EFFECT OF FISH DENSITY AND FEEDING RATES ON GROWTH AND FOOD CONVERSION OF GILTHEAD SEABREAM (*SPARUS AURATA* LINNAEUS, 1758)

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ABSTRACT

The effect of fish density and feeding rates on growth and food conversion of gilthead seabream (*Sparus aurata*) was studied in floating cages and fiberglass tanks in Sammaliah Island- Abu Dhabi. The results of floating cages experiment showed that there was no significant effects (p>0.) of fish density on growth and food conversion rate but there are significant effects ($p<_{0.05}$) on fish production (4.11, 7.47 and 10.08) kg/m^3 for densities (50,100 and 150) fish/m^3 respectively. No significant differences between weight ranges [(27-125), (21-142), (30-126)] g of these fish at the end of experiment, and also between final weights (82.3, 77.4, 67.2) g for densities (50,100,150) fish/m^3 respectively. The results of fiberglass tanks experiment showed that there are no significant effects of feeding rate on growth, while there are significant effects on the food conversion rate (1.43, 2.86 and 3.71) for feeding rates (5, 7.5 and 10)% of fish weight respectively. Floating cages give better results from fiberglass tanks (growth rate 0.64 g/day compared with 0.4 g/day, final production 7.31 kg/m^3 compared with 4.58 kg/m^3 and final weight 75.6 g compared with 45.8 g).

INTRODUCTION

Gilthead seabream (*Sparus aurata*) is a euryhaline and eurythermal Mediterranean fish, which is commonly found in inshore waters at littoral sandy bottoms (Bauchot and Hureau, 1986), while adults usually enter estuaries and lagoons, but they seasonally migrate out of them (Lasserre, 1974 and 1976). At the turn of next millennium, aquaculture will have to play a more and more definitive role in meeting the dietary needs of an increasing world population while making up for the decline in natural marine resources (Kaushik, 1997). The culture of gilthead seabream began later in order to meet market demand. In Europe the seabream and seabass industry intends to copy the success of salmon growers and their production reach about 75,000 metric tons in 1998 and then the price of seabream decreased from 16 dollars per kg in 1990 to 6 dollars (Lem, 1999). Alexis and Nengas (2003) stated that current production of gilthead seabream and European seabass (*Dicentrachus labrax*) in the Mediterranean area amount to about 110,000 tons.

The production of gilthead seabream in the Mediterranean is affected during the cold season by a pathological condition called "winter syndrome" (Padros *et al.*, 1996 and Tort *et al.*, 1998). Coutteau *et al.* (2001) stated that the incidence of this pathology varies from year to year and from place to place, but it appears recurrently every cold season, particularly in regions where water temperature decreases below 11-12°C. UAE have strong comparative advantages compared to other parts of the world which includes warm sea water that allows a year-round growing season (UAE I., 1999 and Taher, 2006 b). Whenever, Coutteau *et al.* (2001) stated that feeding specific winter diet for gilthead seabream instead of a standard commercial feed during the cold season significantly reduced mortalities due to winter syndrome and drastically improved productivity and food conversion.

Kraljevic and Dulcic (1997) studied growth of gilthead seabream in the Mirna Estuary, Northern Adriatic, while Kraljevic *et al.* (1998) studied the growth of this fish in the eastern Adriatic. Sofronios *et al.* (2005) studied the effects of extra dietary iron supply on growth rate of gilthead seabream reared under reduced water oxygen levels. Sánchez-Muros *et al.* (2006) investigated effect of feeding method and protein source on feeding patterns of gilthead seabream. Bischoff *et al.* (2005) reared gilthead seabream in closed systems.

The objective of present study is to determine the effect of fish density and feeding ratios on the growth and food conversion of gilthead seabream to give some recommendations for the commercial producers of this fish in UAE that began from 1999, to produce fish flesh with less cost.

