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Research Article

Study of External Morphometric Variants and Length-Weight Relationship of *Labeo rohita* (Hamilton-1822) Fed with Varying Protein Levels

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Abstract | External morphometric studies along with Length-weight relationships (LWRs) were carried out for five groups of juvenile *Labeo rohita* fed with various protein: Energy ratios; fish meal (T_0), 25%CP (Crude proteins) (T_1), 30%CP (T_2), 35%CP (T_3) and 40%CP (T_4). Experiment was designed to replace enriched fish meal diets with cheaper plant origin crude protein diets in fish culture. A total of 15 aquaria having 20 samples each were arranged in triplicate for 90 days to study the effect of five feeding groups on Length-weight relation and external morphometric variants of *Labeo rohita*. A total of 75 fish samples @ 5 fish samples per aquaria were analyzed in present study. T_1 showed the highest values for mean wet weight 11.32±1.78, Total length 10.54±0.51, Fork length 8.94±0.46, Standard length 8.27±0.44, Body depth 2.64±0.16 and Body girth 5.28±0.33. Pectoral fin length, pelvic fin length, dorsal fin length and caudal fin length also showed highest values; 1.56±0.09, 1.36±0.09, 1.72±0.15 and 2.27±0.13 respectively in T_1. Length-weight increment order in various treatment groups was $T_1>T_2>T_3>T_4>T_0$. Highly significant correlations ($p<0.01$) were noted when log total length and log wet weight were plotted against each other and with log values of all external morphometric variants except condition factor (K). "b" (regression coefficient) value for LWRs of *Labeo rohita* in various groups was calculated as 3.37, 3.11, 3.20 in T_1, T_2 and T_3 respectively and showed positive allometric growth pattern while negative allometric pattern was observed in T_4 and T_0. The coefficient of determination (r^2) was ranged from 0.888 to 0.989 in LWRs, expressing highly significant correlation ($p<0.01$). The variance inflation factor (VIF) was observed as: 17.86 (T_1), 12.50 (T_2), 01.79 (T_3), 10.75 (T_4) and 10.20 (T_0); expressing multi-collinearity among morphometric variants and LWRs with change in diet compositions. Diets with decreased fish meal percentage and maximum plant origin sources showed an increment in length-weight variants. Present findings indicate that fish dislike the fish meal diet and preferred the plant origin sources.

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Introduction

Morphometric studies usually deal with the study of body forms like shape and size of an organism and also express fish locomotory behavior, mode of feeding, reproductive performances, defensive behavior towards predators, ecology, management and evolution (Webster, 2006; Kalhoro et al., 2015). Thus, noticeable morphometric variants are helpful tools to recognize various species (Bannikov and Tyler, 2008; Narejo, 2010) and explain their taxonomic differentiation (Sarkar et al., 2013). Length-weight relationships (a and b) express length increment proportions to weight gain while condition factor represents fish heaviness or lavishness (Froese, 2006). Condition factor and length-weight relationship studies adds beneficial knowledge towards farmed fish producers as these indices are helpful to measure fish growth, population densities, onset of fish maturity, metamorphosis, life history of fishes and overall fish biomass production (Hossain et al., 2006; Araneda et al., 2008; Ferdaushy and Alam, 2015). LWRs (Length-weight relationships) indices study in fish culture system is leading technique to estimate fish biomass (Adarsh and James, 2016), mean weight gain and known length of the stock (Gupta and Banerjee, 2015), spatial distribution of various species (Kara and Bayhan, 2008), age structure, allometric and isometric growth patterns (Quist et al., 2012). Physical development of an organism can also be quantitatively voiced by length-weight relationship. Moreover, the length-weight data reflects a mirror image of human activities on aquatic ecosystem and provides an important clue regarding climatic and environmental fluctuations (Sarkar et al., 2013).

