Effect of Different Feed Cycling Regimeson Growth, Economic Conversion Index and Body Composition of *Catla catla* (Hamilton, 1822)

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Abstract

A study was conducted to evaluate the effect offeed cycling regimes on growth, survival, feed conversion ratio, economic conversion index and body composition of *Catla catla*. Fingerlings of *C. catla* were randomly distributed into control (daily fed), 2D2F, 4D4F, 6D6F and 8D8F (2, 4, 6, 8 days deprivation and 2, 4, 6, 8 days feeding, respectively) feed cycling regimes. Weight gain and specific growth rate in 4D4F, 6D6F and 8D8F were significantly (P <0.05) lower than control and 2D2F feed cycling regime. Feed Conversion Ratio and Economic Conversion Index were found significantly (P <0.05) better in 8D8F feed cycling regime. Feed cycling regimes had significant (P <0.05) effect on body composition and RNA/DNA ratio. Protein, lipid and RNA/DNA ratio in 6D6F and 8D8F were significantly lower than control and 2D2F feed cycling regime. In conclusion, *Catla catla* fingerlings grown following 2D2F feed cycling regimes showed the capacity for growth compensation without compromising growth parameters.

Keywords: *Catla catla, feed deprivation, refeeding, body composition, RNA/DNA ratio*

Introduction

The feed cost contributes 40 - 70% of the operational cost of majority of aquaculture practices. The cost on feeding can be reduced by adopting appropriate feeding strategies. Taking advantage of ability of some of the fish species to achieve compensatory growth is one of the ways to reduce feed requirement. Compensatory growth refers to the unusual rapid phase of growth, greater than normal or control growth rates associated with adequate refeeding of animals following a period of under nutrition (Weatherly andGill, 1981).

A cyclical feed deprivation and refeeding have been used to induce compensatory growth and which have been found to vary with species.In case of

cyclical feed deprivation and refeeding, complete compensatory growth response was observed in three-spined stickleback, *Gasterosteusaculeatus* (Ali andWootton, 2001; Wu *et al*., 2003), gibel carp, *Carassiusauratusgibelio* and Chinese longsnout catfish, *Leiocassislongirostris* (Zhu *et al*., 2004), thaipangas, *Pangasiushypophthalmus* (Amin *et al*., 2005), *Sparusaurata*(Eroldogan*et al*. ,2006) and rohu, *Labeo rohita* (Prabhakar*et al*., 2008).

Growth and development of organisms are affected by composition of nucleic acids. Under changing environmental conditions the DNA amount remains stable which is indicator of biomass health (Holm-Hansen *et al*. ,1968). RNA,on the other hand, provides an estimate of ribosome numbers in tissues. Thevariation in nutritional status may change ribosome numbers in animal. Thus, measurement of RNA/DNA ratio can provide useful information about nutritional status of animal (Wang and Stickle, 1986).

Catla is the fastest growing species among Indian major carps. The information on compensatory growth of this species is scanty. Therefore, the present study was designed to evaluate the effect of different feed cycling regimes on growth and survival of fingerling of *Catla catla*..

Materials and methods
Experimental design

Fingerlings of catla were procured from Maharaja Fisheries (Gujarat, India) and acclimatized to the experimental conditions in wet Laboratory, College of Fisheries, Ratnagiri, Maharashtra for a period of 15 days. During acclimatization and experimental period, the fish were fedpractical diet. The formulation and proximate composition of diet is shown in Table 1.

Table 1.Formulation (%) and proximate composition (%) of practical diet.

