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LENGTH- WEIGHT RELATIONSHIP (LWR) AND CONDITION FACTOR OF *Amblyceps apangi* NATH & DEY FROM ARUNACHAL PRADESH, INDIA

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Abstract:

Length-weight relationship of *Amblyceps apangi* had been carried out from streams of Dikrong River Arunachal Pradesh, during January 2014 to December 2015. The co-efficient of regression (b) was recorded as 2.213 (males); 2.376 (females); 2.312 in pooled (both sexes). The result reveals that females have better growth than males and both sexes signify a negative allometric growth pattern. The highest Condition factor 'K' value (0.82 ±0.24) for male was found in November and minimum (0.45 ± 0.12) was observed in July. In case of female, the highest value (0.95 ± 0.11) was recorded in November and lowest (0.50 ± 0.09) was noticed in June. Again, the highest K values (0.83 ± 0.16) of male was found in 61-70 mm while in females the highest (0.86 ± 0.13) was in 51-60 mm. The lowest values for both male (0.38 ± 0.07) and female (0.36 ± 0.03) were observed in 141-150 mm. The Relative Condition factor (Kn) value did not show any variation with respect to monthly and size grouping. The result indicates that both the sex was found in a good condition. Moreover, the K values were encountered with GSI values during the quiescent and degenerative phases of the reproductive cycle but minimum K values coincides with the increased GSI during the recrudescent phases both the sexes. Coefficient of correlation (r) shows more or less similar trend in all male, female and pooled. The correlation coefficient 'r' was found to be 0.906 (males); 0.949 (females) and 0.934 (pooled). This result indicates that there was a good correlation between length and weight of the fish.

Keywords: *Amblyceps apangi*, Length-weight relationship, Condition factor, Arunachal Pradesh

Introduction

Length-weight relationship (LWR) is an important expression has a paramount role in fishery biology as it serves several purposes. Like any other morphometric characters, the LWR can be used as a character for differentiation of taxonomic units and the relationship changes with various developmental events in life, such as metamorphosis and onset of maturity (Thomas *et al.*, 2003). Fishes exhibit growth in length and the increment in weight, both this developmental activities during its lifetime. Habitat condition of fishes has a direct proportional relationship with that of length-weight and the relationship vary accordingly. Hence, the growth of a fish is though species specific but it can considerably vary among species inhabiting different geographical location. Increment in size of fish is influenced by many factors such as physico-chemical parameter of soil and water, geographical niche, population of fish using the same food source, size, age and sexual maturity of the fish.

Condition factor is an expression of relative fatness of fish and generally larger values of K, indicates better condition of the fish. This factor is calculated with the intention of describing the "condition" of a particular fish from the relationship drawn between weight of the fish and length (Froese, 2006). The "condition" factor expressed as "coefficient of condition" is denoted by 'K' (also known as Fulton's condition factor, or length-weight factor, or Ponderal index). This index can be said as tool to diagnose the physiological condition of fish in terms of its interaction to the biotic and abiotic factors. Le Cren (1951) proposed the relative condition factor in preference to condition factor which is denoted by 'Kn'. Thus Condition factor measures the deviation from a hypothetical ideal fish where as a relative condition factor measures the deviation from the average weight or length of fish. So, understanding condition factor ('K') and relative condition factor ('Kn') is important in fishery biology as it give us clear knowledge regarding the maturation and spawning of fish at different body lengths during their life span also estimating the condition at different months.

The study of length-weight relationship of *Amblyceps apangi* is very limited in Indian sub continent. So far, Krishan & Dobriyal (2015) studied the length-weight relationship and relative condition factor of *Amblyceps mangois* for the first time from river Mandal a tributary of Ramganga in Garhwal region. Recently, Humtsoe and Bordoloi (2015) also studied the length–weight relationships and reproductive parameters of *Amblyceps apangi* from Nagaland, north-eastern India**.** However no information is available on the length-weight relationship and condition factor of *Amblyceps apangi* from entire region including Arunachal Pradesh Nagaland. Therefore, the present study was undertaken to clarify the pattern of growth and general well being of this fish species from the streams of Arunachal Pradesh.

