The instantaneous growth rate of maricultured Sparedentix hasta (Valenciennes, 1830) and Sparus aurata (Linnaeus, 1758)

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Abstract

The growth rate of two seabream species, was monitored during 2017. Seabreams *Sparedentix hasta* and *Sparus aurata*, were collected at age of 26 to 159 days and at 47 to 173 days for *S. hasta* and *S. aurata* respectively. The data obtained for age groups 47 to 159 days were used for comparison between the two species given 600 and 510 individuals for each species. They were raised from eggs under controlled ambient environmental conditions at the National Mariculture in the Kingdom of Bahrain. Early larvae were fed on live food such as *Artemia* and the fingerlings were fed on commercial feed. Weekly abiotic monitoring indicated that these species could tolerate slight fluctuations in these factors. Dissolved oxygen concentrations, in particular, ranged between 3.4 and 6 mg/l indicating their tolerance of occasional lower oxygen availability. The growth rate was exponential during the monitoring time. The linear correlations between body mass and body length were significant. Although some data indicated that the European seabream, *S. aurata*, can grow significantly faster ($P \leq 0.05$) than *S. hasta*, at certain age. In general, *S. hasta* had a higher instantaneous growth rate (Specific Growth Rate, SGR%). For example, SGR% was 20.29 from 54 to 61 days, whereas *S. aurta* had a value of 4.48%. SGR% ranged from 0.1 to 20.3% for *S. hasta* and from 0.2 to 19 % for *S. aurata*. Morphologically, *S. aurata* appears to have a more rounded and shorter body, but the native species, *S. hasta*, grows significantly longer and heavier. The differences in the rates of growth decreased with time as their body masses increased. There is an inverse relationship between body mass and the specific growth rate in both species. Monitoring SGR% using body mass or body length is one of the most useful indicators of production in mariculture. Attention needs to be considered however, to the husbandry and wellbeing of the cultured species.

Keywords: Growth, Sobaity, Gilthead, Sea bream, Fingerlings, Arabian Gulf, Bahrain

Introduction

Recently, around the world, aquaculture has witnessed great success. Mariculture is about culturing marine organisms (fauna or flora) for human food consumption. Sparid fishes are among the most important groups of fishes used in fish culture. Mariculture activity has been growing fast in the Arabian Gulf in support of the food security strategy in the region.

Seabreams belong to the family Sparidae and are found in shallow and deeper waters of temperate seas (Siddiqui et al., 2014). The species are characterized by different body shapes and colouration (Orrell et al., 2002). This fish group represents high commercial value in the Arabian Gulf and elsewhere because of its pleasant taste. Moreover, sparid species are considered one of the most common candidates due to their tolerance and survival capability in captivity (Mozanzadeh et al., 2017). The native species, *S. hasta*, is known locally as Sobaity, exists in the Indian Ocean (Yousif et al., 2003). Sobaity and the European Seabream, *S. aurata*, are among the cultured fishes in Bahrain enhancing fish stock (Zainal, 2016). These two species exist in the Mediterranean Sea and inhabit lagoons and estuaries (Chaoui et al., 2006). Seabreams include 24 species in the Mediterranean and two migrants from the Red Sea established in the eastern Mediterranean. They can grow to 70 cm in length and 5 kg in weight (EFSA, 2008). *S. aurata*, known as Gilthead seabream, is well known as a non-native species in the Arabian Gulf.

In the Kingdom of Bahrain, mariculture was started as a pilot project in 1979 with the cooperation of the Food and Agriculture Organization (FAO) of the United Nations. The National Mariculture Centre (NaMac) is located at Ras Hayan on the southeastern coast of Bahrain. The centre supports the fish stocks in the country by considering food security. Both species have silver colouartion and are oval, but *S. aurata* has a distinct, larger black patch above its operculum. Both species are protandrous hermaphrodites, meaning that male individuals transfer into females at a certain age.

According to NaMac, *S. hasta* was formally introduced as a mariculture species in 1985, whereas *S. aurata* was introduced from France in 2005. These original individuals were subsequently utilized as the starting points of the next generations. Eggs are maintained under specific conditions until hatched and grown up to a market size of 350–500 g body weight. Either the fingerlings are sold to the private sector or released into the sea to enhance fish stock. In 2014, ASMAK (a Fisheries Company) began producing both seabream species following an agreement with the Ministry of Municipalities Affairs and Urban Planning. ASMAK production has been marketed locally thereafter.

