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Original Article

Length-weight relationships of farmed major carps (*Cattla cattla, Labeo rohita* and *Cirhinus mrigala*) fed with different sources of protein in an intensive polyculture

Relações peso-comprimento de carpas principais (*Catla catla*, *Labeo rohita* e *Cirrhinus mrigala*) cultivadas e alimentadas a partir de diferentes fontes de proteína em uma policultura intensiva

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Abstract

The present findings provide information regarding the length-weight relationships (LWRs) of Indian major carps viz *Cattla cattla, Labeo rohita* and *Cirhinus mrigala* in an intensive polyculture system. Much work has been done in Pakistan with respect to fish LWRs, much of such work has been ignored. Carps were fed with twelve different formulated diets containing four different sources of protein i.e. fish meal (FM), all parts chicken meal (APCM), corn gluten (CGM) and soybean meal (SBM). Each type of protein is used at inclusion level of 25, 35 and 45% into the formulated diets to evaluate the minimum requirement of that ingredient for optimal growth of in-hand species. The values of slope "b" ranged from 2.20 to 4.90 for these species of carps which showed a strong healthy relationship among variables (level of protein and months).

Keywords: length-weight, condition factor, carps, polyculture, *Catla catla*, *Labeo rohita*, *Cirhinus mrigala*.

Resumo

Os achados do presente trabalho fornecem informações sobre as relações comprimento-peso (LWRs) das principais carpas indianas, como *Catla catla, Labeo rohita e Cirrhinus mrigala*, em um sistema de policultura intensivo. Foram realizados muitos trabalhos no Paquistão em relação ao peixe LWRs, entretanto, foram ignorados. As carpas foram alimentadas com doze dietas formuladas diferentes contendo quatro fontes diferentes de proteína, ou seja, farinha de peixe (FM), todas as partes de farinha de frango (APCM), glúten de milho (CGM) e farelo de soja (SBM). Cada tipo de proteína foi utilizado em nível de inclusão de 25, 35 e 45% nas dietas formuladas para avaliar a exigência mínima desse ingrediente para o crescimento ideal das espécies em mãos. Os valores da inclinação "b" variaram de 2,20 a 4,90 para essas espécies de carpas que mostraram uma forte relação saudável entre as variáveis nível de proteína e mês.

Palavras-chave: comprimento-peso, fator de condição, carpas, policultura, *Catla catla*, *Labeo rohita*, *Cirrhinus mrigala*.

1. Introduction

Knowledge of quantitative aspects such as weight-length relationship, condition factor, and growth recruitment is an important tool for successful fish farming and aquaculture. Length–weight relationships allow the conversion of growth-in-length equations to growth in- weight, for use in stock assessment models and the estimation of biomass from length observations (Balik et al., 2006; Kadhar et al., 2012; Ayoade, 2011). Length-weight relationships (LWRs) 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 (Zargar et al., 2012).

Condition factor also provides information when comparing two populations living in certain feeding area, density, climate, and other conditions; when determining the period of maturation; and when following up the degree of feeding activity of species to verify whether it is making good use of its feeding source (Ujjania et al., 2012). The study of the condition factor contributes to

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adequate management of these species and, therefore, to the maintenance of equilibrium in the ecosystem. The aim of this research was to follow a series of investigations to understand the efficacy of different formulated diets containing varying levels of different types of proteins.

