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# Raising the Performance of Gilthead Seabream (*Sparus aurata*) Juvenile in Offshore Cage Culture

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**Research Article**

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**Abstract**

The growth parameters of gilthead seabream (*Sparus aurata*) fry supplied from three different hatcheries stocked in nine HDPE offshore cages (30 m diameter and 22 m depth) were investigated for 450 days. It was determined that the fish obtained from Firm A on the 450th day gained more weight by consuming less feed. Fishes belonging to Firm A consumed an average of 1.8 kg of feed for one kg body weight gain, while fishes belonging to Firm B consumed an average of 2.29 kg and fishes of Firm C consumed an average of 2.18 kg. However, feed conversion rates were not significant between firms. Also, the highest survival rate was determined in fish from Firm B with 96.11%. As a result, the success of fish culture should be guaranteed by the supply of high standard juvenile fish. Otherwise, production costs and fish quality will be adversely affected.

*Key words*: SGR, FCR, hatchery, deformation, offshore cage raising

**Açık Deniz Kafes Kültüründe Çipura (*Sparus aurata*) Yavrularının Performansının Arttırılması**

**Özet**

Dokuz HDPE açık deniz kafesinde (30 m çapında ve 22 m derinliğinde) stoklanan üç farklı kuluçkahaneden temin edilen çipura (*Sparus aurata*) yavrularının büyüme parametreleri 450 gün boyunca incelenmiştir. Firma A'dan elde edilen balığın 450. günde daha az yem tüketerek daha fazla kilo aldığı belirlenmiştir. Firma A'ya ait balıklar bir kg vücut ağırlığı artışı için ortalama 1.8 kg yem tüketirken, Firma B'ye ait balıklar ortalama 2.29 kg ve Firma C'ye ait balıklar ortalama 2.18 kg tüketmiştir. Ancak, yemden yararlanma oranları arasında önemli bir fark tespit edilmemiştir. Ayrıca, en yüksek hayatta kalma oranı % 96.11 ile Firma B'den elde edilen balıklarda tespit edilmiştir. Sonuç olarak, balık kültürünün başarısı, yüksek standartta yavru balıkların sağlanmasıyla garanti altına alınmalıdır. Aksi takdirde üretim maliyetleri ve balık kalitesinin olumsuz etkilenmesi kaçınılmazdır.

*Anahtar kelimeler:* SGR, FCR, kuluçkahane, deformasyon, açık deniz kafes yetiştiriciliği performans arttırma,

## INTRODUCTION

Aquaculture was shown by FAO as the fastest-growing food production sector in the last 10 years (FAO, 2018). In parallel with this, the aquaculture sector has made great development in the last 30 years in Europe, especially in countries with a coast to the Mediterranean. In marine fish culture, many basic problems encountered in seabream culture, which is one of the two most-produced species in Europe, have been resolved over the years. In marine fish farming, many main problems encountered in seabream, one of the two most-produced species in Europe, have been resolved over the years. A detailed description of the biology of the species, biotechnological approaches, and advances in aquaculture engineering have been the basis for this development. Especially, broodstock management, fry production, and different breeding techniques were effective in this success (Calderer and Cardona 1993; Divanach et al., 1996; Izquierdo et al., 2001; Mylonas et al., 2009; Boglione et al., 2013a, b; FAO, 2019). Besides, improvements in cage culture systems and feed technology future an important role in increasing production quantity and quality (Merinero et al., 2005; García García et al., 2016).

In particular, Turkey has an important position in terms of marine fish farming in the Mediterranean basin and produced a total of 205 thousand tons of marine fish production in 2018. 116.915 tons of this amount consists of European seabass (*Dicentrarchus labrax*), 76.680 thousand tons of gilthead seabream and the remaining amount is the production of other marine fish species. In this context, Turkey meets about 40% of the total marine fish production in Europe. However, when considering the sector in detail, there are inevitably some serious and/or unsolved problems currently goes on. Additionally, the most important and current problems in the sector are clearly emphasized as use of water area, transfer of license for production, insurance, mortgage (pledge of license), pledge of livestock, obtaining a loan, marketing sector, increasing input costs that depend on imported raw materials and fluctuations of the exchange rate.

Different studies have been carried out in our country within the scope of culture of gilthead seabream fish in cages (Korkut et al., 2006; Yılmaz, 2007; Sert, 2008; Ozturk, 2017). However, in this study, for the first time, some growth parameters (length-weight relationship, specific growth rate, condition factor, feed conversion rate, deformation rate, and survival rate) were determined in the offshore cage environment of gilthead seabream juveniles obtained from different hatcheries at the same age and date. The purpose of this study is to reveal the factors that affect the quality of production to guide those who will be engaged in offshore cage systems in aquaculture.

## MATERIALS and METHODS

### Cage Systems

The study was carried out by monitoring and evaluating the development data of fish produced in offshore cages of a private marine fish farm in the Mugla region. Three different hatcheries, stocked in nine HDPE cages (30 m diameter and 22 m depth, the experimental period is 450 days). Cages are positioned in accordance with the communiqué No. 26413 dated January 24, 2007, issued by the Ministry of Environment and Forestry, on the determination of closed bay and gulf areas, which are sensitive areas where fish farms cannot be established, and the company has legal production permission. Cage systems are fixed at a depth of 53 m. The cages are 30 m in diameter and are made of HDPE (High-Density Polyethylene) material. The juveniles from 3 different hatcheries were placed in a total of 9 cages. Knotless nets in PE (Polyethylene) structure are used in cages. The nets used have 7-10 mm eye-opening, 30 m in diameter, and 22 meters in depth. Nets were treated against fouling organisms.