It is well known that by providing suitable growth conditions, fishes can grow throughout their lives. Growth can be limited, however, by food availability, competition, disease, and water quality, including temperature, pH, dissolved oxygen (DO) and salinity. The monitoring of growth rate in the mariculture setup is a useful production indicator. Fish growth estimation can be based on absolute growth, which is a gain in body weight per a certain time, or relative growth, representing a growth percentage. There are further approaches used to determine the growth rate, such as specific growth rate percent (SGR%), daily growth (DG), and von Bertantalanfy growth functions, all of which depend on specific correlations between body size and age. These correlations can be either linear, exponential, or asymptotic (Hopkins, 1992). Most fishes grow faster at the early stages of life, whereas adult fishes utilize more energy towards reproduction rather than growth. The present paper investigates the growth rate at the very early stages of two cultured seabream.

Materials and Methods

Seabreams were collected from NaMac at 26 to 159 days of age and at 47 to 173 days for *S. hasta* and *S. aurata* respectively during 2017. The data obtained for age groups from 47 to 159 days were used for comparison between the two species. At the beginning of the production of fish populations, eggs were collected at regular spawning intervals and checked for their viability. Viable eggs are mixed with an antibacterial agent prior to their release into a specific hatchery.

Newly hatched larvae were fed on live food such as *Artemia*. Later, commercial feed (ARASCO), consisting of protein (48% minimum), fat (12% min.) and fiber (1.5% max.) was given. Other components of this feed included fishmeal, starch, fish oil, vitamins and minerals, plus antioxidants and other fungal substances. Fingerlings were fed at intervals of half an hour and larger individuals were fed at intervals of an hour. Fishes from the age group of 20-70 days old were fed on a portion size of 100-1500 μg feed, and for the age group of more than 70 days, fishes were fed on 0.9- 6 mg portion sizes. During this study, no hormones were added to the holding tanks.

The fish samples were obtained from stocks of approximately 30,000 – 40,000 individual fishes in each holding tanks. These tanks had a capacity of 24 tons of water (=24.4398 cubic meters). The tanks were filled with 80% seawater and 20% ground water as per the mariculture center protocol and water circulated via pumping systems. As the fishes grew, they were collected and moved into separate tanks to avoid crowding. Each age group was followed for sampling purpose as they were moved to next tank in series. A sample of thirty individuals of each species were collected using a handheld net from the holding tanks at random every week for 20 weeks. A total number of 600 and 510 individuals of *S. hasta* and *S. aurata* respectively were used for the study.

Water temperature, salinity, pH, and dissolved oxygen (DO) concentrations were recorded using the Thermo Scientific ORION, the Handy Polaris Oxygen-guard, and the OTAGO refractometer. At an earlier age, the two species were separated using petri dishes and a Profile Projector lens (Nikon Profile Projector). This enabled accurate body length measurements. Live fish were dipped in formaldehyde for one second prior to body measurements. As the fish grew, it was easier to measure the total length using calipers to the nearest millimeter. The weight was recorded to the nearest gram using a digital balance (Denver instrument). Thirty small individuals, from each age group, were weighed and the average weight of each individual was calculated. Fingerlings (aged 70 days) were placed in a 10 L aerated seawater tank and were anesthetized using a diluted solution of 5 ml of 2-phenoxyethanol in 15 L of seawater. The fish samples were immediately transferred into a separate fresh seawater tank for recovery.

The specific (instantaneous) growth rate percentage (SGR %) was estimated following the equation of Ricker (1975).

$$SGR\ \% = Ln\ final\ Wt - Ln\ initial\ Wt / days\ X\ 100$$

where Wt. is the fresh body weight in g.

The differences between the growth rates of both species were tested using t-test and one-way ANOVA (SPSS version 22 and Microsoft Excel packages) at a significance level of $p \leq 0.05$. The average lengths on a weekly basis for both species at different age groups until 159 days were calculated.

Absolute growth (G) was also calculated as a final mass (at age 159 days) - initial mass (at age 47 days) divided by the duration.

Results

Water quality was monitored for 20 weeks in the holding tanks of *S. aurata* and *S. hasta* tanks (Table 1). The results showed that the averages of the abiotic factors for the two holding tanks were: (temperature 29.6 ± 4.35 and 28.91 ± 4.65), (pH 7.13 ± 0.53 and 7.15 ± 0.65), (dissolved oxygen 4.88 ± 0.91 and 5.03 ± 0.82) and (salinity 40.35±3.87 and 40.55±3.73) for both species, respectively. The fluctuation in the abiotic factors in the holding tanks was considered to be minor. These values were considered optimum for the abiotic conditions at the mariculture reflecting the ambient values for the time of the year.