Labeo rohita is the most popular, extensively culturable and economically important freshwater fish species in Indian sub-continent particularly in Pakistan which have got high mandate for their tastiness, better growth performances and tolerant abilities in environmental fluctuations (Hussain et al., 2011). This species is an excellent source of highly digestible protein contents enriched with balanced amino acids (Astawan, 2004). Fish industry in present era is focusing on the production of maximum fish biomass within a limited time frame. So, a good and balanced diet input in fish production system always produces healthy, more attractive and quality products. Now, the need of the day is to find out certain substitute ingredients which are more economical, easily palatable and able to fulfill fish protein demands (Young, 2001). Fish industry is expanding day by day to fulfill protein demands of increasing human population, it is necessary to educate the farmers about various inexpensive inputs necessary for fish growth (Akinwole and Faturoti, 2007). Presently, the concept of farmers to feed fish with animal protein sources has been totally changed as these ingredients becoming scarce and costly. The market prices of fish products (fish meal and fish oil) has risen due to less availability, static supply and increasing demands (Gatlin et al., 2007; Naylor et al., 2009). Several alternate protein sources like: algal proteins (Kiron et al., 2012); bacterial proteins (Aas et al., 2006); plant origin protein diets (Gatlin et al., 2007); poultry by-product proteins (Fowler, 1991); invertebrate and nut meal protein diets (Barrows and Frost, 2014) have got entry in aquaculture industry and made this industry to become more sustainable and economical. A substantial advancement to replace and reduce fish meal in the diets of various aquatic species has been made without compromising their health issues and performances (Furuya et al., 2004; Rossi, 2011). Fish meal diet was commonly practiced in sub-continent in last few decades but farming industry has progressively decreased the proportion of fish meal used in commercial diets due to rising costs and sustainability concerns(Davidson et al., 2016).

Various nutritionists (Shioya et al., 2011; Iqbal et al., 2015, 2016; Iqbal and Naeem, 2016) studied the effect of various feed ingredients in combined as well as in individual form on growth, body composition and hematological indices of different fish species particularly Indian major carps. However, the information regarding effect of various feed ingredients on morphometric variants of *Labeo rohita* is very scarce. Thus, the basic concept to design this study was to gradually replace pure fish meal diets with plant origin protein sources to highlight the effect of various protein: Energy ratios on morphometric parameters and growth performances; weight-length, length-length increment and condition factor relationships in *Labeo rohita*.

Materials and Methods

Morphometric relationship and length weight increment studies were carried out for five groups of *Labeo rohita* (Hamilton-1822) fed with previously prepared powdered form of various plant origin protein: Energy ratiosand fish meal (control group); fish meal (T_0), 25% CP (Crude proteins) (T_1), 30% CP(T_2), 35%CP (T_3) and 40% CP (T_4) (Iqbal and Naeem, 2016); reared for 90 days in aquaria in triplicate from July to October, 2016. Fish samples were collected from Al- Raheem private fish seed hatchery, district Muzaffargarh, Punjab, Pakistan. After seven days of acclimatization, fish samples were weighed, measured and randomly stocked @ 20 per aquaria. Fifteen aquaria with water capacity of 40L in five groups were arranged to model the experiment in triplicate. Tap water was used to fill the aquaria and at each third day the old water was replaced with fresh water with ratio 1:4 (Old: Fresh) till the end of experiment. A total of 75 fish samples were collected randomly @ 5 fish samples per aquaria for morphometric variants and length-weight studies. The fish samples were collected by using hand net, anaesthetized with 2-phenoxyethanol and dried with paper towel prior to length-weight measurement. An electronic digital balance (J.S.110-Chyo-Japan) was used to measure the wet weight and measuring ruler was used to calculate external morphometric.

Wet Weight (W) = a X Total Length (TL) b; a Parabolic Cube law equation and Linear regression equation; $_{log}$ W = a + b $_{log}$ TL was used to designate and calculate the LWRs. In linear regression equation; W symbolizes the wet weight of the samples in grams, TL symbolizes the total length in millimeters, "a" considered as the intercept and "b" considered as slope or coefficient of the regression line. "a" is the point where regression line intercepts the y-axis while slope of regression line is denoted by "b". The outliners for LWRs were also identified by plotting straight line graphs between $_{log}$a and $_{log}$b; regression analysis was made repeated after removing outliners (Froese, 2006). The values for Fulton's condition factor "K" for all the fish samples were made calculated by using an equation; $K = 100W/L^3$. For Total length, wet weight and condition factor, multiple regression analysis was performed by using MINITAB for Window-7 and also Variance Inflation Factor (VIF) for regression co-efficient was calculated when the predictor variables are not linearly related. However, regression analyses for all the fish samples were made by using Microsoft Excel.

Results and Discussion

The mean values along with standard deviation and range values for morphometric variants of all the five groups of *Labeo rohita* are given in Table 1.

