Effects of Feed Restriction to Enhance the Profitable Farming of Blackhead Seabream *Acanthopagrus schlegelii schlegelii* in Sea Cages

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Abstract – The feed intake, growth and body composition of juvenile blackhead seabream *Acanthopagrus schlegelii schlegelii* (Sparidae) (5.6 g fish⁻¹) were investigated for 16 weeks in sea cages under seven repetitive feeding cycles: every day feeding (control), 6-day feeding and 1-day fasting (F₆.₁), 5-day feeding and 1-day fasting (F₅.₁), 4-day feeding and 1-day fasting (F₄.₁), 3-day feeding and 1-day fasting (F₃.₁), 2-day feeding and 1-day fasting (F₂.₁), and 1-day feeding and 1-day fasting (F₁.₁). The survival of the fish during the experimental period was not different among the feeding cycles. The greatest weight gain of fish was observed in the control, but not significantly different from that of the F₆.₁ and F₅.₁ groups (p > 0.05). Total feed intake and daily feed intake decreased with the increase of fasting frequency, however, actual feed intake, feed efficiency and protein efficiency ratio increased with the increase of the fasting frequency. Proximate composition of the whole body of fish was not affected by different feeding cycles. These results suggest that juvenile blackhead seabreams subjected to repetitive feeding cycles of 6- or 5-days feeding and 1 day fasting for 16 weeks could achieve compensatory growth, and that such mild feeding deprivation could save significant amounts of feed without causing any profit reduction that might result from a decrease in fish size or quality.

Key words – blackhead seabream, feed restriction, compensatory growth, feeding cycles, profitable

1. Introduction

The optimal levels of feeding for high or maximum growth in several fish species have been studied using various feeding regimes (Quinton and Blake 1990; Cho et al. 2006; Oh et al. 2010). Meanwhile, it has been frequently questioned whether the increase of feeding could result in enhanced growth of fish and enhanced profits for fish farmers. The price of fish feed keeps increasing in world markets. Feed cost normally dominates 50-60% of the total fish production cost (Sveier and Lied 1998). Hence, for contemporary successful fish farming, an optimized feeding regime which could save feed costs without causing growth retardation, quality and profit loss, is needed for profitable aquaculture development and management.

Feed restriction does not always result in growth retardation of fish (Känkänen and Pirhonen 2009; Rosauer et al. 2009; Cho 2011). Compensatory growth response showed that fish temporarily deprived of feed can grow rapidly when feeding is resumed and catch up with fish that were not deprived of feed (Ali et al. 2003; Tian and Qin 2004). Due to this response, restricted feeding regimes were suggested for various fish species (Quinton and Blake 1990; Kim and Lovell 1995; Lee et al. 2000; Wu et al. 2003; Zhu et al. 2005; Reigh et al. 2006; Oh et al. 2008; Cho and Cho 2009), implying that a feeding regime with temporary fasting could be developed as a way of more economically feeding some cultivable fish species.

Development of a feed restriction method is not only required for economical reasons but also to address environmental concerns (Cho et al. 2006). Several studies have shown that organic matter from fish farms can negatively affect the environmental sea bottom situation. This holds for sediment chemistry (Findlay and Watling 1997; Hargrave et al. 1997; Yokoyama et al. 2009), community dynamics of marine seagrasses (Pergent et al. 1999), benthic macrofauna (Hargrave et al. 1997), meiofauna (La Rosa et al. 2001; Mirto et al. 2005; Reigh et al. 2006; Oh et al. 2008; Cho and Cho 2009), implying that a feeding regime with temporary fasting could be developed as a way of more economically feeding some cultivable fish species.
2002), and bacteria (La Rosa et al. 2001). Fish farming, particularly in sea cages, is recognized as one of the causes of water pollution through nutrient loading in many parts of the world including Korea (Islam 2005). Properly organized feed restriction should, therefore, be helpful to reduce the amount of feed input to the sea cages to minimize the pollution of the water column and underlying sea-bottom and improve the long term success of fin-fish farming activities.

The blackhead seabream *Acanthopagrus schlegelii schlegelii* of the family Sparidae is a commercially important fish for marine aquaculture, especially in Far East Asian countries like Korea, Japan and China (Zhou et al. 2011). Juvenile blackhead seabream are commonly reared in sea cages until they grow to market size. In the present study, juveniles were subjected to different cycles of repetitive feed deprivation in contrast to satiation feeding to determine an optimized profitable feeding regime for blackhead seabream.

