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Effect of feed deprivation and refeeding on growth performance and survival of *Labeo rohita*

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Abstract
The present study was aimed to evaluate the effects of feed deprivation and refeeding on growth performance and survival of *Labeo rohita* up to 90 days. Three hundred and sixty healthy fingerlings with average initial length 5.2±0.11 cm and weight 6.73±0.11 g were reared in FRP tanks of 200liter capacity containing freshwater. The control group was fed to satiation every day throughout the experiment. The other three groups were deprived of feed for one day (T_1), three days (T_2), six days (T_3) and two weeks (T_4) respectively and then fed to satiation during the refeeding period. At the end of the experiment, fish Starved and refeed in every alternate day (T_1) had similar body weights to the controls, indicating that complete compensation occurred in T_1, whereas partial compensation was observed in T_2 and T_4 groups. The higher specific growth rate (SGR) of T_1 and T_2 as compared to other treatments was observed at the end of a 90 days experimentation which supported over compensation of fish in the T_1 group followed by T_2. The higher protein efficiency ratio value of *Labeo rohita* was observed in the T_1 and T_2 group might be the result from hyperphagia due to starvation for one day and three days respectively. Hyperphagia might be one of the mechanisms to improve specific growth rate, food conversion ratio and protein efficiency ratio through which compensatory growth occurred, which was independent of duration of starvation.

Keywords: Compensatory growth, stunted growth, deprivation, refeeding, starvation, hyperphagia

Introduction
The compensatory growth is a process in which animals that have been "stunted" by an impoverished environment grow rapidly and catch up with animals of similar age once the environment is optimal. Periods of feed deprivation can be used to increase feed conversion efficiency resulting in more growth in fish. Compensatory feeding offers the possibility of improving the growth rates of fish by a careful choice of feeding schedules/ protocol in which periods of feed deprivation are followed by periods of satiation feeding. If compensatory growth can completely make up for growth loss during starvation, there could be an opportunity to save on fish feed by starving the fish and making up for lost growth when feeding resumes. Using compensatory growth is, therefore, perceived as a way to increase profits in aquaculture operations. Studies on the compensatory growth response of aquatic animals are not only of theoretical value in ecophysiology and evolution, but are also important to applications in aquaculture and fisheries resource management.
In India, very limited work has been done on compensatory growth of fish with regards to restricted feeding and refeeding. Prabhakar *et al*. (2006) [1] studied the effect of starvation followed by re-alimentation on performance and compensatory growth of *Labeo rohita*. Sardar *et al.* (2008) [2] reported the effect of feed quality restriction followed by realimentation on nutrient utilization, biochemical changes, and hematological profiles of Indian major carp, Rohu (*Labeo rohita* H.). Effect of protein restriction with subsequent realimentation on performance and carcass composition of Indian major carp (*Labeo rohita* H.) was studied by Sardar *et al.* (2008) [3]. Realizing the importance of the fish species *Labeo rohita* to India and its cultural importance for the farmers the present investigation has been designed to elucidate the effect of feed deprivation and refeeding on growth parameters like Survival, weight gain, food conversion ratio, protein efficiency ratio, specific growth rate (%), relative growth and daily weight gain and carcass composition of *Labeo rohita* upto 90 days.

Materials & Method
The investigation was carried out in FRP tanks of College of Fisheries (O.U.A.T.), Rangailunda for a period of 90 days from the month of March, 2014 to May, 2014 to assess

the growth performances of fingerlings under varied periods of starvation and feeding. All the treatments and control were conducted in triplicate. Each tank was stocked with 10 numbers of 90 days old fingerlings for the experimental purpose with more or less similar body weight and length (5.2±0.11 cm lengths and 6.73±0.11 g. in weight). Three replicas were maintained for control and each experimental group. Fishmeal based diets having 32% protein content prepared in laboratory were fed to control as well as experimental animals. To serve as control the test animals were fed to satiation on every day basis. Test one (T_1) animals were fed on every alternate day. Test two (T_2) animals were starved for 3 days and the next 3 days were fed up to satiation. 6 days starvation followed by 6 days feeding was adopted for test three (T_3) animals. Test four (T_4) animals were starved for 2 weeks and next 2 weeks were fed up to satiation.