MATERIALS AND METHODS

The experiment of fish density effect on growth and food conversion of gilthead seabream (*Sparus aurata*) fish was conducted in the floating cages of Sammaliah Island – Abu Dhabi from 10/11/2001 to 4/3/2002, where six cages of dimensions (2.5 × 2.5 × 2.5) meters were used. Three densities were used 50, 100 and 150 fish per cubic meter with two replicates. Fishes fed trout commercial fish pellets, at feeding rate 10% of fish weight, then it was reduced to 7% and to 5%. Decreasing the feeding rate was due to unconsumed food that noticed in the bottom of the cages. Pellets size was 3.5 mm with 40% protein. At the beginning of the experiment the pellets were ground to make them easy to take by small fish. The measurement of fish weight was taken periodically (around one month) and food weight was changed after each weighing. The amount of daily ration food for each cage was given twice daily; the first was in the morning (8-9 o'clock) while the second in the afternoon (3–4 o'clock).

The experiment of feeding rate effect on growth and food conversion of gilthead seabream fish was conducted in circular fiberglass tanks on the same island from 19/11/2001 to 3/3/2002, where six tanks (capacity 5 m^3) were used with 500 fish in each one. After three months of acclimatization in these tanks, three feeding rates (5, 7.5 and 10) % of fish weight were used with two replicates. The same regime of measurements and feeding of floating cages experiment were used, but fish were fed six days a week (Friday excluded). More than 70% of water changed six days a weak (Friday excluded).

The food conversion rate (FCR) and specific growth rate (SGR) was estimated by the following equations (Chapman, 1978):

$$\mathbf{FCR} = \frac{\textbf{Weight of food consumed (g)}}{\textbf{Increased weight of fish (g)}}$$

$$\mathbf{SGR} = \frac{\log w_2 - \log w_1}{t_2 - t_1} \times 100$$

Where w_2 is weight of fish at time t_2 and w_1 is weight of fish at time t_1. Daily growth rate was estimated by divided increasing of fish weight on number of days, while final fish production was estimated by dividing total fish weight at the end of experiment on the volume of water. The complete randomized design was used to analysis the results statistically at 0.05

level of significance (Al-Rawy and Khalaf-Allah, 1980).

RESULTS

Table (1) presents the various periods measurements of gilthead seabream reared in floating cages at different densities, where final averages of fish weight (82.35, 77.4 and 67.2 g) were decreasing with increasing fish density (50,100 and 150 fish/m^3) respectively.

Table (2) shows the food conversion rates and specific growth rates for gilthead seabream reared at different densities, where these reared fishes have nearly the same food conversion rates (2.23, 2.23 and 2.31) for densities (50,100 and 150) fish/m^3 respectively, while specific growth rates (2.92, 2.86 and 2.77 respectively) were decreasing with increasing of fish densities.

The values of daily growth rate were decreasing with increasing of fish density table (3), where they are (0.70, 0.65 and 0.57) g/day for fish densities (50,100 and 150) fish/m^3 respectively. Final productions were increased with increasing of fish density in the cages, where the averages values of these productions are (4.11, 7.74 and 10.08) kg/m^3 for fish densities (50,100 and 150) fish/m^3 respectively.

The frequency of final fish weights for all weight groups reared in floating cages at different densities are presented in table (4). It seems from this table that maximum frequency of fish reared at density 50 fish per m^3 was 24.37 for weight group (70-79) g, and maximum frequency of fish reared at density 100 fish per m^3 was 24.02 for weight group (60-69) g, while maximum frequency of fish reared at density 150 fish per m^3 was 31.42 for weight group (60-69) g. Figure (1) shows final distribution of weight groups reared at density of 50 fish per m^3, where more than 60% of fish are distributed between weights of (70-99) g. Figure (2) shows final distribution of weight groups reared at density of 100 fish per m^3, where more than 65% of fish are distributed between weights of (60-99) g. Figure (3) shows final distribution of weight groups reared at density of 150 fish per m^3, where more than 80% of fish are distributed between weights of (50-89) g.

The various periods measurements of gilthead seabream reared in fiberglass tanks at different feeding levels are shown in table (5). These data show initial average fish weights (3.6, 4.25 and 4.15) g and final fish weights (46.45, 43.15 and 47.8) g for feeding ratios (5, 7.5 and 10) % of fish weight respectively.

Table (6) shows values of food conversion and specific growth rates at different feeding levels. Specific growth rate values are (2.46, 2.25 and 2.29) for feeding levels (5, 7.5 and 10) % of fish weight respectively. Food conversion rates increased with increasing of feeding ratios, where they are (1.43, 2.86 and 3.71) for feeding levels (5, 7.5 and 10) % of fish weight respectively.