Table 1 Weekly abiotic factors in their holding tanks of *S aurata and S.* hasta during 2017

Week	pH S. aurata	pH S. hasta	Tempt. °C S. aurata	Tempt. °C S. hasta	D.O. mg/l S. aurata	D.O. mg/l S. hasta	Salinity (‰) S. aurata	Salinity (‰) S. hasta
1	6.36	6.34	42.00	42.50	4.80	5.20	36.00	36.00
2	7.39	5.88	32.00	33.00	4.80	5.00	45.00	45.00
3	6.34	6.78	31.10	30.40	6.00	5.80	40.00	40.00
4	6.80	5.61	30.40	30.40	5.20	4.60	36.00	36.50
5	6.78	7.22	30.40	30.40	3.40	3.50	45.00	45.00
6	6.72	7.19	35.00	27.00	3.70	3.70	40.00	40.00
7	6.82	7.11	31.20	30.00	4.40	4.30	36.00	36.00
8	6.62	6.71	32.00	31.40	4.60	4.40	45.00	45.00
9	7.11	6.89	31.20	25.00	4.80	4.60	40.00	40.00
10	6.28	7.46	31.00	26.00	3.60	4.60	36.00	36.00
11	6.89	7.76	31.60	26.00	3.50	4.30	45.00	45.00
12	7.67	6.88	28.00	25.00	4.20	4.50	40.00	40.00
13	7.76	7.42	28.00	23.80	4.70	5.30	36.50	36.00
14	7.76	7.79	29.50	22.40	5.00	5.70	45.00	45.00
15	7.81	7.64	26.70	22.40	6.10	6.50	40.00	40.00
16	7.43	7.74	26.00	28.50	6.50	5.30	36.50	36.00
17	7.23	7.30	24.70	28.50	5.30	5.60	45.00	45.00
18	7.64	7.82	25.00	30.00	5.30	6.30	40.00	40.00
19	7.74	7.98	23.40	31.40	5.80	5.70	36.00	40.00
20	7.50	7.53	23.20	34.00	5.90	5.70	45.00	45.00
Min.	6.28	5.61	23.20	22.40	3.40	3.50	36.00	36.00
Max.	7.81	7.98	42.00	42.50	6.50	6.50	45.00	45.00
Avg.	7.13	7.15	29.62	28.91	4.88	5.03	40.40	40.58
S.D.	0.53	0.65	4.35	4.65	0.91	0.82	3.81	3.70

Figure 1 and Figure 2 represent the average total lengths and average weights of both *S. hasta* and *S. aurata*, respectively, recorded at a weekly interval during 2017. Statistically significant differences ($P \leq 0.05$) in the total lengths and weights have been observed between the two species throughout the monitoring period. For example, from the age of 47 until 159 days, *S. hasta* increased in total length by 82.12 mm, whereas *S. aurata* attained 74.65 mm. Similar results were obtained in other sets of calculation.

