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Length-Weight Relationship and Zootechnical Performance of *Sparus aurata* and *Dicentrarchus labrax* in Finfish Cages in the Bay of Souahlia (Chlef Coast, Algeria)

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ABSTRACT

The length-weight relationship and growth performance of *Sparus aurata* and *Dicentrarchus labrax* were calculated at the El Mokretar Aqua fish farm in the Bay of Souahlia on the Algerian coast. During harvest, fish samples were collected from the El Mokretar Aqua fish farm in floating cages C8 and C3. Growth parameters were assessed at the start and end of breeding. The simple fisheries stock Aassessment methods (FSA) package estimated the length-weight relationship as LogWt= -1.18+2.08logLt for *D.labrax* and Log Wt= -6.17+3.62logLt for *S. aurata*. These relationships indicate that the European seabass has a negative allometric growth, while the gilthead seabream has a positive allometric growth. During the rearing period, the zootechnical performance of the gilthead seabream and European seabass indicated favorable growth. Weight gain, specific growth rate, Fulton's condition factor, thermal-unit growth coefficient and feed conversion ratio showed a significant difference. These indicators are useful for planning and managing fish farms rearing these selected species.

INTRODUCTION

Global fish farming is becoming more diverse and intensive, making it a promising activity for producing protein with high nutritional value. Recognizing the potential of this activity, large aquaculture companies have invested in the research and production of various productive segments of the most diverse species of fish **(Araujo *et al.*, 2020)**. At 464,000 tons in 2019, the gilthead seabream (*Sparus aurata*) and European seabass (*Dicentrarchus labrax*) are the most important economically farmed species in the Mediterranean Sea **(Carvalho & Guillen, 2021)**. Surprisingly, demand for both species remains high, but stagnant growth in seabass production has resulted in tighter supplies, while seabream production increased marginally in 2021 **(FAO, 2022)**. With the expansion of aquaculture, problems such as mass mortality of fish, stunted growth, and disease spread began to emerge, which can reduce the profitability of aquaculture farms

and make their management ineffective **(Laama *et al.*, 2020)**. Aquaculture is most interested in studying fish growth **(Merdjane & Lounaci, 2020)**. In this context, the study of growth is a useful indicator of fish's health in floating cages to maximize the growth rates of farmed species.

The difference in growth between *S. aurata* and *D. labrax* is useful, implying a combined length-weight relationship with zootechnical performance for more precise quantification and characterization. Numerous comparative studies on both farmed species in terms of growth and zootechnical performance in aquaculture have been conducted **(Besbes & Guerbej, 1996; Arechavala-Lopez *et al.*, 2012; Di Marco *et al.*, 2017; Altan, 2018; Fazio *et al.*, 2018)**. This study aimed to compare the length-weight relationships and growth performance indicators of *S. aurata* and *D. labrax* in an intensive system of the finfish farming to improve fish farming management and understand the behavior of each species in offshore farming.

MATERIALS AND METHODS

1. Sampling

El Mokretar Aqua finfish farming was selected for this study (Fig. 1a). This fish farm is located in the Bay of Souahlia, on the Chlef coast, west of Algiers, Algeria. In 2022, El Mokretar Aqua fish farm had 32 cylindrical offshore floating cages, with a diameter of 25m (grid cages A and B) and 29m (grid cages C and D) (Fig. 1b). Samples were obtained during the harvest process from floating cages for *S. aurata* in C8 and *D. labrax* for C3 (Fig. 1c). About 418 individuals of *D. labrax* and 627 of *S. aurata* were sampled in April 2022 for C8 and June 2023 for C3, respectively. All fish were measured in the field with an ichytometer to determine the total length (Lt) and weighed with a precision scale to determine the total weight (Wt).