Labeo rohita fed with T_1 (25% crude protein) showed the highest values for mean wet weight (WW) 11.32±1.78, Total length (TL) 10.54±0.51, Fork length (FL) 8.94±0.46, Standard length (SL) 8.27±0.44, Body depth (BD) 2.64±0.16 and Body girth 5.28±0.33. Furthermore, Pectoral fin length (PctFL), pelvic fin length (PvFL), dorsal fin length (DFL) and caudal fin length(CFL) also showed highest values like 1.56±0.09, 1.36±0.09, 1.72±0.15 and 2.27±0.13 respectively in T_1 (Table 1). Regression variants of length-weight relationships (LWRs) are summarized in Table 2. "b" values (slope) for LWRs of *Labeo rohita* in various groups were calculated as 3.37, 3.11, 3.20, 2.63 and 2.63 in T_1, T_2, T_3, T_4 and T_0 respectively. "b" values above 3.0 in T_1, T_2 and T_3 showed positive allometric growth pattern while in control group and T_4 it showed negative allometric growth pattern (Table 2). Highly significant correlations ($p<0.01$) were studied in morphometric relationships when log wet weight were plotted against log values of all the external variants (Table 4). Condition factor (K) was observed maximum (0.96±0.03) in T_1 and T_2 while minimum (0.87±0.09) in T_0(Table 1). When K was plotted against wet body weight and total length it showed non-significant correlations ($p>0.05$). The coefficient of determination (r^2) value was ranged from 0.888 to 0.989 in LWRs, expressing a highly significant correlation ($p<0.01$) in all treatment groups (Table 2).

To study the values of variance inflation factor (VIF), the data of total length, wet weight and condition factor was analyzed by using multiple regression analysis and obtained result showed highly significant multi-collinearity. The values of variance inflation factor (VIF) in all the treatment groups were observed as: 17.86 (T_1), 12.50 (T_2), 01.79 (T_3), 10.75 (T_4) and 10.20 (T_0) (Table 3).

Present study revealed that the estimates of b values were found within the range suggested by Froese (2006) for freshwater species. The values of b lower than 3.0 in T_0 and T_4; higher than 3.0 in T_1, T_2, T_3 represents variation in diet compositions fed to various fish groups (Henderson, 2005). However, fish size, length interval, species intraspecific competition, habitat suitability, weather fluctuations, gonadal maturity, sex and season may also influence on LWRs (Naeem et al., 2010; Nieto-Navarro et al., 2010; Yeasmin et al., 2015). In three experimental groups, the slope value was very close (higher) to 3.0 and showed positive allometric growth which is an adequate estimation for length-weight relationships (LWRs) and are agreement with the findings of Arslan et al. (2004) in *Salmo trutta*, Naeem et al. (2011a) in female *Oreochromis mossambicus*, Naeem et al. (2011b) in *Tor putitora*, Rasoolet al. (2013) in farmed and natural population of *Labeo rohita*, Ishtiaq and Naeem (2016) in *Catla catla* and Khalid and Naeem (2017) in *Ctenopharyngodon idella*. Balai et al. (2017) also observed positive allometric growth (3.16) in *Labeo rohita* collected from Lake Jaisamand. Dewivedi et al. (2017) observed 'b' value greater than 3.0 in indian major carp *cirrhinus mrigala*.

Table 1: *Morphometric variables of Labeo rohita (Hamilton-1822) reared for 90 days at different protein: Energy ratios in aquaria.*

