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RESEARCH ARTICLE

THE EFFECTS OF LARGER FISH AND SIZE GRADING ON GROWTH PERFORMANCE OF WHITE SEA BREAM JUVENILES (*DIPLODUS SARGUS*)

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ABSTRACT

This study was conducted to determine the effects of size grading on growth performance of white sea bream (*Diplodus sargus*) juveniles. Wild-caught fish were size sorted into two different groups: small (5.6 g) and large (7.5 g) and then four experimental groups were assigned as 100% small group (S100), 25% large + 75% small group (S75), 50% small + 50% large group (S50), and finally 75% small + 25% large group (S25). Twenty fish were stocked into each tank (450 L) connected with a flow through system in three replicates per treatment. The juveniles were fed to satiation with a commercial feed for 60 days. According to final results, specific growth rate for all periods was similar in all experimental groups ($P>0.05$). No significant differences were found in survival rate ($P>0.05$). On the other hand small fish final weight of S50 was significantly higher than the others ($P<0.05$). There were significant difference between FCR of graded group (S100) and mixed groups (S25, S50 and S75) ($P<0.05$). The results have demonstrated that the larger individuals in the present study did not suppress growth of the smallest individuals. The fish in S100 were adversely affected by the absence of large fish and this was postulated to be due to poor competition for food acquisition in this group. For this reason size grading seems to be unnecessary to improve growth and survival of white sea bream of around 5.6-7.5 g.

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INTRODUCTION

The Mediterranean aquaculture mainly marine fish farming of sea bass, sea bream, Atlantic salmon and turbot has been notable for its development and growth in the last decade. However, this dramatic increase especially in the production of sea bass and sea bream has occurred despite technical constraints and limited markets (Basurco and Abellan, 1995; Ozorio *et al*., 2006). It is now clear that one explicit strategy for step-up of European aquaculture lies in its diversification (Quemener *et al.,* 2002). Currently, about 25 'new' marine fish species are under investigation in the Mediterranean area, including Dover sole (*Solea solea*), blackspot seabream (*Pagellus bogaraveo*) (Ozorio *et al*., 2004) and white seabream (*Diplodus sargus*) (Ozorio *et al*., 2006). A special emphasis is given to the white sea bream farming sector in Southern Europe, because it is considered to be a promising new species, having a high market price and demand (Pousao-Ferreira *et al*., 2001; Ozorio *et al*., 2006; Santos *et al*., 2006; Saaverda *et al*., 2009). However, a decrease in growth rate was faced when approaching the juvenile stage of this species because of its hierarchic behavior (Cejas *et al*., 2003). In general, size variability in a batch of same-age fish is common among farmed fish (Huntingford *et al*., 1990; Stefánsson *et al*., 2000; Saoud *et al*., 2005). This hierarchy effect may be due to direct competition for food or the result of social interactions depressing the growth of the smaller members of the population (Jobling 1982). A wide size distribution in aquaculture is disadvantageous due to social growth suppression of small individuals (Ruzzante, 1994). There are many instruments to overcome this problem. One of the commonest tools is size grading, that is used in the culture of many commercial fish species in an attempt to improve growth

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and survival (Gunnes, 1976; Huet, 1986; Baardvik and Jobling, 1990; Popper *et al*., 1992; Kamstra, 1993; Alev and Dikel 2010, Dikel *et al*., 2010). The main idea behind size grading in general is to separate small and large individuals from each other to avoid potentially negative effects of social interactions (Jobling, 1982, 1995; Knights, 1987). In some fish species, dominant or large individuals exhibit higher growth rates than subordinates (Brown, 1946; Magnuson, 1962; Jobling, 1985, 1995; Koebele, 1985), and several mechanisms have been proposed to explain how larger dominant individuals suppress the growth of small subordinates (Wirtz, 1974; Koebele, 1985; Wallace *et al*., 1988). Competition for food seems to be particularly important in governing growth (Magnuson, 1962; Wallace and Kolbeinshavn, 1988; Jobling and Koskela, 1996), and in the absence of competition from larger individuals, smaller individuals avoid the negative effects of a dominance hierarchy and may achieve higher growth rates (Purdom, 1974). However, size grading, in some cases, has been shown to reduce growth, possibly owing to higher levels of interaction between fish of the same size (Doyle and Talbot, 1986; Baardvik and Jobling, 1990; Sunde *et al*., 1998).

Actually size grading is believed to reduce the harmful effects on small fish, with a consequent reduction in size variation and increased biomass gain. Nevertheless, there is evidence that size grading may not eliminate this effect in all species [e.g., in Arctic charr (*Salvelinus alpinus*), Baardvik and Jobling, 1990; in European eel (*Anguilla anguilla*), Kamstra, 1993; in channel catfish (*Ictalurus punctatus*), Carmichael, 1994; in turbot (*Scophthalmus maximus*), (Sunde *et al*., 1998) and in silver perch (*Bidyanus bidyanus*) Barki *et al*., 2000; marbled spinefoot rabbit fish (*Siganus rivulatus*) (Ghanawi *et al*., 2010). At present there are no clear guidelines about the need for grading in white seabream (*D. sargus*) hatchery operations. Therefore, the following experiment was designed to investigate the effect of size grading and larger fish on growth and survival of juvenile white seabream.

