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Influence of graded levels of protein on external morphometrics, length-length (LLR) and length-weight relationship (LWR) of Genetically Improved Farmed Tilapia(GIFT) from Southern Punjab, Pakistan

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Abstract: This study was planned to evaluate the influence of different levels of crude protein (CP) 15% (T1), 20% (T2) and 25% (T3) on external morphometric parameters, LLR, LWR and condition factor of Genetically Improved Farmed Tilapia (GIFT) fingerlings, a developed strain of Nile tilapia (*Oreochromis niloticus*). An increase in the external morphometric parameters was obtained with increasing protein level and highest values for mean wet weight (30.48±17.54) and Total length (TL) 12.84±1.97wereobserved in T3 (25%CP) fish. Correlation coefficient values (r = 0.961) and (r= 0.992) yielded highly significant (P<0.001) LWR in T1 and T3 respectively while significant (P<0.01) in T2 (r=0.856). Regression coefficient 'b' exhibited negative (T1= 2.829, T2= 2.069) and Positive (b=3.149) allometry in T3 group. Condition factor also exhibited increasing trend with dietary protein level yielding 1.52, 1.56 and 1.68 in T1, T2 and T3 respectively indicating good environmental and fish condition. All lengths of external morphometric parameters showed positive relationship both with total length and wet weight for insignificant and significant correlations. Protein feed of 25% (T3) was found to exhibit highest growth, in terms of weight and estimated morphometrics, in GIFT as compared to T1 and T2 in the current study.

Key words: Morphometric parameters, dietary protein, GIFT, correlation, allometry.

1. INTRODUCTION

Morphometric analysis is performed to study body forms like shape and size of an organism (Kalhoro *et al.,* 2015). This technique is cost-effective and is employed frequently for the identification of fish stocks and for discrimination between the fish populations by describing the fish body shape. (Hanif *et al.*, 2019).

For successful aquaculture, knowledge about fish growth size and their feeding habits is important for selecting a fish species of choice for culture (Kuebutornye *et al.,* 2019).

These parameters also play important role to characterize fish species which provide assistance in maintaining genetic purity and assessing growth performance within population of fish (Onyekwelue *et al.*, 2020).

Studies involving condition factor and length-weight relationships provide beneficial knowledge to fish farmers. As these indices help in measuring fish growth, fish life history and overall production of fish biomass (Ferdaushy and Alam, 2015). length-weight relationships (LWRs)are important morphometrics having significant implications for fishery management (Chen *et al.*, 2020),

One of the most favored fish species in freshwater aquaculture is Nile tilapia (*Oreochromis niloticus*)due to its high tolerance towards environmental conditions (Mjoun *et al.*, 2000). This species was chosen to be improved genetically, by selecting through several generations using conventional breeding methods, known as Genetically Improved Farmed Tilapia (GIFT).

The major source of animal protein used in fish diets is fish meal. Butits expensiveness and scarce availability limit its use in the aquatic feeds.So, there is need to replace fish meal in aqua feeds with other high-qualityingrediants more attentively (Amer *et al.*, 2019). Little work is available to estimate the effect of graded dietary protein levels on fish morphometry (Iqbal and Naeem, 2018; Malik and Naeem, 2020; Iqbal and Naeem, 2020). Thus, present study was planned to evaluate the influence of different plant-based dietary protein levels on morphometric relationships of GIFT.

2. MATERIALSAND METHODS

Five days oldmono sex (male) fingerlings of Genetically Improved farmed Tilapia (GIFT) were obtained from Tawakkal Tilapia Hatchery located at Tawakkal Nager, Muzaffar Garh, Punjab, Pakistan. After two weeks acclimatization of fingerlings fed with fish meal, aninety days feeding trial was carried out in

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hapas (8x6x3ft) during which fish were fed experimental feed @ 5% body weight twice a day. Experimental feed was prepared using locally available cheaper feed ingredients of plant origin. Three treatment groups, on the basis of percentage of plant proteinin feed, (T1=15%,T2=20%, T3=25%) were made and experiment was performed in duplicate. At the end of feeding trial, ten specimens were randomly selected from each treatment hapa (T1, T2, T3) and kept in plastic bags filled with water and oxygen. These samples were transferred to the laboratory of Institute of Pure and Applied Biology, Bahauddin Zakariya University, Multan.