### Juvenile Fish Supply and Monitoring

The fish were supplied from 3 different marine fish hatcheries and titled these hatcheries as Firm A, Firm B, and Firm C. The fish were stocked with an average of 300 thousand juvenile per cage. The average weight of the fish was 3.83±0.16 g total length 7.93±0.07 cm for Firm A, the average weight for Firm B was 3.93±0.29 g total length 7±0.58 cm, and 3.66±0.27 g total length of Firm C was 7.33±0.88 cm. After the fish were placed in the cage in March 2018, their development was followed for each month until the harvest period (June 2019).

### Feed Features and Feeding

During the production, the fish were fed with commercial seabream extruder feed (1-3 mm). The feeds used in feeding during the production are given in Table 1 and the feeding was made with an automatic feeding system integrated on the barge system. It was applied once a day in summer and winter based on the feed water temperature and fish weight. Besides, dissolved oxygen (HI 9142 oxygen meter) and water temperature measurements (thermometer) were made daily to support the feeding regime. Also, the cages were observed with an underwater camera system. The dead fish were removed from the cages by the divers daily.

**Table 1.** Nutrient content of sea bream feeds used

| Nutrient Content / Unit | Quantity |
|---|---|
| Raw Protein (%) | 53 |
| Raw oil (%) | 16 |
| Ash (%) | 8.5 |
| Crude Cellulose | 2.5 |
| Total phosphorus (%) | 1.4 |
| Calcium (%) | 2.1 |
| Sodium | 0.25 |
| Vitamin A (IU/kg) | 13200 |
| Vitamin D3 (IU/kg) | 2400 |
| Vitamin E (IU/kg) | 300 |
| Iron (mg) | 15 |
| Iodine (mg) | 1.5 |
| Cobalt (mg) | 0.5 |
| Copper (mg) | 2.5 |
| Magnesium (mg) | 15 |
| Zinc (mg) | 50 |
| Selenium (mg) | 0.2 |

**Estimation of Growth Parameters**

Length-Weight Relationship

Length-Weight Relationship was calculated according to the following equation,

$W=aTL^b$ (Gould, 1966)

Specific Growth Rate (SGR)

Specific growth rate SGR was calculated according to the following equation (De Silva and Anderson, 1995):

SGR (% body wt.gain/day) = [Logn Final fish wt.– Logn initial fish wt.)] / Time interval x 100

Condition Factor (K)

The weight-length relation of Fulton, which was used to determine the health of fish was calculated using the following formula (Ricker, 1975). $K = W \times 100/L^3$

Feed conversion rate

FCR = Amount of feed consumed (g) / Live weight gain (g) (Santinha et al., 1999).

Survival Rate (SR)

The survival rate of fish is calculated by the formula reported by Pechsiri and Yakupitiyage (2005).

SR % = (Ns / Ni) x 100.

(Ns: Number of fish at the end of the trial; Ni: Number of fish at the beginning of the trial)

**Deformation Rate (DR)**

The deformation rate of fish is calculated by the formula;

DR % = (Ne / Nb) x 100.

(Ns: Number of fish at the end of the trial; Ni: Number of fish at the beginning of the trial).

**Statistical Analysis**

The results obtained are defined as Mean±Standard Error $(\bar{X} \pm s_{\bar{x}})$. The length-weight relationship was tested by regression analysis. In the evaluation of the data obtained, Levene Test was applied to determine the homogeneity of the variances. Then, it was seen that the data had nonparametric test assumptions and Kruskal Wallis Variance Analysis was used in this context. After analysis of variance, the Mann-Whitney-U test was used to reveal which companies are different and the differences are tested at a 95% significance level. The difference between the survival rates of the fishes of the firms was determined with the Chi-Square Test. SPSS 15.0 (SPSS, Chicago, IL) statistics program was used to evaluate the data.

**Findings**

The mean of water temperature and oxygen values monitored in the cage environment during the production made between March 2018 and June 2019 are shown in Figure 1. The highest mean seawater temperature was determined during August 2018 (26.8±0.22 ºC) and the lowest seawater temperature mean was determined in February 2019 (14.6±0.34 ºC) in the cage systems. Also, the lowest oxygen value average in the cage systems was determined in August 2018 (6.3±0.12 mg/l) and the highest oxygen value mean was obtained between February and March 2019 (7.1±0.18 mg/l).