MATERIALS AND METHODS

White sea bream juveniles (*Diplodus sargus*) were caught by beach seine in Yumurtalik Bight and transported to Yumurtalik Marine Research Station of Faculty of Fisheries in Cukurova University. They were then randomly stocked in 2 circular fiberglass tanks (3-m diameter, 1000 L) fitted with a continuous water flow-through system. Fluorescent lighting was provided in addition to natural lighting to maintain a 12-h light: 12-h dark photoperiod with daybreak set at 07:00 h. Water temperature was checked daily. Throughout the 60 days experimental period, the rearing water in each tank was permanently saturated with oxygen by supplying air continuously through air stones from an air blower. Average water temperature ranged from 24.5 to 26.5 °C. The dissolved oxygen and pH were measured every five days, and they averaged 7.2 ± 0.4 mg/L and 7.8 ± 0.5, respectively.

Fish were acclimated to the system for 1 month before the experiment started. After the acclimation period, the fish were individually weighed and manually graded into two size groups: small and large. Four treatments with three replicate tanks (450 L) per treatment were established.

S25: Mixed as 25% small +75% large (small 5.45 ± 0.26 g and large 7.56 ± 0.43 g),
S50: Mixed as 50% small + 50% large (small 5.78 ± 0.19 g and large 7.48 ± 0.22 g),
S75: Mixed as 75% small + 25% large (small 5.68 ± 0.06 g and large 7.21 ± 0.48 g).
S100: Graded Group 100% small (5.68 ± 0.06 g) (mean ± SD).

Stocking rate was twenty fish for each tank and maintained in a flow-through system. Water exchanged was 1 L. min^{-1}. Fish were offered a commercial diet (Çamli Yem Ltd., Izmir, Turkey) containing 50% protein, 15% lipid three times daily (09:00, 13:00 and 18:00 h) until apparent satiation. All the fish in each tank were individually weighed (to the nearest 0.01 mg) every 10 days, after anesthetizing in 0.3-mL/L 2-phenoxyethanol (Sigma, St. Louis, MO, USA). Only large fish in mixed groups were tagged with plastic numbers with suture materials. Each tag consisted of a needle with an attached length of thread (braided polyester-silicone coated). Fish were sutured from dorsal area with gently. No fish died during tagging and no tags were lost during the experiment.

Calculations

Performances of the fish were evaluated by calculating the following parameters from the data collected: Weight gain (g); (W_{final} - $W_{initial}$). Daily weight gain (g day^{-1}); [(W_{final}- $W_{initial}$) day^{-1}]. Specific growth rate (SGR % body weight day^{-1}); [(ln w_1- ln w_0) (t_1 - t_0)$^{-1}$] 100, where w_1 and w_0 are wet weight at times t_1 and t_0. Feed conversion ratio (FCR); consumed feed / (W_{final} - $W_{initial}$) , where W_{final} and $W_{initial}$ are live weights (g) of the fish at day final and initial , respectively and a coefficient of variation [CV= (SD/mean)] for individual fish within each tank was compared among treatments. The mean and standard deviation (± SD) was calculated for all parameters in each group and the differences on growth performance were examined by comparison of mean weights of fish.

Statistical analyses

Data are reported as mean ± S.D (n=20) throughout the text. Data were analyzed by one-way analysis of variance (ANOVA) at a significance level of 0.05%, after confirmation of normality and homogeneity of variance. Where significant differences were detected, data were subjected to Duncan post hoc test for identifying homogeneous subset SPSS11.5 (SPSS Inc., Chicago, IL, USA).

RESULTS

During the experiment, survival ranged from 95.0% to 100% with no statistical difference among the experimental groups and unaffected by treatments (P>0.05). Overall growth performance is reported in Table 1. Some statistically significant differences were noted in overall performance of the treatments, including final weight, weight gain, FCR and $CV_{final}/CV_{initial}$, however, no difference were observed in daily weight gain and SGR. In general, S25 (16.2 g) group had significantly higher growth than that of S100 (13.3 g) (Figure 1).

Table 1. Growth performance and feed utilization of white sea bream reared in four different groups for 60 days

