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SHORT COMMUNICATION KISA BİLGİLENDİRME

THE EFFECT OF FEEDING FREQUENCY AND FEEDING RATE ON GROWTH PERFORMANCE OF JUVENILE BLACK SEA TURBOT (*Psetta maxima*, Linneaus, 1758)

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Abstract: The effects of feeding frequency on growth performance, feed efficiency and size variation of juvenile Black Sea turbot, *Psetta maxima* were investigated. A factorial design of two feeding rates (ad libitum, n=240, weight=23.8 ±0.70 g and total length=11.0 ±0.09 cm; and 1% of bodyweight of fish per meal, n=240, weight=38.6 ±0.45 g and total length=13.0 ±0.03 cm) and three feeding frequencies (one meal in 2 days, one meal a day, two meals a day) with two replicates of each treatment combination were applied in this experiment. Feeding frequencies did not affect fish survival rates (P>0.05). The final body weight and specific growth rate (SGR) were higher in group one meal a day at both feeding rates. There were no significant differences the final body weight and SGR values among the groups (P>0.05). Similar responses were observed for condition factor, feed conversion ratio (FCR) and body weight increase (BWI), and the best FCR and BWI were obtained in the same group. The coefficient of variations (CV) in fish weight increased between initial and final weightings in all replicate groups. However, the CV of fish weight was not significantly affected by feeding frequency (P>0.05). In conclusion, growth performance, SGR and FCR were better in once-daily feeding, and it appears that under the conditions of this experiment, feeding once a day to satiation was sufficient for maximal growth.

Keywords: Black Sea turbot, *Psetta maxima*, Feeding frequency, Feeding rate, Growth, Feed efficiency

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Özet: **Yemleme Sıklığının ve Yemleme Oranının Yavru Karadeniz Kalkan Balığının (*Psetta maxima*, Linneaus, 1758) Büyüme Performansına Etkilesi**

Karadeniz kalkanı, *Psetta maxima* yavrularında yemleme sıklığının, büyüme, yem değerlemdirme ve boy varyasyonuna etkileri araştırılmıştır. İki yemleme oranı (Doyana kadar, n=240, ağırlık=23.8 ±0.70 g ve boy = 11.0 ±0.09 cm; balık ağırlığının %1 kadar yem n=240, ağırlık = 38.6 ±0.45 g ve boy = 13.0 ±0.03 cm) ve üç yemleme sıklığı (iki günde bir yemleme, günde bir yemleme, günde iki kez yemleme) içeren iki tekerrürlü faktöriyel deneme oluşturulmuştur. Yemleme sıklığı yaşam oranını etkilememiştir (P>0.05). Deneme sonunda her iki yemleme seviyesinde günde bir kez yemlenen balıkların ağırlığı ve oransal büyümesi fazladır. En iyi yem dönüşüm oranı (YDO) ve ağırlık artışı aynı grupta gözlenmiştir. Deneme sonunda balık ağırlığı ve oransal büyüme (OB) acısında gruplar arasında önemli fark bulunmamıştır (P>0.05). Kondisyon faktörü, YDO ve ağırlık artışı yönünden de benzer durum söz konusudur. Balık ağırlıkları acısından görülen varyasyon katsayısı (VK) deneme sonunda başlangıca göre artmıştır. Bununla birlikte yemleme sıklığı VK yi önemli bir şekilde etkilememiştir (P>0.05). Sonuç olarak günde bir kez yemlenen balıkların büyüme performansı, OB ve YDO daha iyidir. Bu şartlarda günde bir kez doyana kadar yemlemek en iyi büyüme için uygundur.

Anahtar Kelimeler: Karadeniz kalkanı, *Psetta maxima*, Yemleme sıklığı, Yemleme oranı, Büyüme, Yem randımanı

Introduction

Fish feeding is one of the most important factors in aquaculture because of high feed costs. Commercial feeds for turbot are relatively expensive due to the high inclusion rate of several nutrients to satisfy their requirements for growth. Overfeeding of turbot increases fish production cost and causes deterioration of water quality, which can eventually reduce growth of fish. On the other hand, feeding less than the amount to achieve optimal growth of fish is also undesirable. Therefore, determination of optimum feeding rate and feeding frequency for growth of turbot is critical from both economical and biological standpoints. The optimal feeding strategies improve growth performance, survival, and food conversion ratios, and contribute to minimizing food wastage, reduce size variation, and consequently, increase production efficiency (Goddard, 1996; Kubitza and Lovshin, 1999).

