Evidence of compensatory growth of the gilthead seabream, Sparusaurata (Linnaeus, 1758)

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Abstract:

A feeding experiment was carried out to investigate the possibility using the phenomenon of compensatory growth to improve growth and feed utilization of gilthead seabream, Sparusaurata. Five feeding cycles were employed: daily feeding ; one week of starvation followed by one week feeding (1:1); two weeks of starvation followed by two weeks of feeding (2:2); three weeks of starvation followed by three weeks of feeding (3:3); six weeks of starvation followed by six weeks of feeding (6:6). By the end of the experiment, fish subjected to a feeding cycle (3:3) produced comparable results in terms of growth performance to the fish that were fed daily. Those showed improved food utilization in terms of food conversion ratio (FCR) and feeding efficiency (FE), compared to those on the other treatments. The results of 1, 2, and 6 weeks cycles are not so good as other the 3 weeks cycle a control feeding regimes. The studies so far provide evidence of the adequate of the fish to starvation followed by what may be termed compensatory growth once feeding was resumed when a 3 weeks starvation feeding cycle is employed.

Keywords : Evidence . Compensatory growth; Gilthead seabream, Sparusaurata.

Introduction:

The gilthead seabream, Sparusaurata (L.), (order: Perciformes, Family: Sparidae), is a marine temperate water fish species which has eurythermal (10-36 c^o), and euryhaline (5-60

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ppt) capacities [4,5]; and it is resistant to high variation in the environment. S. aurata is abundant in the Mediterranean sea, and has also reported in the black sea and eastern Atlantic coasts [8]. S.aurata was first cultured in the early 1970's in intensive system in Italy withother country joining this effort in later year [13]. S.aurata have become very important in the Mediterranean region distinguished by their quality market value (Anon,1993). S.aurata is cultured and grown in different aquaculture system both extensively, in brackish water lagoon, and intensively, in tanks, ponds and floating cages. Production of finfish from marine aquaculture has been grown steadily during the past decade. According to [2], the production of S.aurata and D.labrax in the Mediterranean has increased dramatically in recent years from 30,000 metric tons in 1994 to 40,000 mt in 1995 to 48,500 mt in 1996 and to 55,000 mt in 1997. By the end of this year the figures expected a much higher than those in the previous years. Compensatory growth is the phase of rapid growth greater than normal or control growth, with occurs upon adequate refeeding following a period of under nutrition [7]. The effect of food cycling (period of starvation followed by period of refeeding), on compensatory growth in S.aurata would be very interesting in feed management. Compensatory growth occurs in wide range of domestic animals and birds [27]. Among fish species, compensatory growth has been reported for Salmonids, cyprinids and Pleuronectids [2] [25,10]. The objective of this study was to investigate the possibility of the phenomenon of compensatory growth being found in S. aurata and using the phenomenon to obtain optimum feed efficiencies.

Materials and methods:

The growth experiment 2.1

The experiment was carried out over a 15 week period, between 1stOctober 2008 and 21st January 2009. This corresponded to a total of (105) days including an acclimation periods of (3) weeks.

The experimental tanks:

Fifteen square white fiber glass tanks (1.5m^3), located indoor were used , an open system was used during the experimental period. The tanks received borehole water of constant salinity of (37%), and water temperature of (20 c^o). The water was supplied at a rate of between 20-25 L/min for each tank to maintain an adequate dissolved oxygen level at excess of 8.0 mg/L and a constant temperature of (21c^o).

The experimental fish:

300 fishes of gilthead seabream, Sparusaurata. were obtained from the previous cage stock of a government fish farm (RassElhelal. Fish Farm Cage), and transfer to the experimental tanks of Marine Biology Research Center in Tajura, with sufficient oxygenation. The experimental fish had an average body weight of 127 grams, the fish was distributed randomly in the tanks (20 fish /tank). During the acclimation the fish were fed to satiation once a day at 8.00 am. At the start and at the end of the experiment, a random sample of each tank was weighed; at seven day intervals from each tank were also randomly sampled and under anesthetic (2-phenoxy ethanol), weighed and measured in order to monitor the growth performance. The weight of the fish was taken using an electronic balance to an accuracy of (0.1g.).

Diets and feeding regimes:

A pelleted commercial food of 2.5 mm diameters (EWOS S.A; Spain), the nutritional composition of the experimental feed used in the experiment is given in Table.1. Five feeding regimes were evaluated over an experimental period of 12 weeks. 15 tanks were randomly assigned to each of the following treatments:1-(12 weeks of daily satiation feeding); 2-(starvation for one week followed by one week of satiation feeding); 3-(starvation for two weeks followed by two weeks of satiation feeding); 4-(starvation for three weeks followed by three weeks of satiation feeding); and 5-(starvation for six weeks followed by six weeks of satiation feeding). Feeding regimes is employed is given in. (Table. 2).