Even though the water used in the study was hard, seasoning of water was done before use. The experimental tanks were cleaned manually and siphoning was done every day in order to remove excess left over feed and remaining faecal matter. An equal volume of clean water was replaced after siphoning. Once in three days 30% of the total volume of water from each FRP tank was exchanged. Important water quality parameters like pH, temperature, dissolved oxygen; total alkalinity, hardness and ammonia were measured from each of the experimental containers at fortnightly intervals by following the standard procedures (APHA, 1985). At an interval of every 15 days, the fishes were sampled treatment wise. The increment in total length and weight were measured and recorded for further computation of the result. Carcass composition of test animals before the experiment started and at the end of experiment was conducted in all treatments.

Table 1: Physico- chemical parameters during the experimental period

Parameters	Average Value
Temperature	28.5±0.36 ºC to 30.45±0.30 ºC
pH	7.5±0.20 to 8.0±0.48
Dissolved Oxygen	5.20±0.46 to 6.80±0.42 mg/l.
Ammonia	0 to 0.06±0.11 ppm
Alkalinity	70±0.04 to 75±0.2 ppm
Hardness	250±0.10 to 300±0.11 ppm

The experimental diet was prepared containing 32% protein level using locally available ingredients like rice polish, sesame oil cake, fish meal, corn flour, fish oil, vitamin and mineral mixture following the standard procedures for formulation of pellet feed. Rice polish was procured from the local market, sun dried properly to reduce the moisture content and then pulverized. The fish meal was prepared in the laboratory. Silver bellies were collected from the local market, cleaned properly and dried in an oven at 100°C for 6 hrs. Then it was dried properly, the dried fishes were pulverized in a pulveriser to get fish meal. Corn flour was procured from the market and added as one of the components, which serves as binder as well as provides stability to the diet**.** Sesame oil cakes were procured from the local market, sun dried properly to reduce the moisture content then pulverized. Vitabest (Natural vitamin supplement) manufactured by Virbac Animal Health India Pvt Ltd. used as a fat source for the preparation of the experimental diets at 3% per kg feed. The composition of vitabest is cod liver oil (50%) & Refined soya oil (50%). Water was added to different feed ingredients @ 30% of the total quantity in order to get a thick consistency for preparation of thick dough for utilization during the process of sterilization and palletisation. The vitamin and mineral mixture (Agrimin Forte) manufactured by Virbac Animal Health India Pvt Ltd chemicals used for the preparation of the diet at 2% per kg feed. Water was added to different feed ingredients @ 30% of the total quantity in order to get a thick consistency for preparation of thick dough for utilization during the process of sterilization and palletisation. Water was added to different feed ingredients @ 30% of the total quantity in order to get a thick consistency for preparation of thick dough for utilization during the process of sterilization and palletisation.

Table 2: Formulation and proximate composition of the experimental feed

Ingredients used for preparation of diet (%)	
Fish meal	27.5
Sesame oil cake	27.5
Corn flour	20
Rice polish	20
Oil	3
Vitamin/mineral Premix	2
Proximate composition of diet (% on dry matter basis)	
Moisture	7.02
Crude protein	32.16
Crude fat	6.48
Total ash	18.43
Crude fibre	6.01
Acid insoluble ash	2.39
Nitrogen Free Extract (NFE)	27.51

The quantity of different vitamins and minerals included in gram per kg diet were, Vitamin-A, 70,000 IU; Vitamin D3 70,000 IU ; Vitamin E 250 mg; Nicotinamide 1000 mg; Cobalt 150 mg; Copper 1200 mg; Iodine 325 mg; Iron 1500 mg; Magnesium 6000 mg; Potassium 100mg; Sodium 5.9 mg; Sulphur 0.72%; Zinc 9600 mg; Calcium 25.5%; Phosphorus 12.75%.

