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Research Article

Growth Performance, Body Traits and Fillet Composition of the European Sea Bass (*Dicentrarchus labrax*) Reared in Various Salinities and Fresh Water

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Abstract: The effects of various salinities and fresh water (FW) (0.4 ppt) on the growth performance, body traits and fillet composition of juvenile and young sea bass (*Dicentrarchus labrax*) in FW were investigated in two separate experiments in this study.

In Experiment 1, following acclimation, sea bass juveniles (9.5 ± 0.5 g) were reared in 240-L fibreglass tanks (40 x 40 x 150 cm) for 90 days in five different treatments (FW, 10, 20, 30 and 40 ppt). The fish cultured in FW, 10 and 20 ppt grew better than those at 30 or 40 ppt ($P < 0.05$). Salinity did not affect the crude protein, lipid or ash content of the fish ($P > 0.05$). Yet, the dry weight of the fish grown in FW was significantly lower than those reared in saline waters ($P < 0.05$).

In Experiment 2, young fish weighing 108 ± 5.4 g were stocked in 1.5-ton tanks following acclimation to FW and seawater (SW). No fish mortality was recorded in complete FW over the period of 90 days. The final weights of the fish cultured in SW and FW were 174.15 ± 11.24 g and 180.85 ± 7.14 g, respectively ($P > 0.05$). Fish growth rates were 0.72 g day^{-1} in SW and 0.81 g day^{-1} in FW. Salinity did not significantly affect the meat crude protein, lipid or ash content ($P > 0.05$). Food conversion efficiency (FCE) was slightly higher in SW (77%) than in FW (74%). The mean fillet weight of the fish reared in FW was 16% higher than for SW. Fillet yields in FW and SW were 52% and 50%, respectively. From the blood plasma ions, Na^+ and Cl^- were lower in the fish grown in FW as compared to SW ($P < 0.05$), but K^+ level did not vary between the treatments ($P > 0.05$).

Key Words: *Dicentrarchus labrax*, sea bass, body traits, salinity, freshwater, growth, fillet yield, fillet composition

Değişik Tuzluluklarda ve Tatlı Suda Yetiştirilen Deniz Levreğinde (*Dicentrarchus labrax*) Büyüme Performansı, Vücut Özellikleri ve Fileto Kompozisyonu

Özet: Bu çalışmada, iki ayrı deneme halinde, yavru ve genç deniz levreği (*Dicentrarchus labrax*) bireylerinin farklı tuzluluklarda ve tatlı sudaki (TS) (‰0,4) büyüme performansları, vücut özellikleri ve fileto kompozisyonu araştırılmıştır.

Birinci denemede, deniz levreği yavruları (9,5 ± 0,5 g) 240-L'lik fiberglas (40 x 40 x 150 cm) tanklar içerisinde farklı tuzluluklarda (TS, ‰10, 20, 30 ve 40) 90 gün boyunca yetiştirilmişlerdir. TS, ‰10 ve 20 tuzluluklarda yetiştirilen bireyler ‰30 ve 40 tuzluluklardaki bireylerden daha iyi bir büyüme göstermişlerdir ($P < 0,05$). Balığın ham protein, yağ ve kül içerikleri tuzluluktan etkilenmemiştir ($P > 0,05$). Ancak, tatlısudaki balıkların kuru ağırlığının, tuzlu suda yetiştirilenlerdekinden önemli ölçüde daha düşük olduğu belirlenmiştir ($P < 0,05$).