Ingredients	Quantity (%)
Fish meal	31.44
Groundnut oil cake	31.44
Rice bran	37.05
Vitamin-mineral mix *	0.07
Proximate Composition	
Moisture (%)	4.6
Crude protein (%)	34.8
Crude lipid (%)	5.97
Crude fibre (%)	3.4
Ash (%)	7.31
Carbohydrate (%)	43.92
Gross energy (kcalg^{-1})	432.24

*Vitamin-mineral mix (Emix^{TM} plus, quantity kg^{-1}): Thiamine Mononitrate- 30 mg, Riboflavin IP- 30 mg, Pyridoxine hydrochloride IP- 9 mg, Vitamin B_{12} IP- 45 mcg, Niacinamide IP- 300 mg, Calcium pantothenate IP- 50 mg, Folic Acid IP- 1.5 mg, Biotin USP- 100 mcg, Ascorbic acid IP- 150 mg.

The fingerlings were subjected to five feed cycling regimes, *i.e.*, 2D2F, 4D4F, 6D6F, 8D8F (2, 4, 6, 8 days deprivation and 2, 4, 6, 8 days feeding respectively in cycles) and control (fish were fed daily to satiation)with four replicates for each regime. The fingerlings (average weight 0.9831 ± 0.15g) were stocked at the rate of 20 numbers in each experimental pool (500L) and reared for a period of eight weeks. In all experimental groups, fishes were fed at 5% body weight per day with formulated diet at 09:00 h and 16: 00 h. Daily 10% of water was exchanged andtotal water exchange was done once a week.

Water quality parameters such as temperature and pH were measured every other day using a Cyberscan PC300 meter, while dissolved oxygen and total alkalinity were monitored weekly following methods described in APHA (2005). Temperature ranged from 27 – 29 °C, pH varied from 7.8 – 8.5, dissolved oxygen maintained above 5 – 7.2 mg L^{-1} and total alkalinityfluctuated between 90 – 95 mg L^{-1} throughout the experiment and werefound in the optimal range.

Growth and Chemical analysis

At the end of the experiment, all the fishes were individually weighed. Weight gain (%), SGR (% day^{-1}), FCR and ECI were calculated,

The proximate composition of formulated diet and fish was analysed as per procedures described in AOAC (2006). The samples for RNA and DNA analysis were stored at -20 °C in refrigerator. RNA and DNA were isolated following technique of Schneider (1957) and quantified with diphenylamine and orcinol respectively by using spectrophotometer (Genesis 10uv, Thermo Fisher Scientific, India).

Statistical analysis

Statistical analysis was carried out using one-way analysis of variance (ANOVA) to test the significant difference among the experimental treatments. Statistical difference between means was determined using Student's Newman Keul multiple range test (P< 0.05) (Zar 2004).

Results and discussion
Growth, feed utilization and survival in fishes

Growthperformance indicators and survivalobserved in all feed cycling regimes are tabulated in Table 2. Growth performance parameters were found significantly better (P < 0.05) in control than other feed cycling regimes. Weight gain and SGR in 2D2F regime were significantly (P< 0.05) higher than 4D4F, 6D6F and 8D8F regimes whereas found statistically similar between 2D2F and control. Results of present study indicated that *C. catla* showed full compensatory growth when subjected to short duration of deprivation (2D2F regime)whereas it failed to compensate as duration of deprivation increased (8D8F regime).Similar results were obtained for complete compensatory growth in terms of weight gain and specific growth rate in *L.rohita* (Prabhakar*et al*., 2008); hybrid tilapia (Wang *et al*., 2000); gibel carp, *Carassiusauratusgibelio* and Chinese longsnout catfish, *Leiocassislongirostris*(Zhu *et al*., 2004);thaipangas, *Pangasiushypophthalmus*(Amin *et al*., 2005) and *Sparusaurata*(Eroldogan*et al*., 2006).However, Ali *et al.* (2006) and Iqbal*et al.* (2006) observed weak compensatory growth in *L. rohita* and *C. mrigala* respectively when subjected to 5 and 10 days deprivation and refeeding.This indicates that response of compensatory growth varies with the duration of the deprivation. In the present study, it was observed that compensatory growth depends on duration of feed deprivation and short term deprivation (2D2F);thus, elicited full compensatory growth in *C. catla*.