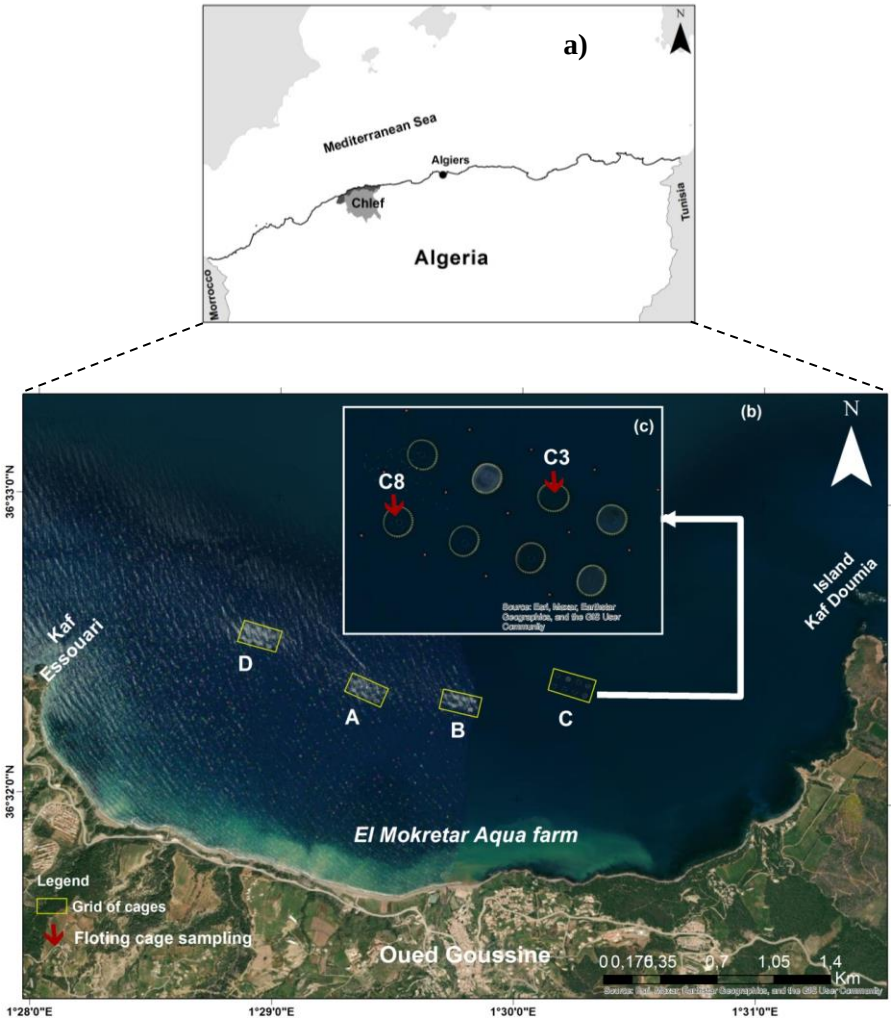

Fig. 1. Map of the study area showing:
a) Localization of Chlef wilaya, **b)** Disposal of grid cages at El Mokretar Aqua fish farm, and **c)** Sampling fish by floating cages

The regression slope values indicate whether the growth is isometric (b = 3), allometric positive (b > 3) or negative (b < 3). Student's t-test was used to determine whether the mean *b*-coefficient (slope) was significantly different from 3 with an error level of 0.05 to investigate the growth difference between *S. aurata* and *D. Labrax* **(Ogle, 2013)**.

2. Zootechnical performance

Several methods are used in aquaculture to estimate fish growth in terms of size increase over time **(Zainal & Altuama, 2021)**. These methods can be represented by the zootechnical performance indicator presented in Table (1). One-way ANOVA was used to test for differences in calculated indicator growth performance among species.

Table 1. Performance growth indicator used in this study

Indicator	Formula	Reference
Specific Growth Rate (SGR) (% day $^{-1}$)	$SGR = \frac{\ln \text{final body weight}(Wf) - \ln \text{initial body weight } initial\ (Wi)\ (g)}{\text{days}} * 100$	Magnoni *et al.* (2023), Di Marco *et al.* (2017); Muller –feuga (1990)
Thermal-Unit Growth Coefficient (TGC) (%)	$TGC = \frac{poids\ final^{\frac{1}{3}}(Wf) - poids\ initial^{\frac{1}{3}}(Wi)}{\text{somme des températures } (\Sigma T)} * 100$	Mayer *et al.* (2012)
Feed Conversion Ratio (FCR)	$FCR = \frac{\text{Final fish biomass (Bf)} - \text{Initial fish biomass (BI) (Kg)}}{\text{Ratio of amount of feed dispensed (Kg)}}$	Bavčević *et al.* (2010) ; Parma *et al.* (2020)
Fulton's condition factor (g/cm) (K)	$F = \frac{\text{Fish body weight } (W)\ (g)}{\text{Total length }^3 (L)\ (cm)} *100$	Di Marco *et al.* (2017) ; Bavčević *et al.* (2020) ; Magnoni *et al.* (2023)