	S25	S50	S75	S100
Overall Fish Performance				
Initial Weight (g)	7.0 ± 0.39	6.55 ± 0.04	6.1 ± 0.09	5.7 ± 0.07
Final Weight (g)	16.2 ± 0.80^a	15.65 ± 0.21^b	14.8 ± 0.18^b	13.3 ± 0.29^c
Weight gain (g)	9.2 ± 0.49^a	9.10 ± 1.17^a	8.7 ± 0.19^a	7.6 ± 0.34^b
Daily Weight gain (g/day)	0.153 ± 0.01^a	0.150 ± 0.02^a	0.145 ± 0.00^a	0.126 ± 0.01^a
FCR	1.6 ± 0.06^b	1.7 ± 0.24^b	1.6 ± 0.19^b	1.9 ± 0.26^a
SGR	1.4 ± 0.06^a	1.5± 0.12^a	1.5 ± 0.03^a	1.4 ± 0.05^a
$CV_{final}/CV_{initial}$	1.2 ± 0.09^{ab}	0.8 ± 0.14^b	1.1 ± 0.19^{ab}	1.5 ± 0.51^a
Small Fish Performance				
Initial Weight (g)	5.5 ± 0.26	5.7 ± 0.04	5.7 ± 0.06	5.7 ± 0.07
Final Weight (g)	12.1 ± 0.85^c	14.6 ± 0.53^a	13.8 ± 0.40^{ab}	13.3 ± 0.29^b
Weight gain (g)	6.6 ± 0.59^c	8.9 ± 0.57^a	8.1 ± 0.43^b	7.6 ± 0.34^b
Daily Weight gain (g/day)	0.0.110 ± 0.01^b	0.148 ± 0.02^a	0.135 ± 0.01^{ab}	0.126 ± 0.01^b
SGR	1.3 ± 0.04^c	1.6±0.07^a	1.5 ± 0.06^{ab}	1.4 ± 0.05^{bc}
CV_{final}	0.15 ± 0.04^a	0.10 ± 0.02^a	0.13 ± 0.02^a	0.15 ± 0.02^a
Large Fish Performance				
Initial Weight (g)	7.6 ± 0.43	7.4 ± 0.12	7.2 ± 0.48	
Final Weight (g)	17.5 ± 0.82^a	16.7 ± 1.83^a	17.6 ± 0.64^a	
Weight gain (g)	9.9 ± 0.70^a	9.3 ± 1.71^a	10.4 ± 0.40^a	
Daily Weight gain (g/day)	0.165 ±0.01^a	0.155 ± 0.03^a	0.173 ± 0.01^a	
SGR	1.4 ± 0.08^a	1.4 ± 0.16^a	1.5 ± 0.07^a	
CV_{final}	0.15 ± 0.03^a	0.10 ± 0.02^{ab}	0.07 ± 0.03^b	

Values in the same row with different superscripts are significantly different ($P< 0.05$) as determined by ANOVA. Values are means ± standard deviation (n=3)

Table 2. Slope, intercept, and regression coefficient (R^2) of growth linear model $W = axt + b$ where W is weight in grams and t is time in days. Values not sharing same letter are significantly different ($P < 0.05$)

Treatment	Slope (a)	Intercept (b)	R^2
S25	1.54^a	5.03	0.99
S50	1.52^a	4.55	0.99
S75	1.47^b	4.20	0.99
S100	1.27^c	4.05	0.99

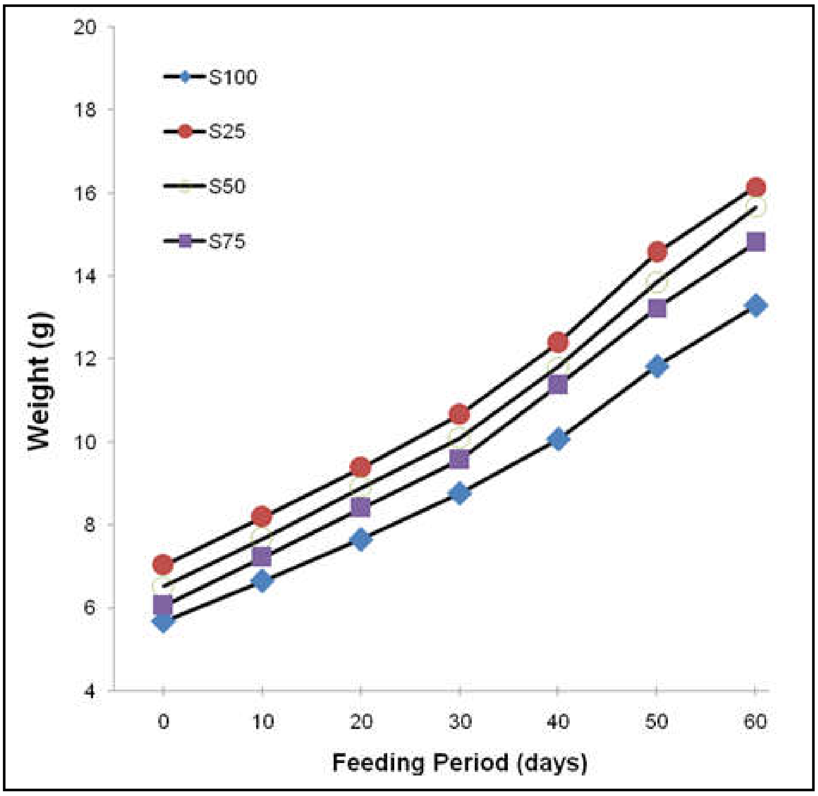

Figure 1. Growth of size graded juvenile white sea bream over 60 days. Data represent mean± SEM (n=3)