Morphometric variables	Diet variables in treatment groups									
	T1		T2		T3		T4		T0	
	Mean±S. Dev.	Range	Mean±S. Dev.	Range	Mean±S. Dev.	Range	Mean±S. Dev.	Range	Mean±S. Dev.	Range
WW(Wet weight)(g)	11.32±1.78	9.09-16.03	10.55±1.55	8.65-14.71	10.12±3.19	6.81-17.71	9.16±1.39	6.54-11.42	6.58±1.66	4.13-10.2
TL(Total length)(cm)	10.54±0.51	9.8-11.9	10.31±0.48	9.6-11.4	10.20±0.99	9.1-12.5	9.89±0.5	9.0-10.8	9.07±0.59	8.2-10.4
K(Condition Factor)	0.96±0.03	0.91-1.07	0.96±0.03	0.9-1.0	0.93±0.03	0.87-0.97	0.94±0.05	0.87-1.04	0.87±0.09	0.63-0.94
SL(Standard length)(cm)	8.27±0.44	7.6-9.4	8.08±0.35	7.4-8.8	8.05±0.81	7.1-9.9	7.72±0.39	7.1-8.4	7.11±0.44	6.5-8.2
FL(Fork length)(cm)	8.94±0.46	8.2-10.2	8.76±0.38	8.2-9.6	8.69±0.83	7.8-10.6	8.41±0.42	7.7-9.2	7.75±0.46	7.1-8.8
HL(Head length)(cm)	2.31±0.11	2.2-2.5	2.31±0.18	2.1-2.7	2.25±0.18	2.0-2.6	2.22±0.12	2.0-2.4	2.02±0.09	1.9-2.2
SnL(Snout Length)(cm)	1.66±0.11	1.4-1.8	1.71±0.12	1.5-1.9	1.68±0.19	1.5-2.12	1.58±0.09	1.4-1.7	1.5±0.06	1.4-1.6
BD(Body depth)(cm)	2.64±0.16	2.4-3.0	2.58±0.18	2.35-2.95	2.47±0.22	2.2-2.95	2.47±0.12	2.25-2.65	2.37±0.32	1.6-2.75
BG(Body girth)(cm)	5.28±0.33	4.8-6	5.18±0.35	4.7-5.9	5.06±0.54	4.4-6.2	4.95±0.25	4.5-5.3	4.75±0.65	3.2-5.5
DFL(Dorsal fin length)(cm)	1.72±0.15	1.5-2.1	1.65±0.16	1.4-2.0	1.55±0.17	1.3-1.9	1.65±0.09	1.5-1.8	1.41±0.13	1.2-1.6
PctFL(Pectoral fin length)	1.56±0.09	1.4-1.8	1.53±0.08	1.3-1.7	1.44±0.16	1.3-1.8	1.47±0.07	1.3-1.6	1.30±0.12	1.1-1.5
PvFL(Pelvic fin length)(cm)	1.36±0.09	1.1-1.5	1.34±0.08	1.2-1.5	1.3±0.12	1.2-1.6	1.27±0.07	1.1-1.4	1.22±0.13	1.0-1.4
AFL(Anal fin length)(cm)	1.32±0.1	1.2-1.5	1.32±0.1	1.2-1.5	1.26±0.11	1.1-1.5	1.26±0.08	1.1-1.4	1.20±0.12	1.0-1.4
CFL(Caudal fin length)(cm)	2.27±0.13	2.0-2.5	2.24±0.21	1.9-2.6	2.17±0.19	1.9-2.6	2.17±0.17	1.9-2.4	1.99±0.17	1.7-2.2
ED(Eye Diameter)cm	0.58±0.03	0.5-0.6	0.57±0.04	0.5-0.6	0.59±0.05	0.5-0.7	0.55±0.05	0.5-0.6	0.57±0.04	0.5-0.6
pDFL(Pre-dorsal fin length)	3.98±0.24	3.7-4.4	3.83±0.23	3.6-4.4	3.78±0.41	3.2-4.6	3.58±0.25	3.1-4.0	3.30±0.28	2.9-3.8
pPctFL(Pre-pectoral fin length)	2.32±0.14	2.2-2.6	2.23±0.13	2.1-2.6	2.18±0.17	2.0-2.5	2.09±0.19	1.7-2.4	2.03±0.13	1.8-2.2
pPvFL(Pre-pelvic fin length)	4.34±0.23	3.9-4.8	4.36±0.22	4.0-4.9	4.27±0.53	3.6-5.3	4.12±0.22	3.7-4.5	3.73±0.43	2.9-4.3
pAFL(Pre-anal fin length)	6.36±0.43	5.8-7.6	6.36±0.29	6.0-6.9	6.21±0.68	5.4-7.8	5.91±0.36	5.2-6.1	5.62±0.49	4.7-6.3
CdPdL(Caudal peduncal Length)	1.4±0.12	1.3-1.7	1.44±0.12	1.2-1.6	1.37±0.16	1.2-1.7	1.34±0.11	1.1-1.5	1.15±0.11	1.0-1.3
CdH(Caudal Height)	3.97±0.17	3.6-4.4	3.94±0.18	3.6.4.4	3.84±0.36	3.4-4.5	3.44±0.22	3.0-3.8	3.55±0.45	2.9-4.1

The obtained data in all groups showed a positive correlation in length-weight relationship as value of "r" is very near to 1.0 depicting high accuracy with highly significant correlation. Though, highly significant correlation was observed in all treatment groups which may be due to less number of samples in each treatment. To justify the results, log transformed data of wet weight for all fish samples in one feeding group was also analyzed collectively against log total length, a highly significant correlation was also observed. Thus, representing good health status of reared fish. Narejo (2006) concluded same results by studying length-weight relationship in *Cirrhinus reba* (Hamilton) from Manchar Lake. The length-weight relationship is significantly correlated but fins length in some cases showed differences in various experimental groups which in accordance to the findings of Faith et al. (2004).