The Black Sea turbot, *Psetta maxima*, which is a commercially important flatfish species, is considered a potential candidate for diversification in marine aquaculture industry in Turkey. Although several reports exist on its biology in the Black Sea coast, Turkey, including stock assessment (Zengin, 2000; Suzuki et al., 2001; Samsun et al., 2007), broodstock management (Hara et al., 2002; Başaran and Samsun, 2004), the larval and juvenile development (Şahin, 2001a, 2001b; Kohno et al., 2001; Moteki et al., 2001; Şahin and Üstündağ, 2003; Türker et al., 2005), and some commercial fishing aspects (Samsun, 1995; Samsun and Kalaycı, 2004), there are no studies which deal on growth performance and feeding schedules except for Türker (2006) which determine the effect of feeding frequency on growth, feed consumption, and body composition of juvenile Black Sea turbot at low temperature. Nevertheless, the optimal feeding frequency for turbot and its effect on growth and feed utilization are still unclear.

The present study was carried out to investigate the effects of feeding frequency on growth performance, feed efficiency and size variation of juvenile Black Sea turbot, with the aim of finding the minimum number of feedings per day (within a fixed time – interval) required to produce good growth and survival with an efficient food conversion.

Materials and Methods

The study was conducted at the Central Fisheries Research Institute (CFRI), in Trabzon, Turkey, from 3 December 2003 to 11 March 2004. The 180 days old hatchery-reared juveniles were randomly stocked in twelve 200-L indoor rectangular fiberglass tanks, with a rearing volume of 160-L, with 40 individuals in each tank. The water flow rate was manually controlled to levels not exceeding 15 l/min. The seawater used in the hatchery was pre-treated using pressurized sand filters and a UV sterilization system. The water was aerated with two air stones at a moderate rate. Natural illumination and day-length were maintained in the tanks during the experimental period. Temperature twice in a day, dissolved oxygen (DO), pH and salinity values weekly intervals were measured.

A factorial design of two feeding rates (ad libitum, n = 240, weight= 23.8±0.70 g and length = 11.0±0.09 cm; and 1% of bodyweight of fish per meal, n = 240, weight= 38.6±0.45 g and length = 13.0±0.03 cm) and three feeding frequencies (one meal in 2 days at 0800, D1/2; one meal a day at 0800, D1; two meals a day at 0800 and 1600, D2) with two replicates of each treatment combination were applied in this experiment.

Fish were fed on commercial 3 mm extruded sea bream feed manufactured by Çamlı Yem, İzmir, Turkey, containing 45% crude protein, 12% crude lipid, while having an metabolized energy content of 3232 kcal/kg. Feeding was achieved during the daytime. All fish were hand-fed throughout the feeding trial. Faces and uneaten feed were cleaned daily by siphoning from tanks.

Body weight (±1 g) and total length (±1 mm) were recorded for all fish on an almost biweekly interval. All biometric data were taken only after feeding had been ceased for 24 h. Following these bi-weekly inventories feed rates were adjusted to reflect the new biomass gain in each tank. Feed conversion ratio (FCR = feed intake/gain), specific growth rate (SGR = ln final weight - ln initial weight/days), feed efficiency (FE = 100 × weight gain) / food intake), body weight increase (BWI = final body weight - initial body weight / initial body weight × 100), condition factor (K = body weight / total length^3 × 100) were also calculated. The coefficient of variation was used to examine the inter-individual weight variation among the fish in each tank (CV = 100 × SD /mean weight of the fish in each tank).

All statistical analyses were performed with Statistica 7.0 for Windows software (StatSoft, 1984-2004). To assess normality of distributions a Kolmogorov–Smirnov test was used, and homogeneity of variances was tested using the Levene's *F*-test (Zar, 1999). All data were analyzed by two-way analysis of variance (ANOVA) and differences between means compared by the Tukey test at a 95% confidence interval (P<0.05). The data are presented as mean ± SEM of the replicate groups.