Materials and Methods

Monthly samples were collected from the streams of Dikrong River within the Rono Hills, Doimukh region during January 2014 to December 2015. Fishes were caught by using the indigenous technique '*Sebhok panaa*' (Nyishi dialect), *'Hibook'* (Galo dialect) and electro-fishing device. The indigenous technique involved drying up of the target place of the rivers by diverting the stream to the nearby and encircling by boulders. Total length and total weight of the fishes were recorded using digital caliper (Mitutiya) and digital weight machine (Precisa ES 225SM-DR). The length of the fish was taken from the tip of snout (mouth closed) to the extended tip of the caudal fin nearest to 0.01mm and weighed upto the nearest 0.01 g. For which, altogether 502 specimens of *Amblyceps apangi* (Fig. 1) were used for calculation of length-weight relationship and of which 264 females ranged from 43 to 149 mm while, 238 males ranged from 43 to 154 mm. The total length, weight, sex and maturity of gonad were recorded and then preserved in 10% formalin for subsequent analysis.

Length-weight relationship**:** The length-weight relationship was calculated by the allometric growth formula as used by Ricker (1973) in the form of: $W = a L^{b}$; where 'W' stands for weight, 'L' for length, 'a' is a constant and 'b' the exponent. The equation was transformed into a logarithmic as suggested by Le Cren (1951) and expressed as: Log W = Log a + b Log L; where 'a' is a constant being initial growth and 'b' is the growth coefficient. The values of 'a' and 'b' were determined empirically.

Figure 1. *Amblyceps apangi*

The observed average weight of the species has been plotted against the average observed length to examine the nature of parabola. The regression of log-weight on log length has been calculated by the method of "least squares" by grouping the sample data. The data are first graphed at 4 cm interval and the relationship is calculated for different life stages. Correlation of co-efficient (r) for length and weight has also been calculated.

Condition factor and Relative condition factor: Condition factor or Ponderal index (K) was determined by using the following formula:

$$K = \frac{W \times 10^5}{L^3}$$

Where, K = Condition factor; W = mean weight of the fish (g); and L = mean length of the fish (mm); the number 10^5 is a factor to bring the Ponderal index (K) near to unity (Carlander, 1970). Relative condition factor 'Kn' introduced by Le Cren (1951) was estimated by using the formula

$$Kn = \frac{W}{\widehat{W}}$$

Where, W = actual weight of fish in gram (g)

$\widehat{W}$ = calculated weight of the fish in (g)

Results and Discussion

The logarithmic regression equations of length-weight relationship in male, female and pooled (both sexes) of *Amblyceps apangi* was represented as follows:

Male: Log W = -3.685 + 2.213 Log L

Female : Log W = -3.980 + 2.376 Log L

Pooled: Log W = -3.864 + 2.312 Log L

The value of regression coefficient (b) of male, female and pooled was 2.21, 2.37 and 2.31 respectively (Table 1). The significance of variation in the estimated regression coefficient 'b' from '3' was tested using 't' test for both the sexes and pooled. The t-test produced the result as 29.80 in males, 32.90 in females and 20.43 in pooled. From the findings it is evident that there is a significant departure of b from the standard 3 ($p<0.05$) for male, female and polled. In the present study the highest b value was found in female compared to male. The exponential value of female gained the weight at a faster rate in relation to its length whereas a low exponential value in male implies a low growth rate. Further, both the sex had a clear deviation from the isometric growth pattern and the growth pattern didn't follow the cube law (b=3). This signifies a negative allometric growth pattern ($b < 3$) of development which means increase of weight in either sex is not proportional to the increment in body length. The pooled data of both the sexes also gave a negative allometric growth pattern ($b < 3$). Further, the present finding was found to be contrary with the findings of Humtsoe and Bordoloi (2015). According to Le Cren (1951) variation in growth rate of the same species during different months are influenced by many factors such as environmental factors, food supply, ecological conditions of the habitats or variation in the physiology. The allometric growth was also observed in other freshwater fishes due to change in error sampling, locality, shape, sex, gonad maturity, stomach fullness and condition of the fish or environmental conditions (Bagenal & Tesch, 1978; Froese, 2006; Abujam & Biswas, 2014; Abujam & Biswas, 2016; Dakua et al., 2016).