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Table 2: *Descriptive statistical values; a, b values; confidence limits and coefficients of determination of Labeo rohita reared at various protein:Energy ratios.*

Equation	Diet variables	Relationship parameters a	b	95% CI of a	95% CI of b	Standard error (b)	r	r^2	P value (b)
W= a+b TL (n = 30)	T1	-24.231	3.37	-28.65- -19.80	2.95-3.79	0.2	0.970***	0.941	1.72E-12
	T2	-24.472	3.11	-25.42- -17.52	2.723-3.488	0.18	0.972***	0.945	3.74E-12
	T3	-22.533	3.20	-24.68- -20.38	2.992-3.412	0.1	0.995***	0.989	3.53E-13
	T4	-16.898	2.63	-21.65- -12.23	2.164-3.106	0.22	0.947***	0.898	2.44E-09
	T0	-17.281	2.63	-22.9- -11.66	2.013-3.250	0.28	0.943***	0.888	1.42E-06
TL = a+b W (n = 30)	T1	7.383	0.28	6.98-7.78	0.24-0.31	0.02	0.970***	0.941	1.72E-12
	T2	7.101	0.30	6.701-7.500	0.267-0.342	0.018	0.972***	0.945	3.74E-12
	T3	7.072	0.31	6.857-7.286	0.289-0.329	0.009	0.995***	0.989	3.53E-13
	T4	6.768	0.34	6.204-7.332	0.280-0.402	0.029	0.948***	0.898	2.44E-09
	T0	6.846	0.34	6.308-7.383	0.258-0.417	0.036	0.942***	0.888	1.42E-06
K= a+b W (n = 30)	T1	0.899	0.005	0.796-1.003	-0.004-0.014	0.004	0.284ns	0.081	0.22444
	T2	0.924	0.003	0.820-1.028	-0.007-0.013	0.005	0.158ns	0.025	0.51838
	T3	0.912	0.002	0.847-0.977	-0.004-0.008	0.003	0.162ns	0.026	0.57984
	T4	0.863	0.008	0.687-1.038	-0.01-0.027	0.009	0.231ns	0.053	0.35648
	T0	0.655	0.032	0.464-0.845	0.004-0.06	0.013	0.605*	0.366	0.02842
K= a+b TL (n = 30)	T1	0.926	0.003	0.580-1.273	-0.029-0.036	0.016	0.050ns	0.003	0.83564
	T2	0.999	-0.004	0.674-1.326	-0.036-0.027	0.015	0.068ns	0.005	0.78209
	T3	0.897	0.003	0.694-1.101	-0.017-0.023	0.009	0.094ns	0.009	0.74873
	T4	1.029	-0.009	0.494-1.563	-0.063-0.045	0.025	0.087ns	0.008	0.73124
	T0	0.443	0.047	-0.407-1.294	-0.047-0.14	0.04	0.314ns	0.099	0.29536

r: *Correlation Coefficient;* **a:** *Intercept;* **b:** *slope;* **S.E:** *Standard Error; *** P<0.001; ** P<0.01; * P<0.05; n.s p>0.1*

Table 3: *Multiple regression parameters, coefficient of determination (r^2) and variance inflation factor (VIF) of Labeo rohita reared at various protein:Energy ratios.*

Relationship	Diet variables	a	b_1±S.E	b_2±S.E	r^2	VIF
$K = a + b_1W + b_2TL$	T_1	2.77	0.076±0.004	-0.253±0.016	0.944***	17.86
	T_2	2.70	0.079±0.006	-0.250±0.018	0.920***	12.50
	T_3	2.30	0.063±0.021	-0.197±0.069	0.443**	01.79
	T_4	2.93	0.113±0.005	-0.306±0.014	0.907***	10.75
	T_0	2.99	0.147±0.011	-0.341±0.030	0.902***	10.20

Condition factor (K) is usually used to assess the living state, surroundings of the fish and feeding behavior of fish (Mozsar et al., 2015). Higher is the K value, healthier and heavier is the fish with better surroundings and energy reserves. The condition factor ranged from 0.87 to 0.96 (mean value: 0.915) in present study which is in line to the findings of Abowei (2009) while calculating LWRs of five fish species of the Nkoro River in Nigeria. Isa et al. (2010) also calculated condition factor value; 0.9105±0.1986 while studying twelve freshwater species of the Kerian River in Perak and Lake Peduat Kedah; the similar findings to present study. Shakir et al. (2010) concluded that K value equal to 1.0 shows isometric growth, greater than 1.0 shows positive allometric growth and the value less than 1.0 is credited to under nourished fish with negative allometric growth. The K value in this study is very near to 1.0, (0.96) in T_1 and T_2 presenting adequate supply of nutrients with favorable environmental conditions.