İkinci denemede, 108 ± 5,4 g ağırlığındaki balıklar, denizden (D) tatlı suya (TS) alıştırıldıktan sonra, 1,5 tonluk tanklara stoklanmışlardır. 90 günlük yetiştirme periyodu içerisinde, TS grubunda herhangi bir ölüme rastlanmamıştır. D ve TS gruplarındaki balıkların deneme sonu ağırlıkları sırasıyla 174,15 ± 11,24 g ve 180,85 ± 7,14 g ($P > 0,05$) olarak ölçülmüştür. Balıklarda büyüme oranı D grubunda 0,72 g / gün, TS grubunda ise 0,81 g / gün olarak hesaplanmıştır. Balıkların etlerindeki ham protein, yağ ve kül içeriği tuzluluktan etkilenmemiştir ($P > 0,05$). Yem çevirim etkinliği D grubunda %77, TS grubunda ise %74 olarak gerçekleşmiştir. TS grubunda ortalama fileto ağırlığı D grubundakilere göre %16 daha yüksek çıkmıştır. TS ve D gruplarındaki fileto oranları sırasıyla %52 ve %50 olarak belirlenmiştir. D grubuyla kıyaslandığında, TS grubundaki balıkların kanındaki Na^+ ve Cl^- içerikleri daha düşük çıkmıştır ($P < 0,05$), fakat K^+ miktarı her iki grupta da değişmemiştir ($P > 0,05$).

Anahtar Sözcükler: *Dicentrarchus labrax*, deniz levreği, vücut özellikleri, tuzluluk, tatlısu, büyüme, fileto oranı, fileto kompozisyonu

Introduction

The European sea bass, *Dicentrarchus labrax*, being a member of the family Morenidae is a remarkable euryhaline species capable of tolerating both hypersaline and freshwater (FW) environments (1,2). It has been used as a 'police fish' to control the reproduction and overpopulation of *Tilapia* sp. in FW ponds (3). The larval and juvenile development occurs in brackish waters and low saline environments encountered in lagoon and river mouths (4,5). Larvae of sea bass tolerate low salinities

(5-6 ppt) and display better growth performance at 10-20 ppt than at oceanic salinities (6-8).

The salinity tolerance of sea bass has been the subject of a number of studies (9-12). Other studies have been carried out on the acclimation of sea bass from seawater (SW) to FW (13,14), but little information is available on the growth performance and survival of this marine species in complete FW. Dendrinos and Thorpe (15) found that sea bass juveniles were not able to survive in salinities lower than 3 ppt. These authors report a complete mortality within a few days following transfer from normal SW to FW. Trials have shown that direct transfer from SW to FW led to death of all individuals in 48 h (13); hence, a slow acclimation protocol lasting 17 days was recommended for sea bass juveniles (14).

The cage farming of European sea bass and gilthead sea bream is thriving on the Aegean coast of Turkey as there are numerous suitable sites. The lack of sheltered bays suitable for cage culture in other parts of the country (e.g. the Mediterranean coast) has forced aquaculturists to consider estuaries, which are always subjected to extreme fluctuations in salinity due to dilution by FW, and even FW resources themselves. Although the sea bass is known to occur in brackish water, streams, rivers and FW ponds, the potential of successfully growing this species has not been demonstrated. As it is a very popular fish commanding high prices in markets, it would certainly be a good candidate for culture in such water bodies.

Hence, this study was carried out to investigate the effects of various salinity levels and FW on the growth, body traits and fillet composition of juvenile and young sea bass in fibreglass tanks in the laboratory. The primary aim was to examine the possible benefits and aquaculture potential of sea bass in low salinities and FW.

Materials and Methods

This study was conducted in two separate experiments at the Marine Research Station of the Faculty of Fisheries, Çukurova University, Yumurtalık, Turkey. Water parameters such as temperature, salinity, pH, and dissolved oxygen were continuously monitored with a salinometer (YSI 30, USA), an oxygenmeter and a pH-meter (WTW, Germany).

Experiment 1

The effects of various salinities (FW, 10, 20, 30 and 40 ppt) on the growth performance of juvenile were studied in this experiment. Juveniles weighing 9.50 ± 1.88 g (mean ± s.d.) supplied by a commercial farm (Akuvatur, A.S., Tuzla, Adana, Turkey) were reared in a 10-ton fibreglass tank in our station at 40 ppt for one week prior to acclimation to the experimental salinities. Acclimation was done for approximately 1-1.5 days by lowering the salinity with well water by 2 ppt h^{-1} until the desired salinity levels (FW, 10, 20, 30 and 40 ppt) were reached. Throughout the study, sea water was mixed daily with freshwater, and aerated with an air-blower when all test salinities were adjusted with the salinometer.