In such cases exponential value must be exactly '3' but practically owing to the environmental conditions of the fish or condition of the fish, the actual relationship between the variables does not follow cube law (Le Cren, 1951). According to Wootton (1990) if fish growth is isometric the exponential value will be exactly 3.0 or else a value significantly smaller or larger than the given standard indicates an allometric growth pattern. However, Froese (2006) reported for isometric growth the exponential value must be between 2.5 and 3.5. A smaller value shows a negative allometric growth which indicates that a fish becomes lighter with the advancement in its size whereas a positive allometric is seen when values are larger which implies that the fish attains a heavier weight for a particular length**.**

The correlation coefficient 'r' between log length and log weight for males and females of *Amblyceps apangi* was found to be 0.906 and 0.949 and for their pooled 0.934 (Fig. 2, Fig. 3, Fig.4). This result indicates that there is a good correlation between length and weight of the fish. In overall it reveals that length-weight regression coefficient were highly significant in both the sexes. The results of statistical analysis of length-weight relationship showed a fine correlation (r) between length and weight in *A. apangi.* A similar result was also recorded by Humtsoe and Bordoloi (2015). Graphical representation indicated a curvilinear relationship in case of observed value and a straight line relationship in respect to logarithmic transformation (Fig. 2-4).

Table1. Length-weight relationship parameters of *Amblyceps apangi*

Sex	n	log a	b	Sb	t	P
Males	238	-3.685	2.213	0.005	29.80	P<0.05
Females	264	-3.980	2.376	0.005	32.90	P<0.05
Pooled	502	-3.864	2.312	0.002	20.43	P<0.05

Legend: n = number of fish studied; *log a* = intercept; *b* = regression coefficient; Sb = standard error and t = results of bailey's t-test on 'b'