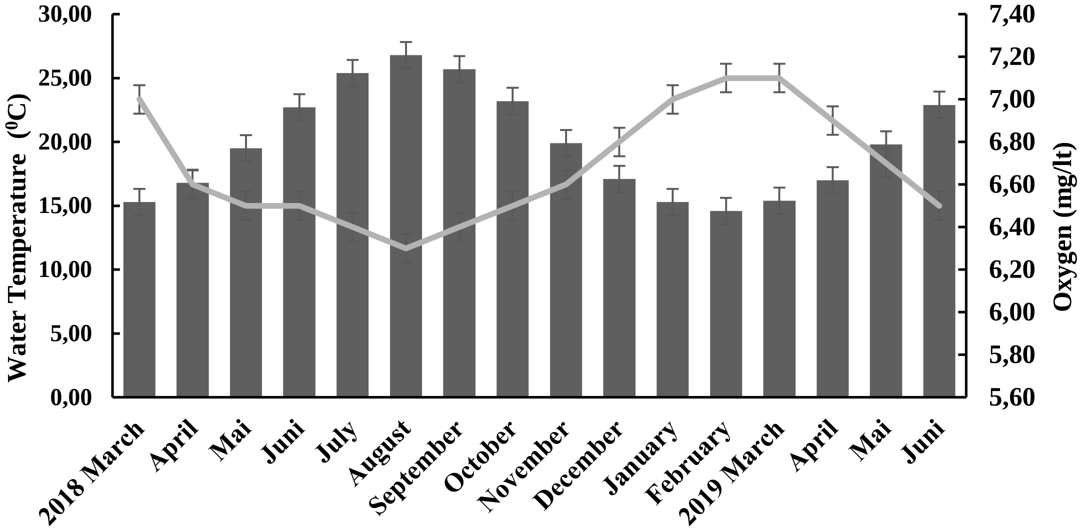


**Figure 1.** Water temperature and oxygen mean values between

March 2018 and June 2019 $(\bar{X} \pm s_{\bar{x}})$.

Regression analysis of fish was determined for Firm A y= 250.4ln(x)–560 ($R^2$= 0.8622), Firm B y= 279.23ln(x)–660 ($R^2$ = 0.9092) and Firm C y= 279.23ln(x)–660 ($R^2$= 0.9092). There was no significant difference between regression analysis of fish (p>0.05).

When the specific growth rates of the fish during the production are analyzed, it was seen that after the fish were put in the cage, this value increased to a high level in May 2018, and then it tended to decrease depending on the fish size. The specific growth rate of the whole process was determined as 1%/day in June 2019, when the fish were harvested. The data obtained during the production period are shown in Figure 2 on a monthly. In terms of specific growth rate, there was no difference in fish obtained from companies at monthly periods and at the end of production (p>0.05).

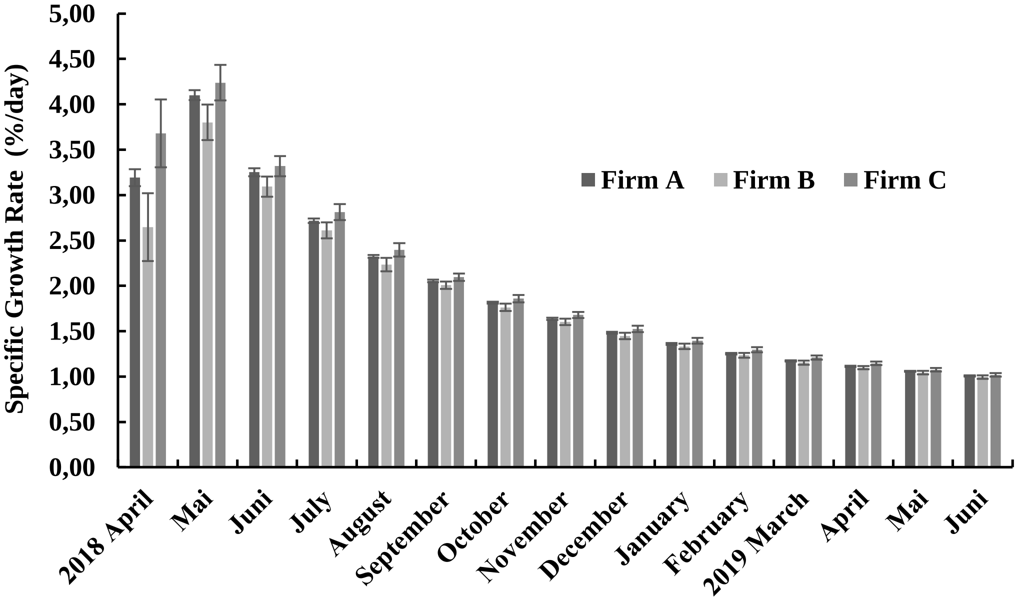


**Figure 2.** The specific growth rate for Firm A, Firm B, and Firm C (%/day) $(\bar{X} \pm s_{\bar{x}})$

Besides, in the examination of fish in terms of condition factor, it was determined that this factor varies between 1-1.19 in fish belonging to companies. In this context, this value was determined as 1.19 for Firm A, 1.05 for Firm B, and 1.12 for Firm C. There was no significant difference between firms in terms of condition factor ($p > 0.05$).

At the mean biomass of cages, the highest biomass was found in cages where juveniles from Firm A was placed. Although the difference between cages was not significant ($p > 0.05$), fish belonging to Firm A showed an average of 1650 kg more weight than fish from Firm B and an average of 2700 kg more than fish from Firm C (three cages mean values) (Figure 3).