The daily growth rates and final productions at different feeding levels indicated that there were no great differences. There aren't big differences between daily growth rates and final productions at different feeding levels table (7), where the values of daily growth rates are (0.41, 0.37 and 0.42) g/day and values of final production are (4.64, 4.31 and 4.78) kg/m^3 for feeding levels (5, 7.5 and 10) % of fish weight respectively.

Table (1) Fish and food weights of gilthead seabream reared in floating cages at different densities.

Cage No.	Fish Density (Fish/m^3)	Measurement Date								
		10/11/2001		8/12/2001		13/1/2002		3/2/2002		4/3/ 2002
		Average Fish Weight (g)	Food Weight (g)	Average Fish Weight (g)	Food Weight (g)	Average Fish Weight (g)	Food Weight (g)	Average Fish Weight (g)	Food Weight (g)	Average Fish Weight (g)
1	50	$2.3_{\pm 0.85}$	92	$7.3_{\pm 1.33}$	291	$32.7_{\pm 2.22}$	1294	$50.0_{\pm 7.97}$	1000	$84.4_{\pm 17.91}$
2	50	$3.0_{\pm 0.85}$	120	$8.3_{\pm 1.13}$	330	$31.8_{\pm 2.06}$	1262	$50.5_{\pm 8.23}$	1010	$80.3_{\pm 17.61}$
3	100	$2.8_{\pm 0.79}$	224	$7.8_{\pm 1.26}$	620	$28.9_{\pm 1.81}$	2297	$46.2_{\pm 7.51}$	1848	$77.7_{\pm 17.68}$
4	100	$2.6_{\pm 0.74}$	208	$7.6_{\pm 1.27}$	608	$27.5_{\pm 1.82}$	2189	$40.8_{\pm 6.92}$	1632	$77.1_{\pm 18.6}$
5	150	$2.6_{\pm 0.78}$	312	$6.7_{\pm 1.00}$	798	$23.6_{\pm 1.72}$	2820	$38.4_{\pm 6.71}$	2304	$62.3_{\pm 13.61}$
6	150	$2.6_{\pm 0.82}$	312	$7.3_{\pm 1.33}$	868	$28.5_{\pm 1.93}$	3392	$42.5_{\pm 7.12}$	2550	$72.1_{\pm 16.13}$

Table (2) Food conversion and specific growth rates of gilthead seabream reared in floating cages at different densities.

Fish Density	Date	Food Conversion Rate	Average	Specific Growth Rate	Average
50/ m^3	10/11/2001 to 8/12	1.43	$2.23_{\pm 1.19}$	3.87	$2.92_{\pm 1.14}$
	8/12/2001 to 13/1/2002	1.14		3.94	
	13/1/2002 to 3/2	3.73		2.11	
	3/2 to 4/3	2.63		1.77	
100/m^3	10/11/2001 to 8/12	1.51	$2.23_{\pm 1.17}$	3.74	$2.86_{\pm 0.93}$
	8/12/2001 to 13/1/2002	1.34		3.60	
	13/1/2002 to 3/2	3.90		2.05	
	3/2 to 4/3	2.17		2.06	
150/m^3	10/11/2001 to 8/12	1.66	$2.31_{\pm 1.09}$	3.53	$2.77_{\pm 0.95}$
	8/12/2001 to 13/1/2002	1.32		3.64	
	13/1/2002 to 3/2	3.78		2.11	
	3/2 to 4/3	2.48		1.81	

Table (3) Daily growth rates and final productions of gilthead seabream reread in floating cages at different densities.

Fish Density (fish/m^3)	Average Fish Weight (g)					Daily Growth Rate (g/day)	Final Production (kg/m^3)
	10/11/ 2001	8/12/ 2001	13/1/ 2002	3/2/ 2002	4/3/ 2002		
50	$2.6_{\pm 0.91}$	$7.8_{\pm 1.33}$	$32.2_{\pm 2.24}$	$50_{\pm 8.52}$	$82.3_{\pm 17.73}$	0.70	4.11
100	$2.7_{\pm 0.77}$	$2.7_{\pm 1.28}$	$28.2_{\pm 1.80}$	$43.5_{\pm 7.1}$	$77.4_{\pm 18.45}$	0.65	7.74
150	$2.6_{\pm 0.80}$	$7.0_{\pm 1.21}$	$26.0_{\pm 1.92}$	$40.4_{\pm 7.21}$	$67.2_{\pm 17.6}$	0.57	10.08

Table (4) Weights frequency of gilthead seabream reared in floating cages at the end of the experiment (4/3/2002).