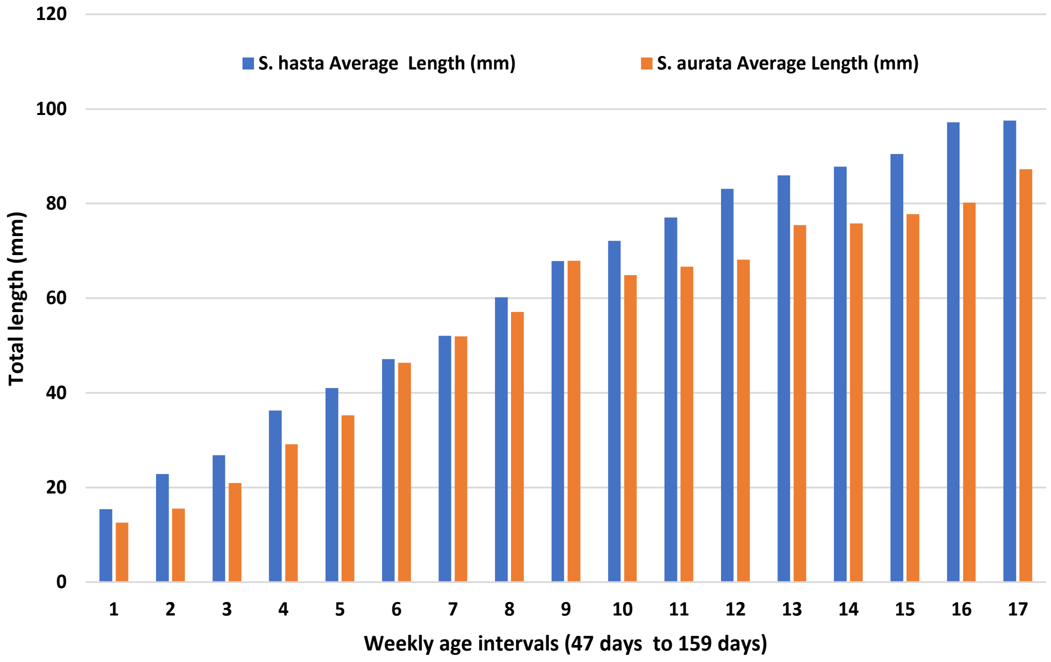

Figure 1. Average total length (mm) recorded at a weekly age interval for *S. hasta* and *S. aurata*

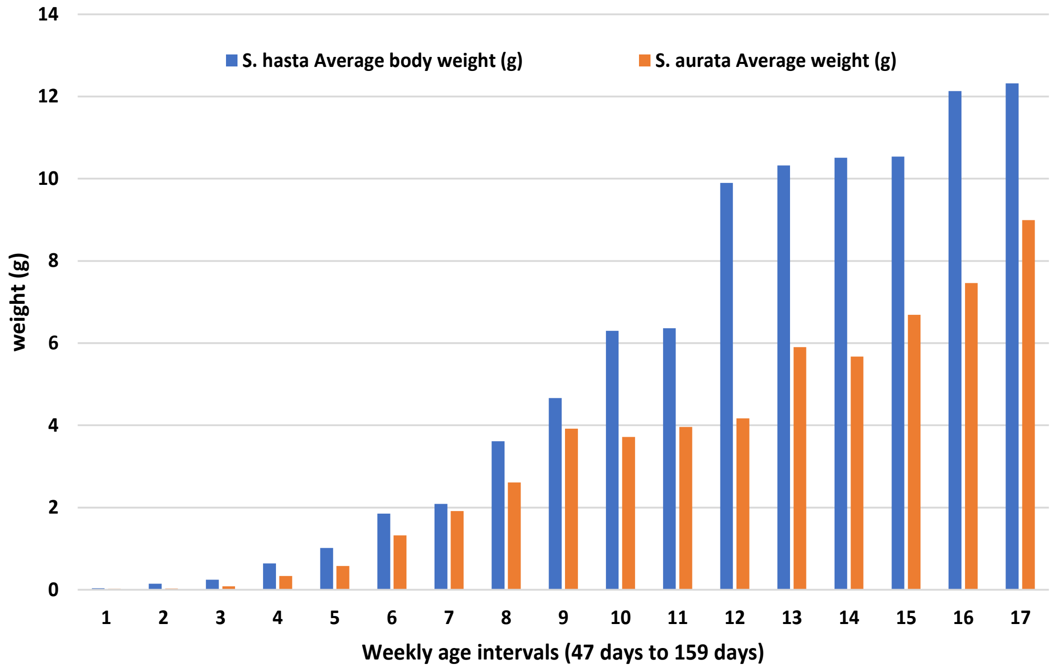

Figure 2. Average weight (g) recorded at a weekly age interval for *S. hasta* and *S. aurata*

Although some data indicated that *S. aurata* can grow significantly ($P \leq 0.05$) faster than *S. hasta* (Figure 3), at certain age groups, *S. hasta* in general had a higher instantaneous growth rate. For example, from 54 to 61 days, the SGR% was 20.29% whereas *S. aurta* had a value of 4.48%. In addition, the absolute growth in weight was estimated to be:

G = (12.322-0.003) / 133 = 0.092624 *S.hasta*

G = (11.923-0.019) / 133 = 0.089504 *S. aurata*

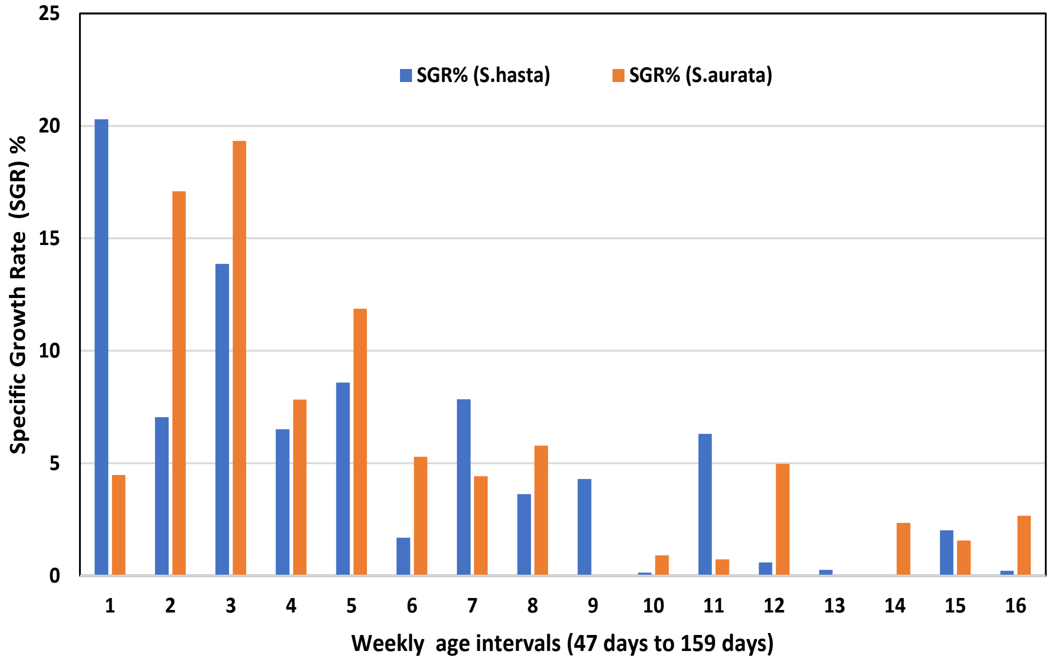

Figure 3. Weekly Specific Growth Rate (SGR%) for *S. hasta* and *S. aurata*

Both species grew exponentially at these early ages (Figures 4 and 5). As the fishes grew older the specific growth rate declined. The maximum rate was during the first five weeks and the minimum rate was towards the end of the investigation.