The fish were randomly stocked into each fibreglass tank of 240 L (150 x 40 x 40 cm) at a density of 20 individuals and cultured for 90 days. The rearing water was filtered with a sand filter and a series of cartridge filters to 1 µm. Throughout the culture period, the rearing water in each tank was permanently saturated with oxygen by supplying air continuously through airstones with an air-blower. A daily water exchange of 50% was applied with pre-prepared waters throughout the study. The fish were fed four times daily to satiation by hand with a granulated sea bass feed (Table 1) produced by Pınar A.Ş. (İzmir, Turkey). Every 10 days, 10 fish from each tank were caught, rolled in tissue paper to remove surface moisture and their weights and total

Table 1. Nutritional composition of the pelleted feed used as food for the European Sea bass during the experiments. Data obtained from Pınar A.Ş., İzmir, Turkey.

Chemical composition	Per kg of feed
Crude fat (g)	120
Crude ash (g)	30
Crude protein (g)	460
Dry matter (g)	880
Crude fibre (g)	30
Metabilisable energy ME (cal)	4,100
Vitamins and minerals[a]	

[a] Supplied per kg of feed: 20,000 i.u. vitamin A; 2,000 i.u. vitamin D3; 100 i.u. vitamin E; 150 mg vitamin C; 15 mg vitamin K; 20 mg thiamine; 50 mg vitamin B2; 10 mg vitamin panthothenic acid; 20 mg pyridoxin; 210 mg inositol; 2,000 mg choline; 0.06 mg vitamin B12; 300 mg niacin; 1.2 mg biotin; 8.0 mg folic acid; 70 mg Zn; 60 mg Mg; 60 mg Mn; 10 mg Fe; 4.0 mg I; 5.0 mg Cu; 0.5 mg Co; 0.05 mg Se.

lengths (TL) were recorded with an electronic balance to the nearest 0.01 g and with callipers to the nearest 0.1 mm, respectively. The fish were not fed 24 h prior to sampling. At the end of the experiment, four fish grown at FW, 20 ppt and 40 ppt were randomly sampled for protein, lipid, ash and dry weight determination. Two cuts were made below the anterior dorsal fin in each fish and the tissue samples were immediately stored at –20 °C for further analysis.

Experiment 2

This experiment was performed to compare the growth performance, body traits and fillet composition of young sea bass weighing 108 ± 5.4 g in FW and normal SW (40 ppt). Ten fish, which had been grown in our station, were randomly stocked into 1.5-ton round fibreglass tanks in two replicates both for FW and SW treatments and were reared for 90 days. An acclimation rate similar to that explained above was used for the FW group. The fish were fed sea bass commercial pellets (Pınar A.Ş., İzmir, Turkey) (see Table 1) to satiation twice daily by hand throughout the study. The body weight and length measurements of all the fish in each tank were obtained monthly as above. All other experimental rearing procedures were identical to those described in Experiment 1. At the end of the experiment morphometric measurements were obtained from all the fish in each tank as shown in the figure in order to compare any possible differences in body traits between the FW and SW groups. The fish were eviscerated, and the weights of the viscera, gonads, visceral fat, and carcass [total weight - (head + viscera weight)] were measured. After evisceration, the whole fillets (skin and ribs intact) on both sides were removed in a single cut along the backbone from the head toward the tail. All the weights and lengths were measured to the nearest 0.01 g with a digital balance and 0.1 mm with callipers, respectively.