2. Materials and Methods

Experimental design and sampling

The juveniles of blackhead seabream were obtained from a private hatchery (Geoje, Gyeongsangnamdo, Korea), and acclimatized to experimental conditions in a floating sea cage farm [Tongyeong Marine Living Resources Research & Conservation Center (TMRC), Gyeongsangnamdo, Korea] for a month. During acclimatization, fish were fed on a commercial diet of dry pellets (Aller Aqua Co., Christiansfeld, Denmark: 11.4% moisture, 42.5% crude protein, 9.4% crude lipid, 8.0% ash, and 21.2 kJ/g energy) to apparent satiation twice a day. After this conditioning period, a total of 2100 juveniles (body weight, 5.6 ± 0.1 g) were divided into 7 groups, and each group was randomly assigned to one of seven different feeding cycles: every day feeding (control), 6-day feeding and 1-day fasting (F6.1), 5-day feeding and 1-day fasting (F5.1), 4-day feeding and 1-day fasting (F4.1), 3-day feeding and 1-day fasting (F3.1), 2-day feeding and 1-day fasting (F2.1), and 1-day feeding and 1-day fasting (F1.1). Fish in control, F6.1, F5.1, F4.1, F3.1, F2.1 and F1.1 groups were fed to satiation for 112, 96, 94, 90, 84, 75 and 56 days, respectively. In other words, they were fasted for 0, 16, 18, 22, 28, 37 and 56 days in total, respectively, during the experimental period (16 weeks). Each feeding cycle group consisted of 3 replicate cages with 100 juveniles per cage (1 × 2 × 2 m, mesh size 3 mm). Fish in all feeding cycle groups were fed by hand with commercial dry pellets (the same as during the acclimation period) twice a day at 09.00 and 16.00 hrs. Pellets were dropped into each cage at intervals of 5 min until the fish ceased to eat due to satiation, and the container of the pellets was weighed before and after every feeding to record the amount of feed eaten by the fish. Care was taken to ensure that all feed provided was eaten by the fish. During the experiment, water temperature [17.9 to 25.8°C (22.3 ± 1.9°C)], salinity (31.4-33.2 psu), pH (8.2-8.3) and dissolved oxygen (6.2-9.2 mg L⁻¹) were monitored daily.

Growth performance

At the end of the feeding trial, all fish were made to fast for 36 hrs to empty their gut and then anaesthetized with 2-phenoxyethanol (Sigma, St. Louis, MO, USA) solution (150 mg L⁻¹) to minimize the stress prior to measurement. Fish in each experimental cage were bulk-weighed and counted to calculate growth rate, feed utilization and survival. Specific growth rate (SGR), daily feed intake (DFI), actual daily feed intake (ADFI), feed efficiency (FE) and protein efficiency ratio (PER) were also calculated as follows:

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\text{Specific growth rate (SGR, % day}^{-1}) = 100 \times \frac{\ln W_f - \ln W_i}{t} \\
\text{Daily feed intake (DFI, % BW day}^{-1}) = 100 \times \frac{C}{[(W_f + W_i)/2]/t} \\
\text{Actual daily feed intake (ADFI, % BW day}^{-1}) = 100 \times \frac{C}{[(W_f + W_i)/2]/\alpha} \\
\text{Feed efficiency (FE) = 100 × (W_f - W_i)/C} \\
\text{Protein efficiency ratio (PER) = (W_f - W_i)/D} \\
\]

Where \( W_f \) and \( W_i \) are final and initial weights (g), \( BW \) is body weight, \( t \) is the experimental duration (day), \( \alpha \) is the feeding duration (day), \( C \) is the total amount of the consumed feed on a g-dry weight basis, and \( D \) is crude protein intake.

Proximate composition analysis

Thirty fish from each replicate of the seven feeding cycles were randomly sampled and stored at -30°C for the analysis of proximate body composition. Proximate composition of the experimental diets and fish were analyzed according to standard methods (AOAC 1990). Crude protein content was determined by the Kjeldahl method using an Auto Kjeldahl System (Foss Tecator, Hoganas, Sweden). Moisture content was measured by oven drying at 105°C for 6 hrs. Crude lipid was determined by the ether-extraction method and ash content was determined by a muffle furnace at 600°C for 3 hrs.

Statistical analysis

Data associated with growth, feed utilization and survival...