Preparation of diet

All the feed ingredients as mentioned above were procured and dried properly before preparation of the experimental diet to ensure reduction in moisture to prevent formation of crumbles. The dried ingredients were weighed individually and mixed well using pulverizer. The quantity of individual ingredients required to formulate one kg of diet was worked out using Pearson's square method to balance protein and energy levels. All the weighed ingredients were mixed thoroughly in a pulverizer and oil was added to the dry ingredients. Subsequently all the ingredients were hand mixed to ensure homogenous mixing followed by addition of required quantity of water and hand kneaded to form dough. The dough thus prepared was sterilized in an autoclave at 121 PSI for 15 minutes. Sterilized dough then cooled under room temperature. After proper cooling, a required quantity of weighed vitamin and mineral premix was added, mixed properly by hand kneading to prevent immobilization of vitamin and mineral premix, which were further palletized by using a hand pelletizer to form experimental feed pellets. The pellets thus formed were sun dried. Finally, the dried pellets were powdered to approximate sizes before feeding to the experimental animals.

Moisture was determined by oven drying at 100±2 °C for 12 to 14 h till constant weight is achieved. Crude protein was determined indirectly from the analysis of total nitrogen (crude protein = N x 6.25) by the Micro- Kjeldahl method. Crude fat was determined by repeated extraction with ether for 6 hrs. in Soxhlet apparatus. Ash was determined from dried samples in a porcelain crucible placed in a muffle furnace at 60 °C for 6 hrs. The growth rates in terms of relative length and weight gain, daily length and weight gain (g), percentage specific growth rate, feed conversion ratio (FCR) and protein efficiency (PER) ratio were calculated by following the standard procedures.

The data recorded during the process of present investigation were subjected to "t-test" to know the significant differences between the treatments to arrive at a conclusion with respect to period of feed deprivation and refeeding.

Result

The effect of feed deprivation and refeeding on growth performance and survival of *Labeo rohita* fingerlings feeding formulated feeds consisting of fish meal as the main sources of protein was analyzed with respect to different growth parameters. There was zero mortality observed up to the end of the experiment. It indicates that water quality parameters were suitable for animals during the experimental period. The average water temperature during study varied between 28.5-30.45 ºC. Average pH value 7.5-8.0 and Dissolve oxygen 5.2-6.8 mg/l was recorded. No considerable difference in initial length and weight observed among all treatment groups.

Table 3: Body length (cm) of *Labeo rohita* fingerlings with different feed deprivation and refeeding schedule of control and test groups at the end of the experiment (90th day)

Growth Parameters	T_0	T_1	T_2	T_3	T_4
Initial Length (cm)	5.2±0.11	5.2±0.15	5.1±0.11	5.3±0.1	5.36±0.15
Final Length (cm)	11.4±0.11	14.2±0.15	11.5±0.26	10.2±0.07	10.83±0.25
Increment in Length (cm)	6.2±0.11	9.0±0.15	6.4±0.18	4.9±0.08	5.47±0.2
Daily length gain (cm)	0.06±0.006	0.10±0.006	0.07±0.006	0.05±0.0	0.06±0.006
Relative length gain (%)	117.80±6.1	172.08±5.94	122.44±1.19	93.75±3.8	101.92±4.88

The length of different groups of fingerlings of *Labeo rohita* was measured at every 15 days interval up to 90 days. Among all the groups the group deprived and refeed for every alternate day (T_1) recorded the height length of 14.2±0.15cm at 90 days followed by 11.5±0.25cm the group under 3 days starvation and 3 days feed to satiation (T_2) compared with the control group which has a length of 11.4±0.11cm. The maximum length increment of 9.0±0.15 cm was observed in T_1 at the end of the study. In the case of T_3 (6 days deprivation and 6 days refeeding) and T_4 (2 weeks deprivation and 2 weeks refeeding) fails to compensate growth in length as compared with control. The daily length gain and relative length gain percentage was also higher in every alternate day starved and refeed group (T_1) than three days, six days and two weeks starved and fed to satiation group.