In addition, blood samples for determination of Na^+, K^+, Cl^- ions and tissue samples for proximate analysis were taken from randomly selected fish. The blood was taken from three fish chosen at random from each treatment after the fish had been stunned by a blow to the head, and blood was collected from punctured caudal fin. Each blood sample was immediately centrifuged at 5000 g for 10 min and Na^+, K^+ and Cl^- ion concentrations in the plasma were analysed by the Indirect Ion Selective Electorate (ISE) method by using a Vitro 750 Johnson and Johnson Analyser (Central Laboratory, Faculty of Medicine, Adana, Turkey). Tissue samples (n = 4 from each tank) were again taken from the musculature below the dorsal fin as explained in Experiment 1 for the determination of protein, lipid, ash and dry weight. The meat protein content of the fish was estimated by the Kjeldahl method (16). Total lipid was estimated

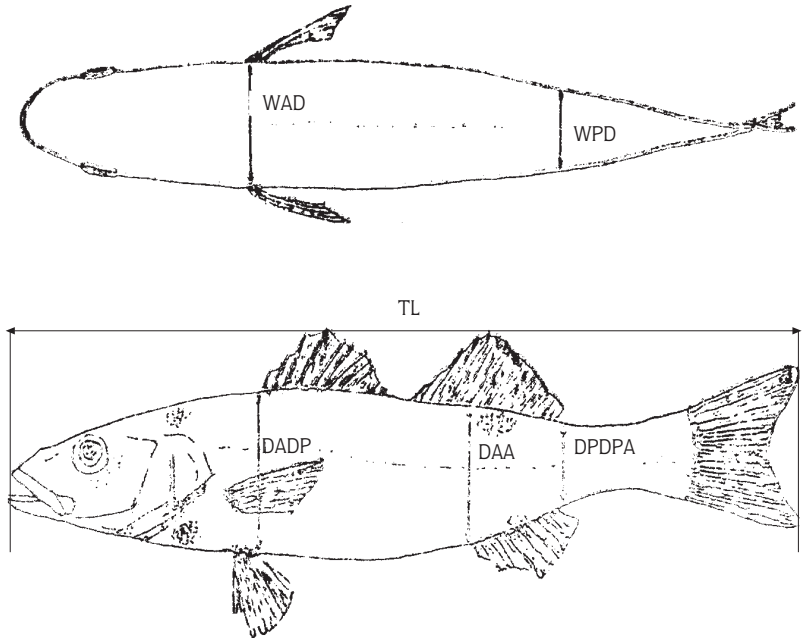

Figure. Some morphometric measurements taken from sea bass grown for 90 days in freshwater and sea water. WAD (width at anterior of dorsal fin), WPD (width at posterior of dorsal fin), DADP (depth at anterior of dorsal to pelvic fin), DAA (depth at anterior of anal fin), DPDPA (depth at posterior of dorsal to posterior of anal fin).

gravimetrically by the chloroform-methanol method of Bligh and Dyer (17). The samples were dried to constant weight at 103 °C. Ash content was estimated by keeping the samples at 450 °C for 5 h (18).

Statistical calculation

Data were analysed using one-way ANOVA and any significant differences were determined at the 0.05 probability level by Scheffès test after the normality and homogeneity (Bartlett's test) of the data were checked (19) with Minitab statistical software.

Results

Experiment 1

During the acclimation from SW to the test salinities, an acclimation rate of 2 ppt h^{-1} did not cause any fish mortality in the tanks. Even when 10 juvenile fish were directly transferred from SW to FW, only one fish died immediately. The remaining fish regained their normal feeding and swimming activities three days after the abrupt transfer from SW to FW.

Over the experimental period of 90 days, the temperature, oxygen, and pH were 23.4-26.2°C, 5.89-6.98 ppm, and 7.92-8.29, respectively. The fish grown at 10 and 20 ppt had higher growth rates (0.269-0.279 g day^{-1}) than those at normal SW (40 ppt) and 30 ppt (Table 2). The highest final weights were displayed at 10 ppt (33.45 g) and 20 ppt (33.41 g). The fish reared in FW had the second best weight at the end of the experiment. The daily growth rates in FW, 30 and 40 ppt were 0.265, 0.238 and 0.245 g day^{-1}, respectively. The specific growth rates at 30 and 40 ppt were lower than those displayed at salinities below 20 ppt or even in FW (Table 2). The specific growth rates at FW, 10 and 20 ppt were 1.37, 1.41 and 1.39, respectively. No mortality was recorded during the 90-day culture period in any of the treatments.

