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Effect of different supplementary diets on length-weight relationship and condition factor of stinging catfish, *Heteropneustes fossilis* (Bloch.) under captive conditions

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Abstract

An experimental study was conducted to observe the efficacy of different supplementary formulated diets on growth of *Heteropneustes fossilis* in terms of length-weight relationship and condition factor for 150 days. Four diets (Control - D_1; Experimental - D_2 - D_4) were prepared by using plant protein sources i.e. soybean meal and groundnut meal in addition to traditional feed components i.e. rice bran and mustard meal of control diet. Significantly higher ($p<0.05$) average final body weight (23.92g) and specific growth rate (0.66) was recorded with diet D_2 having major contribution from the soybean meal (24% rice bran, 24% mustard cake, 50% soybean meal). Maximum value of exponential 'b' (2.73), correlation coefficient 'r' (0.8510) and condition factor 'K' (0.67) in the diet D_2 further showed the positive effect of soybean meal on fish growth. However, the range of exponential 'b' from 1.99 to 2.73 and condition factor 'K' from 0.59 - 0.67 in all the diets indicate robustness or well being of fish throughout the study period. Thus, the results of the study showed the acceptability of soybean meal by *H. fossilis* in terms of higher growth and condition factor.

Introduction

Stinging catfish, *Heteropneustes fossilis* (Bloch.), commonly known as Singhi, is considered as one of the highly demanded freshwater air breathing fish species in the Indian subcontinent and Southeast Asian region. It is one of the hardy fish and needs less management practices for commercial production [12]. Moreover, it is very popular and highly priced due to its high digestibility, palatability, medicinal and nutritive value and lesser spines as well as fat. In-spite of all these advantages, the culture of singhi is not commercialized till now in India due to less or non-availability of quality seed and feed. In context to nutritionally balanced feed for *H. fossilis*, protein is by far the most important nutrient required for optimum growth of fish, which can be supplied from various animal and plant protein sources [34, 13, 32]. Among major plant protein sources, soybean meal (SBM) is the product obtained after oil extraction and reported to have crude protein levels of 44-48 % [25] along with balanced amino acids profile. Further, it has more than 90% digestibility in various freshwater omnivorous fish species. Several experiments revealed that the diets containing 28-32% crude protein primarily from SBM provide growth equivalent to diets containing animal protein such as fish meal and meat and bone meal [31, 33, 28] without requiring supplementation of any crystalline amino acids. Likewise, groundnut meal (GNM) is also considered as one of the important plant based protein supplement for promoting fish growth. It is highly palatable and has better binding properties for feed pelleting than soybean. It is one of the richest sources of B_1 and niacin, which are otherwise low in cereals.

Though a good deal of work has been carried out to study the effect of supplementary diets on different aspects of survival and growth of *H. fossilis* [14,27,4,19,21], but limited studies had been conducted on growth and culture potentiality of *H.*

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fossilis in terms of length-weight relationship (LWR) and condition factor (K). Therefore, the study has been carried out under captive conditions to know the effect of SBM and GNM on growth *H. fossilis* with respect to both these parameters.

Materials and Methods

Experimental design

The experiment was carried out in triplicate for 150 days in FRP pools (500liters capacity), having two inch soil layer at the bottom. After initial filling of pools with water, fingerlings of *H. fossilis* (Bloch.) were stocked @ 10/pool. At the time of stocking, the average total body length (cm) and weight (g) of fish ranged from 10.58 - 10.82 and 8.23 - 8.87 respectively.

Experimental diets and feeding of fish

For preparation of the diets (Control - D_1; Experimental - D_2 - D_4), ingredients were grinded, mixed and steam cooked to prepare the pellets (Table 1). The proximate analysis of different feed ingredients and prepared diets (Table 2) was done as per [2]. Nitrogen free extract was calculated by subtracting the values of crude protein, ether extract, crude fat and ash from 100. Gross energy (kcalg^{-1}) was calculated by using the energy factor 5 for proteins [38], 9 for fats and 4 for carbohydrates [16].