Table 1. Proximate composition (%) of the experimental feed (EWOS S.A; Spain).

Proximate	Crude protein	Crude lipid	Crude fiber	Moisture	Ash
Composition (%)	49.35	13.11	2.71	7.94	9.50

Proximate analysis (% wet weight).

Assessment of fish performance:

Using the body weight recorded of the start and at intervals during the experiment were used to calculate the mean initial and final body weight for each treatment. The parameters used to assess growth performance and feed utilization were: SGR (%BW/day)=Log(Fin.BW-Int.BW)X100/days; FCR=Food intake/Increasein biomass; FE (%) = Increase in biomass/Food consumedX100 .

Statistical analysis:

Using the individual data for the three replicates of each treatments, statistical analysis were carried out to establish whether there were any significant differences between different treatments for each of the performance parameters. The Student-Newman-Keuls Multiple Range Test [28] was used at a level of significance of $p<0.05$. The analysis was performed on a personal computer using BMDP Statistical Software Package (Version PC 90).

Results:

Assessment of growth performance:

The sorting procedure employed ensured that were no significant differences ($p < 0.05$) in initial body weight between different feeding cycles. The mean initial body weight for all treatments ranged between 125g (6:6) and 128 (1:1). After 6 weeks of the experimental period, it was observed that fish subjected to a cycle of 3 weeks of starvation followed by 3 weeks of satiation feeding produce comparable results , in terms of body weight, to those subjected to a daily feeding regime. This was superior to the performance of all other treatments (Table.2), At the end of the experiment, the results remained consistent, i.e. the fish fed every day alternate three weeks showed a comparable growth response in terms of body weight to the fish on a daily feeding cycle (Table.3). The fish that were starved and fed on the other regimes (1:1 and 2:2) showed a reduced performance compared with the fish fed the feeding cycles 3:3, 6:6 and the daily feeding regime. Similar response was also observed on the basis of specific growth rate (%BW/day), a comparable growth performance always being found in feeding cycle (3:3) and the daily feeding regime. Other treatments showed slower growth.

It appears that where as deprivation period of either 1, 2 or 6 weeks did not impose a sufficiently severe nutritional stress on *S. aurata* to induce a compensatory growth response, such a deprivation period of three weeks did .In all parameters there was a strong trend for the mean values for feeding cycle 3:3 to be identical at ($p<0.05$) to those under a daily feeding regime. This results is in agreement with the results of all growth performance found at week 6 Table.2.The trend of body weight loss during the period of the experiment was different for all treatments (Table.3). There was, generally, a large weight loss from the first week to week 3, followed by reduced rates of weight loss in subsequent weeks.

Assessment of feed utilization:

There were to be significant differences ($p<0.05$) in FCR among the various feeding cycles. After 6 weeks of the experiment, feeding cycle of 3 weeks of starvation and 3 weeks of satiation feeding showed the better result in terms of food conversion ratio (FCR) than any of the other treatments, i.e daily, 1:1, 2:2, and 6:6. The feeding cycle 3:3 showed significantly much better FCR by the end of the experiment than other feeding regimes (daily, 1:1, 2:2. and 6:6).The mean values of FCR varied between 1.8 (3:3) and 3.1 (1.1). (Table.3).

Feeding efficiency (FE) at week 6 showed the same trend as FCR. By the end of the experiment, the higher values of FE were found in 3:3 , followed by feeding cycle (6:6) , (2:2), daily and (1:1) respectively. The mean values of FE ranged from 32.5 (1:1) to 56.8 (3:3). The values are not significantly different at the ($p<0.05$) level.

Mortality:

Minor mortalities have been recorded during the experimental period .Mortalities were one fish (0.33% mortality) in feeding cycle 1:1; and two fishes (0.66% mortality) in daily and (6:6) feeding cycles. These values are considered as normal for this species.

Table 2. Growth performance and feed utilization of *Sparusaurata* fed differentfeeding cycles at week 6.