Fish samples were anesthetized with MS-222 and blotted dry using paper towel. Electronic digital balance (Shimadzu Elb-300 Japan) was used to weigh each specimen. Various external morphometric parameters i.e., total body length, standard length, fork length, head length, eye diameter, body depth and girth, lengths of dorsal, pectoral, pelvic, anal and caudal fins and caudal fin height, were measured using ruler.

Statistical analysis between total body length and wet body weight of fish for T1, T2 and T3 was obtained using the equation LogW= Log a+b log TL, which is logarithmic transformation of the formula $W = a\ L^b$. Relationships of total length as well as wet weight against various external morphometrics were estimated applying linear regression. Condition factor was calculated with the following formula:

Condition factor (K) = $W/L^3 \times 100$

3. **RESULTS**

The mean values, ranges and standard deviations (± S.D.) of various studied externalmorphometric parameters and condition factor for GIFT are given in **(Table-1).**

A highly significant positive correlation (*P*< 0.001) was observed between total length and wet body weight both in non-transformed and log-transformed data in GIFT fed with 15% and 25% crude protein inT1and T3,respectively, while significant (*P*< 0.01) relationship in case of GIFT fed with 20% crude protein T2 **(Table2).** The regression coefficient 'b' between log total body length and log wet body weight amounted to 2.839 in T1, 2.069 in T2 and 3.149 in T3. The values, 2.839 in T1 and 2.069 in T2, were less than 3.0 indicating negative allometry, i.e., more increase in length than wet body weight, while the value 3.149 greater than 3.0 represents positive allometry in T3 showed more increment in body weight than body length (Table 2). Condition factor (K) plot against total length and wet body weight showed a non-significant (*P*>0.05) correlation coefficient for bothnon-transformed and log transformed data in T1, T2 and T3 **(Table 2).**

Table 1. Mean values and ranges (cm) of various external morphological parameters of GIFT (*n* =10).

Parameters	**T1 (15%)**		**T2 (20%)**		**T3 (25%)**	
Body Measurements	**Mean ± S.D.**	**Range**	**Mean ± S.D.**	**Range**	**Mean ± S.D.**	**Range**
Wet body weight (WT)	19.93 ± 4.87	13.60 - 28.00	27.16 ± 6.49	17.90 - 38.10	38.48 ± 17.54	16.70 - 70.30
Condition factor (K)	1.52 ± 0.10	1.36 - 1.67	1.56 ± 0.25	1.13 - 2.09	1.68 ± 0.23	1.19 - 2.02
Total length (TL)	10.90 ± 0.90	9.80 - 12.50	12.04 ± 1.30	10.40 - 15.00	12.84 ± 1.97	10.10 - 16.10
Standard length (SL)	8.47 ± 0.94	7.60 - 10.20	9.04 ± 0.72	8.10 - 10.10	9.10 ± 1.59	7.70 -12.40
Fork length (FL)	10.26 ± 1.10	9.30 - 12.50	11.10 ± 0.82	9.50 - 12.10	11.22 ± 1.80	9.60 - 15.00
Head length (HL)	3.28 ± 0.62	2.70 - 4.50	3.36 ± 0.21	3.00 - 3.60	3.41 ± 0.54	2.80 - 4.40
Eye diameter (ED)	0.68 ± 0.06	0.60 - 0.80	0.69 ± 0.07	0.60 - 0.80	0.74 ± 0.12	0.60 - 1.00
Body girth (BG)	9.02 ± 0.25	7.60 - 10.50	9.92 ± 0.68	8.90 - 11.00	10.40 ± 2.66	8.10 - 15.30
Body depth (BD)	4.30 ± 1.17	3.50 -7.50	4.45 ± 0.37	4.00 - 4.90	4.83 ± 1.53	3.60 - 8.40
Dorsal fin length (DFL)	1.94 ± 0.25	1.50 - 2.30	2.16 ± 0.30	1.70 - 2.70	2.18 ± 0.65	1.30 - 3.50
Pectoral fin length (PtFL)	3.07 ± 0.30	2.70 - 3.70	3.33 ± 0.35	3.00 - 4.00	3.46 ± 0.57	2.80 - 4.50
Pelvic fin length (PvFL)	2.31 ± 0.28	1.80 - 2.70	2.41 ± 0.21	2.00 - 2.60	2.45 ± 0.42	2.00 - 3.40
Anal fin length (AFL)	2.10 ± 0.29	1.80 - 2.80	2.23 ± 0.36	1.80 - 3.00	2.29 ± 0.51	1.60 - 3.40
Caudal fin length (CFL)	2.36 ± 0.22	2.10 - 2.80	2.56 ± 0.28	2.10 - 3.00	2.58 ± 0.52	2.10 - 3.70
Caudal fin height (CFH)	1.97 ± 0.42	1.50 - 2.50	2.17 ± 0.47	1.70 - 3.10	2.32 ± 0.75	1.50 - 3.70