Weight Group	Weight Frequency % at different densities		
	(50 fish/m^3)	(100 fish/m^3)	(150 fish/m^3)
20 - 29	0.62	0.49	0
30 - 39	1.25	1.47	1.91
40 – 49	1.25	1.96	9.19
50 – 59	5.62	7.84	16.47
60 – 69	10.00	24.02	31.42
70 – 79	24.37	17.65	19.42
80 – 89	20.62	22.06	14.94
90 – 99	18.75	14.21	3.83
100 – 109	9.37	5.88	3.06
110 – 119	6.87	2.94	0.77
120 – 129	1.25	0.49	0.38
130 – 139	0	0	0
140 - 149	0	0.98	0

Table (5) Measurements of gilthead seabream reared in fiberglass tanks at different feeding levels.

Tank No.	Feeding Levels (%)	Measurement Date								
		19/11/2001		8/12/2001		13/1/2002		2/2/2002		3/3/ 2002
		Average Fish Weight (g)	Food Weight (g)	Average Fish Weight (g)	Food Weight (g)	Average Fish Weight (g)	Food Weight (g)	Average Fish Weight (g)	Food Weight (g)	Average Fish Weight (g)
1	5	$3.5_{\pm 0.91}$	88	$6.6_{\pm 0.99}$	166	$15.5_{\pm 1.72}$	389	$24.0_{\pm 1.85}$	600	$47.9_{\pm 7.77}$
2	5	$3.7_{\pm 0.90}$	92	$6.6_{\pm 1.05}$	166	$20.2_{\pm 1.98}$	504	$25.6_{\pm 1.99}$	640	$45.0_{\pm 7.85}$
3	7.5	$3.7_{\pm 0.88}$	139	$8.4_{\pm 1.15}$	315	$22.8_{\pm 2.05}$	857	$27.8_{\pm 2.11}$	1042	$39.6_{\pm 6.87}$
4	7.5	$4.8_{\pm 0.96}$	180	$7.0_{\pm 1.15}$	264	$17.9_{\pm 1.65}$	673	$27.8_{\pm 2.08}$	1042	$46.7_{\pm 6.92}$
5	10	$4.0_{\pm 0.92}$	200	$7.3_{\pm 1.14}$	366	$23.4_{\pm 1.98}$	1170	$33.4_{\pm 2.23}$	1670	$47.9_{\pm 7.88}$
6	10	$4.3_{\pm 0.91}$	215	$6.6_{\pm 1.08}$	330	$22.4_{\pm 1.82}$	1121	$33.9_{\pm 2.23}$	1694	$47.7_{\pm 7.55}$

Table (6) Food conversion and specific growth rates of gilthead seabream reared in fiberglass tanks at different feeding levels.

Feeding Level (%)	Date	Food Conversion Rate	Average	Specific Growth Rate	Average
5	19/11/2001 to 8/12	0.96	$1.43_{\pm 0.66}$	3.19	$2.46_{\pm 0.67}$
	8/12/2001 to 13/1/2002	0.96		2.82	
	13/1/2002 to 2/2	2.36		1.68	
	2/2/ 2002 to 3/3	1.45		2.16	
7.5	19/11/2001 to 8/12	2.36	$2.86_{\pm 1.19}$	3.15	$2.25_{\pm 0.83}$
	8/12/2001 to 13/1/2002	1.43		2.76	
	13/1/2002 to 2/2	4.07		1.59	
	2/2/2002 to 3/3	3.58		1.50	
10	19/11/2001 to 8/12	3.68	$3.71_{\pm 1.81}$	2.71	$2.29_{\pm 0.96}$
	8/12/2001 to 13/1/2002	1.35		3.41	
	13/1/2002 to 2/2	4.05		1.82	
	2/2/2002 to 3/3	5.76		1.24	

Table (7) Daily growth rates and final productions of gilthead seabream fish reared in fiberglass tanks at different feeding levels.