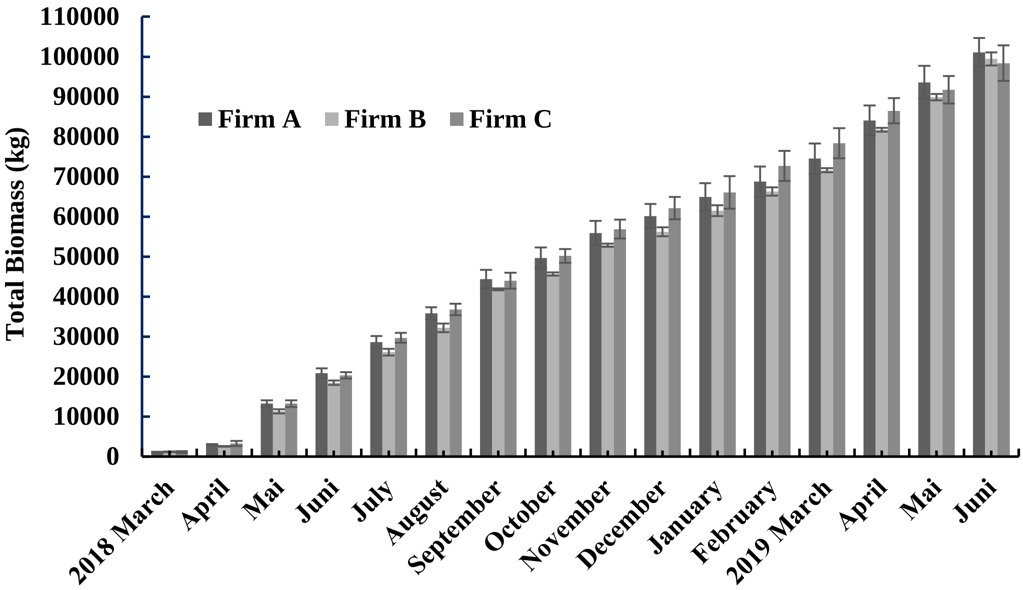


**Figure 3.** Total biomass value of fish of Firm A, Firm B, and Firm C $(\bar{X} \pm s_{\bar{x}})$

In the evaluation of the feed conversion rate of fish, based on the 450th day, it was determined that the fish supplied from Firm A gained more live weight by consuming less feed. Fishes belonging to Firm A consumed an average of 1.8 kg of feed for one kg of live weight gain, while fishes belonging to Firm B consumed an average of 2.29 kg and fishes of Firm C consumed an average of 2.18 kg (Figure 4). However, feed conversion rates were not significant between firms ($p > 0.05$).

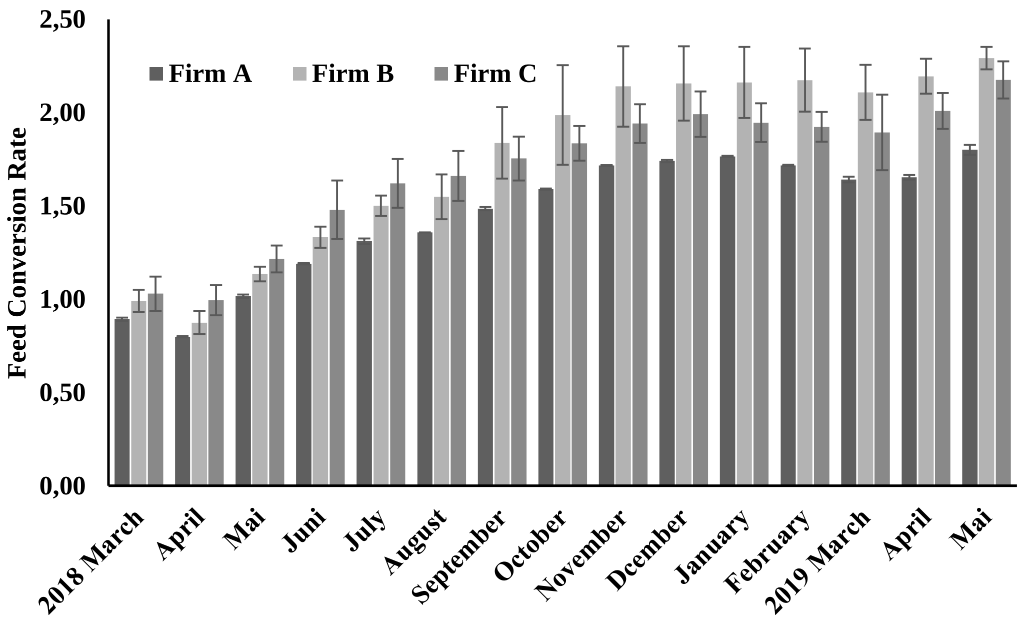


**Figure 4.** Feed conversation rate of fish of Firm A, Firm B, and Firm C $(\bar{X} \pm s_{\bar{x}})$

In March 2018, when the fish came to the cages, the deformation rates were determined as 4.33%, 7.33%, and 9.33%, respectively. In the evaluation made at this stage, deformation rates were found to be significant between the fishes coming from Firm A and Firm C, Firm A and Firm B, and Firm B and Firm C ($p<0.05$). However, in the evaluation made at the end of production (450th day), deformation rates were determined as 1.5%, 3.33%, and 2.67%, respectively. In this context, only the deformation ratio between Firm A and Firm B was found significant ($p<0.05$). The deformation rates of the fish coming from the facilities at the beginning and end of production are shown in Figure 4.