RESULTS

Table (2) summarizes all descriptive statistics for El Mokretar Aqua fish farm gilthead seabream and the European seabass. *D. labrax* had the greatest body length (31.37± 2.46cm) and weight (412.69± 79.41g), while *S. aurata* had the smallest length (24.73± 1.74cm) and weight (239.86± 57.65g). Individuals of the Gilthead seabream differed significantly in length and weight from those of seabass (*P-value*< 0.05). Individuals of *D. labrax* were larger than those of *S. aurata*, weighing 683g versus 449g. Both species were farmed. The coefficient of variation for total weight was the most significant, while the coefficient for total length was the least variable, at around 7%.

Table 2. Mean with standard deviation, median, mode, min and max of total length (cm) and total weight (g) for the gilthead seabream and European seabass from El Mokretar fish farm in the Bay of Souahlia

	Dicentrarchus labrax (n=417)		*Sparus aurata* (n=627)	
	Wt	Lt	Wt	Lt
Mean ± sd	412.69± 79.41*	31.37±2.46*	239.86±57.65*	24.73±1.74*
Max	683.00	49.00	449.00	29.1
Min	239.00	26.00	76.00	18.00
Median	403	31	241.0	25
Mode	403	30.5	236	26
Coefficient of variation (%)	19.24	7.84	24.03	7.03

* Significant differences between *S.aurata* and *D. labrax* in weight and length using t-test (*P*-value< 0.05).

Weight is the most important factor in aquaculture. Fig. (2a) depicts the weight frequency distribution of *D. labrax* in C3. The most common total weight ranged between 339 and 488g, while the least common weight was greater than 489g but less than 289g. *S. aurata* weight frequency distribution in C8 corresponds to 176 and 325g. The weight that occurs the least frequently was greater than 326g and less than 175g (Fig. 2b).

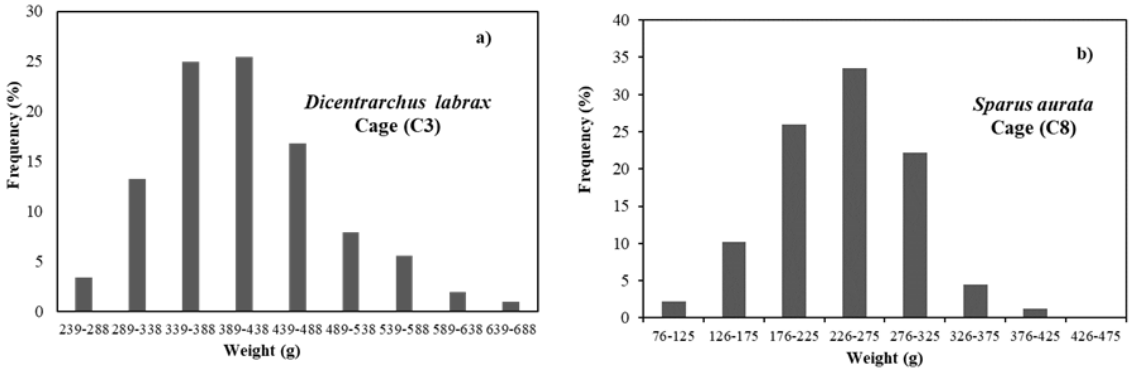

Fig. 2. Frequency distribution of total weight for **(a)** *D.labrax* and **(b)** *S.aurata* from El Mokretar Aqua fish farm

Fig. (3) and Table (3) illustrate the length-weight relationship of the European seabass and gilthead seabream from El Mokretar Aqua fish farming. The r^2 values for *S. aurata* ranged from 0.996 to 0.628 for *D. labrax*. The growth types of the European seabass and gilthead seabream were different, and the *b*-coefficient was significantly different from 3 (*P*-value< 0.05). In fish farming El Mokretar Aqua, the gilthead seabream showed a positive allometric growth (b> 3), whereas the European seabass showed a negative allometric growth (b < 3).