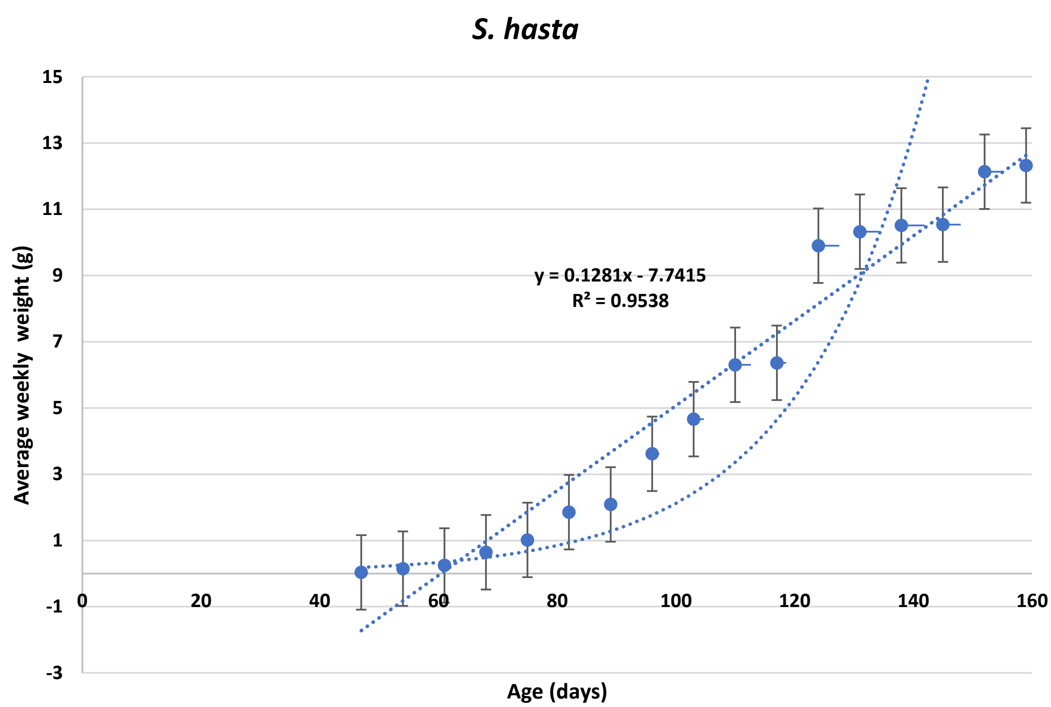

Figure 4. Relationship between average weight and age of *S. hasta*

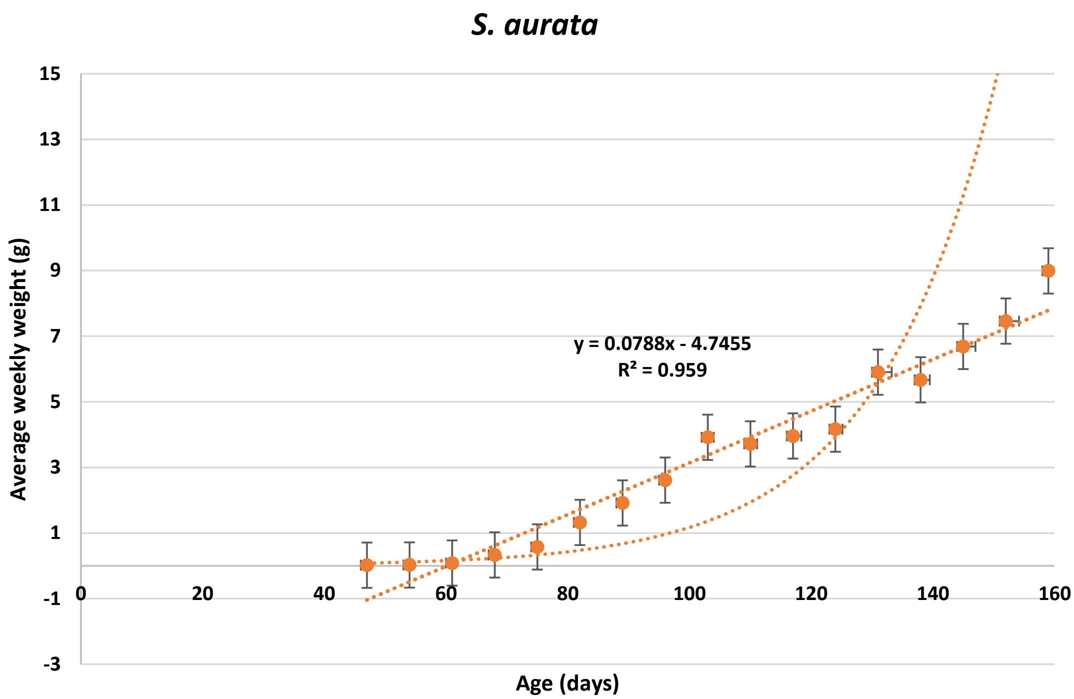

Figure 5. Relationship between average weight and age of *S. aurata*

The linear form of the relationships between weight and length for both species suggested a high correlation indicating that there is a proportional growth between the length and weight. Consequently, the regression line is valid to model the linear relationship (Figure 6 and Figure 7).