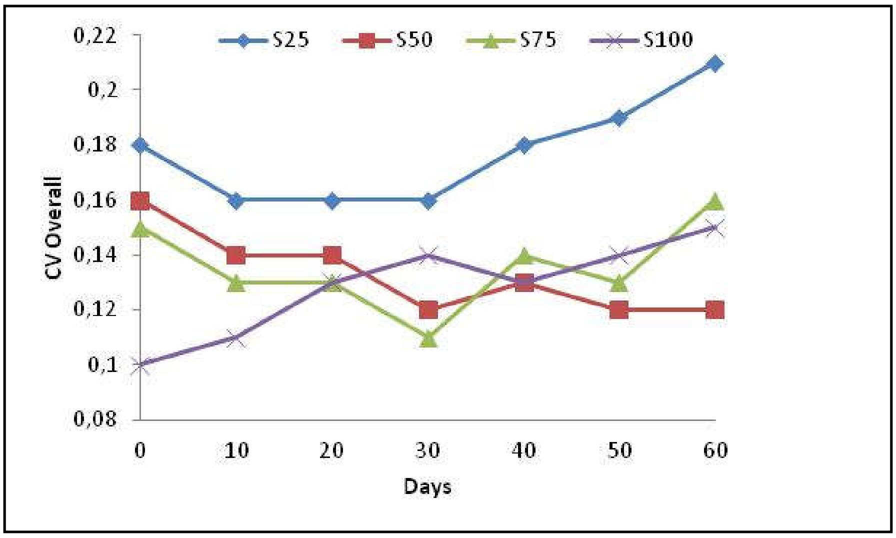

Figure 2. Coefficient of variation (CV) in overall fish weight within each treatment for juvenile white sea bream over 60 days. Data represent mean± SEM (n=3)

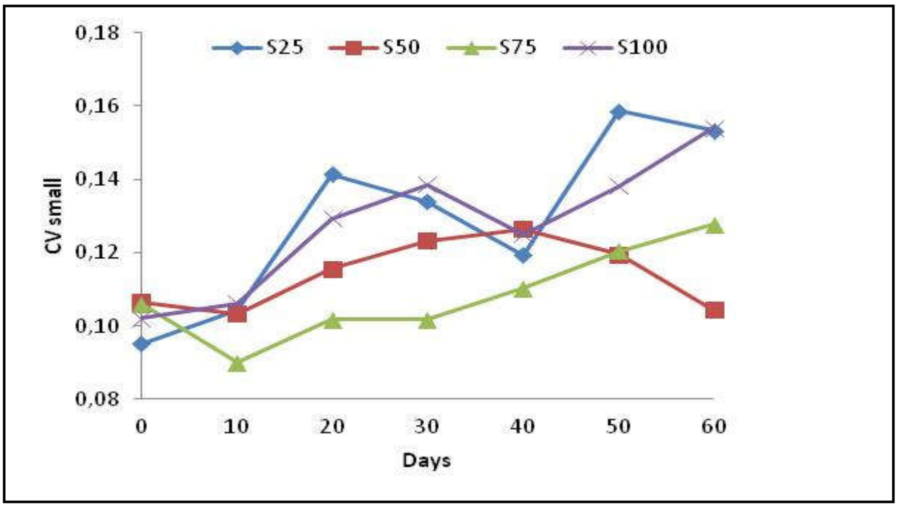

Figure 3. Coefficient of variation (CV) in small fish weight within each treatment for juvenile white sea bream over 60 days. Data represent mean± SEM (n=3)

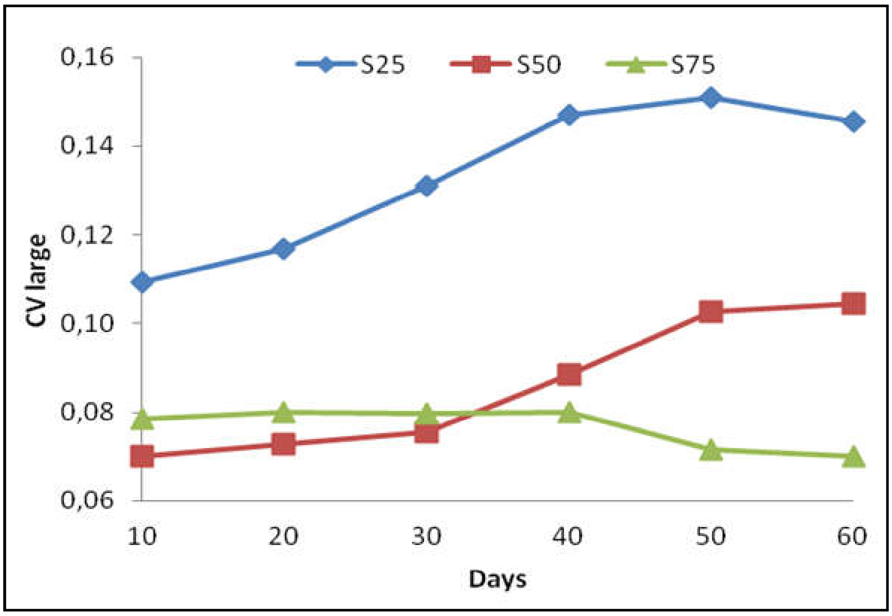

Figure 4. Coefficient of variation (CV) in large fish weight within each treatment for juvenile white sea bream over 60 days. Data represent mean± SEM (n=3)

The slope of growth curve (weight vs. time) for fish in S25 treatment was significantly greater than those in all other treatments. The slope of growth for S100 treatment was significantly lesser than that of S50 or S75 treatment (Table 2). FCR for fish in S100 (1.9) was significantly greater than those for S25 (1.6), S50 (1.7 g), or S75 (1.6) treatments (Table 1). It is noteworthy that the CV_{final} / $CV_{initial}$ of S100 group was higher than their respective CV_{final} / $CV_{initial}$ (Table 1). Coefficient of variation (CV) in overall fish weight within each treatment for juvenile white sea bream over 60 days is shown in Figure 2.

