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Effect of Short Term Food Deprivation and Re-Feeding on Growth, Feeding and Biochemical Body Composition in Sobaity Fish, *Sparidentex hasta*

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Abstract: In this study, the effects of different food deprivation and re-feeding has been examined on growth, nutrition, body composition and composition of liver. The groups consisted of the constant control over the experimental period until full feeding was twice daily, groups of 2-8 days of food deprivation followed by 8-32 days of re-feeding in repeated cycles during 80 days. At the end of expriment, the daily food intake, ash and moisture content of the body composition were significantly affected by alternating periods of food deprivation and re-feeding ($p<0.05$). But alternating periods of food deprivation and re-feeding are not effective on weight gain, specific growth rate, condition factor, feed conversion efficiency, protein efficiency ratio, lipid and protein content of body omposition and content of the liver glycogen and lipid ($p>0.05$). After the feeding period, roups that have experienced food deprivation showed complete compensatory growth. Because growth in these groups showed no significant difference compared with the control group. The study establish that, sobaity fish have ability to achive optimal growth after food deprivation and re-feeding periods.

Key words: Food deprivation, re-feeding, growth, feed intake, body composition, *Sparidentex hasta*

INTRODUCTION

Different species of fish confronted with food deprivation naturally. This phenomenon occurs, for example, during the Winter when long-term migration takes place for spawning or when food in the living area is reduced for various reasons. These changes are seasonal but can be changed and continue from a few weeks to several months. These food deprivation periods can cause a severe decrease in the energy resources of fish body and result in the exhaustion of fish tissues to survive (Frape, 1998). In the way that in short-term food deprivation the viscera and intestines lipid start to move as an energy source and water replaces with muscle fat. When the food resources come back to their normal state, muscle weight, liver glycogen and muscles fat also decrease (Jobling, 1994). On the other hand during the period of food deprivation, metabolism of body reduces, so that, the reduction in weeks after food deprivation is lower than in the weeks prior to food deprivation. It is also believed that the reduction of metabolism rate is continued for a certain period after the removal of undesirable conditions (Hornick *et al*., 2000). The response of some fish during food deprivation and re-feeding is hyperphagia which increases feed efficiency and improves the growth rate. These responses act as a management tool and increase the benefits of aqua culture activities to compensatory growth studies. Also, feeding strategies that stimulate the compensatory growth in fish can be considered as other useful ways to increase growth and feed efficiency (Gaylord and Gatlin, 2000). Compensatory growth has been studied in a wide range of fish species such as, salmonids (Johansen *et al*., 2001; Nikki *et al*., 2004; Sevgili *et al*., 2013a b; Tasbozan *et al*., 2016), Nile tilapia (*O. niloticus*) (Wang *et al*., 2009), hybrid tilapia (*O. mossambicus***O. niloticus*) (Wang *et al*., 2000, 2005), gibel carp (*Carrasius auratus gibelio*) (Qian *et al*., 2000; Xie *et al*., 2001), Chinese sturgeon (*Acipenser sinensis*) (Liu *et al*., 2011), hybrid striped bass (*Morone chrysops***Morone saxatilis*) (Turano *et al*., 2007, 2008) and other pecies. These feeding strategies, for example, can lead to improvement in time management three of employees, water quality and feeding activity of fish (Gaylord and Gatlin, 2000; Eroldogan *et al*., 2008; Guzel *et al*., 2011).

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The cost of formulated food and man power for the fish feeding is considered as a large amount of the total cost for cultivation of carnivorous fish. So, improvement in feeding strategies has great importance in cultivation ofcarnivorous fish. Sobaity fish is from a carnivorous species and mostly feeds on invertebrates and crustaceans (Abdessalaam, 1995). This fish is found in shallow and deep water in the Persian Gulf and the coast of India and it has great commercial importance (Fischer and Bianchi, 1984). The objective of the present study were to determine feeding time patterns in growth, food intake and body composition of sobaity fish in short-term food deprivation cycle protocols and re-feeding.