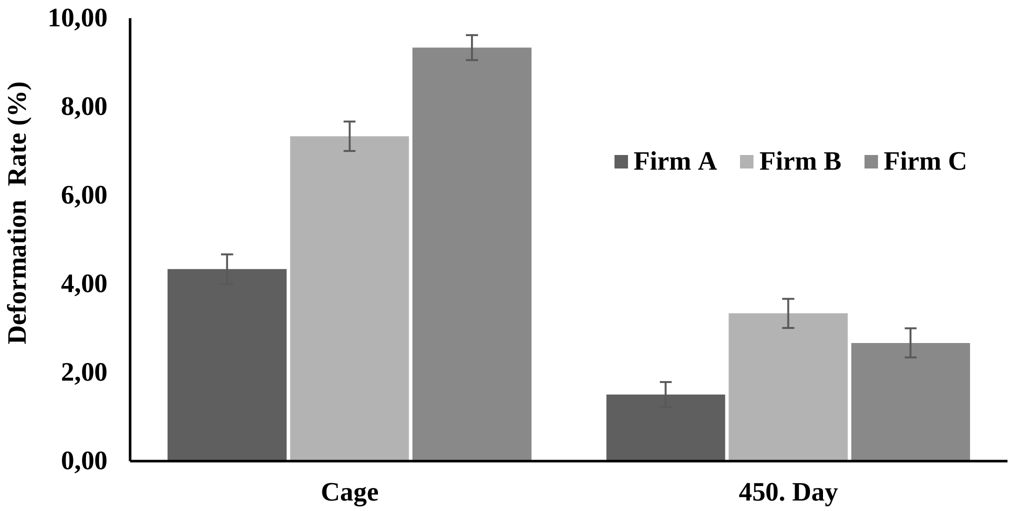


**Figure 5.** Deformation rate of fish at the beginning and end of production (%) $(\bar{X} \pm s_{\bar{x}})$

Besides, in the evaluation, the living rates at the end of production were also examined, and the highest survival rate was determined in fish from Firm B with 96.11%. The survival rate of fish belonging to Firm A and Firm C was 95%. There was no difference in the survival rates of fish by firms ($p>0.05$).

**DISCUSSION and RESULTS**

The facility where the breeding is done and the fish produced to comply with the legal legislation. The fish produced in this context were grown by animal welfare and health regulations and the breeding conditions were in line with the industrial production in the Mediterranean basin (Mayer et al., 2008; García et al., 2016).

Water temperature has a key effect on physiological processes in the development of fish (Brett and Groves, 1979). Maximum growth can be achieved at optimum temperature values between these temperature tolerance values. The temperature rise to some extent maximizes food consumption by fish. With the passing of the upper-temperature limit, a decrease in food consumption begins (Jobling, 1997). In this context, the temperature affects the vital activities of all organisms as well as the fish. Many important processes and parameters are under the direct effect of the water temperature, from the maturation of the ovaries to the embryonic development of the eggs, from the immune system to the live weight gain. For gilthead seabream, the limits of survival and growth depending on the water temperature vary between 5-32 °C. It is minimized in activity and growth below 15 °C. At 12 °C, the fish stop receiving food (EFSA, 2009). In seabream cultivation in the Black Sea region, it was reported that the growth stopped almost immediately with the water temperature falling below 16 °C after November and that the fish lost weight in the period between January and April (Sahin et al., 1999). The compatibility of the water temperature of the Mugla region with the species did not harm the survival and development of the species.

Dissolved oxygen value in water, another important parameter in terms of aquaculture, has an important effect on development. As the temperature and salinity of the water increases, the solubility and the amount of oxygen decreases in the water. Oxygen consumption decreases proportionally as the temperature increases and ends at a lethal (lethal) temperature value. Bream fish need 140-300 mg/kg of oxygen per hour under routine conditions at temperatures between 13-29 °C. Oxygen value reaching 3-4.5 mg/l causes hypoxia, which causes disruption in cortisol, glucose hematocrit values. For seabream, 7.4 mg/l oxygen value determines normoxic life. Oxygen fluctuations are limited in the seas, especially in the open region. In the mesh cage environment, suitable stock density, mesh opening, and flow rates allow continuous water conditions to be constantly found in the cage environment in terms of oxygen values. Within the scope of these evaluations, while the oxygen values were determined as the lowest water temperature during the production in August 2018, this value remained within the normal limits for the fish.

The length-weight relationship is very important in terms of fish biology. This relationship allows the fish to be estimated from height to weight, to define the condition index, to the morphology of populations in different environments, and to evaluate the life processes of living things (Petrakis and Stergiou, 1995). In the data obtained in the study, it is seen that the length-weight relationship is quite strong for each group. The specific growth rate ranged from 1.01-1.05% on day 450. These specific growth rates are higher than the Western Mediterranean data (Petridis and Rogdakis, 1996), but are lower than commercial growth values (Kaushik, 1998) in the Aegean Sea. This situation may be influenced by parameters such as the genetic structure, feeding regimes, feed quality, and stock density of the fish, as well as the most important effect on these values is the water temperature (Sola et al., 2007). The data obtained in general is to take place in a laboratory environment. In this context, commercially obtained data are meaningful. However, growth data differ depending on the periodic changes in water temperature during the long rearing period.