Total Length-Length of various external morphometric parameters (LLR)

The relationship of log-transformed data of total length (TL) versus standard length (SL), fork length (FL) and head length (HL) was found to be highly significant (*P*< 0.001), while TL versus body depth (BD) and caudal fin height (CFH) exhibited significant correlation (*P*<0.01) in 15% CP fed (T1) fish. Log TL versus logbody girth (BG) and log dorsal fin length yielded least significant correlation while rest of the parameters yieldednon-significant relationship in T1 fish for log-transformed values (Table 3).

Table 2. Regression analysis data of total length (cm), wet body weight (g) and condition factor for GIFT (*n* = 10).

Equation	Treatments	Relationships a	b	95% CI of a	95% CI of b	R	r^2
W = a + b TL	T1 (15%) T2 (20%) T3(25%)	-37.408 -25.301 -73.733	5.260 4.357 8.802	49.257- -5.558 -49.519- -1.083 -85.996- -1.469	4.177 - 6.344 2.356 - 6.358 7.779 - 9.825	0.969*** 0.871** 0.989***	0.939 0.759 0.980
Log W = a + b Log TL	T1 (15%) T2 (20%) T3(25%)	-1.644 -0.809 -1.933	2.829 2.069 3.149	-2.334- -0.954 -1.909 - 0.291 -2.273 - -1.593	2.1642 - 3.496 1.049 - 1.088 2.8311 - 3.4661	0.961*** 0.856** 0.992***	0.923 0.733 0.985
TL = a + b W	T1 (15%) T2 (20%) T3(25%)	7.339 7.308 0.985	0.179 0.174 0.111	6.585 - 8.092 5.079 - 9.536 7.997 - 8.896	0.142 - 0.216 0.094 - 0.254 0.098 - 0.124	0.969*** 0.871** 0.989***	0.9399 0.759 0.980
Log TL = a + b Log W	T1 (15%) T2 (20%) T3(25%)	0.616 0.575 0.621	0.326 0.354 0.313	0.517 - 0.715 0.326 - 0.824 0.575 - 0.666	0.249 - 0.403 0.179 - 0.529 0.281 - 0.344	0.961*** 0.856** 0.992***	0.923 0.733 0.985
K = a + b TL	T1 (15%) T2 (20%) T3 (25%)	1.783 2.872 2.310	-0.025 -0.109 -0.052	0.791 - 2.775 1.294 - 4.451 1.599 - 3.020	-0.1152 -0.066 -0.239 - 0.021 -0.11 1- 0.006	0.215^{ns} 0.565^{ns} 0.591^{ns}	0.046 0.319 0.349
Log K = a + b Log TL	T1 (15%) T2 (20%) T3 (25%)	0.3562 1.191 0.706	-0.170 -0.931 -0.452	-0.334 - 1.046 0.091 - 2.291 0.177 - 1.236	-0.836 - 0.496 -1.950 - 0.088 -0.946 - 0.042	0.204^{ns} 0.598^{ns} 0.598^{ns}	0.042 0.357 0.358
K = a + b W	T1 (15%) T2 (20%) T3 (25%)	1.5065 1.651 1.868	0.0004 -0.004 -0.006	1.156 - 1.857 0.775 - 2.527 1.547 - 2.189	-0.017 - 0.018 -0.035 - 0.028 -0.015 - 0.003	0.023^{ns} 0.091^{ns} 0.469^{ns}	0.001 0.008 0.220
Log K = a + b Log W	T1 (15%) T2 (20%) T3 (25%)	0.152 0.275 0.386	0.021 -0.062 -0.114	-0.145 - 0.449 -0.471 - 1.022 0.074 - 0.699	-0.209 - 0.252 -0.586 - 0.461 -0.330 - 0.102	0.075^{ns} 0.097^{ns} 0.397^{ns}	0.006 0.009 0.157

correlation coefficient (r), r^2: coefficient of determination, intercept (a), regression coefficient (b), Cl: confidence interval, *** *P* < 0.001, ** *P*< 0.01, ns *P*> 0.05