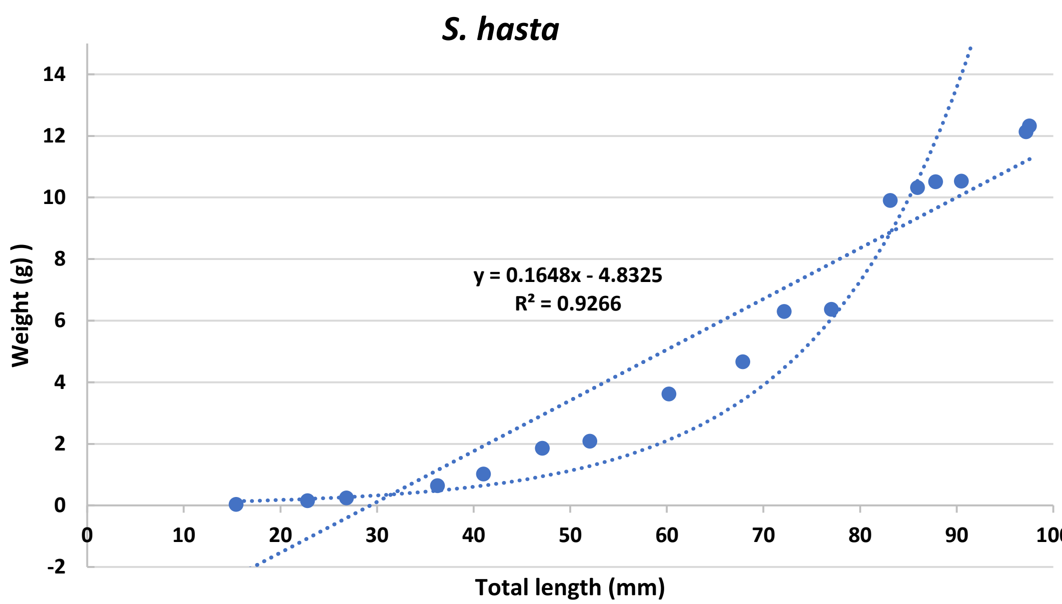

Figure 6. Length-weight relationship of *S. hasta*

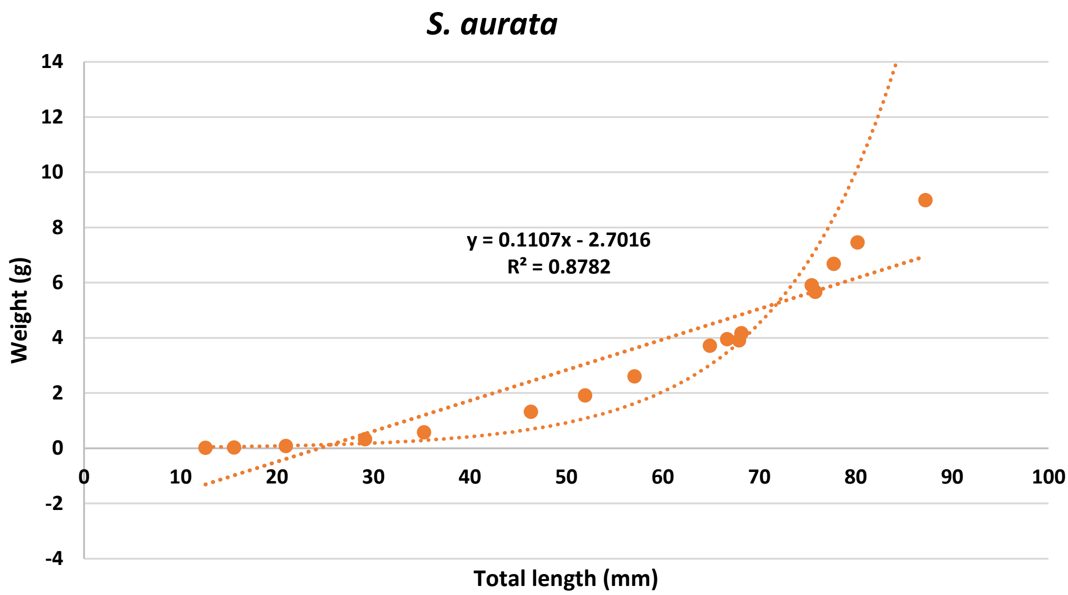

Figure 7. Length-weight relationship of *S. aurata*

For both species as presented in Figures (8 and 9), the weekly SGR% was inversely related to the body weight.