By the end of the feeding trial, small fish final weight, average weight gain (8.9 g) and SGR (1.6 % body weight day^{-1}) of the S50 group was higher than the others (P<0.05). Graded small individuals (S100) grew slower compared to the others. As clearly depicted, the most remarkable growth performance was obtained when number of small fish and large fish were balanced (S50). Small fish of S50 had highest SGR (1.6%) among all other treatments. CV_{final} for small fish was ranged from 0.10 to 0.15. A relatively large variability in the data was responsible for a lack of statistically significant results for CV for small fish despite evident numerical differences throughout the experimental period (Figure 3). No significant differences were recorded for final weight, weight gain, daily weight gain and specific growth rate in large fish whereas there were significant differences in CV large final values among treatments (Figure 4).

Briefly, the major affects of large fish in the treatments were as follow: 1) absence of large fish had significant effect on the growth performance of small fish. 2) The presence of small fish has no impact on the growth of large fish. 3) Different proportions of large fish in mixed size groups have shown similarly growth performance.

DISCUSSION

The results of present study demonstrated that the presence of large fingerlings of white sea bream had positive impacts on the growth performance of smaller individuals when kept together at equal numbers. It is generally accepted that intraspecific competition and agonistic interaction are found to be greater when fish of the similar size are reared together in fishes like Arctic charr *Salvelinus alpinus* L. (Baardvik and Jobling, 1990), turbot *Scophthalmus maximus* (Sunde *et al*., 1998) and Atlantic halibut *Hippoglossus hippoglossus* (Stefánsson *et al*., 2000). However, some recent studies have produced findings different from the above-mentioned general assumption (Wallace and Kolbeinshavn, 1988; Baardvik and Jobling 1990; Jobling *et al*., 1991; Kamstra, 1993; Strand and Øiestad, 1997; Sunde *et al*., 1998; Dou *et al*., 2004). Some mechanisms have been proposed to explain how size hierarchies influence the growth, e.g., physiological stress (Jobling, 1985; Abbott and Dill, 1989; Huntingford *et al*., 1993; Griffiths and Armstrong, 2002), disproportional food acquisition (Koebele, 1985; Grant, 1997), and activity differences (Adams *et al*., 1998; Sloman and Armstrong, 2002). These mechanisms are all based on the general assumption that relative size is the most important determinant of fighting ability in aggressive behavior as well as attacking opponents and obtaining preferential access to food (Dou *et al*., 2004). Differential access to food or disproportional food acquisition is often considered to be an important factor responsible for the retardation of growth of the subordinates in fish populations (Magnuson, 1962; Jobling and Wandsvik, 1983; Koebele, 1985; Abbott and Dill, 1989). The mechanism underlying this social interaction is that dominants defend the point of sources of food or areas with high prey concentration, thus behaviorally preventing the subordinates accessing food (Dou *et al*., 2004). In present study, provision of excessive food might have made it unworthy for the large white sea bream juveniles to defend food for all the time. As a result, the large juveniles might have lost their competitive advantage over the small ones and therefore the small juveniles could get equal overall access to food. In line with these results, food intake of the juvenile medaka and rainbow trout is highly correlated with dominance, but that relationship tends to become unstable if food is offered to excess (Magnuson, 1962; McCarthy *et al*., 1992). Besides, FCR for graded small white sea bream was higher than FCR's for the other groups and this is thought to be due to poor competition for food among the graded fish. The mixed groups (predominantly small group and large group) had lowest FCR values. These findings suggest that FCR's of white sea bream were affected from proportion of size fraction in the stock. To our understanding, it is likely that dominance hierarchy would be further enlarged when food supply is limited in white sea bream juveniles.

Monopolization and defense of food resources have consequences in the social environment of groups of juvenile white sea bream, generating the establishment of dominance hierarchies (Castro and Caballero, 1998) as a consequence of agonistic interactions and asymmetry in fighting ability (Maynard Smith and Parker, 1976). Lutnesky and Szyyper (1991) and Ryer and Olla (1995) observed that agonistic behavior increases when the distribution of food is spatially clumped; however, the results of Castro and Santiago (1998) indicate that the levels of aggression were greater in groups of juvenile white sea bream given spatially variable food than in groups given spatially fixed food. These authors claim that feeding regime of juvenile white sea bream is affected by food distribution to the culture media. As also suggested by Castro and Santiago (1998), it appeared in our study that small juvenile white sea bream tended to consume more food under variable food supply compared to dominant individuals. In the present experiment, the coefficients of variation in weight in S100, S25 and S75 groups were similar ranging between 1.1 and 1.5. However, CV of S50 was markedly smaller (0.8) than all the other groups. Growth differences among fish of the same generation could be due to environmental factors, associated physiological differences, and/or to the formation of social hierarchies, or due to genetic differences (Brown, 1946). In a population in which the CV increases with time, hierarchy effects might be responsible for the suppression in growth of certain individuals (Purdom, 1974). Dominance hierarchies lead to trade off between increased resource acquisition and energy loses associated with agonistic encounters. In the study, the growth rates of subordinate fish can be depressed as a consequence of dominant aggression but aggression may also involve energetic costs and loss of feeding opportunities during time spent in territory.