The values of correlation coefficient in 20% CP fed (T2) fish, for log- transformed data of total length versus SL, FL, BD, PtFL, AFL and CFL showed significant correlation (*P*<0.01); relationship of TL with BG andDFL was highly significant. Total length versus HL, ED and CFH was found least significant (*P*< 0.05) and PvFL exhibited non-significant relationship in T2 fish (Table 3).

The relationship between total length (TL) versus SL, FL, HL, BG, BD, PtFL, PvFL, AFL, CFL and CFH was noted to be highly significant (*P*< 0.001) while ED and DFL exhibited significant correlation (*P*<0.01) for log- transformed data among T3 (25% CP)fish **(Table 3).** All the non-significant and significantly correlated external morphometric parameters showed positive relationship with total length. These parameters were found to increase with increasing length **(Table3).**

Table3.Regression analysis data of log-transformed total length (cm) with different morphometrics (log-transformed values) for GIFT (n = 10).

Equation	Treatments	Relationship Parameters		95% CI of a	95% CI Of b	R	r^2
		a	b				
Log SL = a + b Log TL	T1 (15%)	-0.419	1.298	-0.633 - -0.205	1.091 - 1.504	0.981***	0.963
	T2 (20%)	0.253	0.653	-0.106 - 0.613	0.320 - 0.986	0.848**	0.719
	T3 (25%)	-0.167	1.049	-0.249 - -0.085	0.972 - 1.125	0.996***	0.992
Log FL = a + b Log TL	T1 (15%)	-0.231	1.197	-0.545 - 0.082	0.895 - 1.499	0.955***	0.912
	T2 (20%)	0.363	0.632	0.034 - 0.692	0.327 - 0.937	0.861**	0.741
	T3 (25%)	0.011	0.968	-0.037 - 0.058	0.924 - 1.012	0.999***	0.997
Log HL = a + b Log TL	T1 (15%)	-1.618	2.064	-2.073 - -1.162	1.624 - 2.503	0.966***	0.936
	T2 (20%)	0.051	0.446	-0.316 - 0.419	0.105 - 0.786	0.729*	0.534
	T3 (25%)	0.147	0.031	0.014 - 0.279	0.019 - 0.042	0.915***	0.837
Log ED = a + b Log TL	T1 (15%)	-0.429	0.251	-1.384 - 0.525	-0.669 - 1.172	0.217^{ns}	0.047
	T2 (20%)	-1.237	1.022	-2.104 - -0.370	0.219 - 1.825	0.719*	0.518
	T3 (25%)	-0.756	0.555	-1.104 - -0.409	0.231 - 0.879	0.813**	0.661
Log BG = a + b Log TL	T1 (15%)	-0.3853	1.291	-1.181 - 0.410	0.523 - 2.058	0.808*	0.653
	T2 (20%)	0.357	0.592	0.094 - 0.619	0.348 - 0.836	0.892***	0.797
	T3 (25%)	-0.609	1.511	-0.891 - -0.328	1.248 - 1.774	0.978***	0.956
Log BD = a + bLog TL	T1 (15%)	-7.111	1.052	-14.006 - -0.215	0.422 - 1.683	0.806**	0.649
	T2 (20%)	-0.056	0.652	-0.458 - 0.346	0.279 - 1.025	0.819**	0.670
	T3 (25%)	-1.199	1.747	-1.515 - -0.883	1.452 - 2.042	0.979***	0.959
Log DFL= a + b Log TL	T1 (15%)	-1.010	1.249	-1.923 - -0.097	0.369 - 2.130	0.756*	0.572
	T2 (20%)	-1.005	1.242	-1.452 - -0.558	0.828 - 1.656	0.926***	0.857
	T3 (25%)	-1.279	1.494	-2.252 - -0.306	0.585 - 2.404	0.801**	0.642
Log Pt FL = a + b Log TL	T1 (15%)	0.287	0.191	-0.692 - 1.266	-0.753 - 1.136	0.163^{ns}	0.027
	T2 (20%)	-0.334	0.808	-0.849 - 0.181	0.331 - 1.284	0.809**	0.464
	T3 (25%)	-0.540	0.989	-0.824 - -0.256	0.724 - 1.255	0.949***	0.902
Log Pv FL= a + b Log TL	T1 (15%)	-0.634	0.959	-1.648 - 0.381	-0.019 - 1.938	0.624^{ns}	0.389
	T2 (20%)	-0.193	0.539	-0.810 - 0.424	-0.033 - 1.110	0.609^{ns}	0.371
	T3 (25%)	-0.664	0.974	-0.933 - -0.396	0.723 - 1.225	0.954***	0.909
Log AFL= a + b Log TL	T1 (15%)	0.109	0.203	-1.256 - 1.473	-1.114 - 1.519	0.125^{ns}	0.016
	T2 (20%)	-0.939	1.201	-1.704 - -0.176	0.4930 - 1.908	0.810**	0.657
	T3 (25%)	-1.063	1.312	-1.406 - -0.721	0.992 - 1.632	0.958***	0.917
Log CFL= a + b Log TL	T1 (15%)	0.286	0.082	-0.621 - 1.193	-0.793 - 0.957	0.076^{ns}	0.006
	T2 (20%)	0.352	0.183	-0.767 - 1.473	0.091 - 0.276	0.850**	0.723
	T3 (25%)	-0.859	1.183	-1.042 - -0.678	1.013 - 1.354	0.985***	0.969
Log CFH= a + b Log TL	T1 (15%)	-2.069	0.371	-4.640 - 0.503	0.135 - 0.606	0.789**	0.623
	T2 (20%)	-1.008	1.266	-2.338 - 0.323	0.033 - 2.498	0.642*	0.412
	T3 (25%)	-1.799	1.979	-2.264 - -1.335	1.546 - 2.413	0.966***	0.933