Multiple regression analysis (MRA) for wet weight and total length against condition factor was performed for all the treatment groups and a highly significant correlation was observed in all the treatment groups except T_3 which showed significant correlation. To ob

Table 4: *Descriptive statistical values of log transformed regression data of wet weight (ww) with various morphometric variants for Labeo rohita reared at various protein: Energy ratios.*

Equation	Diet variables	Relationship parameters a	b	95% CI of a	95% CI of b	Standard error (b)	r	r^2	P value
TL = a+b W	T1	0.69	0.31	0.65-0.73	0.27-0.35	0.02	0.972	0.946	0.000***
	T2	0.68	0.32	0.64-0.72	0.28-0.36	0.02	0.975	0.950	0.000***
	T3	0.68	0.32	0.66-0.71	0.30-0.35	0.01	0.993	0.986	0.000***
	T4	0.71	0.3	0.65-0.76	0.24-0.36	0.03	0.940	0.884	0.000***
	T0	0.77	0.23	0.71-0.83	0.16-0.3	0.03	0.904	0.818	0.000***
K= a+b W	T1	-0.08	0.06	-0.2-0.03	-0.04-0.17	0.05	0.274	0.072	0.241n.s.
	T2	-0.05	0.03	-0.17-0.06	-0.08-0.14	0.05	0.150	0.022	0.534n.s.
	T3	-0.05	0.02	-0.13-0.01	-0.04-0.1	0.03	0.228	0.052	0.431n.s.
	T4	-0.12	0.09	-0.28-0.05	-0.08-0.27	0.08	0.275	0.076	0.268n.s.
	T0	-0.31	0.31	-0.49- -0.14	0.09-0.52	0.03	0.688	0.473	0.009**
SL=a+b W	T1	0.55	0.34	0.51-0.59	0.31-0.38	0.02	0.979	0.958	0.000***
	T2	0.62	0.28	0.55-0.69	0.21-0.34	0.03	0.902	0.813	0.000***
	T3	0.57	0.33	0.55-0.59	0.31-0.35	0.01	0.995	0.989	0.000***
	T4	0.59	0.31	0.55-0.62	0.27-0.34	0.02	0.977	0.954	0.000***
	T0	0.68	0.21	0.62-0.74	0.13-0.29	0.03	0.879	0.772	0.000***
FL=a+b W	T1	0.6	0.33	0.57-0.64	0.3-0.36	0.02	0.978	0.957	0.000***
	T2	0.64	0.29	0.59-0.69	0.24-0.34	0.02	0.952	0.907	0.000***
	T3	0.62	0.32	0.6-0.64	0.3-0.34	0.01	0.993	0.987	0.000***
	T4	0.63	0.3	0.58-0.69	0.25-0.36	0.03	0.945	0.893	0.000***
	T0	0.71	0.21	0.66-0.76	0.15-0.27	0.03	0.921	0.848	0.000***
DFL=a+b W	T1	-0.31	0.52	-0.44- -0.18	0.4-0.64	0.06	0.905	0.819	0.000***
	T2	-0.35	0.55	-0.54- -0.16	0.37-0.74	0.09	0.836	0.699	0.000***
	T3	-0.18	0.37	-0.23- -0.13	0.32-0.42	0.02	0.980	0.960	0.000***
	T4	-0.04	0.27	-0.16- -0.08	0.14-0.39	0.06	0.755	0.569	0.000***
	T0	-0.14	0.36	-0.19- -0.09	0.30-0.42	0.03	0.971	0.943	0.000***
PtFL=a+b W	T1	-0.15	0.32	-0.26- -0.028	0.21-0.44	0.05	0.816	0.666	0.000***
	T2	-0.12	0.3	-0.25-0.01	0.17-0.42	0.06	0.767	0.589	0.000***
	T3	-0.19	0.36	-0.25- -0.14	0.3-0.42	0.03	0.968	0.938	0.000***
	T4	-0.11	0.29	-0.19- -0.04	0.21-0.37	0.04	0.894	0.799	0.000***
	T0	-0.17	0.35	-0.25- -0.09	0.25-0.44	0.04	0.925	0.856	0.000***
PvFL=a+b W	T1	-0.23	0.34	-0.4- -0.05	0.18-0.51	0.08	0.722	0.522	0.000***
	T2	-0.24	0.36	-0.37- -0.12	0.24-0.48	0.06	0.836	0.699	0.000***
	T3	-0.16	0.28	-0.25- -0.07	0.19-0.37	0.04	0.888	0.789	0.000***
	T4	-0.2	0.32	-0.32- -0.089	0.2-0.44	0.05	0.819	0.671	0.000***
	T0	-0.21	0.37	-0.34- -0.09	0.22-0.52	0.07	0.855	0.731	0.000***
AFL=a+b W	T1	-0.35	0.44	-0.48- -0.22	0.32-0.57	0.06	0.875	0.767	0.000***
	T2	-0.22	0.34	-0.43- -0.019	0.13-0.54	0.09	0.650	0.422	0.003**
	T3	-0.17	0.28	-0.23- -0.12	0.22-0.33	0.02	0.956	0.915	0.000***
	T4	-0.22	0.33	-0.34- -0.1	0.21-0.45	0.06	0.819	0.670	0.000***
	T0	-0.23	0.38	-0.31- -0.14	0.28-0.48	0.05	0.926	0.857	0.000***
CFL=a+b W	T1	0.177	0.17	-0.002-0.36	0.000078-0.34	0.08	0.444	0.197	0.05n.s,.
	T2	-0.13	0.47	-0.37-0.1	0.23-0.7	0.11	0.717	0.513	0.001***
	T3	0.07	0.27	-0.02-0.16	0.17-0.36	0.04	0.874	0.764	0.000***
	T4	0.07	0.27	-0.14-0.29	0.047-0.5	0.11	0.539	0.291	0.021*
	T0	0.06	0.30	-0.03-0.15	0.18-0.41	0.05	0.866	0.751	0.000***
BG=a+b W	T1	0.302	0.4	0.245-0.359	0.346-0.455	0.02	0.964	0.930	0.000***
	T2	0.27	0.43	0.17-0.38	0.32-0.53	0.05	0.904	0.817	0.000***
	T3	0.36	0.35	0.31-0.40	0.30-0.39	0.02	0.979	0960	0.000***
	T4	0.44	0.26	0.34-0.54	0.16-0.36	0.05	0.808	0.653	0.000***
	T0	0.25	0.52	0.09-0.42	0.31-0.72	0.09	0.859	0.738	0.000***