Jobling and Baardvik (1994) reported that increased CV was caused by hierarchical effect and some members of the population were dominant because of agonistic behaviors. Agonistic behaviors are instinctual acts performed by animals for the sake of surviving, continuing their bloodline, attacking, defending, or simply providing access to food sources. The researchers concluded that dominant members of the population caused level of CV increasing in time. In another similar study, growth was reported to slow down because of the hierarchy caused by large fishes on small ones. Another important reason generally reported in various studies is the genetic differences between fishes, which are thought to produce an agonism arising from the nature of the fish (Ghanawi *et al*., 2010). In the present study, when we generally evaluated the performances of individual members, we observed that weight gain in the S100 group was lower than those displayed by S25, S50 and S75 groups. When CV results are taken into account, the highest value was seen to be present in S100 group, in which weight gain was lowest. Other similar studies also reveal that a continuous competition of surviving takes place and highest levels of CV values, hierarchical relations and dominance are observed in groups, which consist of the same-sized members. Our results suggest that highest level of hierarchical interactions (high CV) and dominance were present in the S100 group, whilst these were almost nil in the S50 group, in which growth was highest and CV (0.8) lowest. This is consistent with studies by Jobling and Reinsnes (1986) and Jobling (1990) who also found out that hierarchical relation did not develop and length grading was not needed during the fingerling stage in mixed groups consisting of small and large sized members with a proportion of half-to-half.

In conclusion, we demonstrated that size grading in white sea bream juveniles culture did neither lead to improved growth nor survival and also the presence of larger individuals did not suppress smaller individuals. Therefore, it appears that size grading is unnecessary to improve growth and survival of white sea bream at size of around 5.6-7.5 g. Furthermore, based on our results, culturing small and large fish together at the same tank for a purpose of achieving better growth is also not recommended. These current findings contribute to the better understanding of the hatchery management of this species at fingerling stage, but further studies are clearly needed to deepen our insight about behavior of large fish under commercial stocking densities in white sea bream hatcheries.

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REFERENCES

Abellan, E. and A. Garcia-Alcazar. 1995. Pre-growout experiences with white sea bream (*Diplodus sargus,* Linnaeus, 1758) and sharpsnout seabream (*Diplodus puntazzo*, Cetti, 1977). In: MarineAquaculture Fin sh Species Diversi cation. Cahiers Options Mediterraneennes, 16, pp. 7–63. MEDRAP II (FAO/UNDP).

Abellán, E., A. García-Alcázar, A. Ortega, S. García-Alcázar, P. Martín. 1994. Cultivo de nuevas especies de espáridos mediterráneos: experiencias de preengorde y engorde del sargo común (*Diplodus sargus*, L. 1758) y del sargo picudo (*Diplodus puntazzo*, Cetti, 1777) Technical Report of the Spanish Institute of Oceanography,148,11pp.

Adams, C.E., F.A. Huntingford, J.F. Turnbull, C. Beattie. 1998. Alternative competitive strategies and the cost of food acquisition in juvenile Atlantic salmon (*Salmo salar*). Aquaculture 167, 17– 26.

Alev, M.V., S. Dikel. 2010. Effect of larger fish and size grading on growth and biomass gain in nile tilapia (*Oreochromis niloticus*) in cage conditions. *Journal of Science and Engineering,* Vol 24 No 4. 222-231 pp.

Baardvik B.M. and M. Jobling. 1990. Efect of size-sorting on biomass gain and individual growth rates in Arctic charr, *Salvelinus alpinus* L. Aquaculture 90,11-16.

Barki A., S. Harpaz, G. Hulata, and I. Karplus. 2000. Effects of larger fish and size grading on growth and size variation in fingerling *silver perch*. Aquaculture International 8, 391-401.

Brown, M.E. 1946. The Growth of Brown Trout (Salmo trutta Linn.). I. Factors Influencing The Growth of Trout Fry, Journal of Experimental Biology, 22: 118-129.

Carmichael, G.J. 1994. Effects of Size-grading on Variation and Growth in Channel Catfish Reared at Similar Densities, Journal of World Aquaculture Society, 25: 101-108.

Castro, J.J., J.A. Santiago. 1998. The in uence of food distribution on the aggressive behaviour of juvenile white-sea bream (*Diplodus sargus* cadenati de La Paz, Bauchot and Daget, 1974). Aggr. Behav 24:379–384.

Cejas, J.R., E. Almansa, J.E. Villamandos, P. Badía, A. Bolanos, A. Lorenzo. 2003. Lipid and fatty acid composition of ovaries from wild fish and ovaries and eggs from captive fish of white sea bream (*Diplodus sargus).* Aquaculture 216, 299–313.

Cejas, J.R., M. Samper, S. Jerez, R. Fores, J.E. Villamandos. 1993. Perspectivas de cultivo de breca Pagelluserythrinus y sargo *Diplodus sargus*; primeros resultados de crecimiento comparado con la dorada *Sparusaurata*. Actas IV Congr. Nac. Acuicult., 21 – 24 Sept. 1993, Ila de Arousa, Spain, 127 – 132.