MATERIALS AND METHODS

Fish rearing and experimental design: All the practical and administrative procedures of this study were conducted from October 2012 to January 2013 in the Emam Khomeyni fisheries research station. A total of 300 sobaity fry with the average weight of 28.47±0.24 g were selected. Sobaity fry distributed randomly among 12 round fiberglass tanks with the containing capacity of 300 L each. At the time of experiment, the containing water of each tank was 250 L (25 fry per each tank). In order to provide oxygen for fry an air stone placed in each tank. To keep the temperature in favorable state, each tank equipped with a thermal controlling system (350 W ha). In order to be adapted with concentrate food, 2 weeks before the beginning of experiment, fry were fed on concentrate food. To review the effects of food deprivation periods and re-feeding on growth function, feeding, body composition, lipid and glycogen of liver were considered in 3 treatments with 3 times repetitions (Fig. 1). The duration of this study was 80 days. For this purpose, 4 groups were designed.

The three groups were periodically starved Fig. 1; 2 days food deprivation followed by 8 days re-feeding (T_1), 4 days food deprivation followed by 16 days re-feeding (T_2) and 8 days food deprivation followed by 32 days re-feeding (T_3). There was another group for the control group that were fully fed during all steps of experiment. At the end of food deprivation period, all groups were fully fed. In order to have equal food distribution, less water turbulences and an increase in perdurability of food in water, during the time offeeding, aerating to the tanks were stopped and after 20 min re-aerating were performed. Also, there were no feeding in biometry and sampling days. Temperature, pH and salinity were measured daily. Temperature were measured by a

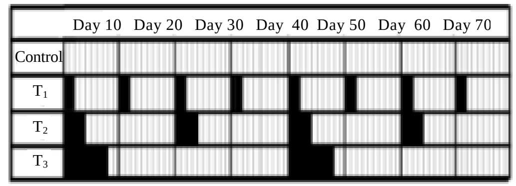

Fig. 1: Food deprivation and re-feeding groups during the experimental period (white = feeding and black = food deprivation)

digital portable thermometer, pH and salinity of water were measured by respectively, pH meter and salinometer. oxygen also measured weekly.

Growth and feed efficiency parameters: During the experiment, fish mortality were recorded and dead individuals removed from the tanks without adding any replacement. Biometry in individuals were taken every 10 days (weight with the accuracy of 0.1 g, total length and the standard lenght with the accuracy of 0.1 cm). After every biometry, growth indexes like Weight gain (Wg), Special Growth Rate (SGR), Condition Factor (CF), Protein Efficiency Rate (PER), Food Change Rate (FCR), Food Change Efficiency (FCE) and Daily Food Intake (DFI%) were measured (Kankanen and Pirhonen, 2009; Houde and Schekter, 1981).

Sampling and chemical analysis: At the beginning, middle and end of period, 6 individuals were selected randomly from each group for carcass composition analysis. Sampling were taken from the first group (2 days of food deprivation) in the days of 2-80 from second group (4 days of food deprivation) in the days of 4-80 and from the third group (8 days of food deprivation) in the days of 8-80 and from the control group on all the days mentioned. Measurements of carcass compositions were performed according to AOAC (1990). The moisture was measured by oven drying at 105°C for 24 h. Ash content was determined by incineration in German carbolite furnace for 4 h at 550°C. To measure the crude protein, the Kjehldal method and the automatic Kjeldahl analyzer (BUCHI 3700 analyser unit K Sweden) were used. In order to measure lipid an automatic Soxhlet device was used in the construction of Sweden and lipid was extracted by petroleum ether extraction. After removing liver's tissue the tissue were transferred to laboratory by a liquid nitrogen tank and were transferred to a freezer at -8°C. Liver glycogen and lipid were measured by respectively, Lo *et al.* (1970) and Frings *et al.* (1972).

