07
Khri river	40	1.67	1.07
Umran river	40	1.43	1.02

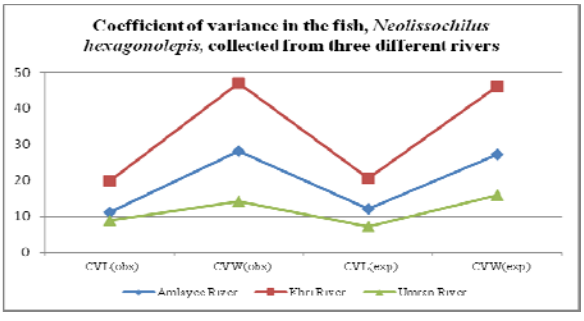

Fig 1: Covariance among the fish, *N. hexagonolepis*

The value of 'b' was observed to be different from all the rivers. Moreover, 'r' value was found to be highly significant. The calculated value of Chi-square test is greater than the tabulated value indicating that the growth characters of the species depends upon different rivers. The coefficient of variance for the length and weight of the species from different rivers were analysed (figure.1). The result indicated that the growth of the fish is good in all three water body.

4. Discussion

The exponential value of the LWR (b) representing the body forms is related to the ecological and biological factors such as

Dissolved Oxygen content in the water, food supply, spawning conditions and other factors such as sex and age of fish [22, 23, 24]. In the present study, the 'b' value in *N. hexagonolepis* followed the Cube law (b=2.31) in one of the area studied i.e. Amlayee river, indicating an isometric pattern of growth in the fish, whereas, the value of 'b' from the other two area studied did not followed the Cube law (b=1.10 and b=1.90) indicating an allometric pattern of growth in the fish. The differences in the 'b' value can be attributed to the ecological features of the area studied. Besides, LWR in fish is influenced by many factors such as presence of food, feeding ratio, gonad development, spawning period, season, sex and habitat [25]. Morphological changes due to age also cause substantial changes in the exponent of length on weight [26]. The variation in the 'b' value for the same species could be attributed to difference in sampling, sample size or length ranges [3].

The value of the correlation coefficient (r) calculated indicates a high correlation between the length and weight and proved to be highly significant. If the value is found to be higher than 0.5, it shows that the LWR is positively correlated and vice versa [27]. If the value of 'r' is high (<0.5), it indicates that the length increases with increase in weight of the fish [28].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 [29, 30] indicated that if r > 0. 9 and weight increases in length, then it is clear that the fish maintains its shape throughout its life.

Condition factors (K) provide external measures of overall health of the fish [31]. The K value indicates the size at which the fish matures and the variation in the value in relation to size may attribute spawning and feeding intensity due to availability of select food or absence of food [32]. The K value is used to show irregular trend in various size dropped due to the dominance of maturing and immature fishes. The Condition factor takes into consideration the health and general well-being of a fish as related to its environment; hence it represents how fishes are fairly deep bodied or robust [33]. The value of K > 1 indicates the well-being of the fish to be good. The higher values of 'K' in a particular period seem to be the preparation for the reproductive activities [34].

The value of 'K' usually shows fluctuations which may due to sample size, different stages of maturity, spawning on the parts of females or difference in weight of food content in the stomach [1].

Variations in the condition factor of many fishes were observed in relation to their reproductive cycle [35], feeding rhythms, physio-chemical factors of environment, age, physiological state of fish or some other unknown factors [36]. During the present study also, similar pattern was observed among *N. hexagonolepis.*

The coefficient of variance for the length and weight of the species was found out to be almost equal in both the observed as well as the calculated value (figure.1). The analysis of the coefficient of variance the species indicates that the growth of the fish was good, as expected, in all the three rivers that were studied and conservation program for the species may be taken up in these rivers.

5. Conclusion

The present studies establish that the fish, Chocolate Mahseer, *N. hexagonolepis* shows different growth pattern in different habitat depending upon water quality, food availability etc. The value of the condition factor (Kn) was greater than 1 which indicated that the well-being of the fish studied from different rivers was good and it can be said that the rivers are suitable habitat for the species.

6. Acknowledgement

Financial support of UGC, New Delhi is gratefully acknowledged.

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