Table 4: Body weight (g) of *Labeo rohita* fingerlings with different feed deprivation and refeeding schedule of control and test groups at the end of the experiment (90th day)

Growth Parameter	T0	T1	T2	T3	T4
Initial Weight (g)	7.06±0.11	6.73±0.11	7.10±0.07	7.16±0.05	7.13±0.15
Final Weight (g)	16.24±0.31	23.82±1.02	18.66±0.43	14.26±0.42	16.07±0.11
Increment in Weight (g)	9.18±0.21	17.09±0.56	11.56±0.25	7.10±0.23	8.94±0.13
Daily weight gain (g)	0.09±0.005	0.18±0.01	0.12±0.005	0.07±0.005	0.09±0.005
Relative weight gain (%)	129.88±7.46	254.02±9.13	162.84±6.51	100.10±9.31	125.34±4.98

A significant difference in body weight of fish observed between control group and all other groups with one-day alternate deprivation and refeeding. A total weight gain of 17.09±0.56 g was measured at the end of the experiment in case of T1 which was significantly higher than all other treatment i.e. T_2, T_3 T_4 and control. Partial compensation was also observed in T_2 which has a total weight gain of 11.56±0.36 g. The least weight gain was noted for both T_3 (6 days deprivation and 6 days refeeding) and T_4 (2 weeks deprivation and 2 weeks refeeding) as compared to others at 90 days trial. It is clear from the result that treatment T_1 showed significantly higher followed by T_2 treatment group. The daily weight gain and relative weight gain percentage was noted maximum in one-day alternate feeding and starvation group (T1) followed by T_2, T_0, T_4 and T_3.

Table 5: Growth performances & survival of *Labeo rohita* fingerlings of control and test groups at the end of the experiment (90th day)

Growth Parameters	T0	T1	T2	T3	T4
Food Conversion Rati	1.77±0.01	0.94±0.06	1.01±0.04	1.47±0.24	0.99±0.13
Specific growth rate (%)	0.91±0.03	1.39±0.06	1.06±0.02	0.76±0.04	0.89±0.02
Protein efficiency ratio	1.87±0.03	3.51±0.13	3.29±0.10	2.25±0.05	3.5±0.07
Survival (%)	100	100	100	100	100

Specific growth rate of 1.39±0.06% was recorded at 90th day in the T_1 group which was impressively higher than fish of the control group. In addition, SGR in fish in T_1 & T_2 treatments were significantly higher than that of control but not significantly different from that of fish of T_3 and T_4 treatments. The lowest SGR of was obtained T_4 treatment. Feed conversion Ratio (FCR) of fish was good in T_1 compared with others. T_4 also had good FCR against T_2, T_3

and T_0 but lower than the T_1 group. T_1 reflects a stable FCR maintained throughout the experiment. Protein Efficiency Ratio (PER) of fish in T_1 was 3.51±0.13% and T_4 was 3.5±0.07% which was considerably higher than T_2, T_3 and T0 at the end of 90 days treatment. PER was determined to be similar in every 15 days study up to 90 days in the T_1 group.

Table 6: Final carcass composition of fishes (% on dry matter basis)

Parameter (%)	T0	T1	T2	T3	T4
Moisture	6.43	7.05	4.29	6.91	4.45
Crude Protein	54.26	58.38	58.67	61.00	56.44
Crude Fat (Ether Extract)	20.10	12.91	10.14	9.96	12.89
Crude Fibre	0.79	0.54	0.19	0.19	0.41
Total Ash	16.27	17.84	19.32	19.41	20.03
Acid Insoluble Ash	0.27	0.37	0.47	0.34	0.28
NFE	1.88	2.94	6.92	2.19	5.5

Concentrations of crude protein, crude lipid, ash and moisture were expressed as % dry weight. Moisture, crude protein, crude fibre, crude fat and NFE content of the whole body was notably different among treatments. However Total ash and acid insoluble Ash content of the whole body of fish was not significantly different among all treatment groups. The highest crude protein percentage observed in the six days deprivation and refeeding group as compared to others. The moisture percentage reduced from initial 8.12 to 7.05 in case of T_1 followed by 6.91 with T_3. The higher crude protein content of the carcass was observed but the increased value was determined for T_1, T_2, T_3 and T_4 test fish at the end of the 90 days experiment. From the observations obtained, evidence that growth was achieved due to good assimilation and absorption of feed by experimental fish.