	Feeding cycle (Weeks)				
	Daily	(1:1)	(2:2)	(3:3)	(6:6)
Ini.BW	126.8 ^{a}	128.9 ^{a}	127.8 ^{a}	126.6 ^{a}	125.1^{a}
	(6.5)	(4.2)	(5.1)	(4.3)	(0.2)
Fin.BW	151.6^{a}	141.5^{a}	124.7nd	149.5^{a}	112.0nd
	(3.6)	(7.9)	(4.2)	(7.3)	(1.1)
SGR (%/da	0.5^{b}	0.2^{b}	- 0.1 ^{a}	0.4^{b}	-0.2^{a}
	(0.2)	(0.1)	(0.2)	(0.1)	(0.1)
FCR	2.2^{a}	3.3^{a}	12.1^{a}	2.0^{a}	-nd
	(0.6)	(0.8)	(14.6)	(0.5)	(0.0)
FE (%)	43.9^{a}	32.1 ^{a}	-14.6nd	55.5^{a}	-nd
	(16.3)	(9.0)	(37.5)	(19.9)	(0.0)
M (%)	0.00	0.00	0.00	0.00	0.00

BW=Body weight, SGR=Specific growth rate, FCR=Food conversion ratio, FE=Feeding efficiency, M=Mortality.
Means in a row followed by the same superscript are not significantly different ($p<0.05$). Number between parentheses refer to standard deviation. nd=not determined.

Table 3. Growth performance and feed utilization of *Sparusaurata* fed differentfeeding cycles at week 12 .

	Feeding cycles (Weeks)				
	Daily	**(1:1)**	**(2:2)**	**(3:3)**	**(6:6)**
Ini. BW	**126.8^{a}**	**128.9 ^{a}**	**127.8^{a}**	**126.6^{a}**	**125.1^{a}**
	(6.5)	**(4.2)**	**(5.1)**	**(4.3)**	**(0.2)**
Fin. BW	**176.8^{b}**	**157.9^{a}**	**155.5^{a}**	**175.7^{b}**	**163.1^{a}**
	(3.0)	**(2.7)**	**(4.4)**	**(6.7)**	**(0.3)**
SGR (%/day)	**0.4^{b}**	**0.3^{a}**	**0.2^{a}**	**0.4^{b}**	**0.4^{ab}**
	(0.0)	**(0.0)**	**(0.0)**	**(0.0)**	**(0.0)**
FCR	**2.9^{b}**	**3.1^{b}**	**2.9 ^{b}**	**1.8^{a}**	**2.1^{a}**
	(0.2)	**(0.3)**	**(0.3)**	**(0.4)**	**(0.0)**
FE (%)	**34.1^{a}**	**32.5^{a}**	**34.4^{a}**	**56.8^{a}**	**48.6^{a}**
	(2.0)	**(3.1)**	**(3.2)**	**(29.9)**	**(0.7)**
M (%)	**0.66**	**0.33**	**0.00**	**0.00**	**0.66**

BW=Body weight, SGR=Specific growth rate, FCR=Food conversion ratio, FE=Feeding efficiency, M=Mortality. Means in a row followed by the same superscript are not significantly different ($p<0.05$). Number between parentheses refer to standard deviation.

Discussion:

The present investigation show that compensatory growth of *S. aurata* does occur and that the strength of the compensatory growth response depends on the length of the starvation and subsequent refeeding periods. At week 6, the results showed that a feeding cycle of 3 weeks starvation followed by 3 weeks feeding produced comparable results, in terms of body weight and specific growth rate, to a regular daily feeding regime, with no significant differences ($p<0.05$) between them (Table2.).This results is in agreement with that found for *I. punctatus* [12] and for *S. gairdneri* [7]. Fish held on restricted feeding for 3 weeks, followed by a 3 weeks during which they were fed to satiation daily, weighed the same as the daily feeding regime at the end of 12 weeks experimentation (Table 3.) In fact, these fish required only about 3 weeks of full feeding to catch up with the fish fed daily. Fish which were changed from starvation to full feeding after 6 weeks showed a trend toward increase in growth accompanied by an increase in food consumption. This suggests that *S. aurata*, like warm-blooded animals [16], will display accelerated growth for a period when allowed to feed to satiation following food deprivation. It has been reported that the compensatory growth response is accompanied by increased appetite [19]. The specific growth rate, for feeding regimes 3:3 and daily feeding was 0.4%/day . The food conversion ratio and feeding efficiency in feeding 3:3 were 1.8 and 56.8% respectively, compared to 2.9 and 34.1% respectively in the daily feeding regime. Thus, it is clear that some metabolic change occurred during 3 weeks of starvation followed by 3 weeks of satiation feeding, which allowed growth to occur at the same level as in the fish which were fed daily.The maximum growth occurred during the last week of feeding. This observation is in agreement with those of [21] for rainbow trout Onchorhynchusmykiss [21] for Gadusmorhua. It is not possible to determine from this experiment how long the elevated rates of growth would continue. An experimental design incorporating a longer refeeding period would be necessary to determine when the compensatory growth response begins in decline toward the normal rate and how quickly this decline occurs. At week 6 and at the end of the experiment, the fish fed on the 3:3 feeding cycle showed significantly ($p<0.05$) improved food conversion ratio and feeding efficiency when changed from starvation to satiation feeding (Tables.2 and 3), as found by [20] for Chicken, and [23] for European minnows *Phoxinusphoxinus* (*L*.). Improved food conversion ratio has been reported for some mammalian species during recovery from nutritional restriction [26]. Some workers [3,7] have suggested that Salmonid fish also show improved food conversion efficiency during recovery from a period of starvation. The fish on feeding regimes 1:1 and 2:2 grew slowly than fish fed the other treatments : daily ; 3:3 and 6:6 respectively. A good feeding efficiency and low food conversion ratio as a result of better feed utilization for growth is clear in feeding cycle 3:3 compared to fish fed other treatments, as seen in numerous other experiments (Cho, 1992,and Robert et al 1993). The results obtained in this experiment confirm that S.aurata displays a compensatory growth response following exposure to severe feeding restriction.