Fish were fed with formulated diets @ 5% of body weight once a day in evening hours throughout the experimental period. The feed quantity was regulated based on the fortnightly sampling of experimental fish.

Table 1: Percent Composition of supplementary diets

Ingredients	Experimental diets			
	D_1	D_2	D_3	D_4
Rice bran*	49	24	24	24
Mustard meal*	49	24	24	24
Soybean meal*	-	50	-	25
Groundnut meal*	-	-	50	25
Vitamin-mineral mixture	1.0	1.0	1.0	1.0
Salt	0.5	0.5	0.5	0.5

* Solvent extracted; Molasses was added as binder @ 0.5 % to all the diets

Table 2: Percent Proximate composition (DM basis) and gross energy of different feed ingredients and prepared diets

Feed/ feed ingredient	Crude protein	Crude fibre	Moisture	Ash	Ether extract	Nitrogen free extract	Gross energy (kcalg^{-1})
Rice bran	14.88	23.10	11.60	8.60	0.50	41.32	2.44
Mustard meal	36.58	24.80	10.30	7.50	1.16	19.66	2.71
Soybean meal	37.83	10.85	9.30	7.50	1.67	32.85	3.35
Groundnut meal	31.90	27.30	9.90	8.50	0.83	21.57	2.53
D_1	24.73	12.85	7.80	8.10	0.83	39.69	3.15
D_2	30.88	12.85	8.40	5.95	1.33	40.59	3.28
D_3	30.63	21.42	9.20	8.07	0.87	29.81	2.80
D_4	30.89	16.05	15.80	7.98	1.03	28.25	2.76

Water quality analysis

Water quality parameters (temperature, pH, dissolved oxygen, total alkalinity, ammonical - nitrogen, nitrite - nitrogen) were recorded at fortnightly intervals throughout the experiment according to [3].

Growth analysis

Fish were measured in terms of total body length and weight at fortnightly intervals. *Following growth parameters were calculated*

$$\textit{Specific growth rate (SGR)} = \frac{\ln \text{Av. final body weight} - \ln \text{Av. initial body weight}}{\text{Culture days}} \times 100$$

ln = Natural logrithum

Length-weight relationship

The length-weight (log-transformed) relationships were determined by linear regression analysis and scatter diagrams of length and weight. The length-weight relationship of the experimented fish is worked out as per cube law given by [23].

$$W = aL^b$$

Where, W=Weight of fish (g), L is total length (cm), 'a' is the regression intercept and 'b' is the regression slope.

The logarithmic transformation of the above formula is: Log W = log a + b log L

Fulton's condition factor (K): Fulton's condition factor (K) was calculated according to equation: W / L^3 x100 [17]

Where, W=weight of fish (g), L=Length of fish (cm).

Statistical analysis

One way ANOVA was applied to work out the effect of different diets on water quality parameters and growth of fish and two ways ANOVA to determined differences among the treatments and culture period ($p<0.05$). Bray Curtis similarity metrics, Principle Component Analysis (PCA) were conducted through PAST, SPSS (v 16.0) software.

Results

The values for all the water quality parameters were within the optimum range throughout the experimental period (Table 3). Moreover, the differences for these parameters among different treatments were not significant.

Average final body weight (23.92 g) and SGR was (0.66) found to be significantly higher ($p<0.05$) in D_2 followed by D_1, D_3 and D_4. The maximum value of condition factor 'K' was also recorded in diet D_2 (0.67) followed by D_1, (0.64), D_3 (0.60) and D_4 (0.59). The highest values of 'K' in D_2 suggested that fish fed with diet containing soybean meal were much more robust than the fish fed with other diets. Length – weight relationship of fishes in terms of regression co-efficient 'b' (2.73), Correlation co-efficient 'r' (0.8510) was also found to be highest in D_2 (Table 4 and Fig.1-4).