Feeding Ratio (%)	Average Fish Weight (g)					Daily Growth Rate (g/day)	Final Production (Kg/m^3)
	19/11 2001	8/12 2001	13/1 2002	2/2 2002	3/3 2002		
5	$3.6_{\pm 0.92}$	$6.6_{\pm 1.08}$	$17.8_{\pm 1.81}$	$24.8_{\pm 2.08}$	$46.4_{\pm 7.79}$	0.41	4.64
7.5	$4.2_{\pm 0.92}$	$7.7_{\pm 1.15}$	$20.3_{\pm 1.93}$	$27.8_{\pm 2.01}$	$43.1_{\pm 6.96}$	0.37	4.31
10	$4.1_{\pm 0.95}$	$6.9_{\pm 1.09}$	$23.4_{\pm 1.85}$	$33.6_{\pm 2.26}$	$47.8_{\pm 7.52}$	0.42	4.78

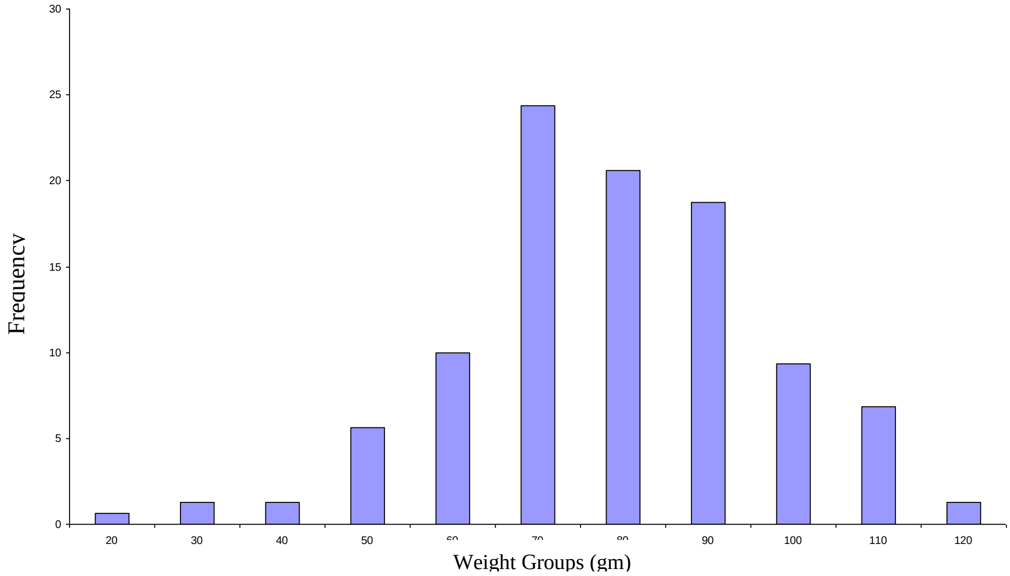

Figure (1) Final distribution of weight groups gilthead seabream reared in floating cages at density (50 fish / cubic meter).

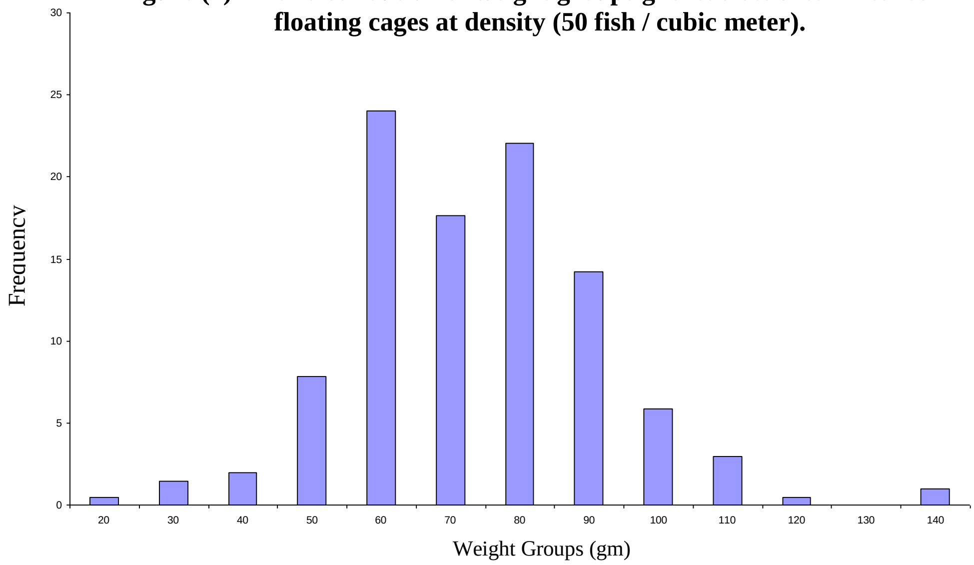

Figure (2) Final distribution of weight groups gilthead seabream reared in floating cages at density (100 fish / cubic meter).