The meat crude protein, lipid and ash levels of the fish cultured at FW, 20 and 40 ppt did not differ significantly from each other ($P > 0.05$) (Table 3). However, the dry weight was higher in SW (23.79%) or at 20 ppt (23.62%) than that (22.51%) in FW ($P < 0.05$).

Table 2. Final mean weight and total length, daily growth rate, specific growth rate and survival of juvenile sea bass (*Dicentrarchus labrax*) reared in varies salinities (FW, 10, 20, 30, 40 ppt) for 90 days. Each value is a mean ± s.d. (n = 10). Means within a row marked with different letters are significantly different ($P < 0.05$).

	Salinity (ppt)				
	FW	10	20	30	40
Final weight (g)	32.02 ± 0.88^{ab}	33.45 ± 2.55^{a}	33.41 ± 0.86^{a}	29.57 ± 1.87^{b}	30.58 ± 0.18^{b}
Final TL (cm)	14.83 ± 0.89^{a}	14.76 ± 0.72^{a}	14.79 ± 0.72^{a}	14.21 ± 0.65^{b}	14.31 ± 0.48^{b}
Daily growth rate ($g^{-1}day^{-1}$)	0.265	0.279	0.269	0.238	0.245
Specific growth rate (% day^{-1})	1.37	1.41	1.39	1.30	1.34
Final survival (%)	100	100	100	100	100

Table 3. Crude protein, lipid, dry weight, and ash content of fillet of sea bass reared for 90 days in various salinities (FW, 20 and 40 ppt) in Experiments 1 and 2. Each sample is a mean ± s.d. (n = 4). Means within a column marked with different letters are significantly different ($P < 0.05$).

	Salinity (ppt)	Crude protein (%)	Lipid (%)	Dry weight (%)	Ash (%)
Experiment 1	FW	20.88 ± 0.12^{a}	10.36 ± 1.89^{a}	22.51 ± 1.61^{b}	1.27 ± 0.41^{a}
	20	21.63 ± 0.23^{a}	10.66 ± 1.23^{a}	23.62 ± 0.06^{a}	1.33 ± 0.50^{a}
	40	21.24 ± 0.10^{a}	11.22 ± 0.65^{a}	23.79 ± 0.21^{a}	1.33 ± 0.52^{a}
Experiment 2	FW	25.01 ± 1.78^{a}	11.64 ± 2.90^{a}	29.84 ± 0.80^{b}	1.25 ± 0.16^{a}
	40	26.40 ± 1.08^{a}	10.00 ± 1.86^{a}	31.19 ± 0.13^{a}	1.50 ± 0.22^{a}

Experiment 2

Over the experimental period of 90 days, the temperature, oxygen, and pH were 24.5-26 °C, 5.5-6.7 ppm, and 7.96-8.12, respectively. The final mean weights of the fish reared in FW (181 g) and SW (174 g) were not significantly different from each other ($P > 0.05$) (Table 4). Yet, each fish grown in FW grew 6.7 g (> 3.8%) more than that in SW within only three months. The daily growth rates in SW and FW groups were 0.72 and 0.81 g day^{-1}, respectively. The food conversion efficiency (FCE) was slightly higher in the SW group (77%) than in the FW group (74%). The condition factors of the fish grown in FW and SW were 1.11 and 1.04, respectively (Table 4).

Examination of the meat crude protein, lipid and ash contents showed that the SW and FW groups did not differ significantly from each other in terms of these parameters ($P > 0.05$) (Table 3). Yet, the dry weight of the SW group was significantly higher than that of the FW group ($P < 0.05$).