BD=a+b W	T1	0.001	0.4	-0.056-0.058	0.346-0.455	0.03	0.964	0.930	0.000***
	T2	-0.05	0.45	-0.15-0.05	0.35-0.55	0.05	0.916	0.840	0.000***
	T3	0.21	0.18	0.06-0.36	0.03-0.33	0.07	0.611	0.373	0.02*
	T4	0.14	0.26	0.04-0.24	0.16-0.36	0.05	0.808	0.653	0.000***
	T0	-0.04	0.52	-0.21-0.12	0.31-0.72	0.09	0.859	0.738	0.000***
ED=a+b W	T1	-0.44	0.19	-0.623- -0.253	0.013-0.366	0.08	0.470	0.221	0.037*
	T2	-0.59	0.34	-0.78- -0.4	0.15-0.52	0.08	0.683	0.466	0.001***
	T3	-0.42	0.2	-0.55- -0.29	0.07-0.33	0.06	0.693	0.481	0.006**
	T4	-0.61	0.37	-0.85- -0.37	0.12-0.62	0.12	0.619	0.383	0.006**
	T0	-0.45	0.25	-0.55- -0.35	0.14-0.37	0.05	0.821	0.673	0.001***
HL =a+b W	T1	0.101	0.25	0.006-0.195	0.160-0.340	0.04	0.808	0.653	0.000***
	T2	-0.078	0.43	-0.24-0.09	0.27-0.59	0.08	0.803	0.644	0.000***
	T3	0.09	0.25	0.03-0.16	0.19-0.32	0.03	0.933	0.871	0.000***
	T4	0.02	0.33	-0.04-0.09	0.26-0.4	0.03	0.922	0.851	0.000***
	T0	0.17	0.16	0.13-0.21	0.12-0.21	0.02	0.922	0.850	0.000***
SnL=a+b W	T1	-0.065	0.271	-0.255-0.124	0.091-0.452	0.08	0.597	0.357	0.005**
	T2	-0.19	0.42	-0.37- -0.02	0.25-0.59	0.08	0.790	0.624	0.000***
	T3	-0.09	0.32	-0.21-0.02	0.21-0.44	0.05	0.867	0.752	0.000***
	T4	-0.12	0.33	-0.2- -0.03	0.24-0.42	0.04	0.892	0.795	0.000***
	T0	0.06	0.13	0.03-0.1	0.09-0.18	0.02	0.887	0.788	0.000***
pDFL=a+b W	T1	0.211	0.370	0.127-0.296	0.290-0.45	0.04	0.916	0.839	0.000***
	T2	0.2	0.37	0.1-0.3	0.28-0.47	0.04	0.894	0.800	0.000***
	T3	0.22	0.36	0.16-0.27	0.31-0.41	0.02	0.973	0.947	0.000***
	T4	0.15	0.42	0.06-0.23	0.33-0.51	0.04	0.934	0.872	0.000***
	T0	0.26	0.32	0.21-0.31	0.26-0.38	0.03	0.962	0.926	0.000***
pPcFL=a+b W	T1	0.003	0.345	-0.098-0.104	0.248-0.441	0.04	0.871	0.758	0.000***
	T2	0.016	0.32	-0.1-0.13	0.2-0.44	0.05	0.814	0.663	0.000***
	T3	0.07	0.26	0.03-0.12	0.21-0.31	0.02	0.959	0.919	0.000***
	T4	-0.2	0.54	-0.32- -0.7	0.41-0.67	0.06	0.911	0.830	0.000***
	T0	0.2	0.45	0.11-0.29	0.33-0.56	0.04	0.934	0.873	0.000***
pPvFL=a+b W	T1	0.294	0.326	0.217-0.371	0.253-0.399	0.03	0.911	0.829	0.000***
	T2	0.3	0.33	0.23-0.37	0.26-0.4	0.03	0.920	0.847	0.000***
	T3	0.21	0.41	0.16-0.27	0.36-0.47	0.03	0.976	0.935	0.000***
	T4	0.32	0.3	0.25-0.4	0.22-0.38	0.03	0.900	0.811	0.000***
	T0	0.13	0.22	0.05-0.2	0.13-0.31	0.05	0.855	0.731	0.000***
pAFL=a+b W	T1	0.358	0.423	0.304-0.412	0.372-0.475	0.02	0.971	0.943	0.000***
	T2	0.51	0.28	0.43-0.59	0.21-0.36	0.04	0.878	0.771	0.000***
	T3	0.44	0.36	0.38-0.49	0.30-0.41	0.02	0.972	0.944	0.000***
	T4	0.42	0.36	0.34-0.51	0.27-0.44	0.04	0.911	0.831	0.000***
	T0	0.48	0.33	0.41-0.56	0.23-0.42	0.04	0.918	0.842	0.000***
CdPdL=a+b W	T1	-0.396	0.516	-0.514- -2.78	0.403-0.628	0.05	0.915	0.837	0.000***
	T2	-0.31	0.46	-0.5- -0.12	0.27-0.64	0.09	0.786	0.618	0.000***
	T3	-0.21	0.34	-0.32- -0.09	0.23-0.46	0.05	0.889	0.790	0.000***
	T4	-0.3	0.45	-0.45- -0.16	0.3-0.6	0.07	0.843	0.711	0.000***
	T0	-0.21	0.33	-0.31- -0.1	0.2-0.46	0.06	0.865	0.749	0.000***
CdH=a+b W	T1	0.442	0.149	0.311-0.573	0.024-0.274	0.06	0.509	0.260	0.022*
	T2	0.47	0.12	0.31-0.63	-0.03-0.28	0.07	0.371	0.138	0.117n.s.
	T3	0.28	0.3	0.21-0.36	0.23-0.37	0.03	0.932	0.870	0.000***
	T4	0.28	0.26	0.13-0.44	0.09-0.42	0.08	0.638	0.407	0.004**
	T0	0.2	0.42	0.05-0.35	0.24-0.61	0.08	0.836	0.699	0.000***