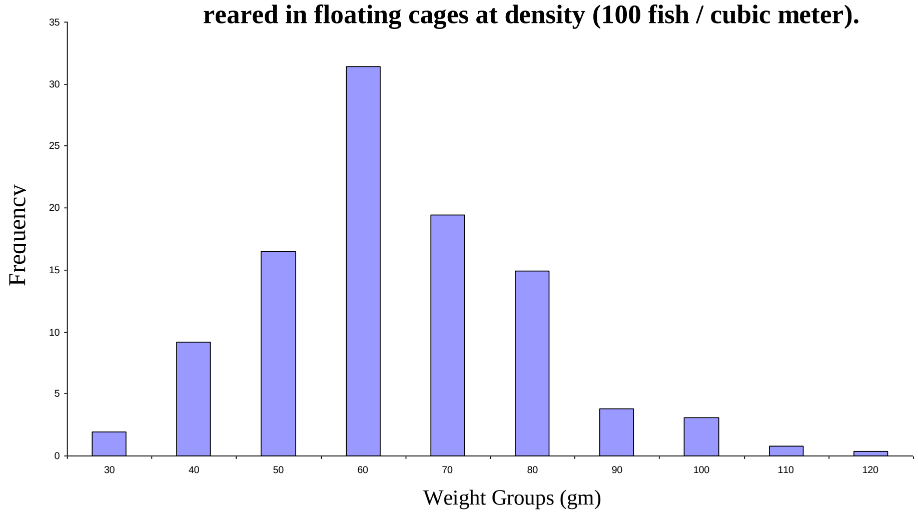

Figure (3) Final distribution of weight groups gilthead seabream reared in floating cages at density (150 fish / cubic meter).

DISCUSSION

Statistical analysis to the values of food conversion rate and specific growth rate for gilthead seabream reared in floating cages at different densities showed that there are no significant differences between these values. These fishes have nearly same weight ranges at the end of experiment and statistical analysis proved that there are no significant differences between these weight ranges at different densities. Statistical analysis of final weights reached by these fishes proved that there are no significant differences between these final weights at different densities. Statistical analysis of daily growth rates proved that there are no significant differences between fishes reared at different densities. Final productions for these fishes are increased with increasing of fish density and statistical analysis of its values proved that there are significant differences these productions at different fish densities.

From the above results it can be concluded that there was no significant effects of fish density on growth and food conversion rate, but it affected markedly the fish production. For this reason it is recommended to use fish density of 150 individuals per cubic meter for commercial fish farms to get more production of gilthead seabream fish in less area. However, it is necessary to mention that this density may be high, especially when fish grow towards marketable size, and more experiments are needed to determine the optimum density of fish in these situations.

The values of food conversion and specific growth rates for gilthead seabream reared in fiberglass tanks at different feeding ratios showed that there are no significant differences in the specific growth rates, while there are significant differences in the food conversion rates. These results lead to conclude that fish reared at (7.5 and 10) % feeding levels don’t consume all the amount of food. This conclusion can be supported by field observations of unconsumed food in tanks of these two feeding ratios, while there was no any amount of unconsumed food in tanks of (5%) feeding level. It seems that feeding level 5% is the best for commercial fish farms of gilthead seabream because they need 1.43 kg of food to produce one kg of fish, while they need 2.86 and 3.71 kg of fish food for fish fed at feeding levels (7.5 and 10) % respectively. In addition to this economic concept, the unconsumed food leads to many ecological problems especially water quality that may inhibit fish growth. However, it is necessary to mention that 5% feeding level may be high for largest gilthead seabream fish, so more experiments are needed to determine these levels at different fish size. Sánchez-Muros *et al.* (2006) stated that FCR of gilthead seabream reared in tanks in Spain was 1.64 when using demand feeding and 2.63 when using hand feeding. Bischof *et al.* (2005) found FCR of 1.09 and 1.2 for gilthead seabream reared in two closed system tanks.