correlation coefficient (r),coefficient of determination (r^2), intercept (a), regression coefficient (b), Cl: confidence interval,*** P<0.001, ** P< 0.01,P< 0.05*, P> 0.05 ns

Wet body weight-length of various external morphometric parameters (LWR)

Correlation coefficient values for regression analyses of log-transformed data of wet body weight (W) with SL, FL and HL, BG, DFL yielded highly significant, for BD significant and non-significant results with ED, PtFL, PvFL, AFL, CFL and CFH in T1 (15%) fed fish (Table 4). Relationship between log-transformed data of W and SL, FL, HL, BG, CFH exhibited significant (P< 0.01); W versus BD and CFL yielded least significant while W against ED, PtFL, PvFL, AFL was found non-significant (P>0.05) in T2 fed fish. Wet body weight showed highly significant correlation with DFL in T2 fish **(Table 4).**

Regression analysis revealed that all the log-transformed length parameter(SL, FL, HL BG, BD, DFL, PtFL, PvFL, AFL, CFL and CFH)against log-transformed data of wet body weight in T3 (25% CP) correlated highly significantly (P< 0.001), except for the eye diameter which yielded significant (P< 0.01) result (Table 4). All parameters of external morphometry showed positive relationship in log-transformed data with body weight in T1, T2 and T3 fed fish.

Table 4. Regression analysis data of log-transformed values of body weight (g) and different morphometric parameters (log-transformed values) for GIFT (*n* = 10).