The findings also provide evidence that there may be a complete recovery of body weight of fish fed 3:3 by the end of the experiment. In other words, *S. aurata* can be said to have displayed a complete, rather than a partial compensatory growth response. Partial compensatory occurs when animal display higher rates of weight gain, following a starvation period , than they do during daily feeding regimes, but do not manage to fully restore body weight to the same levels as occurs during daily feeding. A partial compensation is the response most often recorded in both domestic animals [27,19] and fish [25], although, complete compensation has previously been recorded in some studies carried out on fish [7,21]. [15,11] suggested high energy feeds might promote more rapid rates of weight gain during the period of compensatory growth than feeds having lower energy. It appears clear from the proximate analysis of the feed used in this experiment that the energy content in terms of protein (49.35%) and lipid (13.11), is sufficient to meet energy requirements of the *S. aurata*, at least according to the results quoted by various authors [24]. Possible mechanisms for the compensatory growth response must account for the increase in protein synthesis necessary to allow for the recovery growth found during the last week of feeding in 3 weeks starvation followed by 3 weeks satiation feeding.

For S. aurata, at least the results clearly demonstrate this species shows a compensatory growth response which has the potential of commercial exploitation, particularly the regime involving alternate three weeks of starvation followed by three weeks of satiation feeding.

Conclusion:

S.aurata display a compensatory growth response, which is seen as a rapid and complete recovery of body weight when the fish were starved, and subsequently fed to satiation. The length of starvation and refeeding periods had a profound effect on the strength of the compensatory growth response. A feeding cycle of 3 weeks starvation followed by 3 weeks of refeeding produced comparable results in terms of growth performance to a continuous daily feeding regime. The fish on the 3 weeks restricted and 3 weeks feeding cycle showed improved food utilization. Compensatory growth is accompanied by more efficient food utilization .The duration of the starvation and feeding periods studied in this experiment may not be practically applicable to all fish farm situations and may result in disease problems due to starvation stress, but the phenomenon certainly warrants further investigation. For*S. aurata*, at least , the results clearly demonstrate that this species shows a compensatory growth response which has the potential of commercial exploitation, particularly the regime involving alternate three weeks of starvation followed by three weeks of satiation feeding. These conclusions should be seen both in the light of economical as well as environmental implications.

دليل النمو التعويضي في سمكاالآوراتا

gilthead seabream, Sparusaurata (Linnaeus, 1758)

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المستخلص:

أجريت تجارب التغذية لاختبار استخدام ظاهرة النمو التعويضي لتحسين فاعلية النمو وكفاءة استخدام الغذاء لسمك الآوراتا (*S. aurata*). طبقت خمسة دورات للتغذية في التجربة (تغذية يومية)؛ أسبوع تجويع واسبوع تغذية (1:1)؛ أسبوعين تجويع وأسبوعين تغذية (2:2)؛ ثلاثة أسابيع بثلاثة (3:3) وستة أسابيع بستة (6:6).عند نهاية التجربة أتضح بأن الأسماك التي عولجت بنضام تغذية ثلاثة أسابيع (3:3) أعطت نتائج متقاربة من حيث فاعلية النمو مع الأسماك التي عولجت بنضام تغذية يومية، كما اضهرت النتائج كفاءة في استخدام الغذاء من حيث معامل التحويل الغذائي (FCR)، وكفاءة التغذية (FE%) مقارنة بدورات التغذية الأخري. أما نتائج دورات التغذية في الأسابيع (6,2,1) ليست جيدة كما في دورة التغذية (3:3) ونضام التغذية اليومي. الدراسة أعطت دليل علي حدوث ظاهرة النمو التعويضي للأسماك عند تطبيق دورة التغذية ثلاثة أسابيع تجويع بثلاثة أسابيع تغذية.

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