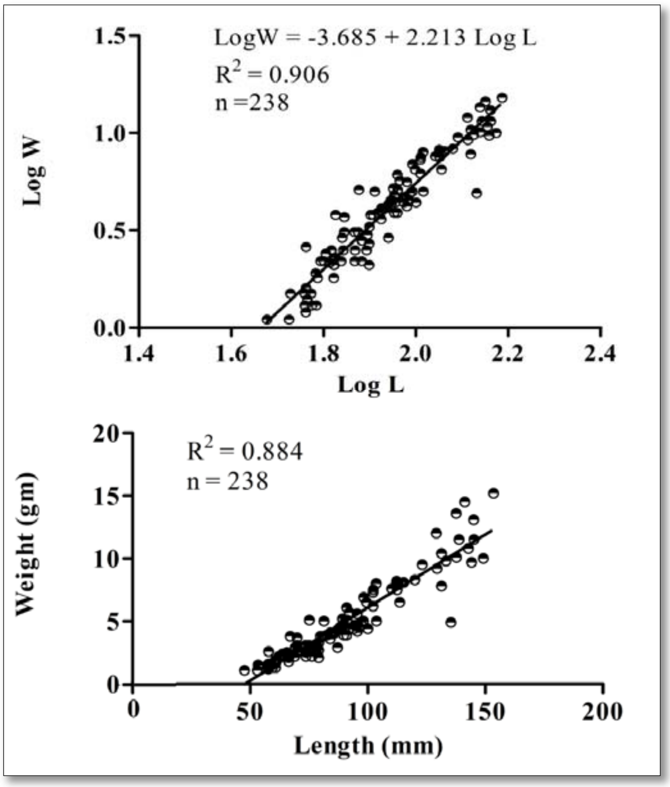

Figure 2. Length–Weight relationship in males of *Amblyceps apangi*

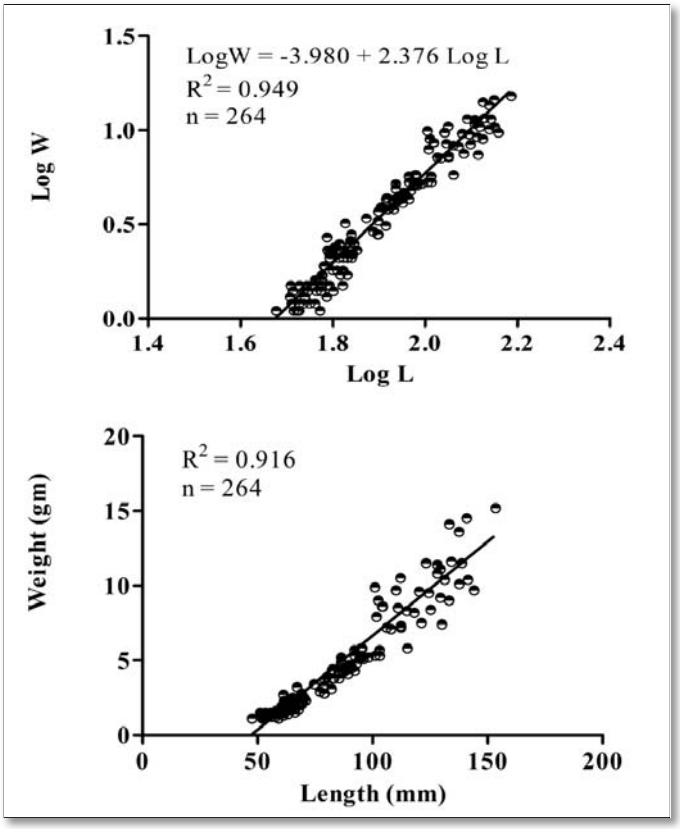

Figure 3. Length –Weight relationship in females of *Amblyceps apangi*

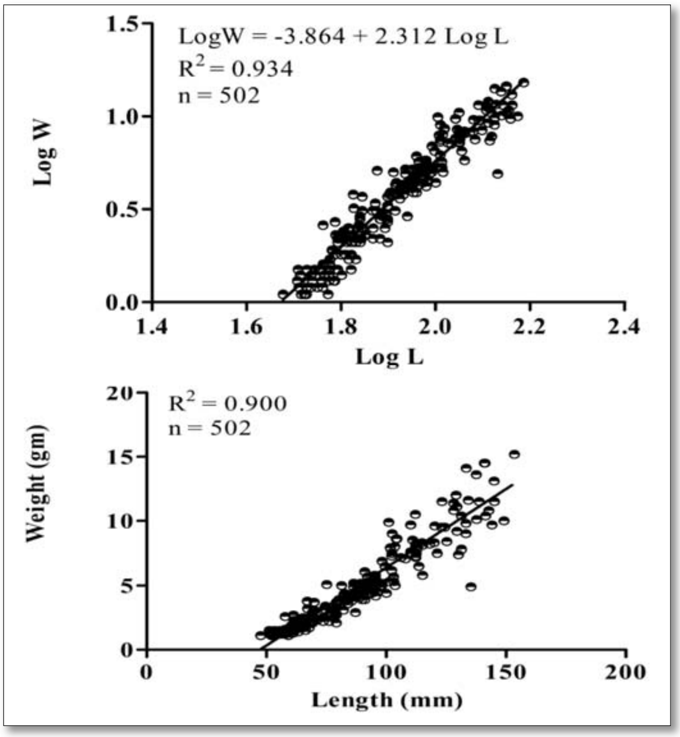

Figure 4. Length –Weight relationship of *Amblyceps apangi*

The average monthly fluctuations in the K values of male and females were represented in Table 2.. The highest K value (0.82 ±0.24) for male was found in November and that of minimum value (0.45 ± 0.12) was observed in July. In case of female, the highest value (0.95 ± 0.11) was recorded in November and that of lowest (0.50 ± 0.09) was noticed in June. The peak was observed in November then gradually declining trend from May onwards (Fig. 5). A similar trend was evident in female also and being peak in November while, the lowest values were recorded in June-August (Fig. 5). The K values were in increasing trend after the termination of the monsoon season. Variation in the value of 'K' indicate different parameter or state being of a fish, as to state of sexual maturity, the degree of food source available. Coefficient of condition value also seems to vary with age, sex of some of the species (Anibeze, 2000) and with the system of environment (Gomiero & Braga, 2005).