Dikel, S., B. Ünalan, O.T. Eroldoğan, A. Hunt. 2010. Effects of Dietary L-carnitine Supplementation on Growth, Muscle Fatty acid Composition and Economic Profit of Rainbow Trout (*Oncorhynchus mykiss*) Turkish Journal of Fisheries and Aquatic Sciences 10: 173-180.

Divanach, M., G. Kentouri, F. Charalambakis, A. Pouget. 1993. Esterioti Comparison of growth performance of six Mediterranean fish species reared under intensive farming conditions in Crete (Greece), in raceways with the use of self feeders,in: G. Barnabé, P. Kestemont (Eds.), Production, Environment and Quality. Bordeaux Aquaculture '92, E.A.S. Special Publication, vol. 18, European Aquaculture Society, Ghent, Belgium (1993), pp. 285–297.

Dores, E., L. Narciso, S. Morais, P. Pousão-Ferreira. 2000. Larvi culture of the white sea bream (*Diplodus sargus*): a new approach. Aqua.Special Publication, vol. 28. European aquaculture Society, Oostende, Belgium, p. 187. Nice, France, 2–6 May 2000.

Dou, S-Z., R. Masuda, M. Tanaka, and K. Tsukamoto. 2004. Size hierarchies a¡ecting the social interactions and growth of juvenile Japanese founder, *Paralichthys olivaceus*. Aquaculture 233, 237-249.

Doyle, R. W, and A. J. Talbot. 1986. Arti cial selection on growth and correlatedselection on competitive behaviour in sh. Canadian Journal of Fisheries and Aquatic Sciences 43, 1059–1064.

Ghanawi, J., and I. Saoud. 2010. Effect of Size Sorting on Growth Performance of Juvenile Spinefoot Rabbit sh, *Siganus rivulatus* Department of Biology, American University of Beirut, Bliss Street, Beirut, Lebanon Shymaa M. Shalaby, Aquaculture Division, National Institute of Oceanography and Fisheries, Anfoshy,Alexandria, Egypt, Journal of the World Aquaculture Socıety Vol. 41, No. 4

Grant, J.W.A. 1997. Territoriality. In: Godin, J.G.J. (Ed.), Behavioural Ecology of Teleost Fishes. Oxford Univ. Press, Oxford, pp. 81–103.

Griffiths, S.W, J.D. Armstrong. 2002. Kin-biased territory overlap and food sharing among Atlantic salmon juveniles. J. Anim. Ecol. 71, 480– 486.

Gunnes, K,. 1976. Effect of size grading young Atlantic salmon (*Salmo salar*) on subsequent growth. Aquaculture 9, 381-386.

Huet, M. 1986. Textbook of fish culture, breeding and cultivation of fish, 2nd edition. Fishing News Books Ltd, Farnham, Surrey, UK.

Huntingford, F.A., N. B. Metcalfe, J. E. Thorpe, W. D. Graham, and C. E. Adams. 1990. Social dominance and body size in Atlantic salmon parr, *Salmo salar* L. J. Fish Biol. 36:877–881.

Jobling M., R. Knudsen, P.S. Pedersen, and J. Dos Santos. 1991. Effects of dietary composition and energy content on the nutritional energetics of cod, Gadus morhua. Aquaculture 92: 243- 257.

Jobling, M. 1982. Some observations on the effects of feeding frequency on the food intake and growth of plaice, *Pleuronectes platessa* L. Journal of Fish Biology 20:431–444.

Jobling, M. 1985. Growth. In: Fish Energetics: New Perspectives (ed. by P. Tytler & P. Calow), pp. 213-230. The John Hopkins University Press, Baltimore, MD, USA.

Jobling, M. 1995. Simple indices for the assessment of the influences of social environment on growth performance, exemplified by studies on Arctic charr Aquaculture International March, Volume 3, Issue 1, pp 60-65.

Jobling, M. and J. Koskela. 1996. Interindiviudal variations in feeding and growth in rainbow trout during restricted feeding and in a subsequent period of compensatory growth. Journal of Fish Biology 49, 658–667.

Jobling, M., and T. G. Reinsnes. 1986. Physiological and social constraints on growth of Arctic charr, *Salvelinus alpinus L.*: an investigation of factors leading to stunting. Journal of Fish Biology 28:379–384.

Kamstra, A. 1993. The effect of size grading on individual growth in eel, *Anguilla anguilla*, measured by individual marking. Aquaculture 112, 67–77.

Knights, B. 1983. Food particle size preferences and feeding behaviour in warm water aquaculture of the European eel, *Anguilla anguilla* (L.). Aquaculture 30,173^190.

Koebele, B.P. 1985. Growth and the size hierarchy effect: an experimental assessment of three proposed mechanisms; activity di!erences, disproportional food acquisition, physiological stress. Environmental Biology of Fishes 12, 181-188.

Lutnesky, M.M.F, J.P. Szyyper. 1991. The influence of spatial food distribution on agonistic behavior in juvenile mahimahi, *Coryphaena hippurus*. Journal of Applied Ichthyology 7:253–256.

Magnuson, J. J. 1962. An analysis of aggressive behavior, growth, and competition for food and space in medaka (*Oryzias latipes*). Canadian Journal of Zoology 40:313–363.