Calculation and statistical analysis: Statistics were performed using the SPSS Computer Software Version 15.0 for Windows. The normality of distribution of variables was tested using Kolmogorov-Smirnov test. The possible differences in the variables among the groups were tested using one-way ANOVA. Post hoc comparisons between means were tested using Tukey test. Data were expressed as mean±Standard Error (SE) and differences were considered significant at the $p<0.05$ level.

RESULTS AND DISCUSSION

During the experiment period, temperature was 24.81±1.34°C and pH was 7.64±0.5.

Growth and feed efficiency parameters: The results of food deprivationthe and re-feeding on the growth and feed efficiency parameters in *Sparidentex hasta* are shown in Fig. 2-4. There were no significant difference in the initial body weight between groups ($p>0.05$). At the end of experiment there were no significant differences in WG, SGR, CF, FCE and PER between different groups ($p>0.05$). But there were significant differences in DFI between T_3 group compared to control group at 80 days ($p<0.05$).

Carcass compositions and liver glycogen and lipid: The results of food deprivationthe and re-feeding on carcass compositions in *Sparidentex hasta* are shown in Fig. 5. According to the results, food deprivation and re-feeding had a significant effect on body protein content in T_1 and T_3 at the end of experiment ($p<0.05$). Content of body lipid in T_1-T_3 groups were significantly lower than that of control group ($p<0.05$). But there were no significant differences in content of ash and moisture between different groups of experiment ($p>0.05$). At the end of experiment, food deprivation and re-feeding had not a significant effect on lipid and glycogen content of liver between different groups ($p>0.05$) (Fig. 6).

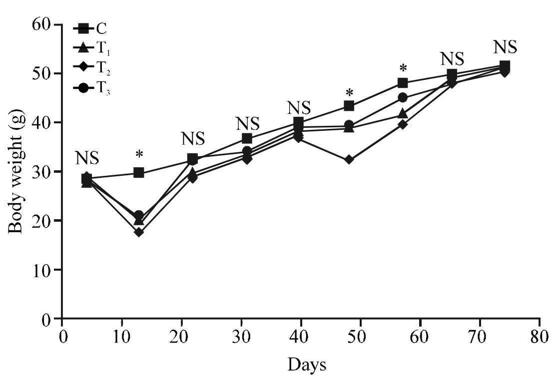

Fig. 2: Changes in body weight of sobaity fish in different groups during the experimental period

Compensatory growth has been reported in a wide range of animal from insects (Metcalfe and Monaghan, 2001) to birds and mammals (Dobson and Holmes, 1984). Several studies have been conducted by researchers in the largest group of vertebrates, namely fish. In the first, the term “Compensatory growth” were used for mammals and later it was used for warm-blooded domestic animals (Wilson and Osbourn, 1960). Few research was done in relation to compensatory growth in fish aquaculture in the early 1990’s when it was considered. Addition, studies of marine fishes are limited to only a few groups (Ali *et al*., 2003). Ability to compensate for growth retardation is an important adaptation that allows the fish in spite of variable and unpredictable environmental conditions to remain in mainstream. In addition, in the marine environment due to the abundance of food sources there is a greater chance of survival. This