Table 2.Comparisons of different biological parameters, Feed conversion ratio and Economic conversion index of fingerlings of *Catla catla* fed with different feed cycling regimes for eight weeks

Parameter	Feed cycling regime				
	Control	**2D2F**	**4D4F**	**6D6F**	**8D8F**
Weight gain (%)	116.93 ± 5.41^{a}	107.10 ± 2.56^{a}	85.44 ± 7.40^{b}	52.64 ± 4.71^{c}	34.11 ± 5.77^{d}
SGR (% day^{-1})	1.15 ± 0.04^{a}	1.14 ± 0.02^{a}	0.96 ± 0.04^{b}	0.64 ± 0.05^{c}	0.46 ± 0.07^{d}
FCR	1.39 ± 0.03^{a}	0.72 ± 0.01^{b}	0.39 ± 0.01^{c}	0.33 ± 0.01^{d}	0.28 ± 0.01^{d}
ECI	31.38 ± 0.77^{a}	16.41 ± 0.20^{b}	8.85 ± 0.26^{c}	7.4 ± 0.23^{d}	6.37 ± 0.27^{d}
Survival (%)	90.00 ± 2.04^{a}	87.50 ± 3.23^{ab}	83.75 ± 2.39^{abc}	75.00 ± 4.56^{bc}	60.00 ± 4.56^{c}

Values (means of four replicates in each feed cycling regime ± SE, n=4) with different superscript in the same row are significantly different (P < 0.05)

FCR and ECI were significantly (P< 0.05) lower in 8D8F compared to control, 2D2F and 4D4F regimes. However, no significant difference was observed for FCR and ECIbetween 8D8F and 6D6F. In the present study, FCR and ECI got decreased with increase in duration of deprivation. Eroldogan*et al.* (2008)and Amin *et al*. (2005) reported the similar trend in juveniles of *S. aurata* and Thai pangas, *P. hypophthalmus* respectively. The lowest FCR and ECI in deprived and refed fish, which may be due to the less number of days during refeeding, ultimately reduced feed quantity and feed cost.

Table 3. Body composition of fingerling of *Catla catla* fed with different feed cycling regimes for eight weeks

Parameter	Feed cycling regime				
	Control	**2D2F**	**4D4F**	**6D6F**	**8D8F**
Moisture (%)	63.21 ± 0.62^{a}	65.04 ± 0.36^{ab}	68.59 ± 1.69^{bc}	71.81 ± 1.81^{cd}	76.21 ± 2.22^{d}
Crude Protein (%)	18.58 ± 0.44^{a}	17.19 ± 0.16^{a}	14.95 ± 0.97^{b}	12.73 ± 0.84^{c}	10.20 ± 0.89^{d}
Crude Lipid (%)	7.10 ± 0.17^{a}	6.43 ± 0.13^{a}	5.23 ± 0.31^{b}	4.45 ± 0.21^{b}	3.58 ± 0.43^{c}
Ash (%)	9.97 ± 0.37^{a}	10.59 ± 0.11^{a}	10.87 ± 0.39^{a}	10.65 ± 0.68^{a}	9.82 ± 0.99^{a}
RNA/DNA ratio	5.05 ± 0.06^{a}	4.90 ± 0.10^{ab}	4.77 ± 0.09^{ab}	4.60 ± 0.07^{bc}	4.09 ± 0.01^{d}

Values (means of four replicates in each feed cycling regime ± SE, n=4) with different superscript in the same row are significantly different (P < 0.05).

Survival of the control was significantly higher than that of the 6D6F and 8D8F regimes (P< 0.05) however, when compared with 2D2F and 4D4F regimes it was not significantly different (P>0.05). Survival observed in the present study is in accordance with Wang *et al*.,2009. The significantly lower survival in 8D8F feed cycling regime may be attributed to the comprehensive starvation, poor growth and condition of fish.