The K^+ ion levels of the blood plasma were not affected in the young European sea bass grown for 90 days in SW (2.85 ± 0.51 mM) or FW (2.55 ± 0.35 mM) ($P > 0.05$). Yet, significant differences were apparent between Na^+ and Cl^- ion levels in the fish cultured in these treatments. Na^+ and Cl^- ion levels were significantly higher in the blood of those cultured in SW (Na^+ = 171.00 ± 1.41 mM, Cl^- = 155.00 ± 4.24 mM) than in FW (Na^+ = 159.25 ± 1.71 mM, Cl^- = 129.00 ± 2.08 mM) ($P < 0.05$).

Some measurements related to body traits are summarised in Table 5. Depth at anterior of anal fin (DAA) and width at posterior of dorsal fin (WPD) were significantly higher for sea bass reared in FW than in SW ($P < 0.05$). However, width at anterior of dorsal fin (WADP), depth at posterior of dorsal to posterior of anal fin (DPDPA) and width at anterior of dorsal fin (WAD) were not significantly different from each other ($P > 0.05$). Although the mean fillet weight of the fish grown in FW (95.82 g) was 13 g higher than that (82.79 g) in SW, this difference was not statistically significant ($P > 0.05$). Total yield in FW group was 134 g higher (> 3.8%) than that in the SW group (Table 4). Fillet yields of sea bass reared in FW and SW were 52% and 50%, respectively (Table 5) ($P > 0.05$).

Discussion

The present results confirm that the European sea bass is a very successful hypo- and hyperosmoregulator species both during juvenile and young stages (2). Although it is extremely tolerant to salinity fluctuations, a number of studies have shown that this species cannot tolerate a direct transfer from SW to FW (13,15). The former reported a loss of appetite and heavy mortality in FW in sea bass juveniles (24 ± 1) which had even been acclimated to FW for 2 weeks (15). These authors further attempted to acclimatise the fish weighing 80 g or 220 g to FW but without success. More recently, in a study by Jensen et al. (2), only a few fish (weighing 6.2 g) died after direct transfer from 15 ppt to FW. These researchers reported that the lower and upper salinity thresholds were 0-5 ppt and 60 ppt, respectively. Our work demonstrated that sea bass juveniles (9.5 g) were able to withstand an abrupt salinity change from 40 ppt and even to FW. Only one fish died out of 10 a few hours following the sudden transfer from SW to FW indicating that juveniles need gradual acclimation (5). Those which tolerated the salinity shock regained their normal swimming and feeding activity within three days. The fish

Table 4. Mean weight, final total length, daily growth rate, specific growth rate, food conversion efficiency (FCE) and condition factor of sea bass (*Dicentrarchus labrax*) grown in sea water and fresh water for a 90-day grow-out period. Each value is a mean ± s.d. (n = 10). Means within a row marked with the same letters are not significantly different ($P > 0.05$).

	Sea water	Freshwater
Final weight (g)	174.15 ± 11.24[a]	180.85 ± 7.14[a]
Final total length (cm)	25.57 ± 0.22[a]	25.31 ± 0.07[a]
Total yield (g)	3483	3617
Daily growth rate (g^{-1} day^{-1})	0.72	0.81
Specific growth rate (% day^{-1})	0.52	0.57
FCE* (%)	77	74
Condition factor*	1.04 ± 0.09	1.11 ± 0.03

* FCE = weight gain / food intake

* Condition factor = weight / $length^3$

Table 5. Body traits of sea bass (*Dicentrarchus labrax*) reared in sea water and fresh water for 90 days. Each value is mean ± s.d. (n = 10). Means within a row followed by different letters are significantly different (P < 0.05).