Condition factor is one of the nutrition and development criteria in fish and it is one of the parameters in which the morphological structure is evaluated. Although the condition factor differs for fish species, it differs according to the age, gender, breeding season, ripening period, the fullness of the intestines, the content of the food consumed, the amount of lubrication, and the development in the muscle structure (García García et al., 2016). When the condition factors of the fishes of the firms are analyzed, the values obtained between 1-1.20 can be accepted as the main indicator of good growth, which was defined as 1.25-1.75 by Barnham and Boxter (1998). In this context, the effect of the feed content and amount used in the feeding of the fish on the development is very valuable in terms of the meaning of the feeding application.

When the total biomass in the cages is examined, it is seen that approximately 100 tons of fish are obtained for each cage on average. Although there is no statistical difference between the cages in terms of total biomass, the development of the fish of Firm A is greater than that of Firm B and Firm C (1600-2700 kg). This situation is very thought-provoking for the cage companies producing at high capacity.

Another important issue when analyzing the data obtained is the feed conversion rate. Approximately 70% of fish costs in aquaculture are feed outgoings. The feed should be evaluated in the best way by the fish and the maximum growth should be gained with minimum feed. Also, 85-90% of feed production is provided from imported raw materials. This situation causes the feed prices to be negatively affected by exchange rate movements. The rate of feed conversion in the Mediterranean basin for gilthead seabream has been expressed as an average of 2 (Garcia, 2016). In the evaluation, it was determined that the fish produced from the offspring of Firm A provided a1 kg body weight gain with 1.8 kg feed. For other companies, these values were 2.29 (Firm B) and 2.18 (Firm C). This situation is very thought-provoking. In this case, approximately 0.45 kg more feed consumption occurs for one kg of fish in production. Considering the average of the cage, it is seen that 45 tons more feed is consumed for one cage. These consumption amounts increase exponentially at high production capacities. Considering that feed prices are based on 1.5 Euros in today's conditions, the resulting cost figures reach high budgets.

Especially in the Mediterranean basin, the high increase in seabream and seabass production led to an increase in the number of skeletal deformations. The deformation forms encountered in aquaculture conditions are among the problems that have a high impact on the growth, survival, and economic values of living things. In the production studies carried out in today's conditions, there is a deformation rate between 15% and 50% depending on the production protocol in seabream fish, and this rate can reach 45-100% on a tank basis in some cases (Boglione et al., 1993; Andrades et al., 1996; Koumoundouros et al., 1997; Georgakopoulou et al., 2010). These results are defined not only for gilthead seabream but also with similar comments in species such as European seabass (*D. labrax*; Chatain, 1994), red seabream (*Pagrus major*; Hattori et al., 2003), and common dentex (*Dentex*

*dentex*; Çoban, 2005). The poor development and high mortality observed in deformed fish cause high economic losses with the emergence of various diseases (Divanach et al., 1996; Loy et al., 1996). Permanent shape differences (deformations) that can be easily distinguished by consumers generally occur in the embryological and postlarval stages of production (Daulas et al., 1991). The developmental disorder theoretically causes the phenotype differences of individuals who show genetically the same characteristics in the same environmental conditions. Increasing phenotype changes cause a lot of stress because it negatively affects many activities of fish (Scheiner, 1993). It is not yet understood whether individuals with deformation exhibit the same feature during their life in embryonic and postembryonic periods. One of the causes of spinal disorders seen in juvenile and adult seabream fish are deformations in the notochord that occur in the larval period.

In aquaculture, skeletal abnormalities point to a serious economic problem, which reduces fish survival rates and fish prices (consumers prefer not to buy deformed fish). Deformed fish also brings ethical issues and concerns. Swimming performance and feeding of deformed fish can cause improper health conditions, resulting in high stress and pathogen sensitivity, low nutritional rates, and low growth rates. In this context, when the deformation rate of the fish coming from the firms is analyzed, it is seen that this value is above the acceptable limits for Firms B and C. Considering these rates at the end of production, it is seen that deformed individuals die in the process as expected. This negative effect on total biomass, feed consumption, and survival. In this context, questioning the production techniques of hatcheries and separating deformed individuals better without going to the cage is quite meaningful in terms of the success of net cage farming, which takes about 15-17 months. In addition to this, living rates were determined to be quite high as a result of production. This success can be accepted as an indicator of production. However, it should not be forgotten that the high rate of living does not mean that an efficient culture application is made.

As a result, it was determined clearly how important fry quality in terms of development and feed conversion in the cage culture of bream. It is seen that production costs and fish quality will be adversely affected if long-term cage farming is not guaranteed by the supply of high standard juvenile fish. In this context, inevitably, marine fish hatcheries should constantly review their production techniques, establish a good rootstock management strategy, and give importance to genetic studies.