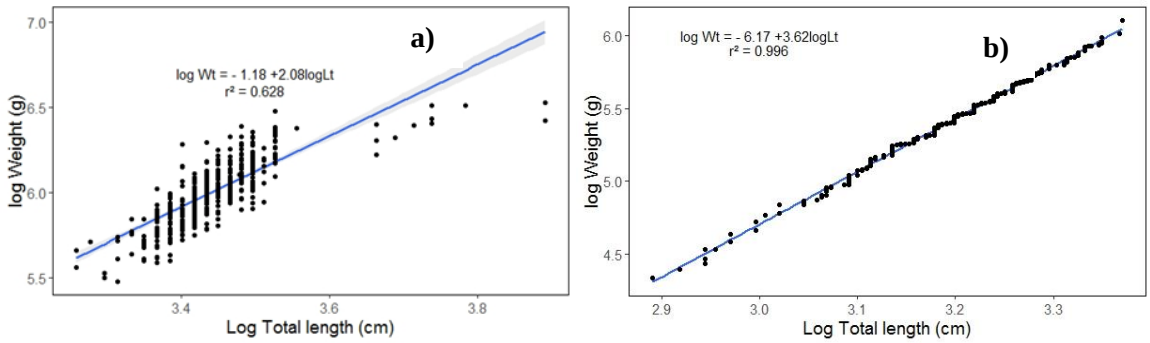

Fig. 3. Length –weight relationship for **(a)** *D.labrax* and **(b)** *S. aurata* farmed at El Mokretar Aqua fish farm

Table 3. The European seabass and gilthead seabream length–weight regressions for the finfish farming El Mokretar Aqua

Species	Log a	B	95% confidence interval (b)	r^2	Growth
S.aurata	-6.17	3.62*	3.61 - 3.64	0.996	positive Allometry
D.labrax	-1.18	2.08*	1.93 - 2.24	0.628	Negative Allometry

* The t-test confirmed the length-weight relationship's b-coefficient (slope b). It indicates that allometry growth is not significantly different from 3 (*P*-value< 0.05).

Table (4) shows the zootechnical characteristics of *D. labrax* and *S. aurata* breeding at El Mokretar Aqua fish farm. Over a 381-day rearing period, the European seabass increased their mean weight from 11.86 to 412.69g for a total weight gain of 400g. Over 340 days, the average weight of the gilthead seabream increased from 7 to 240g, with a weight gain of 233g. Large-weight individuals (683g for *D. labrax* and 449g for *S. aurata*) were observed during sampling for both species. Nonetheless, *S. aurata* is thought to reach a commercial size of more than 250g in 381 days (www.fao.org/fishery/culturedspecies/Sparus_aurata/en) and more than 350g (https://www.fao.org/fishery/en/culturedspecies/dicentrarchus_labrax?lang=en). At the end of breeding, *D. labrax* had a higher density and biomass than *S. aurata*. Finally, the overall survival rate for *S. aurata* was 96.07%, while it was 90.52% for *D. labrax*, but mortality was negligible for both species in floating cages C8 and C3, respectively.

Table 4. Zootechnical characteristics of *D.labrax* and *S. aurata* farmed at the El Mokretar Aqua fish farm

Indicator	***D. labrax*** **(C3)**	***S. aurata*** **(C8)**
Start of breeding	20 May 2022	13 May 2021
End of breeding	07 June 2023	18 April 2022
Age (day)	381	340
Initial number of fish (n)	225,000	375,000
Mean initial weight (Wi) (g)	11.86	6.98
Mean final weight (Wf) (g)	412.69	239.87
Weight gain (g)	400.83	232.89
Daily weight gain (g/day)	1.05	0.68
Initial biomass (Kg)	2, 668.5	2, 617.5
Final biomass (kg)	84, 050.51	86, 422.28
Initial density (kg/m^3)	0.40	0.40
Final density (kg/m^3)	12.73	13.09
Survival rate (%)	90.52	96.07

Figs. (4, 5) show that the specific growth rate (SGR) and condition factor (K) for the gilthead seabream were higher.