Body Traits	Sea water	Freshwater
Depth at Anterior of Dorsal to Pelvic Fin (DADP) (mm)	48.29 ± 2.42[a]	49.91 ± 7.69[a]
Depth at Anterior of Anal Fin (DAA) (mm)	46.19 ± 2.51[b]	48.46 ± 2.66[a]
Depth at Posterior of Dorsal to Posterior of Anal Fin (DPDPA) (mm)	29.49 ± 2.13[a]	30.11 ± 1.45[a]
Width at Anterior of Dorsal Fin (WAD) (mm)	29.12 ± 1.56[a]	27.98 ± 2.75[a]
Width at Posterior of Dorsal Fin (WPD) (mm)	15.79 ± 2.28[b]	17.39 ± 1.15[a]
Carcass Weight (g)	101.43 ± 18.45[a]	112.6 ± 19.14[a]
Fillet Weight (g)	82.79 ± 15.27[a]	95.82 ± 17.00[a]
Fillet Yield (FY)* (%)	49.82 ± 2.26[a]	51.69 ± 2.54[a]
Visceral Weight (g)	15.34 ± 4.28[a]	13.26 ± 3.51[a]
Visceral Lipid Weight (g)	7.77 ± 2.92[a]	6.55 ± 2.60[a]
Gonad Weight (g)	0.76 ± 0.03[a]	0.85 ± 0.35[a]

* FY = (Fillet weight / final weight) x 100

cultured in FW after an acclimation rate of 2 ppt h^{-1} did not show any sign of stress or mortality throughout the culture period of 90 days in our experiments. Therefore, an acclimation rate of 2 ppt h^{-1} appears to be suitable if sea bass is to be acclimatised from 40 ppt SW to FW without any adverse effects on growth or survival.

The present study shows that juvenile and young sea bass were not only able to survive successfully in FW but could also grow well in this medium. Our results do not agree with the findings of Dendrinos and Thorpe (15), who observed an immediate loss of appetite and heavy mortality in fish gradually acclimated to FW over a period of two weeks. These authors found that when fish suffering salinity shock after FW transfer were placed into 5 ppt saline water, no further mortality occurred and the fish immediately recovered. Further attempts by these authors to acclimatise the fish into FW again failed. In our study, however, neither juvenile nor young fish had any difficulty in acclimation to FW. Hence, euryhaline capability does not seem to be affected by fish size, confirming the suggestion of Jensen et al. (2). It is difficult to see why there is a clear difference in tolerance to FW between the sea bass stocks used by Dendrinos and Thorpe (15) and those used by us. It is known that inherent differences to salinity tolerance exist in shrimp populations located in different parts of the world (20,21). This type of environmental adaptation may also be true for different geographical strains in fish. In fact, a difference in tolerance to salinity has already been suggested between the European sea bass populations inhabiting marine and lagoon ecosystems (22). It was also found that hatchery juveniles tolerate direct transfer to low salinities better than wild juveniles (14).

The results from juvenile size bass (9.5 g) in the first experiment indicated that the optimum salinities for growth lie between 10 and 20 ppt (Table 1). In addition, the growth obtained with complete FW was also similar to that obtained with the above reduced salinities (P > 0.05). A decrease in salinity from 40 ppt to 10 ppt resulted in fish 3 g heavier within a growing period of only three months. The fish growth rates (0.245-0.279 g day^{-1}) obtained at temperatures between 23.4 and 26.2 °C were much higher than that reported by Khulman (23), who obtained 0.055 g day^{-1} at 15-19 °C for the same species. In our study, daily growth rates at 10, 20 and FW were 0.279, 0.269 and 0.265 g day^{-1}, respectively. In contrast to our findings, for the same species, Dendrinos and Thorpe (15) determined 30 ppt to be the best salinity and reported that the growth rates were lower at 25, 33, 20, 10 and 5 ppt in order of decreasing rate. The data in the literature for larvae also indicate that reduced salinities favour growth in comparison to oceanic salinities. For example, Johnson and Katavic (7) reported better growth rates in larvae at 10 and 20 ppt than at 30 and 38 ppt. Alliot et al. (6) also found better larval growth at 6-24 ppt than at 37 ppt. The results of our first experiment clearly show that the growth at 40 ppt (normal SW) was significantly lower

than that in FW. Our second experiment revealed that young sea bass also tolerate FW and grow well. The fish grown in FW attained a weight about 4% heavier than those in SW within a growing period of three months. Roche et al. (24) reported better growth performance over of 11 weeks in *D. labrax* at 5 ppt as compared to normal oceanic salinity. Zanuy and Carrillo (25) obtained similar growth rates in sea bass grown for 14 months at 37.8 and 3.5 ppt. Therefore, the present results indicated for the first time that sea bass can be reared in FW at a growth rate comparable to that in SW or low saline water.