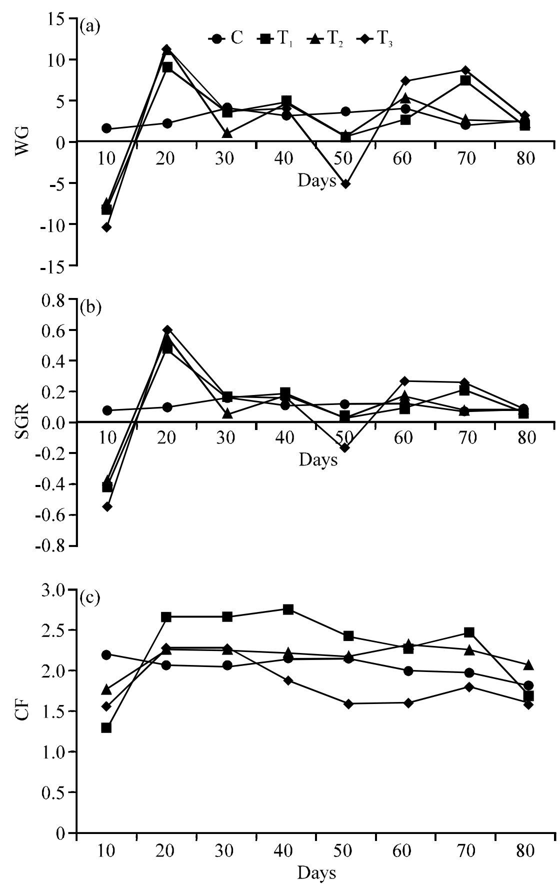

Fig. 3: Changes in: a) WG; b) SGR and c) CF of Sobaity fish in different groups during the experimental period

compensation capability allows the fish to reach the minimum size required for these physiological changes at younger ages (Maclean and Metcalfe, 2001). Considering the lack of weight differences between fishes under various dietary deprivation at the end of the experiment it can be concluded that the fish have ability to adapt to the conditions of this experiment and have managed to reach the same weight of the fish in the control group. The results of this study were consistent with the finding of (Foss *et al*., 2009; Xie *et al*., 2001) regarding the lack of significant difference in the final weight of control fish and the fish that have been down under the different periods of food deprivation and re-feeding. If the amount of food is reduced the fish will first compromise with a new level of feeding by losing weight and by feeding on this new level will show a weight gain proportional to the nutritional requirements in the new condition. In addition, the lack of weight difference between treatments in the present study may be attributed to the reduction in body weight loss during food deprivation due to the ability of fish to reduce the amount of basal metabolism rate. Basal metabolic rate during food deprivation is mainly due to decreased metabolic rate and visceral mass.

Therefore, the weight loss during the period of hunger has decreased which together with re-feeding during the experiment caused the difference between the groups under food deprivation and the control group to decrease. In contrast, the results of this study are not consistent with the results of Heide *et al.* (2006), Nikki *et al.* and Wang *et al.* (2000). Differences in various studies can be due to the size and characteristics of the

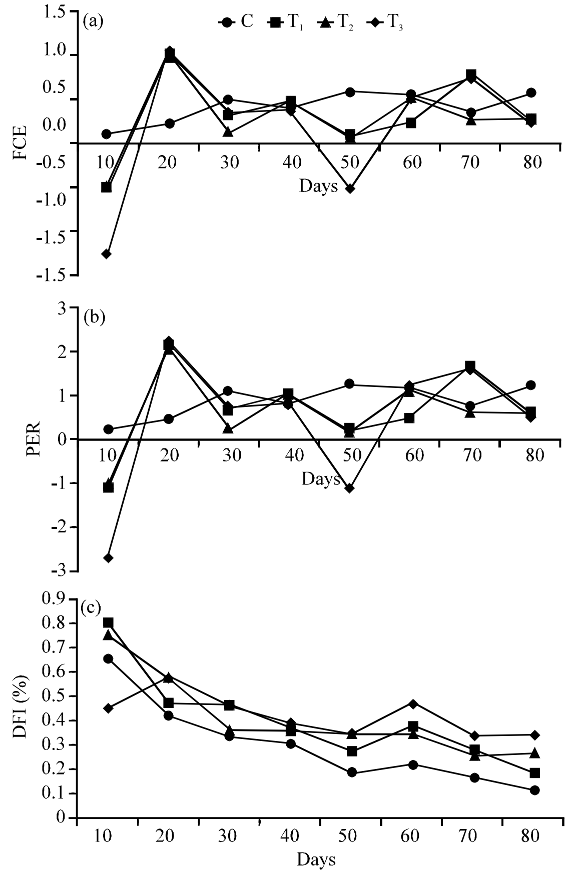

Fig. 4: Changes in: a) FCE; b) PER and d) DFI% Sobaity fish in different groups during the experimental period