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**REFERENCES**

Akpinar, A. (2019) *Çipura (Sparus aurata) balıklarınınoffshore tip ağ kafeslerde gelişimi*. Ege Üniversitesi, Fen Bilimleri Enstitüsü, İzmir.

Andrades, J.A., Becerra, J., & Fernández-Lebrez, P. (1996). Skeletal deformities in larval, juvenile and adult stages of cultures gilthead seabream (*Sparus aurata* L.). *Aquaculture, 141*, 1-11.

Barnham, C. & Baxter, A. (1998). *Condition Factor, K, for Salmonid Fish, Fisheries Notes*. Department of Environment & Primary Industries Press, Melbourne.

Boglione, C., Marino, G., Bertolini, B., Rossi, A., Ferreri, F., Cataudella, S. (1993). *Larval and postlarval monitoring in seabass: morphological approach to evaluate finfish seed quality*. In:Barnabe, G., Kestemont, P. Eds., Production, Environment and Quality. EAS Special Publication Press, Belgium.

Boglione, C., Gavaia, P., Koumoundouros, G., Gisbert, E., Moren, M., Fontagne, S., & Witten, P. E. (2013a). A review on skeletal anomalies in reared fish larvae & juveniles. Part 1: normal and anomalous skeletogenic processes. *Reviews in Aquaculture, 5*, 99-120.

Boglione, C., Gisbert, E., Gavaia, P. Witten, P. E., Moren, M., Fontagne, S., & Koumoundouros, G. (2013b). A review on skeletal anomalies in reared European fish larvae and juveniles. Part 2: main typologies, occurrences and causative factors. *Reviews in Aquaculture, 5*, 121-167.

Brett, J.R., & Groves, T. D. D. (1979). *Physiological energetics.* In: Hoar, W.S., Randall, D.J.,Brett, J.R. (Eds.), Fish Physiology. Bioenergetics and Growth (8). Academic Press, New York.

Calderer, A., & Cardona, L. (1993). *Cr´ıa intensiva de la dorada (Sparus aurata) y la lubina (Dicentrarchus labrax).* In: Acuicultura Marina: Fundamentos Biol´ogicos y Tecnol´ogicos de la Producci´on (ed. F.C. Orsay (Coord.). Publicacions Universitat de Barcelona Press, Barcelona.

Chatain, B. (1994). Abnormal swimbladder development and lordosis in seabass (*Dicentrarchus labrax*) and seabream (*Sparus aurata*). *Aquaculture, 119*, 371-379.

Çoban, D. (2005). *Sparidae familyasına ait balıklarda yetistiricilik kosullarında gozlenen kemik ve kıkırdak deformasyonlarının belirlenmesi*. Ege Universitesi, Fen Bilimleri Enstitusu, Doktora Tezi, İzmir.

Daulas, C., Economou, A.N., & Bantavas,I. (1991). Osteological abnormalities in laboratory reared seabass (*Dicentrarchus labrax*) fingerlings. *Aquaculture*, *97*, 169-180.

De Silva, S. S., & Anderson, S. (1995). *Fish Nutrition in Aquaculture*. Springer Press, USA.

Divanach, P., Boglione, C., Menu, B., Koumoundouros, G, Kentouri, M., & Cataudella, S. (1996). *Abnormalities in finfish mariculture: An overview of the problem, causes and solutions*. In Handbook of contributions and short communications presented at the Int. Workshop on 'Seabass and Seabream Culture: Problems and Prospects', European Aquaculture Society Press, Italy.

EFSA. (2009). Scientific report of EFSA prepared by Working Group on seabass/seabream welfare on Animal Welfare Aspects of Husbandry Systems for Farmed European seabass and gilthead seabream. *Annex I to The EFSA Journal*, *844*, 1-89.

FAO. (2018, June 20). Fisheries Statistic. Retrieved from http://www.fao.org/fi/statist/statist.asp

FAO, (2019, June 29). Cultured Aquatic Species Information Programme (*Sparus aurata*). Retrieved from http://www.fao.org/fishery/culturedspecies/ *Sparus_aurata*/en

García García, B., Rosique Jiménez, C., Aguado-Giménez, F., & García García, J. (2016). Life Cycle Assessment of Gilthead Seabream (*Sparus aurata*) Production in Offshore Fish Farms. *Sustainability*, *8*, 1228.

Georgakopoulou, E., Katharios, P., Divanach, P., & Koumoundouros, G. (2010). Effect of temperature on the development of skeletal deformities in gilthead seabream (*Sparus aurata* Linnaeus, 1758). *Aquaculture*, *308*, 13–19.

Gould, S. J. (1966,). Allometry and size in ontogeny and phylogeny. *Biological Reviews*, *41*, 587-640.

Hattori, M., Sawada, Y., Takagi, Y., Suzuki, R., Okada, T., & Kumai, H. (2003). Vertebral deformities in cultured red seabream, Pagrus major, Temminck and Schlegel. *Aquaculture Research*, *34*, 1129-1137.

Izquierdo, M.S., Fern´andez-Palacios, H., & Tacon, A.G.J. (2001). Effect of broodstock nutrition on reproductive performance of fish. *Aquaculture*, *197*, 25-42.