2. Materials and Methods

A polyculture of Indian major carps *(Catla catla, Labeo rohita* and *Cirhinus mrigala)* was established in thirty-six re-circulatory concrete raceways with the dimension of 22′×50′ (W×L). Juveniles of *C. catla, L. rohita* and *C. mrigala* were reared in chlorine free water in the number of 33:33:34 respectively (Wahab et al., 2002). Twelve different combinations of formulated diets were prepared by using four different sources of protein i.e. fish meal (FM), all parts chicken meal (APCM), corn gluten (CGM) and soybean meal (SBM), and each source of protein was added in three different levels (25, 35 and 45%) into the experimental diets. Each raceway was treated with a different type of formulated diet for a period of one year and each feeding trial was performed into three raceways to confirm the efficacy of the diet. Temperature, dissolved oxygen, pH and other water quality parameters were within the optimum range for the growth of the in-hand species. The water temperature ranged from 10.1°C to 30.5°C, pH ranged 7.8 to 8.4 and dissolved oxygen was within the range of 5.1 to 8.4 mg/l during the whole experimental period.

Carps were captured from each raceway to measure body weight and total length at the end of every month and released back to their respective raceway. For the sake of convenience, growth parameters i.e. wet body weight and total length was calculated as mean of three replicates.

The coefficient of condition (K) was determined by using computer software A Bee version 1.0 developed by Pauly and Gayanilo Junior (1997), with the help of Formula 1:

$$K = W / w \ (W,\ Observed\ weights\ and\ w,\ predicted\ weight) \quad (1)$$

The data acquired on monthly basis, was subjected to statistical analysis by using MINTAB version 20.

3. Results and Discussion

Length-weight relationship provides an obvious allusion about the growth pattern of fishes by giving the value of condition factor (K) from known length (independent variable) and unknown weight (dependent variable) of fish and vice versa.

Table 1 shows the relation between total length and weight of major carps fed with different levels of animal and plant based diets. At the end of feeding trial, the mean values of K of all stocked major carps i.e. *Catla catla, L. rohita* and *C. mrigala* were within the range of 0.87 to 0.99 in all diets.

Tabulated form of length-weight relationship of major carps (*C. catla, L. rohita and C. mrigala*) (Table 2) indicates that all values of coefficient "b" of major carps fed with FM 25%, FM 35%, CGM 25, CGM 35, CGM 45 and SBM 25% were within range from 2.5 to 3.5i.e. *C. catla* 2.90 and 3.01, *L. rohita* 3.16 and 2.55 *C. mrigala* 2.70 and 2.70 in case of 25% and 35% levels of fish meal, *C. catla*, 2.51, 2.23 and 2.26 *L. rohita* 2.23, 2.33 and 2.20, *C. mrigala* 3.11, 3.03 and 2.97 by 25%, 35% and 45% levels of corn gluten meal respectively, while *C. catlaL. rohita* and *C. mrigala* acquired 2.93, 2.74 and 2.78 values of coefficient "b" respectively by 25% level of soy bean meal (Table 2). On the other hand in FM 45%, diets, these values were closed to 4 (*C. catla* 3.48, *L. rohita* 3.74 and *C. mrigala* 3.92) as mentioned by Tarkan et al. (2006), Frota et al. (2004) and Ujjania et al. (2012).

For all inclusion levels of APCM, slightly lower values of coefficient b were observed in *C. catla* but for *L. rohita,* lower value of coefficient b was only obtained by 35% level of APCM (3.46). Higher values were obtained by 25% and 45% levels (3.67 and 4.78) respectively as mentioned by Freitas et al. (2017). The most statistical relationships were observed in *Cirhinus mrigala* by all three levels of APCM (values of slopes; 4.47, 4.61 and 4.77 for 25%, 35% and 45% levels respectively). In case of soybean meal some values were more than 4 in 35% and 45% level i.e. *C. catla* 4.04, 4.94 *L. rohita* 4.38 as mentioned by Ujjania et al. (2012).

Beside these adequate associations, values of coefficient of determination (r^2) and correlation coefficient (r) were also verified a strong coordination among under observed growth variables.

Highly significant differences were observed for mean total length against months and levels of protein for all carps in all diets ($P<0.05$) except for *L. rohita* in FM based diets which showed a non-significant relation with levels of protein ($P = 0.399$) (Table 2).