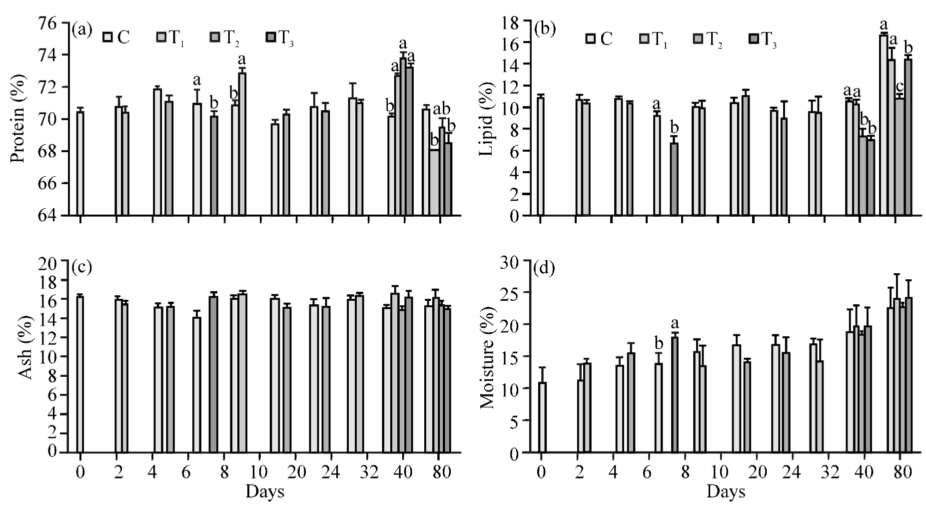

Fig. 5: Changes in: a) Crude protein; b) Crude lipid; c) Ash and d) Moisture contents of Sobaity fish in different groups after different periods of food deprivation and re-feeding during the experimental period. Means with different letters in the same column ar e significantly different ($p<0.05$)

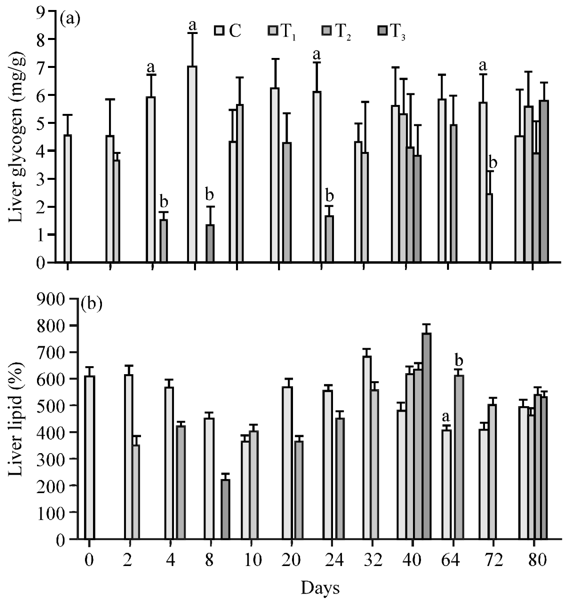

Fig. 6: Changes in: a) Liver glycogen and b) Lipid of Sobaity fish in different groups after different periods of food deprivation and re-feeding during the experimental period. Means with different letters in the same column are significantly different ($p<0.05$)