Table 2. Average monthly condition factor (K) of both the sexes of *A. apangi*

Month	Condition factor (K)	
	Male	Female
Jan	0.68 ±0.13	0.73 ±0.11
Feb	0.71 ±0.18	0.66 ±0.08
Mar	0.65 ±0.21	0.83 ±0.20
Apr	0.76 ±0.32	0.61 ±0.48
May	0.53 ±0.09	0.67 ±0.10
Jun	0.48 ±0.11	0.50 ±0.09
Jul	0.45 ±0.12	0.52 ±0.11
Aug	0.59 ±0.11	0.65 ±0.19
Sep	0.71 ±0.09	0.65 ±0.07
Oct	0.55 ±0.05	0.79 ±0.16
Nov	0.82 ±0.24	0.95 ±0.11
Dec	0.72 ±0.18	0.81 ±0.08

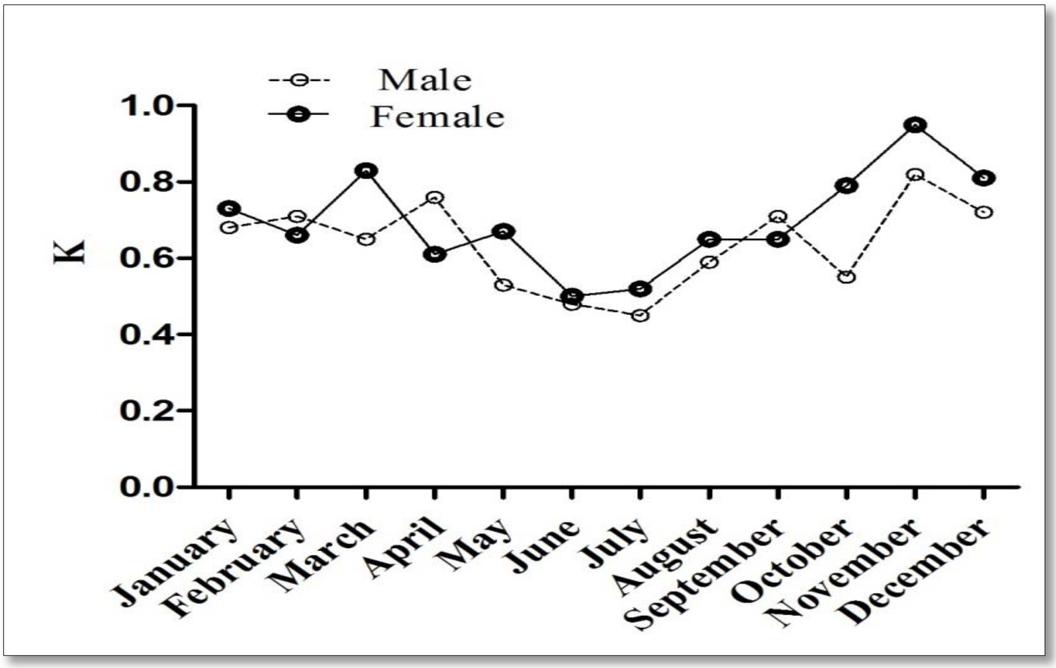

Figure 5. Monthly variation in the condition factor (K) of Male and female

It was observed that the condition factor (K) for both male and females was low during the spawning period (May, June, July, August). Although, the condition factor was high during degenerative (September, October, November, December) and Quiescent phases (January, February, March, April). Le Cren (1951) reported that increase or decrease in the condition factor is related to the maturity cycle of the fishes. It is also noteworthy that full development of alimentary canal may also influence the 'K' factor. The 'K' values recorded in June-August showed a decreasing trend which coincided with the occurrence of peak value of gonadosomatic index (GSI) in both sexes.. The decrease in these months may be due to the feeding intensity of gravid fish decline during spawning period (Da Costa & Araujo, 2003; Abujam & Biswas, 2014; Abujam & Biswas, 2016; Dakua et al., 2016). The high 'K' values during the subsequent spawning period and preparatory phase in both the sexes may be related to the period of feeding intensity increases so as to regain the lost energy and also to rebuild their body reserve for the development of gonads as a preparation for the next spawning period.