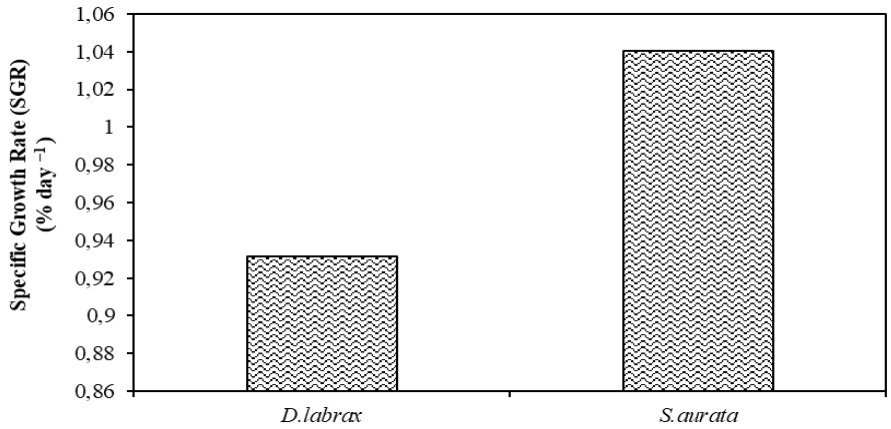

Fig. 4. Specific growth rate (SGR) for *D.labrax* and *S.aurata* at El Mokretar Aqua fish farm

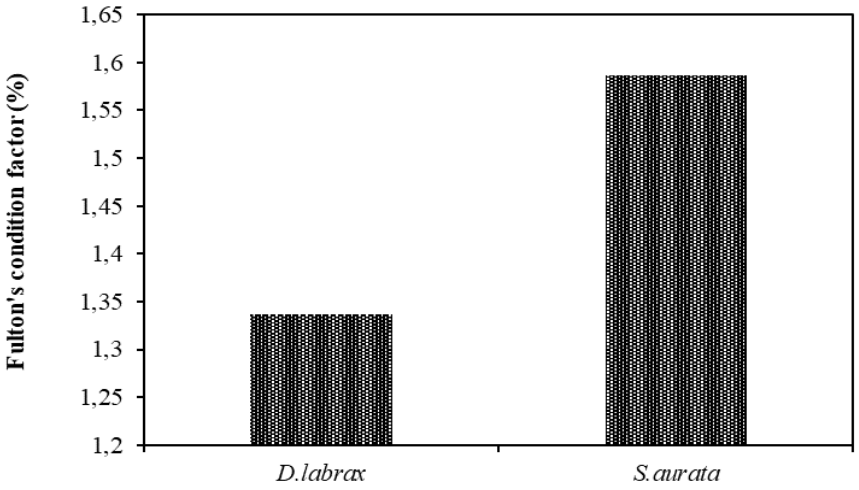

Fig. 5. Fulton's condition factor (K) for *D.labrax* and *S.aurata* at El Mokretar Aqua fish farm

The K value for the European seabass ranged from 1.34 to 1.59% for the gilthead seabream. *S. aurata* farmed had a higher feed conversion ratio (1.62) than *D. labrax*, which was around 1.69 (Fig. 6).