species in relation to the compensatory response or to the difference in species characteristics. In this regard, Wang *et al*. (2000) and Zhu *et al*. (2004) stated that salmonids require more time for compensatory growth and in addition it has been proved that in order to induce compensatory responses in larger animals require longer periods of food deprivation than smaller animals (Foss *et al*., 2009). Also, the causes of the differences in the studies done 7 by the researchers with each other and with this research can be due to the severity of food deprivation, the severity of malnutrition or experimental (Jobling and Koskela, 1996) or different culture systems (Eroldogan *et al*., 2008). At the end of the experiment the specific growth rate did not show any significant difference among the fish exposed to food deprivation compared to the control group. Studies on gibel carp fish (Xie *et al*., 2001) and on *Sparus aurata* (Eroldogan *et al.*, 2008) similar to the findings of this study, showed no significant differences in the specific growth rate of fish under food deprivation compared to the control group. Perhaps the reason for this may be attributed to the hierarchy of feeding in fish rearing tanks, since, fish show offensive behaviors after the elimination of food deprivation and most people are trying more to get food (Ali *et al*., 2003) also high individual variation may affect the effect of each group on growth efficiency (Sun *et al*., 2006).

Unlike to the views of these researchers Heide *et al*. (2006), Wang *et al*. (2000), Zhu *et al*. (2001), Tian and Qin (2003, 2004) reported contradictory results. In the studies of these researchers, the specific growth rates in the food deprivation groups were higher than the control group. The reason for this may be due to low energy costs during the period of food deprivation due to rest periods, increased feed efficiency, increased daily intake or a combination of all of these factors (Heide *et al*., 2006). Another possible reason for the high growth rate in food deprivation groups can be the reduction of metabolic rate in fish under food deprivation conditions due to their kinetic activity (Hayward *et al*., 2000; Jobling, 1980; Wieser *et al*., 1992).

Nikki *et al*. (2004) also, found a higher growth rate in some food-deprived groups in comparison with the control group and suggested the higher potential of these fish to compensate for starvation. At the end of experiment, the results of the condition factor showed no difference in any of the groups. Ali *et al*. (2003), Kankanen and Pirhonen (2009) in their studies, obtained similar results while Iqbal *et al*. (2006) were recorded a significant difference in this factor. The reason for these differences in these studies can be due to the severity of food deprivation, the severity of malnutrition or experiment conditions (Jobling and Koskela, 1996). Overall, according to the results of growth indices in this study it can be stated that the groups exposed to food deprivation showed a complete compensatory growth because the growth rate in these groups were no significant 8 difference compared to the control group. Over compensation has been reported in hybrid sun fish (Hayward *et al*., 1997) and channel catfish (Chatakondi and Yant, 2001). Full compensation were observed in *Oncorhynchus mykiss* (Nikki *et al*., 2004; Quinton and Blake, 1990), *Leiocassis longirostris* (Zhu *et al*., 2004), *Phoxinus phoxinus* (Russell and Wootton, 1992), *Gibel carp* (Xei *et al*., 2001), *Lates calcarifer* (Tian and Qin, 2003) with different protocols. In some studies, including (Wang *et al*., 2000; Jobling, 1980; Heide *et al*., 2006; Eroldogan *et al*., 2006; Wu *et al*., 2002) were reported partial compensation and the lack of compensation discussed by Hayward *et al*. (2000) study. The response to compensatory growth in fish can be related to the duration and severity of food deprivation before re-feeding (Bull and Metcalfe, 1997; Hayward *et al*., 1997). Also, studies on the response of fish to compensatory growth have shown that temperature (Dobson and Holmes, 1984; Maclean and Metcalfe, 2001), water quality (Quinton and Blake, 1990; Wicks and Randall, 2002), light period (Maclean and Metcalfe, 2001) and density (Hayward *et al*., 2000) affect the rate and severity of compensatory growth. One of the first mechanisms involved in compensatory growth responses is increasing food intake, known as hyperphagia phenomenon (Ali *et al*., 2003).