Equation	Treatments	Relationships a	Relationships b	95% CI of a	95% CI of b	R	r^2
Log SL = a + b Log W	T1 (15%) T2 (20%) T3(25%)	0.385 0.585 0.479	0.419 0.262 0.331	0.218 - 0.552 0.374 - 0.796 0.453 - 0.505	0.291 - 0.549 0.115 - 0.409 0.313 - 0.349	0.936*** 0.823** 0.998***	0.875 0.677 0.996
Log FL = a + b Log W	T1 (15%) T2 (20%) T3 (25%)	0.516 0.705 0.611	0.382 0.239 0.304	0.319 - 0.713 0.487 - 0.923 0.571 - 0.651	0.230 - 0.535 0.086 - 0.392 0.276 - 0.331	0.899*** 0.787** 0.993***	0.808 0.619 0.988
Log HL = a + b Log W	T1 (15%) T2 (20%) T3 (25%)	-0.380 0.232 0.102	0.699 0.211 0.286	-0.579 - -0.181 0.070 - 0.394 -0.031 - 0.235	0.545 - 0.853 0.098 - 0.324 0.194 - 0.378	0.965*** 0.835** 0.929***	0.932 0.697 0.865
Log ED = a + b Log W	T1 (15%) T2 (20%) T3 (25%)	-0.3051 -0.6221 -0.4130	0.1055 0.3424 0.1745	-0.7037 - .0934 -1.177 - -0.067 -0.562 - -0.265	-0.203 - 0.414 -0.047 - 0.732 0.004 - 0.072	0.268^{ns} 0.582^{ns} 0.811**	0.072 0.339 0.657
Log BG = a + b Log W	T1 (15%) T2 (20%) T3 (25%)	0.328 0.655 0.317	0.484 0.239 0.481	0.071 - 0.585 0.499 - 0.812 0.227 - 0.406	0.285 - 0.683 0.129 - 0.349 0.419 - 0.543	0.893*** 0.871** 0.987***	0.797 0.759 0.976
Log BD = a + b Log W	T1 (15%) T2 (20%) T3 (25%)	-0.318 0.305 -0.123	0.734 0.240 0.553	-0.916 - 0.280 0.043 - 0.567 -0.246 - -0.001	0.272 - 1.198 0.057 - 0.424 0.468 - 0.637	0.791** 0.729* 0.983***	0.626 0.533 0.966
Log DFL = a + bLog W	T1 (15%) T2 (20%) T3 (25%)	-0.331 0.283 -0.341	0.478 0.434 0.460	-0.640 - -0.021 -0.685 - 0.119 -0.772 - 0.089	0.238 - 0.717 0.152 -0.716 0.162 - 0.758	0.852*** 0.782*** 0.783***	0.725 0.612 0.614
Log Pt FL = a + b Log W	T1 (15%) T2 (20%) T3 (25%)	0.341 0.179 0.076	0.112 0.251 0.309	-0.062 - 0.743 -0.201 - 0.560 -0.057 - 0.208	-0.199 - 0.424 -0.016 - 0.518 0.217 - 0.400	0.282^{ns} 0.609^{ns} 0.939***	0.079 0.371 0.883
Log Pv FL= a + b Log W	T1 (15%) T2 (20%) T3 (25%)	-0.006 0.184 -0.989	0.285 0.143 0.499	-0.467 - 0.454 -0.208-0.575 -1.213- -0.765	-0.071 - 0.641 -0.131 - 0.418 0.345 -0.655	0.546^{ns} 0.392^{ns} 0.935***	0.298 0.154 0.874
Log AFL= a + b Log W	T1 (15%) T2 (20%) T3 (25%)	0.075 -0.154 -0.250	0.189 0.358 0.412	-0.472 - 0.621 -0.732 - 0.425 -0.403 - -0.098	-0.234 - 0.613 -0.048 - 0.764 0.306 - 0.518	0.343^{ns} 0.584^{ns} 0.954***	0.118 0.341 0.910
Log CFL= a + b Log W	T1 (15%) T2 (20%) T3 (25%)	2.247 -0.039 -0.124	0.088 0.313 0.369	0.032 - 4.463 -0.408 - 0.331 -0.222 - -0.026	-1.627 - 1.802 0.054 - 0.572 0.302 - 0.437	0.042^{ns} 0.701* 0.976***	0.002 0.492 0.952
Log CFH= a + b Log W	T1 (15%) T2 (20%) T3 (25%)	-0.774 -0.564 -0.572	0.734 0.648 0.619	-1.738 - 0.191 -1.140 - 0.012 -0.786 - -0.357	-0.013 -1.480 0.244 - 1.052 0.471 - 0.768	0.626^{ns} 0.794** 0.959***	0.391 0.631 0.921

Correlation coefficient (r), r^2: coefficient of determination, intercept (a), regression coefficient (b), Cl: confidence interval, *** $P< 0.001$, ** $P < 0.01$, *$P < 0.05$,$P> 0.05^{ns}$

4. DISCUSSION

The current investigation reveals an increasing trend in all the studied external morphometric parameters with the increase of level of crude protein. The highest values for mean wet weight (W)38.48±17.54g, total length (TL) 12.84 ± 1.97 cm and all external morphometrics recorded in T3 GIFT fed with 25% crude protein feed are in agreement with findings of Iqbal and Naeem (2018) in Labeorohita and Iqbal *et al.* (2020) in hybrid (*Labeorohita*♀x*Catlacatla*♂). They had reported highest growth at 25% crude protein feed of plant origin. in mean wet weight, TL and similar studied external morphometric parameters.