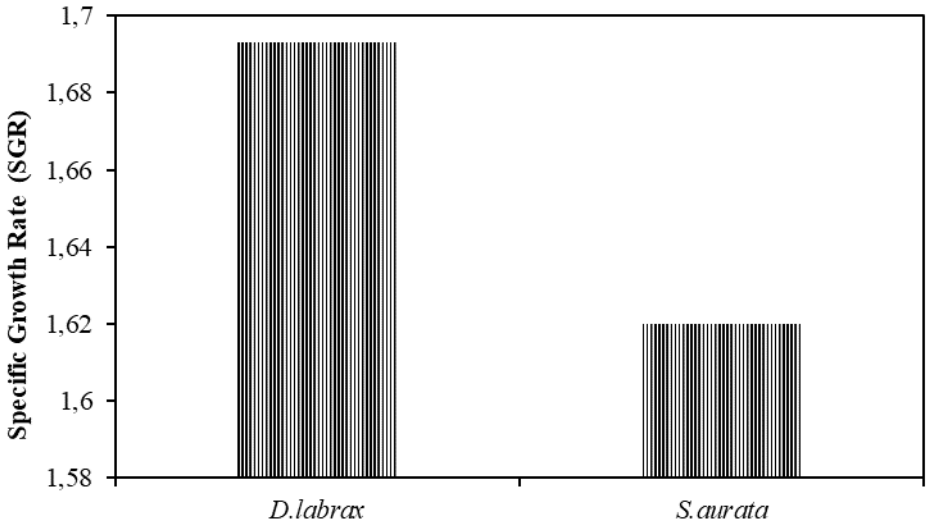

Fig. 6. Feed conversion ratio (FCR) for *D.labrax* and *S.aurata* at El Mokretar Aqua fish farm

D. labrax had a higher thermal-unit growth coefficient (TGC) than *S. aurata*, with 1.89 versus 1.76% (Fig. 7). Finally, there was a significant difference in growth performance between the gilthead seabream and European seabass (ANOVA *P*-value< 0.05).

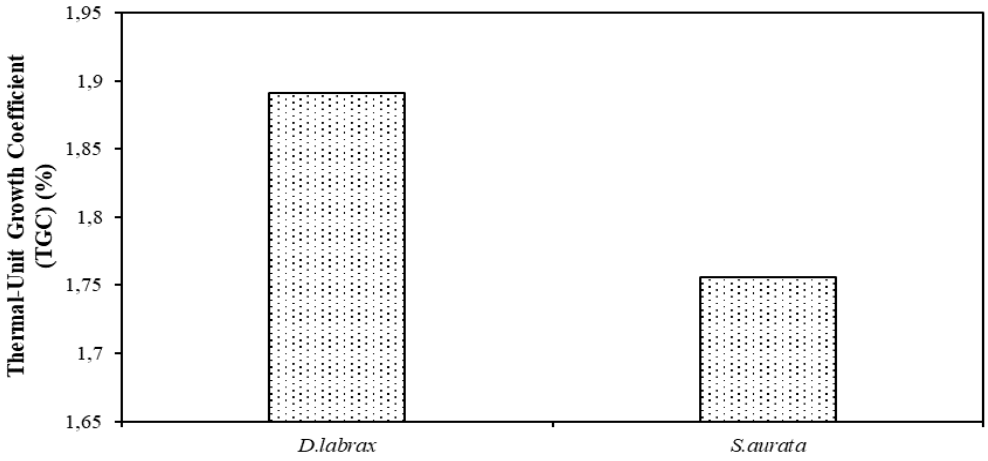

Fig. 7. Thermal –unit gowth coefficient (TGC) for *D.labrax* and *S.aurata* at El Mokretar Aqua fish farm

DISCUSSION

The length-weight relationships and zootechnical performance of *S. aurata* and *D. labrax* farmed in an intensive fish farm, El Mokretar Aqua, on the coast of Chlef, Algeria, are compared in this study. These two species were reared in C8 and C3 floating cages, respectively. They were, however, subject to the same physicochemical conditions as

seawater. The well-being of farmed fish requires adequate nutrition in the feed **(Zainal & Altuama, 2021)**. The two species studied are fed a Naturalleva-type commercial food (50% protein, 33% lipid, and 17% carbohydrates). Length-weight relationship is an important parameter for an accurate biomass estimation, which is important for fish farmers to manage their businesses **(Orduna *et al.*, 2023)**. Because these variables can be entered into an equation to calculate the relative K, this relationship is also a useful indicator of fish health **(Zainal & Altuama, 2021)**.

Weight gain, SGR, and TGC are aquaculture models that apply to the concave portion of the growth curve **(Fazio *et al.*, 2018)**. This study aimed to link the zootechnical performance data obtained with the length-weight relationship. The length-weight relationships of *S. aurata* and *D. labrax* are presented, showing different growth patterns within each floating cage at El Mokretar Aqua fish farm. *S. aurata* exhibited a positive allometric growth, meaning that the fish became stouter as body length increased **(Orduna *et al.*, 2023)**. In contrast, *D. labrax* showed a negative allometric growth. The *b*-coefficient in the length-weight relationship for *S. aurata* ranged between 3.00 and 3.62 (Table 5).