In relation to different length group, the highest K values (0.83 ± 0.16) of male was found in the 61-70 mm size group whereas in females the highest (0.86 ± 0.13) was in 51-60 mm (Table 3). The lowest values for both male (0.38 ± 0.07) and female (0.36 ± 0.03) were observed in 141-150 mm size groups. It reveals that the K values were higher in small fishes and lower in fish having large size. From the findings, it can be assumed that increase in the length of fish is directly proportional to the decrease in condition factor of this fish (Fig. 6). Fishes with length group between 50-60 and 61-70 mm in both the sexes were of juvenile and immature stage, so it is expected that they will have a high 'K' value compared to the other length group as fishes at this stage have a high feeding intensity. Kund et al. (2011) reported that condition factor of small fishes are higher compared to the larger one due to voracious feeding nature. Bakare (1970) and Fagade (1979) reported that the condition factor relatively decreases due to the gradual increase in length. Although smaller than the juvenile one, a moderate value of 'K' was noticed in the fish having TL 80-90, 91-100, 101-110 mm, this might be due to the occurrence of large number of developing and matured fish within that group range. Lowest ''K' values were observed in the fishes having TL >120, which indicated that fishes within this length group were in fully gravid stage or in the initiation of spent stage.

Table 3. Mean Length group Ponderal index (K) of both the sexes of *A. apangi*

Length class (mm)	Condition factor (K)	
	Male	Female
50-60	0.80 ±0.19	0.86 ±0.13
61-70	0.83 ±0.16	0.79 ±0.16
71-80	0.65 ±0.18	0.67 ±0.09
81-90	0.66 ± 0.11	0.67 ±0.07
91-100	0.59 ±0.10	0.62 ±0.05
101-110	0.60 ±0.11	0.69 ±0.13
110-120	0.54 ±0.04	0.55 ±0.09
121-130	0.51 ±0.03	0.47 ±0.07
131-140	0.39 ±0.09	0.48 ±0.07
141-150	0.38 ±0.07	0.36 ±0.03
151-160	0.41 ±0.10	--