P>0.05(Non-significant (n.s.); P<0.05(significant); P<0.01(very significant**); P<0.001(highly significant***).*

serve multi-collinearity (correlation between predictors), Variance inflation factor (VIF) was calculated. VIF indicates that how much the variance of regression coefficient increases due to collinearity (Heckman, 2015). In present study, VIF values were greater than 5.0 indicating a highly significant multi-collinearity in multiple regression analysis (MRA); whereas VIF = 1 (Little bit correlated), 1< VIF <5 (Moderately correlated), VIF > or = 5 (Highly correlated).

Length-weight relationship and external morphometric analysis of *Labeo rohita* were studied by many scientists prior to this study but there is no comparative analysis of different variants when fish is fed with various Protein: Energy diets. So, a positive significant correlation was observed in morphometric variants with change in diet compositions.

Present study revealed that fish fed with pure fish meal diet showed minimum increment in weight and length. Diets with decreased fish meal percentage and maximum plant origin sources showed an increment in length-weight variants. Present findings indicate that fish dislike the fish meal diet and preferred the plant origin sources. Furthermore, it is suggested that more feeding groups with lowest fish meal concentration and decreased crude protein ratios like 20% and 15% may be piloted in forthcoming studies to observe weight-length increment in experimental fish.

Author's Contribution

Muhammad Javed Iqbal: Conducted the research, collected the data, did statistical analysis and wrote the paper and this manuscript is part of his Ph.D. work.
Muhammad Naeem: Supervisor and made available the resources for completion of research and also helped in reviewing the manuscript.

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