Discussion

During starvation and refeeding the animals may partially or completely catch-up with body weight with those that have not gone food restriction. According to Jobling (2010) [4] compensatory growth refers to the capacity of fishes to grow abnormally rapidly after a period of reduced growth resulting from starvation or reduced food availability or some other unfavourable conditions. In the present study an attempt has been made to monitor compensatory growth on *Labeo rohita* fingerlings by recording length and weight in accordance with the previous investigators at supra. Gradual increase in length of control, T_1, T_2, T_3 and T_4 was evidenced in the present study. Temporary deprivation and refeeding (one day, three days starvation and one day, three days refeeding respectively) makes animals grow rapidly to make up for the loss. During six days and two weeks starvation and six days and two weeks refeeding schedule (T_3 and T_4 test animals) length gain and weight gain were lower than those of control, T_1, and T_2. Wang *et al*. (2000) [5] had also observed similar results in hybrid tilapia deprived for 2-4 weeks.

Complete compensation was reported within 3 weeks of refeeding in 1-2 g *Phoxinus phoxinus* after a 16 days deprivation (Russell and Wootton, 1992) [6] and in 16-120g rainbow trout after a 3 week deprivation (Quinton and Blake, 1990) [7]. After 4 weeks of refeeding body weight of hybrid tilapia that were feed deprived for 2-4 weeks were significantly lower than the control (Wang *et al*. 2000) [5]. It is similar to the result obtained from the present study where the fingerlings were deprived of food for 6 days and 2 weeks followed by 6 days and 2 weeks refeeding respectively (T_3 and T_4 group). The probable reason might be inability or low ability for food conversion, inability to utilize food efficiency to compensate for growth and/or greater weight loss during deprivation period. The higher specific growth rate in the T_1 group indicates that compensatory growth occurred. The high daily length gain, high daily weight gain, high specific growth rate was evident for the T_1 group at the end of the 90 days experiment.

Pravakar *et al.* (2006) [1] reported *Labeo rohita* subjected to starvation and refeeding at three or seven days alternately, during 90 days experiment period, could be able to compensate growth retardation and to catch-up the final body weight of control. 15 days starved and 15 days fed, 25 days starved and 25 days fed *Labeo rohita* failed to compensate growth during 90 days. Similar observations were also recorded by Singh and Balange, (2005) [8], for *Cirrhinus mrigala* restricted for 4 weeks. Hyperphagia might be the major contributor to the high growth rate during compensatory growth (Miglavs and Jobling, 1989 [9]; Russell and Wootton, 1992 [6] ; Jobling and Koskela, 1996 [10]; Jobling *et al*. 1994 [11]) and improved food efficiency had been reported for some fishes showing compensatory growth (Bilton and Robins, 1973 [12]; Dobson and Holmes, 1984 [13]; Russell and Wootton, 1992 [6]; Jobling *et al*. 1994 [11]). Wang *et al.* (2000) [5] observed hyperphagia but without any feed efficiency relating to the control.

Cirrhinus mrigala fry were able to achieve complete growth compensation within 6-8weeks following feed deprivation for 1-2 weeks (Singh and Balange, 2005) [8]. In contrast, *Labeo rohita* fingerlings of T_1 and T_2 group showed compensatory growth, but fingerlings of T_3 and T_4 group failed to achieve compensatory growth. The result indicated by Prabhakar *et al*. (2006) [1] conforms to the observations of the present study. Prabhakar *et al.* (2006) [1] demonstrated that rohu fingerlings starved and re-alimented for 3 or 7 days alternately during 90 days trial period could be able to compensate the growth retardation to catch-up the final body weight of fish of control. But the fish starved and re-alimented for 15 and25 days were unable to compensate the growth retardation during the 90 days period.