Two-way analysis of variance for coefficient of condition (K) of under observed carps versus treatment (inclusion levels of protein) and months (Table 3) attributed that no significant differences of K were noted for 25%, 35% and 45% inclusion levels of all animal and plant based protein diets but month wise differences were evident ($P<0.05$) except for *L. rohita* in APCM ($P = 0.888$) and *C. catla* in SBM ($P = 0.173$).

In the present experimental trails, polyculture of Indian major carps viz. *Catla catla, Labeorohita* and *Cirhanus mrigala* was performed to determine the effectiveness of diverse feed ingredients in varying levels. Formerly Bandyopadhyay and Kumar (2006), Kadhar et al. (2012) and Sahu et al. (2007) were also reared these Indian major carps in intensive culturing system.

In fisheries studies, the status of determining length-weight relationship to examine growth pattern is eminent (Sangun et al., 2007; Balik et al., 2006). The log transformed length-weight relationships of all examined carps treated with both animal and plant origin diets are presented in Table 1. All raceways treated with fish meal based diets contained exceptionally high values of slope 'b' (2.5 to 3.5, in case of 25% FM and 35% FM and 3.48 to 3.92, in case of 45% FM). All values were in accordance with the findings of Sarkar et al. (2013), Bhakta et al. (2019), Deuri et al. (2020) and Coulter et al. (2018).The obtained values of regression coefficient (r and r^2) were also confirmed the aptness of environmental conditions.

The more satisfactory relationship between total length and body weight was evident in raceways received 25%,

Table 1. Length-weight relationship of major carps after one year feeding trial of different plant and animal based protein diets (N=100/Treatment).