Hyperphagia is determined by increasing food intake and also the duration of daily feeding (Nicieza and Metcalfe, 1997). Hyperphagia has been proved during compensatory growth in fishes (Metcalfe and Thorpe, 1992). In the present study, the amount of daily food intake in T_3 (8 days of food deprivation and 32 days re-feeding) was significantly higher than the control group and the numerical value of this index in other groups was higher than the control group, so, hyperphagia seemed almost clear. Increased food intake during compensatory growth has been reported for Arctic charr (Jobling and Miglavs, 1993), Atlantic halibut (Heide *et al*., 2006), Rainbow trout (Boujard *et al*., 2000; Quinton and Blake, 1990), Three-spined stickleback and Minnow (Zhu *et al*., 2001), *Carassisus auratus gibelio* and *Leiocassis longirostris* (Zhu et al., 2004), *Leiocassis ongirostris* (Zhu et *al*., 2005).

The results of body composition in this study showed that the short-term periods of food deprivation and re-feeding were ineffective on some parameters such as ash and moisture. These results are consistent with results of (Qinton and Blake, 1990; Tian and Qin, 2003, 2004; Ali *et al*., 2006; Eroldogan *et al*., 2008; Oh *et al*., 2007; Ribeiro and Tsuzuki, 2010; Liu *et al*., 2011; Adakly and Tasbozan, 2015). Because of this lack of difference in the amount of moisture is probably the inverse relationship between body lipid and water (with an equal volume of water substitution catabolized lipid). Similar findings by Denton and Yousef (1976), Mlglavs and Jobling (1989) and Quinton and Blake (1990) also have pointed out that body weight during the hunger period is preserved by absorbing water to compensate for loss of organic material. In the present, study there were significant difference in body lipid between 2 and 3 groups compared to control group. Similar results have been reported in Pikeperch (Mattila *et al*., 2009), Atlantic halibut (Heide *et al*., 2006), Great sturgeon (Zhu *et al*., 2004), See bass (Adakly and Tasbozan, 2015) and Rainbow trout (Tasbozan *et al*., 2016). Figure 5 shows at the end of experiment, body protein was also affected by periods of food deprivation. In this regard, similar results have been reported by Wang *et al*. (2000) and Eroldogan *et al*. (2008). The usual response of fish to satisfy their energy needs during food deprivation is the use of lipid resources associated with protein. In fact, protein is used when the lipid resources are depleted (Henderson *et al*., 1988; Weatherley and Gill, 1987). Some researchers including Tian and Qin (2004), Ali *et al*. (2006), Iqbal *et al*. (2006), Mattilla *et al*. (2009), Quinton and Blake (1990) reported no effect of food deprivation on the rate of body protein. The cause of the difference in the biochemical composition of the fish body between the present study and other studies on food deprivation and re-feeding probably relates to differences in experimental protocols, physiological conditions of fish, environmental conditions, species, age and size of fish body (Jobling and Baardivk, 1994; Jobling and Koskela, 1996).

In the present study there were no significant different between different group in liver lipid and glycogen levels. It seems that the rapid and complete renewal of liver glycogen after the re-feeding of fish under food deprivation is a tactic for the rapid storage of energy of food and then used to synthesis of body materials. Similar results were also evaluated in *Rutilis rutilis* (Mendez and Wieser, 1993) and *Catostomus commersoni* (Bandeen and Leatherland, 1997). In most species, liver glycogen is the first part used as a source of energy when it is reduced, fat stores are used as energy and when both sources are roughly reduced the muscle protein is mainly used for energy (Navarro and Gutierrez, 1995; Echevarria *et al*., 1997; Meton *et al*., 2003). In contrast to our study, Liu *et al*. (2011) performed a study on the effects of food deprivation and re-feeding in *Acipenser sinensis*. They stated that at the end of re-feeding, liver lipid levels were significantly higher in the group of 14 days of food deprivation than in other groups.

CONCLUSION

After the feeding period, groups that have experienced food deprivation showed complete compensatory growth. Because growth in these groups showed no significant difference compared with the control group. Also, the present results indicate that Sobaity fish have ability to achive optimal growth after food deprivation and refeeding periods.

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