Higher specific growth rate of T_1 and T_2 as compared to other treatments was observed at the end of 90 days experiment which supported over compensation of fish in T_1 group followed by T_2. Cho, (2011) [13] corroborates the same result for juvenile Olive flounder. High values of relative length gain and relative weight gain of T_1 and T_2 group in this study indicates that compensatory growth was achieved in *Labeo rohita* fingerlings probably resulted from hyperphagia, good feed conversion ratio and protein efficiency ratio corroborating with studies made by several authors (Cho, 2011 [14]; Rueda *et al*. 1998 [15]; Geylord and Glatin, 2001 [16]; Wang, 2000 [5]; Tian and Qin, 2004 [17]; Cho, 2005 [18]; Cho *et al*. 2006 [19]).

Two weeks of feed deprivation and two weeks of refeeding to *Labeo rohita* fingerlings had almost the same values on weight gain, daily weight gain, daily length gain, and specific growth rate as that of control group. But less value on average increment in length and weight relative length and weight gain were recorded. Similar results have also been reported by S. Yengkokpam, N.P. Sahu, A.K. Pal, D. Debnath, S. Kumar, K.K. Jain (2014) [20] on the same species. Loss of body weight may be due to redirection of energy reserves to meet the demands of metabolic activities of fish during starvation

(Kokabas *et al.* 2013) [21]. This indicates that compensatory growth also achieved with two weeks starvation and two weeks refeeding. Higher protein efficiency ratio value in the T_1 and T_2 group might be the result from hyperphagia due to starvation for one day and three days respectively. Hyperphagia might have one of the mechanisms to improve specific growth rate, food conversion ratio and protein efficiency ratio through which compensatory growth occurred. Similar observations are also recorded by Schwarz *et al*. (1985) [22], Wang *et al.* (2000) [5] and Nikki *et al*. (2004) [23].

Conclusion

At the end of the experiment the length and weight of T_1 fingerlings (one day starvation and one day refeeding) were noted as highest followed by T_2 group among all other treatment groups and control. The result was indicative of steady growth in length and weight. No mortality throughout the experiment indicated that feed deprivation ranging from one day to two weeks and then refeeding had no effect on survival of *Labeo rohita* fingerlings. In the T_3 and T_4 groups of treatment, Labeo *rohita* fingerlings recorded the lowest value for all attributes than control, T_1, T_2 and control groups. The compensatory growth in *Labeo rohita* depends on length of feed deprivation. It is possible that a short-term starvation in *Labeo rohita* farming doesn't sacrifice fish length and weight gain of fish.