Williams and Caldwell (1978) stated that the FCR of the English sole (*Parophrys vetulus*) was 3.0, while Colman (1970) showed that it was 4.0 for plaice (*Pleuronectus platessa*). Seng-Keh and Higuchi (1981) mentioned that the FCR for tilapia (*Tilapia aurea*) reared in different salinities was (2.5-3.5), while for largescale mullet (*Liza macrolepis*) was 4.45 and for yellowfin seabream (*Acanthopagrus latus*) was 2.24. For common carp (*Cyprinus carpio*) the FCR was 1.72 (Huisman, 1976), while for White-spotted rabbitfish (*Siganus canaliculatus*) was 1.98 (Taher, 2006_a). Comparing previous values of FCR with the results of the present study (1.43), it is obvious that the value of FCR for gilthead seabream is the best among all other cultivated fishes.

Statistical analysis of the results of this experiment showed that there are no significant differences in the daily growth rates, final weights and productions between gilthead seabream reared in fiberglass tanks at different feeding levels, while when these results comparing with the results of floating cages experiment, it was found big differences. The average of daily growth rate in the floating cages was 0.64 g/day, while it was 0.4 g/day for fiberglass tanks. The average of final production in the floating cages was 7.31 kg/m^3, while it was 4.58 kg/m^3 for fiberglass tanks. The final average weight of fish reared in floating cages was 75.6 g., while it was 45.8 g for fishes reared at fiberglass tanks. The reason of these differences could be the good conditions in the floating cages, comparing of fiberglass tanks that may contain more wastes and some harmful substances that inhibit fish growth, in addition to high value of dissolved oxygen in floating cages comparing with fiberglass tanks that depend on pumping aeration. For these reasons it is recommended to use floating cages for the commercial rearing of gilthead seabream.

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تأثير الكثافة السمكية ومعدل التغذي على النمو والتحويل الغذائي لاسماك الشانك (*SPARUS AURATA* LINNAEUS, 1758)

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الملخـص

درس تـأثير الكثافـة السـمكية ونسـبة التغذيـة علـى النمـو ومعـدل التحـول الغـذائي لأسـماك gilthead seabream (Sparus aurata) المرباة داخل الأقفاص البحريـة العائمـة وأحواض الفيبـركلاس فـي جزيـرة السـمالية-أبـوظبي. أظهـرت نتـائج تجربـة الأقفـاص البحريـة عـدم وجـود تـأثيرات معنويـة للكثافـة السـمكية علـى نمـو ومعـدل التحـول الغـذائي لهـذه الاسماك ووجود تأثيرات معنويـة لهـا علـى الانتاجيـة السمكية، حيث كانـت (4.11، 7.47، 10.08) كغـم/م3 للكثافـة السـمكية (50، 100، 150) سـمكة/م3 بالتعاقـب. كمـا تبـين عـدم وجـود اختلافـات معنويـة فـي مـديات الأوزان [(27-125)، (21-142)، (30-126)] غم وفي الأوزان النهائيـة (82.3، 77.4، 67.2) غـم بـين الكثافـات السـمكية المختلفـة (50، 100، 150) سـمكة/م3 بالتعاقـب. أظهـرت نتـائج تجربـة الاسـماك فـي أحـواض الفـايبركلاس عـدم وجـود تـأثيرات معنويـة لنسـبة التغذيـة علـى معـدل نمـو الأسماك ووجود تأثيرات معنوية لها على معدل التحول الغذائي، حيث كـان 1.43، 2.86، 3.71 لنسـب التغذيـة (5، 7.5، 10)% مـن وزن الأسـماك بالتعاقـب. أعطـت الأقفـاص البحريـة العائمـة نتـائج أفضـل مـن أحـواض الفايبركلاس، حيث كان معدل النمو 0.64 غم/يوم مقارنـة بـ 0.4 غم/يوم، وكانت الانتاجية النهائية 7.31 كغم/م3 مقارنة بـ 4.58 كغم/م3، بينمـا كـان معدل وزن الاسماك النهائي 75.6 غم مقارنة بـ 45.8 غم.