Table 5. Length-weight relationships of *S. aurata* reported in the literature

Length–weight relationship	r^2	Growth	Area of study	Reference
$W= 0.31L^{3.62}$	0.996	Positive allometry	El Mokretar Aqua Bay of Souahlia, Algeria	Present study
$W= 0.0163\ L^{3.00002}$	0.993	Isometric	Eastern Adriatic coastal Vrgada Island, Croatia	Bavčević *et al.* (2020)
$W = 0.0053L^{3.03}$	*0.950*	Isometric	Northern Aegean coasts of Turkey	Özgür (2022)
$W= 0{\cdot}0037L^{3{\cdot}623}$	0·989	Positive allometry	Spain and Greece	Arechavala-Lopez *et al.* (2012)

The value for *S. aurata* was reported to be comparable to the estimates of **Arechavala-Lopez *et al.* (2012)** for farms in Spain and Greece, but higher than the values estimated by **Bavčević *et al.* (2020)** and **Özgür (2022)** for wild *S. aurata*. The growth of farmed *D. labrax* was comparable to the estimate of **Orduna *et al.* (2023)** in Portugal; however, it was significantly higher than the value reported by **Arechavala-Lopez *et al.* (2012)** and significantly lower than the values reported for wild *D. labrax* in Egypt **(Abd Elnabi *et al.*, 2022)** (Table 6).

Table 6. Length-weight relationships of *D.labrax* reported in the literature

Length–weight relationship	r^2	Growth	Area of Study	Reference
$W= 0.0021\ L^{2.08}$	0.628	Negative allometry	El Mokretar Aqua Bay of Souahlia, Algeria	Present study
$W= 0.0081\ L^{3.0287}$	0.98	Positive allometry	Lagune de Bardawil, Égypte	Abd Elnabi *et al.* (2022)
$W=0.015\ L^{2.777}$	0.929	Negative allometry	Atlantic Ocean, Setúbal district, Portugal	Orduna *et al.* (2023)
$W = 0{\cdot}0009L^{3{\cdot}866}$	0·992	Positive allometry	Spain and Greece	Arechavala-Lopez *et al.* (2012)

As a result, several factors explain these differences between studies, and this study may be related to one or more of these factors, including sex, age, growth rate, diet, number of individuals analyzed, physiological responses, sampling season, water quality, sampling duration, and size selectivity **(Abd Elnabi *et al.*, 2022; Özgür, 2022)**. **Orduna *et al.* (2023)** discovered that the European seabass had a positive allometric value in offshore cages in the spring and autumn. Furthermore, K, representing the relationship between fish length and weight, was used to confirm this relationship **(Abdel-Hakim *et al.*, 2010)**. K indicates the relative robustness of the fish, its fatness, and its level of well-being. This factor assumes that heavier fish of a given length are in a better shape. It also indicates changes due to sex maturation and release **(Abdel-Hakim *et al.*, 2010)**. This finding also indicates changes in food reserves and, as a result, is an indicator of an overall fish condition **(Datta *et al.*, 2013)**.

A higher K value generally indicates fatter fish **(Bavčević *et al.*, 2010; Cabello, 2000)**. If K is 1.5 or 1.6, the stock performs satisfactorily; if higher, it may not be fed correctly; if lower, fish may be underfed or numbers over counted. Our findings show that the Gilthead seabream had a better K than European seabass. These findings are consistent with previous research **(Fazio *et al.*, 2018)**, which found that *D. Labrax* has a lower K than *S. aurata*. The higher K value of *S. aurata* corresponded to a lower FCR. This result implies increased growth efficiency **(Bavčevićet *et al.*, 2010)**. The feeding protocol, which includes frequency, duration, and techniques, affects feed conversion efficiency **(Stavrakidis-Zachou *et al.*, 2019)**. However, the FCR for *S. aurata* in C8 was significantly higher than for *D. labrax* in C3.

Stocking density is a critical factor influencing fish welfare in aquaculture, particularly where high productivity is desired. In our study, we kept the final density in each cage at 13kg/ m^3 for both species farmed, *S. aurata* and *D. labrax*, in accordance with specific

provisions established with the stocking density of 10-20kg/ m^3, are commonly used for mariculture in the Mediterranean **(Jobling *et al.*, 2010)**. SGR is regarded as a growth indicator for fish. It can be manipulated to save time in the production and marketing processes. Knowing the SGR of cultured fish can significantly improve the feeding efficiency **(Zainal & Altuama, 2021)**.