Proximate composition and RNA/DNA ratio in fishes

The proximate body composition of fingerlings at the end of the experiment is presented in Table 3.The lower level of protein and lipid (P< 0.05) were observed in 4D4F, 6D6F and 8D8F regimes as compared to control and 2D2F regimes. The similar results were found inGolden perch, *Macquariaambigua*(Collins and Anderson, 1995); common carp, *C. carpio*, (Bastrop *et al*., 1991);*Tilapia mossambica*,(Chalapathi*et al*., 1987). The depletion of lipid and protein content in 4D4F, 6D6F and 8D8F feed cycling regimes may be due to their utilization as an energy source during starvation period. Moisture content was found to be significantly (P<0.05) higher in fishes undergone 6D6F and 8D8F regimes than in control, 2D2F and 4D4F regimes. Moisture content was found to be inversely proportional to the lipid content of fish which is in accordance with Ali *et al*., 2006. Increase in moisture content with increased duration of starvation may be associated with tissue rehydration resulting due to depletion of body constituents during starvation.No significant difference (P>0.05) was observed in ash content among the treatments during present study which is in accordance with observations ofAli *et al*., 2006.

There was no significant difference in RNA/DNA ratio among control, 2D2F and 4D4F regime (P>0.05) whereas 8D8F regime had significantly lowest RNA/DNA ratio (P< 0.05).In *Labeo rohita*, maximum RNA/DNA ratio was observed in five days deprivation and five days feeding cycle regime which was significantly higher than control and 10 days feeding followed by 10 days feeding cycle over 90 days experimental period (Ali *et al*., 2006) but in the *Cirrhinusmrigala*, maximum RNA/DNA ratio was in control which was significantly higher than five and ten days feed cycling regimes (Iqbal*et al*., 2006). Starved carp had lower white muscle RNA and liver RNA concentration than fed fish, indicating reduced protein synthesis during food restriction period (Bastrop *et al*., 1991). Overall, the result of the present study was in accordance with Ali *et al*. (2006); Iqbal*et al*. (2006) and Bastrop *et al*. (1991). The decreased RNA/DNA ratio in 6D6F and 8D8F feed cycling regimes may be resulted due to reduction in ribosomal activity , *i.e*., increase in protein synthesis per ribosome and decreased RNA/DNA ratio during deprivation suggesting RNA/DNA ratio is more sensitive to the effect of feed cycling (Ali *et al*. 2006). These results indicated that fingerling of *C. catla* showed the compensatory response in terms of RNA/DNA ratio in 2D2F and 4D4F regimes and extended feed deprivation phase affects the nutritional quality of fish. In conclusion, this study shows that the 2D2F feed cycling regime is promising for cost effective production of *Catla catla*without compromising the growth performance and nutritional quality of fish.

References

[1] Ali, M. and Wootton, R.J., 2001. Capacity for growth compensation in juvenile three-spined sticklebacks experiencing cycles of food deprivation. Journal of Fish Biology, 58: 1531-1544.

[2] Ali M., Iqbal, R., Rana, S.A., Athar, M. and Iqbal, F., 2006. Effects of feed cycling on specific growth rate, condition factor and RNA/DNA ratio of *Labeo rohita*. African Journal of Biotechnology, 5: 1551-1556.

[3] Amin A.K.M., Bapary M.A.J., Islam M.S., Shahjahan M. and HossainM.A.R., 2005. The impacts of compensatory growth on food intake, growth rate and efficiency of feed utilization in Thai pangas (*Pangasiushypophthalmus*). PakistanJournal of Biological Sciences,8: 766-770.

[4] AOAC, 2006. Official methods of analysis of the Association of Official Analytical Chemists, 12th edition, In: Horwitz, W. (Ed.), Association of Official Analytical Chemists, Washington D.C., 1094 pp.

[5] APHA (Americal Public Health Association), 2005. Standard methods for the examination of Water and Waste water.21st edition.American Public Health Association, Washington D.C., 2605 pp.