Treatment	Specie	[1] Mean TL(mm)	[2] S.E	Min	Max	[3] K	[4] b(SE)	[5] r	[6] r²	95% CI Coefficient b
FM 25%	*C. catla*	259.3	17.6	190.3	375.6	0.988	2.90(0.18)	0.97	0.96	2.49-3.32
	L. rohita	270.2	20.1	172.2	395.3	0.996	3.16(0.14)	0.98	0.97	2.83-3.48
	C. mrigala	260.7	22.6	190.0	440.2	0.985	2.70(0.18)	0.97	0.95	2.29-3.10
FM 35%	*C. catla*	270.6	14.6	195.0	356.1	0.991	3.01(0.12)	0.99	0.98	2.72-3.30
	L. rohita	275.5	18.5	174.2	371.5	0.996	2.55(0.09)	0.99	0.98	2.33-2.77
	C. mrigala	267.2	16.2	201.1	390.1	0.986	2.70(0.18)	0.97	0.95	2.29-3.10
FM 45%	*C. catla*	274.7	16.2	192.0	359.0	0.984	3.48(0.22)	0.98	0.96	2.99-3.98
	L. rohita	288.3	14.0	206.0	341.0	0.996	3.74(0.25)	0.97	0.95	3.18-4.30
	C. mrigala	312.9	13.5	248.0	392.0	0.993	3.92(0.21)	0.98	0.97	3.43-4.40
APCM 25%	*C. catla*	278.5	18.7	198.0	391.0	0.988	3.54(0.18)	0.98	0.97	3.13-3.95
	L. rohita	289.8	15.8	196.0	351.0	0.995	3.67(0.12)	0.99	0.98	3.40-3.94
	C. mrigala	301.1	13.6	252.0	405.0	0.988	4.47(0.17)	0.99	0.98	4.08-4.87
APCM 35%	*C. catla*	273.9	21.5	190.0	400.0	0.995	3.35(0.09)	0.99	0.99	3.13-3.57
	L. rohita	298.9	20.4	210.0	422.0	0.986	3.46(0.19)	0.98	0.96	3.01-3.90
	C. mrigala	305.7	14.2	251.0	403.0	0.993	4.61(0.14)	0.99	0.98	4.28-4.94
APCM 45%	*C. catla*	330.0	24.2	200.0	443.0	0.995	3.48(0.15)	0.99	0.98	3.14-3.82
	L. rohita	326.5	13.1	220.0	366.0	0.996	4.78(0.20)	0.99	0.98	4.31-5.24
	C. mrigala	337.6	14.3	253.0	407.0	0.986	4.77(0.29)	0.98	0.96	4.11-5.44
CGM 25%	*C. catla*	275.9	27.8	136.8	443.1	0.990	2.51(0.10)	0.99	0.98	2.27-2.74
	L. rohita	269.6	29.8	121.9	449.7	0.984	2.23(0.06)	0.99	0.99	2.10-2.37
	C. mrigala	284.6	22.6	164.3	416.2	0.986	3.11(0.03)	0.99	0.99	3.02-3.19
CGM 35%	*C. catla*	263.7	29.7	130.9	453.0	0.996	2.23(0.12)	0.98	0.96	1.95-2.51
	L. rohita	276.8	30.8	126.7	463.5	0.994	2.33(0.07)	0.99	0.99	2.17-2.48
	C. mrigala	301.4	21.8	156.4	401.5	0.990	3.03(0.05)	0.99	0.99	2.91-3.15
CGM 45%	*C. catla*	300.0	32.0	131.8	486.1	0.999	2.26(0.11)	0.98	0.97	2.00-2.51
	L. rohita	291.0	33.7	137.6	501.0	0.998	2.208(0.09)	0.99	0.98	1.99-2.42
	C. mrigala	303.5	23.5	161.8	423.6	0.998	2.97(0.04)	0.99	0.99	2.86-3.07
SBM 25%	*C. catla*	276.2	17.7	195.0	382.3	0.997	2.93(0.09)	0.99	0.98	2.71-3.15
	L. rohita	238.0	23.3	182.6	420.5	0.981	2.74(0.12)	0.98	0.97	2.45-3.02
	C. mrigala	219.5	18.1	200.3	391.0	0.985	2.78(0.25)	0.96	0.92	2.22-3.35
SBM 35%	*C. catla*	278.6	15.3	162.0	324.6	0.991	4.04(0.24)	0.98	0.95	3.50-4.58
	L. rohita	200.0	11.5	145.2	265.6	0.965	4.38(0.37)	0.96	0.93	3.54-5.21
	C. mrigala	231.4	15.9	159.9	316.2	0.872	3.30(0.47)	0.91	0.82	2.24-4.36
SBM 45%	*C. catla*	275.4	10.7	160.9	269.0	0.979	4.94(0.27)	0.98	0.97	4.34-5.55
	L. rohita	214.5	20.4	154.3	369.1	0.916	3.178(0.49)	0.89	0.80	2.06-4.28
	C. mrigala	237.1	17.0	172.1	348.3	0.938	3.38(0.41)	0.93	0.86	2.45-4.31

Note: FM = fish meal; APCM = all parts chicken meal; CGM = corn gluten meal; SBM = soybean meal. [1]Mean TL = mean total length; [2]S.E = standard error; [3]K = condition factor; [4]b (SE) = value of slope(standard error of b); [5]r = correlation coefficient; [6]r² = coefficient of determination.

Table 2. One-way analysis of variance (ANOVA) for mean total length versus treatments (levels of protein) and months (N=100/Treatment).

Treatment	Specie	R-Sq	R-sq (adj)	Value of P	
				% of Protein	Months
FM	***Cattlacattla***	98.22%	97.16%	0.016**	0.000**
	Labeorohita	96.12%	93.84%	0.399*	0.000**
	Cirhinusmrigala	94.02%	90.49%	0.000**	0.000**
APCM	***Cattlacattla***	98.60%	97.77%	0.000**	0.000**
	Labeorohita	94.71%	91.59%	0.000**	0.000**
	Cirhinusmrigala	98.95%	98.32%	0.001**	0.000**
CGM	***Cattlacattla***	99.62%	99.40%	0.000**	0.000**
	Labeorohita	99.66%	99.46%	0.000**	0.000**
	Cirhinusmrigala	99.84%	99.74%	0.000**	0.000**
SBM	***Cattlacattla***	95.43%	92.73%	0.000**	0.000**
	Labeorohita	93.69%	89.96%	0.000**	0.000**
	Cirhinusmrigala	99.40%	99.04%	0.000**	0.000**

Note: FM = fish meal; APCM = all parts chicken meal; CGM = corn gluten meal; SBM = soybean meal. **Significant; *Non significant.