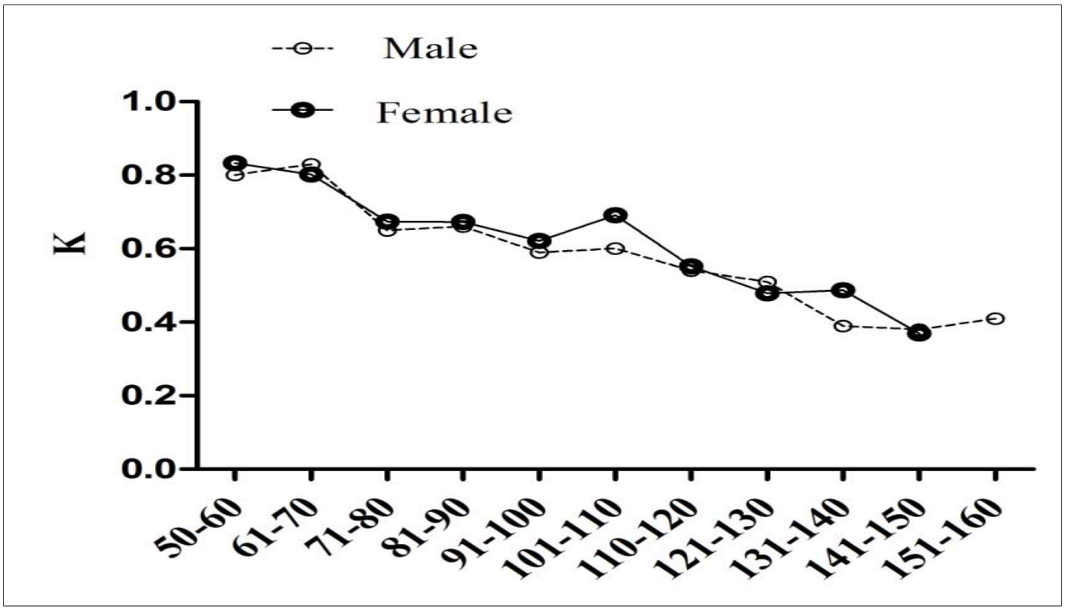

Figure 6. Condition Factor (K) at different length group in *A. apangi*

The relative condition factor (Kn) values for both males and females for different months and size groups were given in Table 4 & 5. The Kn value obtained from the present study did not show any variation with respect to monthly distribution and size wise grouping. The result enumerated was "1" which was uniform throughout the year and also with respect wise grouping for both the sexes. The relative condition factor Kn is an expression to assess the condition of the fish. According to Le Cren (1951) Kn values greater than 1 indicated good condition of the fish whereas a value < 1 is indicative of the reverse nature. Sex wise analysis of Kn value revealed that both male and female have a uniform Kn value (1), which indicate that both the sex are in a good condition and the fish inhibiting the aquatic ecosystem is conducive for the optimum growth of this fish.

Comparing the K values with GSI, it reveals that maximum K values were encountered during the quiescent and degenerative phases of the reproductive cycle whereas minimum K values coincide with the increased GSI during the recrudescent phases in both the sexes (Figure 7 & 8). Statistical analysis of the generated data reveal there exist a correlationship between increased GSI and decreases K value in both sexes, $r = 0.44$, $P = 0.017$ for male and $r = 0.43$, $P = 0.020$ female and the relation between them was significant.

Table 4. Mean monthly Relative condition factor (Kn) of *A. apangi*

Month	Kn	
	Male	Female
January	1.01 ±0.40	1.00 ±0.63
February	0.89 ±0.63	1.00 ±0.48
March	1.11 ±0.38	1.00 ±0.50
April	1.00 ±0.54	0.99 ±0.34
May	1.00 ±0.41	1.00 ±0.25
June	1.00 ±0.48	1.00 ±0.18
July	1.01 ±0.50	1.00 ±0.19
August	1.00 ±0.20	1.00 ±0.21
September	1.02 ±0.58	1.00 ±0.70
October	1.00 ±0.50	1.00 ±0.60
November	1.00 ±0.36	1.00 ±0.31
December	1.00 ±0.40	1.00 ±0.67

Table 5. Relative condition factor (Kn) of *A. apangi* at different length group

Length class (mm)	Kn	
	Male	Female
50-60	1.00 ± 0.26	1.00 ± 0.16
61-70	1.00 ± 0.24	1.00 ± 0.19
71-80	1.00 ± 0.26	1.00 ± 0.16
81-90	1.00 ± 0.13	1.00 ± 0.10
91-100	1.00 ± 0.17	1.00 ± 0.09
101-110	1.00 ± 0.19	1.00 ± 0.19
110-120	1.00 ± 0.08	1.00 ± 0.15
121-130	1.00 ± 0.18	1.00 ± 0.16
131-140	1.00 ± 0.26	1.00 ± 0.16
141-150	1.00 ± 0.16	1.00 ± 0.19
151-160	1.00 ± 0.11	---