In Experiment 2, the data showed that the overall body traits of the fish reared in FW were not different from those in SW. The exceptions were DAA and WPD, both of which were higher in FW ($P < 0.05$). Although fillet weight did not differ significantly, the fish grown in FW for a period of three months had a fillet weight 16% higher than those in SW. Fillet yield (fillet weight / body weight) is an economically important trait in striped bass (26) and may also be important for the European sea bass in the future. The fillet weight and condition factor results indicate that the growth occurred in the flesh of the fish rather than in other body parts. Indeed, no significant differences were apparent between the visceral, visceral lipid and gonad weight of the fish in either of the culture media. Fillet yields obtained in FW (52%) and SW (50%) were also similar ($P > 0.05$). Body traits were correlated with mean fillet weights.

A rise in salinity causes a corresponding increase in the feeding rate in fish (27,28). In catadromous grey mullet, FCE decreased as salinity increased (28). Dendrinos and Thorpe (15) found the maximum FCE in sea bass at 25 and 30 ppt. Zanuy and Carrillo (25) found similar FCE values in sea bass grown at 37.8 and 3.5 ppt. In the current work, the FCE in SW (77%) and FW (74%) were also similar. Based on the literature and the present results, salinity does not seem to have a significant effect on the FCE in sea bass.

As fish mature and begin preparations for spawning, a portion of energy is diverted for gonad development and stored in the form of lipid (29). The level of fat reserves as visceral fat and ovarian development serve as an indicator of spawning preparations (26,30). Zanuy and Carrillo (25) found that sea bass grown in SW did not grow as fast as those in well water of low salinity (3.5 ppt) during the reproductive season. Unfortunately, Experiment 2 in our study was not long enough to determine whether the FW group would grow significantly faster than the SW group due to energy diversion to gonad development in SW. Hence, it would be interesting to observe the relationship between gonad development and growth in the European sea bass grown to maturity in FW.

The determination of the meat protein and lipid content of the fish in our study revealed that the levels were similar to those reported elsewhere for the same species (15). Our results agree with the suggestion of Dendrinos and Thorpe (15), who stated that salinity has no significant effects on the protein and lipid contents in the meat of sea bass. Alliot et al. (6) reported that the body composition of sea bass was influenced by temperature rather than salinity. Yet, FW significantly increased the muscle water content of the fish ($P < 0.05$). Meat water content slightly increases when a euryhaline fish species such as European sea bass is transferred from SW to FW (2,15). The present results showed that the meat of the fish in the FW group had about 1.28-1.38% higher water content than the SW group ($P < 0.05$).

The ionic composition of the blood plasma in euryhaline fishes differs in relation to their FW or marine adaptations (31). Our observations of the ionic constituents (Na^+, K^+ and Cl^-) in the blood plasma revealed results similar to those reported by Jensen et al. (2) for the same species. These authors found an increase in Na^+ and Cl^- levels after a sudden transfer from 15 ppt to 50 ppt and a decrease from 15 ppt to FW. Plasma Na^+ and Cl^- levels reached a steady state four days after the FW transfer. We also found significantly lower Na^+ and Cl^- levels in the blood of fish grown for 90 days in FW than at SW. The K^+ level did not vary much with salinity as also reported by Dendrinos and Thorpe (15). In their study, the ionic constituents of the blood plasma (e.g. Na^+, Ca^{2+}, Mg^{2+} and K^+) did not vary over the range of 5 to 33 ppt throughout the experiment. It appears that sea bass are able to maintain a constant blood ionic composition in salinities between 5 and 33 ppt but not in FW in which Na^+ and Cl^- ions were found to be lower in the study by Jensen et al. (2) as well as in the present study. The former suggested that the stress and mortality occurring after FW transfer may be due to severe ion loss. However, after a gradual acclimation, no sign of stress in sea bass was evident as reflected in the growth data.

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