Table 3: Water quality parameters in different treatments

Parameters	Experimental Diets			
	D_1	D_2	D_3	D_4
Temperature (^{0}C)	30.17^a ±0.34	30.07^a ±0.56	29.70^a ±0.55	30.15^a ±0.55
pH	7.79^a ±0.12	7.97^a ±0.15	8.08^a ±0.15	8.03^a ±0.12
Total Hardness (mgl^{-1})	224.00^a ±19.68	212.54^a ±15.49	217.63^a ±17.51	238.81^a ±22.33
Dissolved Oxygen (mgl^{-1})	7.39^a ±1.63	6.93^a ±1.66	7.81^a ±1.26	8.33^a ±1.33
Total Alkalinity (mgl^{-1})	248.63^a ±18.90	251.81^a ±18.93	264.31^a ±16.44	292.04^a ±18.34
Ammonical nitrogen (mgl^{-1})	0.18^a ±0.07	0.10^a ±0.03	0.18^a ±0.04	0.16^a ±0.05
Nitrite nitrogen (mgl^{-1})	0.03^a ±0.003	0.02^a ±0.002	0.02^a ±0.003	0.02^a ±0.029

*Values (mean±S.E.) with same superscripts in a row / column do not differ significantly (P<0.05)

Table 4: Length weight relationship of *H. fossilis* in different treatments

Parameters	Experimental diets			
	D_1	D_2	D_3	D_4
Av. initial total body length (cm)	10.68^a ± 0.10	10.58^a ±0.08	10.69^a ± 0.04	10.82^a ± 0.11
Av. final total body length (cm)	14.13^b ± 0.31	14.85^a ± 0.39	14.30^b ± 0.29	14.05^b ± 0.63
Av. initial body weight (g)	8.63^a ±0.17	8.87^a ±0.18	8.23^a ±0.23	8.55^a ±0.17
Av. final body weight (g)	18.58^{bc} ±1.68	23.92^a ±0.93	16.61^{bc} ±1.45	15.88^c ±1.99
SGR %/day	0.51	0.66	0.47	0.41
Logarithm equation Log W= Log a+ b Log L	Log W= Log 0.000588 + 2.28 LogL	Log W= Log 0.000457 + 2.73 LogL	Log W= Log 0.000489 + 2.21 LogL	Log W= Log 0.00269 + 1.99 Log L
b	2.28	2.73	2.21	1.99
Regression co-efficient r	0.8057	0.8510	0.7903	0.7168
Coefficient of determination r^2	0.6492	0.7243	0.6246	0.5139
Condition factor K	0.64	0.67	0.60	0.59

*Values (mean±S.E.) with same superscripts in a row / column do not differ significantly (P<0.05)

Fig. 1-4: Logarithmic relationship between length and weight with regression equation of *H. fossilis* in different treatments (D_1 – D_4)