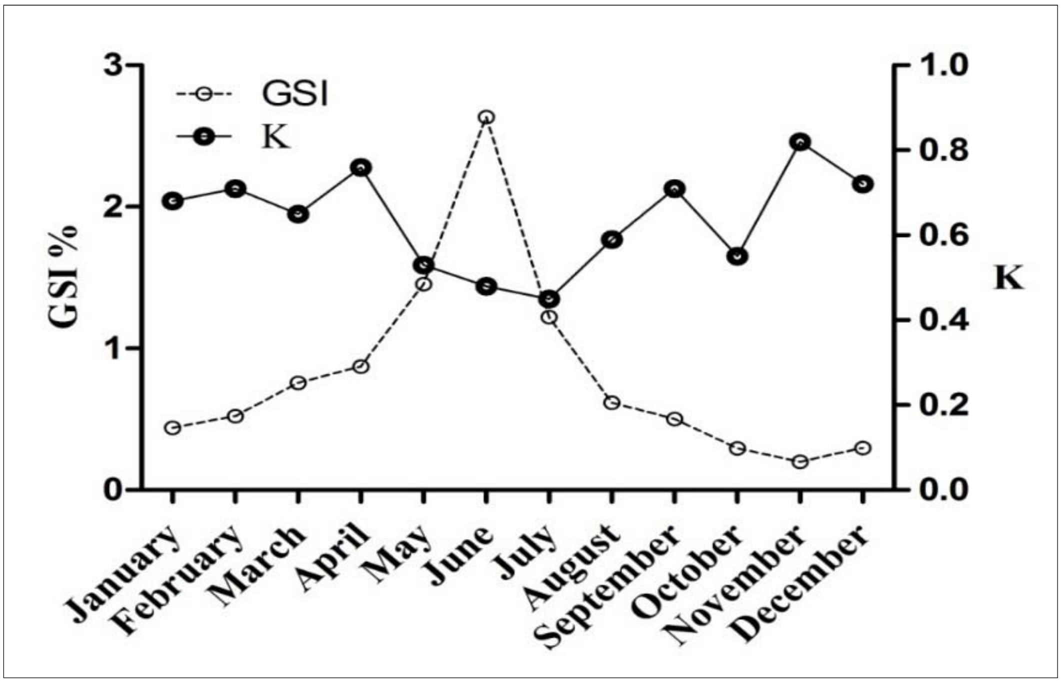

Figure 7. Relationship between GSI and K in male

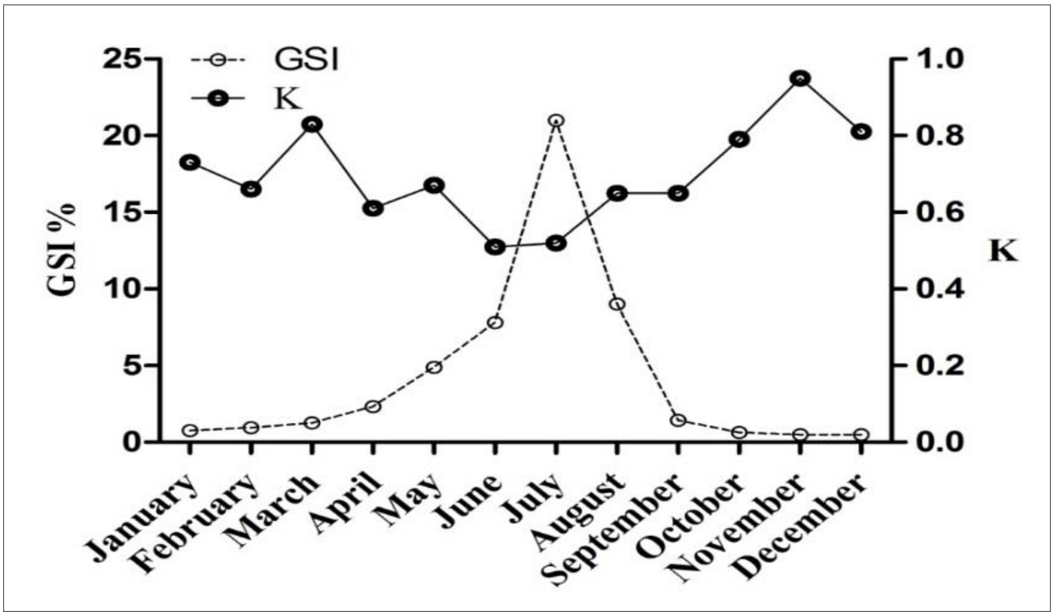

Figure 8. Relationship between GSI and K in female

Conclusion

Thus, from the present findings, it can be concluded that length weight relationship of *Amblyceps apangi* was slightly deviated from the isometric growth pattern (b=3) and did not follow the cube law. The 'b' values for males, females and their pool were found to be below 3; showing a negative allometric growth rate. The 'r' value in respect of length and weight indicated that in all the cases this relationship was positive in different length group as well as in different seasons. The 'K' value was above the ideal value and indicated that the species were in good conditions in their natural habitats. Moreover it also provides baseline information not only on the length-weight relation but also relative condition factor of *Amblyceps apangi*.

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