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Reference

1. Prabhakar SK, Sardar P, Manohar S. Effect of starvation followed by re-alimentation on performance of Labeo rohita (H), Indian Journal of Animal Nutrition. 2006;23(2):113-118.
2. Sardar P, Prabhakar SK, Dutta SC, Minhas HS. Effect of feed quality restriction followed by realimentation on nutrient utilization, biochemical changes, and hematological profiles of Indian major carp, Rohu (*Labeo rohita* H.), J Indian Fish Assoc. 2008;35:141-157.
3. Sardar P, Prabhakar SK, Dutta SC, Minas HS. Effect of protein restriction with subsequent realimentation on performance and carcass composition of Indian major carp (*Labeo rohita* H), Indian Journal of Animal Sciences. 2008;78(3):331-335.
4. Jobling M. Are compensatory growth and catch-up growth two sides of the same coin? quaculture International. 2010;8(4):501-510.
5. Wang Y, Cui Y, Yang Y, Cai F. Compensatory growth in hybrid tilapia, *Oreochromis mossambicus* × *O. niloticus* reared in seawater. Aquaculture. 2000;189:101-108.
6. Russell NR, Wootton RJ. Appetite and growth compensation in the European minnow, *Phoxinus phoxinus* (Cyprinidae), following short periods of feed restriction. Environmental biology of fishes. 1992;34:277-285.
7. Quinton JC, Blake RW. The effect of feed cycling & ration level on compensatory growth response in rainbow trout, *Onchorynchus mykiss*. Journal of fish biology 1990;37:33-41.
8. Singh RK, Balange AK, Vartak VR. Effect of restricted feeding regimes on compensatory weight gain and body tissue composition in *Cirrhinus mrigala* (Hamilton) fry. The Israeli Journal of Aquaculture Bamidgeh. 2005;57(3):185-190.
9. Miglavs I, Jobling M. Effects of feeding regime on food consumption, growth rate & tissue nuclic acids in juvenile Arctic charr, *Salvelinus alpinus* with particular respect to compensatory growth. Journal of fish biology. 1989;34:947-957.
10. Jobling M, Koskela J. Individual variation of feeding and growth in rainbow trout during restricted feeding and in subsequent periods of compensatory growth. Journal of fish biology. 1996;49(4):658-667.
11. Jobling M, Meloy OH, Dos Santos J, Christiansen B. The compensatory growth response of the Atlantic cod: effects of nutritional history. Aquaculture Intl. 1994;2:75-90.
12. Bilton HT, Robins GL. The facts of starvation and subsequent feeding on survival and growth of Fulton channel sockeye salmon fry (*Oncorynchus nerka*). Can. J aquat. Sci. 1973;30:1-5.
13. Dobson SH, Holmes RM. Compensatory growth in the rainbow trout, *Salmo gardineri* Richardson. Journal of fish biology. 2006;25(6):649-656.
14. Cho SH. Effect of dietary composition with different feeding regime on compensatory growth of juvenile olive flounder, *Paralichthys olivaceus*. J Anim. Sci. 2011;24(8):1148-1156.
15. Rueda FM, Martinez FJ, Zamora S, Kentouri N, Dibanach P. Effect of fasting & refeeding on growth & body composition of red porgy, *Pagrus pagrus* L. Auacult. Res. 1998;29:447-452.
16. Gaylord TG, Mackenzie DS, Gatlin DM. Growth performance, body composition, and plasm thyroid status of channel catfish (*Ictalurus punctatus*) in response to short-term feed deprivation and refeeding. Fish physiology & Biochemistry. 2001;24:73-79.
17. Tian X, Qin JG. Effect of previous ration restriction on compensatory growth in Barramundi, Lates calcarifer. Aquaculture. 2004;235:273-283.
18. Cho SH. Compensatory growth of juvenile flounder, *Paralichthys olivaceus* L. changes in biochemical composition & body condition indices during starvation & after refeeding in winter season. J World Aquac. Soc. 2005;36:508-514.
19. Cho SH, Lee S, Park BH, Ji S, Lee J, Bae J, *et al*. Compensatory growth of juvenile Olive flounder, *Paralichthys olivaceus* L. & changes in proximate composition & body condition indexes during fasting and after refeeding in summer season. J World Aquac. Soc. 2006;37:168-174.
20. Dobson, Yengkokpam S, Sahu NP, Pal AK, Debnath D, Kumar S, *et al*. Compensatory growth, feed intake and body composition of *Labeo rohita* fingerlings following feed deprivation. Aquaculture nutrition. 2004;20(2):101-108.
21. Kocabas M, Bacinar N, Kayim M, Er H, Sahin H. The different feeding protocols on compensatory growth of Black Sea Trout *Salmo trutta labrax*. North American Journal of Aquaculture. 2013;75:429-435.

22. Schwarz FJ, Plank J, Kirchgessner M. Effect of protein and energy restriction with subsequent realimentation on performance parameters of carp (*C. carpio* L.). Aquaculture. 1985;48:23-33.
23. Nikki J, Pirhonen J, Jobling M, Karjalainen J. Compensatory growth in juvenile rainbow trout, *Oncorhynchus mykiss*, held individually. Aquaculture. 2004;235:285-296.