Fig. 1

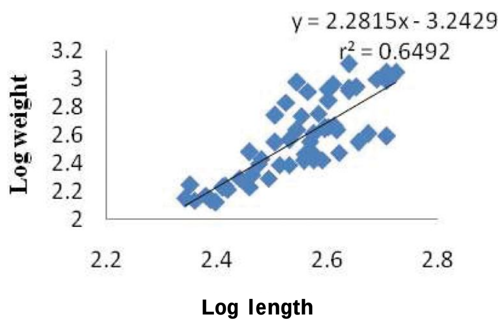


Fig.2

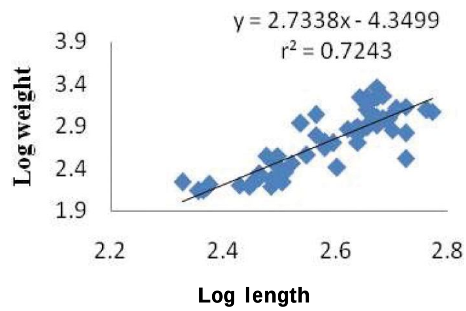


Fig. 3

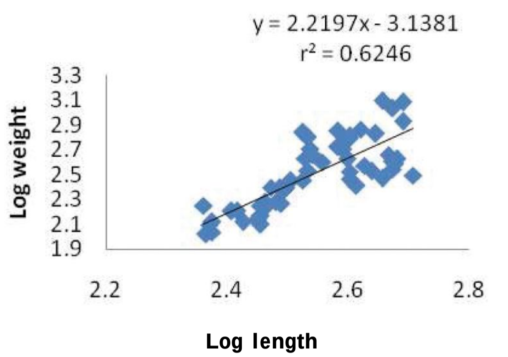
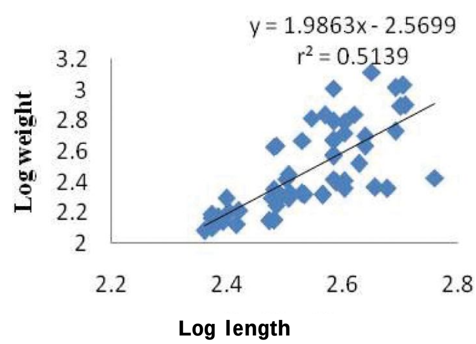


Fig. 4



Discussion

Growth, feed efficacy, feed consumption and overall well being of the fish depends on physico-chemical parameters of water [30] in relation to various environmental factors [9]. All the water quality parameters fluctuated during the experimental period, but were within the favourable range reported for fish culture as suggested by [7-8, 35].

The growth parameters revealed acceptability of SBM by *H. fossilis* (Bloch.), which can be attributed to its higher digestibility. [24 Also reported more than 90% digestibility of SBM in common carp, channel catfish, tilapia etc., [26] used SBM as sole protein source in the diet of *Oreochromis karongae* and obtained higher growth rate in term of SGR, FCR and fish yield. SBM is one of the most efficiently utilized protein sources for catfishes like *H. fossilis*, *C. batrachus* and *C. gariepinus* [37]. The acceptability of SBM by *H. fossilis* even at its highest level in present study also demonstrates its efficient utilization without any deteriorating effect on fish growth. Groundnut meal (GNM) alone or in combination (D_3 and D_4) with soybean meal did not showed encouraging results due to the deficiency of sulphur containing amino acids i.e. methionine and cysteine followed by lysine [18] along with deficient amount of vitamin B_{12} and calcium. The inclusion rates of GNM in experimental and practical diets for aquatic animals reported to be in the range of 5% to 61% [18]. The low feed intake, feed utilization and poor palatability [1] of GNM incorporated diets had also resulted in poor growth performance in *H. fossilis* in present study and therefore must be supplemented appropriately with lysine and methionine to have beneficial effect on fish growth [10].

The application of length-weight relationship (LWR) provide simple alternative to estimate body weight from length measurements that are less variable and more easily measured in the field. Growth is said to be positive allometric, when the weight of an organism increases more than length (b>3) and negative allometric when length increases more than weight (b<3) [39]. When total body length regressed with body weight, the slope value get significantly lower than critical isometric value i.e. 3. In the present study 'b' varied between 1.25 to 2.73 in all the treatments indicating negative allometric growth, which indicates that fish become slender as it increases in length [29]. The results of the study are in conformity with the views of [23, 11] that a fish normally do not retain the same shape or body outline throughout the lifespan and specific gravity of tissue may not remain constant and the actual relationship may depart significantly from Cube Law. Negative allometric growth has also been reported in previous studies in *H. fossilis* [19] and *Channa punctatus* [5,15]. Variation in slope may be attributed to sample size variation, life stages and environmental factors [20]. Highest slope and coefficients of determination (r^2) of *H. fossilis* in D_2 reflected the faster growth of fish compared to other diets.

The condition factor (K) of a fish reflects physical and biological characteristics and fluctuations by interaction among feeding conditions, parasitic infections and physiological factors [23] along with assessment of fish condition [22] based on weight at a given length (indicating energy reserves in fish). It indicates the changes in food reserves and thus the general health condition without undergoing *in vitro* proximate analysis of tissues [36]. Highest condition factor in D_2 showed the positive effect of SBM diet in terms of well being of fish under culture conditions [6].

Conclusion

Wild stock of *H. fossilis* under captive conditions reared on plant protein based formulated diets indicated a favourable response in terms of growth showing easy ecological transition from the wild habitat to the experimental environment. Hence, acceptability for plant based supplementary diets by *H. fossilis* confirms its potentiality for culture under captive conditions.

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