[6] Bastrop, R., Spangenberg, R. and Jürss, K. ,1991. Biochemical adaptations of juvenile carp (*Cyprinus carpio* L.) to food deprivation. Comparative Biochemistry and Physiology, 98: 143-149.

[7] Chalapathi-Rao, M.V., Barthi, D. and Govindappa, S.,1987. Changes in tissue metabolic profiles of fish *Tilapia mossambica* during starvation and refeeding. Environment and Ecology, 5: 579-583.

[8] Collins, A.L. and Anderson, T.A., 1995. The regulation of endogenous energy stores during starvation and refeeding in the somatic tissues of the golden perch. Journal of Fish Biology, 47: 1004–1015.

[9] Eroldogan, O.T., Kumlu, M. and Sezer, B., 2006. Effects of starvation and re-alimentation periods on growth performance and hyperphagic response of *Sparusaurata*. Aquaculture Research, 37**:** 535-537.

[10] Eroldogan, O.T., Tasbozan, O. and Tabakoglu, S., 2008. Effects of restricted feeding regimes on growth and feed utilization of juvenile gilthead sea bream, *Sparusaurata*. Journal of the World Aquaculture Society, 39: 267-274.

[11] Holm-Hansen, O., Sutcliff, W.H. Jr. and Sharp, J., 1968. Measurements of the deoxyribonucleic acid in the ocean and its ecological significance. Limnology and Oceanography, 13: 507–514.

[12] Iqbal, F., Ali, M., Umer, K. and Rana, S.A., 2006. Effect of feed cycling on specific growth rate, condition factor and RNA/DNA ratio of *Cirrhinusmrigala*. Journal of Applied Sciences and Environmental Management, 10: 129-133.

[13] Prabhakar, S.K., Sardar, P. and Das, R.C., 2008. Effect of starvation with subsequent realimentation with respect to compensatory growth of Indian Major Carp, Rohu (*Labeo rohita* H.). Animal Nutrition and Feed Technology, 8: 89–96.

[14] Schneider, W.C., 1957. Determination of nucleic acids in tissues by pentose analysis. InS.P. Colowick, N.O. Kaplan, (Eds.), Methods in enzymology, Vol. 3. Academic Press, New York: 680-684.

[15] Wang, S.Y. and Stickle, W.B., 1986. Changes in nucleic acid concentration with starvation in blue crab, *Callinectessapidus*Rathbun.Journal of Crustacean Biology, 6: 49–56.

[16] Wang, Y., Cui, Y., Yang, Y. and Cai, F., 2000. Compensatory growth in hybrid tilapia, *Oreochromismossambicus*X *O. niloticus*, reared in seawater. Aquaculture, 189: 101-108.

[17] Wang, Y., Li, C., Qin J.G. and Han, H., 2009. Cyclical feed deprivation and refeeding fails to enhance compensatory growth in Nile tilapia, *Oreochromisniloticus*L. Aquaculture Research, 40: 204-210.

[18] Weatherley, A.H. and Gill, H.S., 1981. Recovery growth following periods of restricted rations and starvation in rainbow trout *Salmogairdneri* Richardson. Journal of Fish Biology, 18: 195-208.

[19] Wu, L., Xie, S., Cui, Y. and Wootton, R.J., 2003. Effect of cycles of feed deprivation on growth and food consumption of immature three-spined sticklebacks and European minnows. Journal of Fish Biology, 62: 184-194.

[20] Zar, J.H., 2004. Biostatistical Analysis, Fourth edition. Tan prints (I) Pvt. Ltd., Delhi, India, 663 pp.

[21] Zhu, X., Xie, S., Zou, Z., Lie, W., Cui, Y., Yang, Y. and Wootton, R.J., 2004. Compensatory growth and food consumption in gibel carp, *Carrasiusauratusgibelio* and Chinese longsnout catfish, *Leiocassislongirostris*, experiencing cycles of feed deprivation and re-feeding. Aquaculture,241: 235-247.