The coefficient of determination (r^2) for GIFT was found closer to 1.0 in GIFT (r^2 = 0.923) fed with 15% CP (T1) and (r^2 = 0.985) 25% CP (T3), indicating high degree of correlation. Similar findings have been documented by Khalid and Naeem (2017) in grass carp, and Iqbal and Naeem (2018) in *Labeorohita*. Greater values of r^2 indicate good health condition of fish (Narejo, 2006).

This study revealed that the value of 'b' showed deviation from 'cube law' for all the three feeds T1 (2.829), T2 (2.069) and T3 (3.149) fish because, for an ideal fish b=3.0.Allometric growth is exhibited by T1, T2 and T3 fish which means that increase in rate of body length is not proportional to the rate of increase in body weight (Mahmoudi *et al.,* 2014). Migiro *et al*. (2014) had reported positive (b = 3.3) and negative allometry (b = 2.5) in female and male *Oreochromis niloticus*. It is generally considered that 'b' values may differ among species and could be affected by a number of factors, such as quality and quantity of food, sex ratio, physiological condition, gonadal development, etc. (Amin *et al.,* 2005).

In the present study, condition factor T1 (1.52), T2 (1.56) and T3 (1.68) was found non-significant with total length and weight having greater value than 1.0 and is in line with findings of Gandotra *et al*. (2018) in *Labeodero.* Migiro et al. (2014) had obtained mean K-values of 1.02 and 1.12 for male and female *Oreochromis niloticus*. This may be attributed to adequate food supply, good feeding habit and favored environmental conditions (Ishtiaq and Naeem, 2016).

Relationship of length of various external morphometric parameters with total length

All the studied external morphometric parameters showed positive correlation with length indicating thepositive correlation in morphometric parameters in T1(15% CP), T2(20% CP) and T3(25% CP) similar to the report of Kosai et al. (2014) in *Oreochromis niloticus*, Khalid and Naeem (2017) in grass carp and Malik and Naeem (2020) in *Pangasianodonhypophthalmus*. Kamboj and Kamboj (2019) had also reported that morphometric parameter showed proportional positive increase with increase in the length of fish. The high values of correlation coefficient for most of the morphometrics indicate that the LLRsarelinear over the observed range of value in T1, T2 and T3 for highly significant length parameters and aresimilar to the findings of Ishtiaq and Naeem (2016) in *Catlacatla*and Ishtiaq *et al.,* 2021) in *Ompokbimaculatu*.

Relationship between wet body weight and length of various morphometric parameters

Regression analysis for 15%, 20% and 25% CP fed fish indicated positive relationship of wet weight against the studied parameters and this finding coincides with Khalid and Naeem (2017) in grass carp and Iqbal and Naeem (2018) in *Labeorohita.* fed on 25%. 30%, 35%, 40% CP and fish meal diet. Highly significant positive correlation for log-transformed data was observed in SL, FL and HL, BG and DFL in T1 fish, DFL in T2 fish and all the studied parameters in T3 GIFT (25% CP) with weight except for ED which showed significant correlation. Similar highly significant correlation had been reported by Khalid and Naeem (2017) with weight. Iqbal and Naeem (2018) also showed highly significant and positive correlation between morphometric parameters (SL, FL, HL, DFL, PtFL, PvFL, BG, BD) and weight in 25% CP fed Labeorohita which is in agreement with the current findings.

5. CONCLUSION

The current investigation concludes an increasing trend in growth of all the studied external body parts with the increase in fish size in T3 (25%CP) studied GIFT as all the morphometric parameters increase with length and weight as compared to T1 (15%CP) and T2 (20%CP) fish. GIFT fed with 25% CP yielded highest mean weight and positive allometric growth as compared to GIFT fed with 15% and 20% CP showing negative allometric growth. These findings indicate that diet composition has definite effect on the studied fish.

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