Jobling, M. (1997). *Temperature and growth: modulation of growth rate via temperature change*. In: Wood, C.M., McDonald, D.G. (Eds.), Global Warming: Implications for Freshwater and Marine Fish. Cambridge University Press, Cambridge.

Korkut, A. Y., Kop, A., Cihaner, A., & Altan, O. (2006). Homa Lagununden elde edilen çipuraların (*Sparus aurata* L., 1758) kıyısal ve açık deniz ag kafeslerde gelisimlerinin karsılastırılması, *Ege Üniversitesi Su Urunleri Dergisi*, *23*(1/2), 253-257.

Koumoundouros, G., Gagliardi, F., Divanach, P., Boglione, C., Cataudella, S., & Kentouri, M. (1997). Normal and abnormal osteological development of caudal fin in *S. aurata* L fry. *Aquaculture*, *149*, 215-226.

Kaushik, S. J. (1998). Nutritional bioenergetics and estimation of waste production in non-salmonids. *Aquatic Living Resources*, *11*, 211-217.

Loy, A., Cataudella, S., & Corti, M. (1996). *Shape change of the seabass, D. labrax , in relation to different rearing conditions; an analysis using Bookstein's shape co-ordinate and an application of the tinplate spleens regression analysis*. In Advances in Morphometrics. N.A.T.O. ASI Series. Plenum Press, New York.

Mayer, P., Estruch, V., Blasco, J. & Jover, M. (2008). Predicting the growth of gilthead seabream (*Sparus aurata* L.) farmed in marine cages under real production conditions using temperature- and time-dependent models. *Aquaculture Research*, *39*, 1046-1052.

Merinero, S., Mart´ınez, S., & Tom´as, A. (2009). An´alisis econ´omico de alternativas de producci´on de Dorada en jaulas marinas en el litoral Mediterr´aneo espa˜nol. Retrieved from http://www.revistaaquatic.com/ aquatic/art.asp?t=p&c=188

Mylonas, C.C., Fostier, A., & Zanuy, S. (2009). Broodstock management and hormonal manipulations of reproduction. *General and Comparative Endocrinology*, *165*, 516-534.

Ozturk, D. K. (2017). *Orta Karadeniz bolgesinde ag kafeslerde çipuranın (Sparus aurata L., 1758) buyume performansı ve et kalite degerlerinin belirlenmesi*, Sinop Universitesi, Fen Bilimleri Enstitusu, Doktora Tezi, Sinop.

Petridis, D., & Rogdakis, L. (1996). The development of growth and feeding equation for seabream, *Sparus aurata* L., culture. *Aquaculture Research*, *27*, 413-419.

Petrakis, G., & Stergiou, K. I. (1995). Weight–length relationships for 33 fish species in Grek waters. *Fisheries Research*, *21*, 465-469.

Pechsiri, J., & Yakupitiyage, A. (2005). A Comparative Study of Growth and Feed Utilization Efficiency of Sex-Reversed Diploid and Triploid Nile Tilapia *Oreochromis niloticus* L. *Aquaculture Research*, *36*, 45-51.

Santinha, P.M., Medale. S.J., Corraze, B., & Gomes, B. (1999). Effects of The Dietary Protein: Lipid Ratio on Growth and Nutrient Utilization in Gilthead Seabream *Sparus aurata*. *Aquaculture Nutrition*, *5*, 147-156.

Sert, C. (2008). *Ag kafeslerde alternatif Sparidae turlerinin; sinagrit (Dentex dentex L.,1758), sivriburun karagoz (Diplodus puntazzo Cetti,1777), kırma mercan (Pagellus erythrinus L.,1758), mırmır*

*(Lithognathus mormyrus L.,1758), cipura'ya (Sparus aurata L.,1758) gore gelisim parametrelerinin karsılastırılması*, Ege Üniversitesi, Fen Bilimleri Enstitusu, Yuksek Lisans Tezi.

Sola L., Moretti A., Crosetti D., Karaiskou N., Magoulas A., Rossi A.R., Rye M., Triantafyllidis A., & Tsigenopoulos C.S. (2007). Gilthead seabream–*Sparus aurata, (*eds., Svåsand T., Crosetti D., García-Vázquez E., Verspoor, E.). Genetic impact of aquaculture activities on native populations, *Genimpact EU contract.* Scientific report.

Sahin, T., Akbulut, B., Çiftçi, Y., Aksungur, M., Erteken, A., & Aksungur, N. (1999). Karadeniz'de çipura (*Sparus aurata* L., 1758). T.C. T.K. İ.B. Trabzon Su Urunleri Arastırma Enstitusu, Trabzon.

Scheiner, S. M. (1993). Genetics and evolution of phenotypic plasticity. *Annual Revue Ecological Systematics*, *24*, 35-68.

TUIK. (2018, March 20). Su Urunleri İstatistikleri. Retrieved from http://www.tuik.gov.tr

Yılmaz, Y. (2007). *Ag kafeslerde yetistiriciligi yapılan çipura (Sparus aurata L.1758)'larda farklı stok yogunluklarında buyume performansı üzerine bir arastırma*. Yuzuncu Yıl Universitesi, Fen Bilimleri Enstitusu, Su Urunleri Anabilim Dalı, Yuksek Lisans Tezi, Van.