Results and Discussion

Water temperature, DO, pH and salinity ranged from 10.5 to 15.1 ºC (13.1±0.39 ºC), 7.8 to 9.8 mg/l (9.0±0.63 mg/l), 7.9 to 8.3 (8.2±0.14) and 18.0 to 19.0 ppt (18.5±0.52 ppt), respectively. Water quality was within acceptable ranges for growth of juvenile turbot during the feeding trial.

The mean total lengths and weights of the fish according to feeding strategy in groups D1/2, D1 and D2 are presented in Tables 1 and 2.

No fish died during the experiment. SGR on weight, K, FCR, FE, BWI and CV for juvenile turbot at the end of the feeding trial are given in Table 3. Feeding frequencies did not affect fish survival rates (P > 0.05). The final body weight and SGR were higher in group D-1 at both feeding rates. However, the growth data showed that there were no statistically significant difference the final body weight and SGR values among the groups (P > 0.05). Similar responses were observed for K, FCR and BWI, and the best FCR and BWI were obtained in the same group. The CVs in fish weight increased between initial and final weightings in all replicate groups (Table 3). However, the CV of fish weight was not significantly affected by feeding frequency (P > 0.05).

Table 1. Total lenght of turbot used in the experiment at different feeding frequencies (D1/2: One meal in 2 days; D1: One meal a day; D2: Two meals a day).

Feeding stategy	Sample dates	D1/2	D1	D2
1 % of BW	08 Jan	13.0±0.03	13.0±0.03	13.0±0.03
	28 Jan	14.0±0.05	14.1±0.06	14.1±0.06
	11 Feb	14.8±0.07	14.7±0.09	14.8±0.09
	27 Feb	15.5±0.09	15.5±0.11	15.6±0.10
	08 Mar	15.8±0.10	15.9±0.12	16.0±0.11
Ad libitum	03 Dec	10.9±0.09	10.9±0.10	11.1±0.08
	07 Jan	12.6±0.12	13.1±0.13	12.9±0.12
	12 Feb	14.4±0.15	14.7±0.14	14.8±0.15
	11 Mar	15.4±0.18	15.9±0.17	16.0±0.15

Table 2. Body weight of turbot used in the experiment at different feeding frequencies (D1/2: One meal in 2 days; D1: One meal a day; D2: Two meals a day).

Feeding strategy	Sample dates	D1/2	D1	D2
1 % of BW	08 Jan	38.3±0.42	38.7±0.48	38.8±0.46
	28 Jan	45.6±0.85	46.3±0.99	46.4±1.09
	11 Feb	53.6±1.18	55.1±1.41	55.1±1.35
	27 Feb	61.8±1.52	63.9±1.80	63.8±1.70
	08 Mar	66.4±1.67	68.9±1.95	68.7±1.82
Ad libitum	03 Dec	23.2±0.74	23.6±0.70	24.5±0.67
	07 Jan	35.2±1.22	40.7±1.32	39.5±1.26
	12 Feb	52.5±1.79	58.2±2.01	59.7±1.10
	11 Mar	63.0±2.42	72.5±2.72	73.1±2.54

Table 3. Specific growth rate (SGR), condition factor (K), feed conversion ratio (FCR), feed efficiency (FE), coefficient of variance (CV) and body weight increment (BWI) value of turbot during the experiment ($_i$: initial and $_f$: final values; NS: No significant; $P < 0.05$; D1/2: One meal in 2 days; D1: One meal a day; D2: Two meals a day).

Feeding strategy	Parameters	D1/2	D1	D2	ANOVA
1 % of BW	SGR (%)	0.91±0.077	0.96±0.107	0.94±0.100	NS
	K	1.68±0.016	1.72±0.015	1.71±0.017	NS
	FCR	0.84±0.048	0.72±0.033	0.78±0.027	NS
	FE	1.22±0.079	1.40±0.076	1.28±0.050	NS
	CV_i - CV_f (%)	6.9-15.9	7.8-17.2	7.5-16.8	NS
	BWI (%)	18.0±2.14	19.3±2.39	19.1±2.28	NS
Ad libitum	SGR (%)	0.99±0.164	1.11±0.231	1.08±0.204	NS
	K	1.76±0.019	1.82±0.019	1.82±0.019	NS
	FCR	1.06±0.194	1.05±0.099	1.25±0.108	NS
	FE	1.03±0.196	0.98±0.093	0.81±0.071	NS
	CV_i - CV_f (%)	17.5-22.8	16.3-22.2	14.9-20.5	NS
	BWI (%)	33.9±5.57	41.7±3.52	41.4±5.50	NS