Table 3. Two-way analysis of variance (ANOVA) for coefficient of condition (K) of fish species fed with different plant and animal based protein diets versus treatment (levels of protein) and months. (N=100/Treatment).

Treatment	Species	R-Sq	R-sq (adj)	Value of P	
				% of Protein	Months
FM	***Cattlacattla***	77.58%	64.33%	0.921*	0.000**
	Labeorohita	61.95%	39.47%	0.961*	0.009**
	Cirhinusmrigala	62.62%	40.53%	0.931*	0.008**
APCM	***Cattlacattla***	88.72%	82.06%	0.910*	0.000**
	Labeorohita	19.90%	0.00%	0.979*	0.888*
	Cirhinusmrigala	50.44%	21.15%	0.946*	0.077*
CGM	***Cattlacattla***	97.75%	96.42%	0.811*	0.000**
	Labeorohita	87.80%	80.59%	0.939*	0.000**
	Cirhinusmrigala	64.40%	43.37%	0.998*	0.005**
SBM	***Cattlacattla***	44.33%	11.43%	0.949*	0.173*
	Labeorohita	72.42%	56.13%	0.187*	0.001**
	Cirhinusmrigala	88.84%	82.25%	0.331*	0.000**

Note: FM = fish meal; APCM = all parts chicken meal; CGM = corn gluten meal; SBM = soybean meal. **Significant. *Non significant.

35% and 45% APCM (Table 1). In case of corn gluten meal and soy bean meal based diets, values of b were obtained from 2.2 to 3.11 and 2.74 to 4.94 respectively and pursued cubicle law of growth pattern as the results of Ujjania et al. (2012), who observed a considerably strong relationship of length and weight of *C. catla*, *Labeo rohita and C. mrigala,* representing weight increase more rapidly in contrast with the cubic length. Moata et al. (2005) also confirmed this relationship with higher value of coefficient 'b' (3.41) for young ones of common carps.

Condition factor (K) with numerical value closed to 1 or above provides satisfactory health conditions. In all levels of FM and APCM, overall K values were much closed to 1 however, no significant difference was noted among all levels of fish meal but monthly variations were noted (Table 3). The same trends were exhibited by major carps in corn gluten and soy bean meal treated raceways. These co-ordinations of ecological factors for the growth of experimental carps confirm the consequences of Moata et al. (2005). An isometric type of growth of Indian major carps was also evident in extensive system, but condition index (K) of all experimental carps varies notably among treatments (Bhakta et al., 2019).

In present research trials, level of protein is proved to be a vital factor. Higher levels of Fish meal based diets (35% and 45%),gave lower values of mean weight increment, but high values of mean weight increase were acquired by experimental carps at the same levels of APCM.

On the other hand, a consistency in values was obtained in all levels of corn gluten meal, as it assimilate easily and also improves growth of fish species. Although enhanced growth of carps can be attained by 40% level of plant based protein diet, but its inclusions in higher quantity cause slow development because of absence of some amino acid like methionine, lysine and therionine (Kaur and Saxena, 2005).

4. Conclusion

All the values of "b" in present findings of feed trials were obtained within the ranges of limitations. The present study provides an open way to use less or having zero valued ingredients to make fish diets. This work will provide new discoveries and novel interpretations to the findings and significantly contribute to regional aquaculture development and industry.

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