Matsui, I. 1980. Theory and Practice of Eel Culture, in Balkema A.A.,edt., Aquaculture series 4. 133, Rotterdam, Nederland.

Maynard-Smith, J., GA. Parker. 1976. The logic of asymmetric contests. Animal Behav 24:159–175.

McCarthy, I.D., C.G. Carter, D.F. Houlihan. 1992. The effect of feeding hierarchy on individual variability in daily feeding of rainbow trout, *Oncorhynchus mykiss* (Walbaum). J. Fish Biol. 41, 257– 263.

Ozorio, R.O.A., N. Gouveia, C.A.P. Andrade, V.M.F.A. Timoteo, L.E.C., Conceicao, T. Peleteiro, E.F.S Gomes, and L.M.P. Valente. 2004. Performance of blackspot sea bream (*Pagellus bogaraveo*, Brunnich 1768) fed on different protein / lipid ratios: a potential new species for aquaculture. In: Proceedings of 11th International Symposium on Nutrition and Feeding in Fish (Phuket, Thailand), 2-7 May 2004, 117pp.

Ozorio, R.O.A., L.M.P. Valente, P. Pousao-Ferreira, and A. Oliva-Teles. 2006 Growth performance and body composition of White sea bream (*Diplodus sargus*) juveniles fed diets with different protein and lipid levels. Aquaculture Research 37, 255–263.

Popper, D. M., O. Golden, and Y. Shezifi. 1992. Size distribution of juvenile gilthead sea bream (*Sparus aurata*), practical aspects. Israeli Journal of Aquaculture Bamidgeh 44:147–148.

Pousão-Ferreira, P., E. Dores, S. Morais, L. Narciso. 2001. Lipid requirements of the white seabream (*Diplodus sargus*) larvae. Larvi2001-Fish and Shellfish Larviculture Symposium. Special Publication, vol. 30. European aquaculture Sciety, Oostende, Belgium, p. 187.

Purdom, C. E. 1974. Variation in fish. Pages 347–355 *in* F. R. Harden Jones, editor. Sea fisheries research. Elek Science, London, UK.

Quéméner,L., M. Suquet, D. Mero, J. Gaignon. 2002. Selection method of new candidates for n sh aquaculture: the case of the French Atlantic, the Channel and the North Sea coasts Aquat. Living Resour. 15) 293–302.

Ruzzante, D. E., 1994. Domestication effects on aggressive and schooling behavior in fish. Aquaculture 120, 1–24

Ryer, CH., BL. Olla. 1995. The influence of food distribution upon the development of aggressive and competitive behaviour in juvenile chum salmon, *Oncorhychus keta*. Journal of Fish Biology 46:264–272.

Saavedra M., P. Pousa o-Ferreira, M. Yufera, M.T. Dinis, and L.E.C. Conceicao. 2009. A balanced amino acid diet improves *Diplodus sargus* larval quality and reduces nitrogen excretion. Aquaculture Nutrition 15, 517–524.

Santos, M.N., P. Lino, P. Pousão-Ferreira, C.C. Monteiro. 2006. Preliminary results of hatchery-reared sea breams released at artificial reefs of the Algarve coast (Southern Portugal): a Pilot Study. Bull. Mar. Sci. 78 (1), 1.

Saoud, I. P., D. A. Davis, L. A. Roy, and R. Phelps. 2005. Evaluating the benefits of size sorting tilapia fry before stocking. Journal of Applied Aquaculture 17:73–85.

Seymor, A,. 1984. High Stocking Rates and Moving Water Solve the Grading Problem, Fish Farmer, 7: 12-14.

Sloman, K.A., J.D. Armstrong. 2002. Physiological effects of dominance hierarchies: laboratory artefacts or natural phenomena? J. Fish. Biol. 61, 1 – 23.

Stefanssons M., A.K. Imsland, M.D. Jenssen, T.M. Jonassen, S.O. Stefansson, and R. Fitzgerald. 2000. The effect of different initial size distributions on the growth of Atlantic halibut. *Journal of Fish Biology*, 56,826-836.

Strand, H.K., V. Øiestad. 1997. Growth and the effect of grading, of turbot in a shallow raceway system. Aquacult. Int. 5, 397– 406.

Sunde L.M., A.K. Imsland, A. Folkvord, and S.O. Stefansson. 1998. Effects of size grading on growth and survival of juvenile turbot at two temperatures. Aquaculture International 6,19-32.

TECAM., Survey on Mediterranean Marine Finfish Species Diversification, 1999. Marine finfish species diversification: current situation and prospects in Mediterranean aquaculture. Options Mediterr., Ser. B: Etud. Rech.24. 169 pp.

Wallace, J. C., and A. G. Kolbeinshavn. 1988. The effect of size grading on subsequent growth in fingerling Arctic charr, *Salvelinus alpines* (L.). Aquaculture 73:97–100.

Wankowski, J. W. J., and J. E. Thorpe. 1979. The role of food particle size in the growth of juvenile Atlantic salmon (*Salmo salar L.*). *Journal of Fish Biology*, 14, 351-370.

Wirtz, P. 1974. The in uence of the sight of a conspeci c on the growth of *Blennius pholis* (Pisces, Teleostei). *Journal of Comparative Physiology*, 91, 161–165.

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