In the present study, the Black Sea turbot juveniles were subjected to different daily feeding frequencies at two feeding rates. Feeding was manually performed by controlled feeding (%1 of BW) and visual satiation of the fish (ad libitum) in groups.

Feeding frequencies did not affect fish survival rates in this study. Working with juveniles of gilthead sea bream, *Sparus aurata*, Goldan et al. (1997) reported similar result of no significant effect of feeding frequency on survival rate. There were no final weight differences among groups. It means that limited feeding could not lead to growth difference in any of feeding regime. On the other hand ad libitum feeding provided more growth and the best growth performance were achieved by feeding juvenile turbot one meal per day. This result is not in agreement with an earlier study on juvenile turbot (Türker, 2006) which carried out at low temperature.

Optimum feeding frequency, for maximum growth of fish, may vary with species and size of fish, and culture conditions, including food quality, amount of feed provided and water temperature (Lee et al., 2000a; Kestemont and Baras, 2001), although feeding to satiation once daily seems adequate for species such as estuary grouper *Epinephelus tauvina* (Chua and Teng, 1978), stinging catfish *Heteropneustes fossilis* (Marian et al., 1981), Arctic charr *Salvelinus alpinus* (Jobling, 1983), striped snakehead *Channa striatus* (Sampath, 1984), croaker *Micropogonias furnieri* (Abud, 1990), Korean rockfish *Sebastes schlegali* (Lee et al., 2000b) and yellowtail flounder *Limanda ferruginea* (Dwyer et al., 2002). Another factor that determines the most suitable feeding frequency is the time interval between meals, because the intake of food is related to the capacity of the stomach and the rate of digestion and evacuation (Brett, 1971; Kono and Nose, 1971), and evacuation time is related to the feeding sequence and the size of the fish (Pandian, 1967; Noble, 1973). The differences between species could be explained by the different feeding strategies of fishes in their natural environment, the structure of the digestive system, as well by as the specific circumstances of the experiments (Kucska et al., 2007). The results of the present study indicate that good growth was obtained when turbot juveniles were fed to satiation once a day.

Similar to the growth and survival levels, FCR and SGR values also did not show any significant difference among the three treatments. Our observation of FCR not influenced by feeding frequency is also in agreement with the report of Webster et al. (1992) in cage-reared channel catfish and Wang et al. (1998) in hybrid sunfish.

Feeding frequency, in this study, did not effect on FE. Some authors also reported no effects of feeding frequency on FE (Andrews and Page, 1975; Sveier and Lied, 1998; Wang et al., 1998; Lee et al., 2000a). Some even reported that FE decreased with increasing feeding frequency (Sampath, 1984; Liu and Liao, 1999), and FE increased with the increasing feeding frequency (Marian et al., 1981; Charles et al., 1984).

When fish are reared together in groups the growth of individual fish can result in an increasing disparity in size between the smallest and largest fish, as mean size increases (Jobling, 1982). The CV of body weight is basically used to distinguish size variations which are induced by competition or hierarchy effects. It has been observed that in fish populations where the growth of some individuals is suppressed by competition or hierarchical effects, the CV increases (Jobling, 1982; Sunde et al., 1998). In the present study the final populations were stable, as size variations among the groups of juvenile turbot were similar.

Conclusion

Fish farmers incur a higher cost when cultured fish are fed twice or three times daily compared with once daily because more time and labor are required and more feed is likely to be wasted. Feeding fish twice or three times daily instead of once daily will increase the production costs of fish. Based on food consumption data and growth performance, the highest SGR and lowest FCR were obtained with fish fed once daily, in the present study. It appears that, feeding once a day to satiation may be accepted as sufficient for on growing of turbot under the conditions of this experiment.

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