Variation in environmental factors has a negative economic impact because it alters water quality and aquaculture systems, affecting the final fish product's health, productivity, and quality **(Fazio *et al.*, 2018)**. Because physiological processes in aquaculture cannot escape harsh environments, seasonality dominates the life cycle of fish, influencing body weight, locomotor activity, and food intake **(Fazio *et al.*, 2018)**. The TGC indicator used in this study is simple and flexible, providing an easy way to compare the growth rates of farmed fish while considering a key environmental parameter: water temperature **(Jobling, 2003)**. The TGC value for *D. labrax* was higher in our study because the final weight was higher. **Fazio *et al.* (2018)** discovered that *S. aurata* has higher TGC than *D. labrax*. According to **Jobling (2003)**, the TGC is not temperature-independent over the entire thermal range. Warmer environments, on the other hand, have a longer growing season and a faster growth rate but have a shorter life span than cool water. Fish growth in offshore cages may be aided by relatively stable water temperatures in the preferred range and constant salinity conditions **(Orduna *et al.*, 2023)**. As a result, the average water temperature ranged from 25°C in summer to 16°C in winter (Fig. 8).

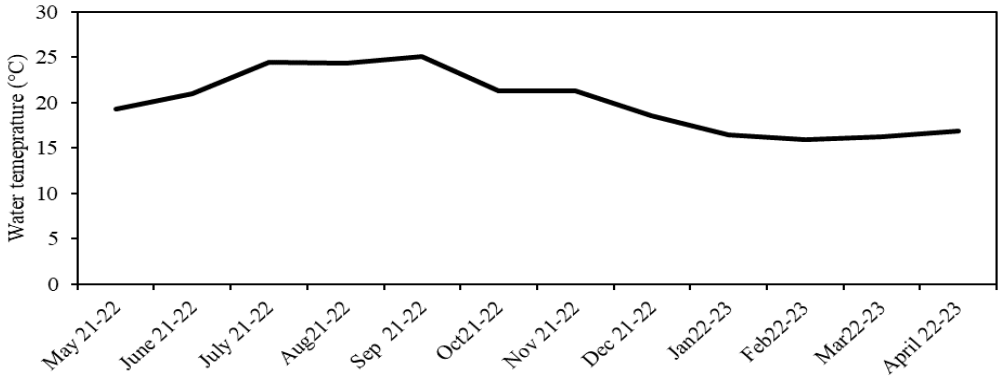

Fig. 8. Average water temperature mesured between May 2021 to April 2023 at El Mokretar Aqua fish farm

Remarkably, the rapid growth rates of *S. aurata* and *D. labrax* indicate that the environmental conditions in the Bay of Souahlia were favorable to the species. The average temperature in the two species' floating cages was very similar. The water temperature range reflects the natural ambient conditions, gradually decreasing from the end of summer to springtime. Low-temperature exposure to the reared gilthead seabream may result in slower metabolic rates, disrupted feeding behavior, and decreased growth **(Fazio *et al.*, 2018)**. The differences in growth performance were more noticeable in the

European seabass than in the gilthead seabream due to the former species' higher feed intake, initial weight, and rearing time, which resulted in a more noticeable weight gain. **Besbes and Guerbej (1996)**, **Altan (2018)**, **Fazio *et al.* (2018)** and **Arechavala-Lopez *et al.* (2012)** demonstrated that the gilthead seabream outperformed the European seabass in terms of growth and development under comparable seawater and feeding quality and quantity conditions.

CONCLUSION

The length-weight relationship and zootechnical performance of *S. aurata* and *D. labrax* farmed in floating cages in the Bay of Souahlia in this study indicated a favorable growth during the rearing period, allowing the development of sustainable management strategies. The findings support the conclusion that both species do not exhibit the same growth behavior in a finfish farm under identical conditions. Additionally, this research will also allow future comparisons between aquaculture species of interest in different rearing conditions, which will help in farm planning and management.

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