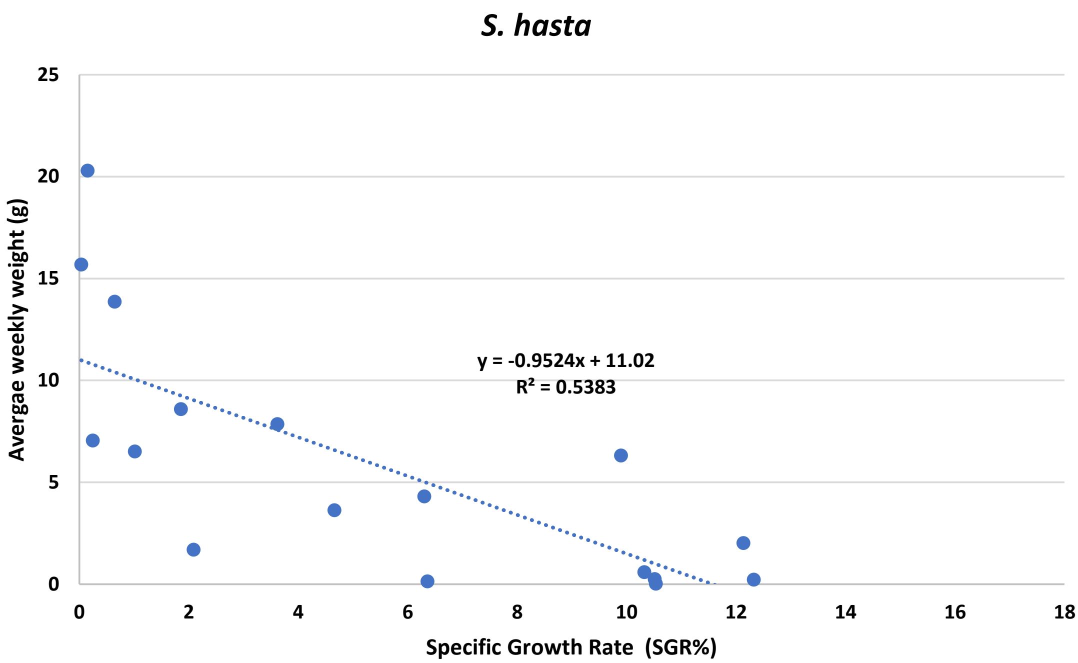

Figure 8. Regression analysis of weight and SGR% of *S. hasta*

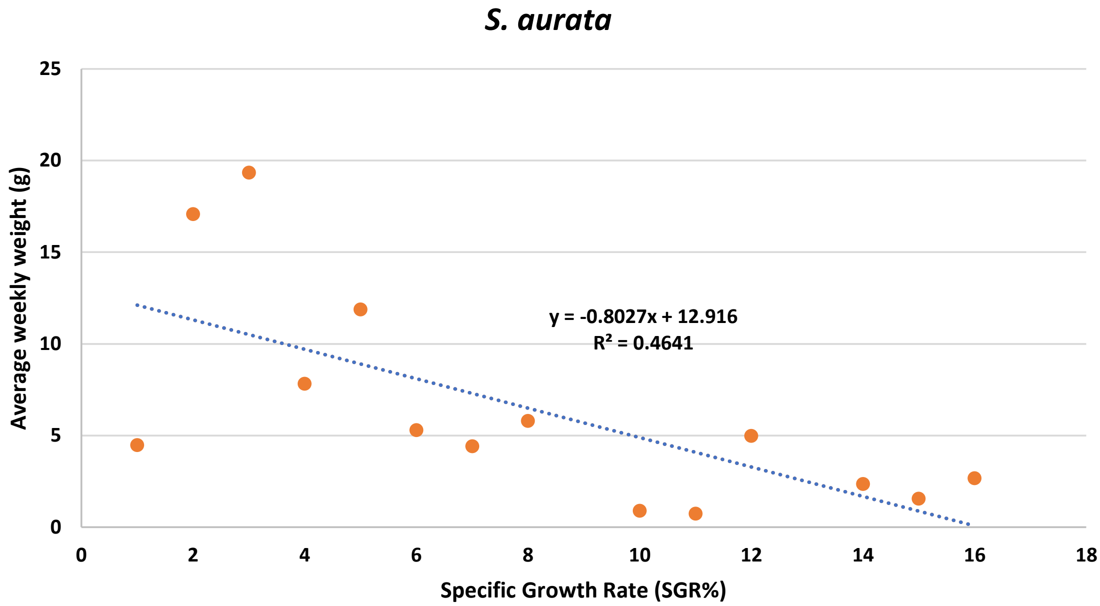

Figure 9. Regression analysis of weight and SGR% of *S. aurata*

At a certain age, the *S. aurata* (82 days-103 days) exhibited slightly higher weight. As the fish grew older, however, these differences were not being significant (P> 0.05). SGR% ranged between 2.91-7.03 for the age group of 5 days up to 60 days in *S. aurata*.

Discussion

The present paper highlights the exponential growth rate of two seabreams raised in a recirculating system at the national mariculture. Monitoring age-specific growth rates is one of the most useful production indicators in Mariculture. Overcoming technological and environmental challenges, the industry can provide opportunities for sustainable and renewable food security in the region.

S. aurata is one of the introduced species on hatchery trials in Bahrain, along with a few other native species such as *S. hasta, Epinephelus coiode, Acanthopagrus latus, Siganau canaliculatus*. In the wild, any non-native species can potentially compete with the native species for resources and food. This may cause some concerns about the possibility of releasing them intentionally or accidentally into the marine environment. *S. aurta* is common in the Mediterranean and has been extensively cultured in Turkey, where the cultured production exceeded the landings from the wild (Ucal, 2002). A review of the general biology and culture of gilthead seabream and some other Sparidae can be found in Pavlidis and Mylonas (2011).

In the natural environment, females can lay up to 30,000 eggs over a spawning time of 3-4 months during which the body colouration can be observed (Zohar et al 1995). By day 40 during which changes in the body dimensions occur, the larval metamorphosis occurs at a length of 16-17mm. In hatcheries, careful management is required since it has been found that the introduction of young fish increases the number of older males that reverse into females and the quality of eggs is affected by the sex ratio used in the tanks (Zohar et al., 1995).

The wellbeing of cultured fish involves providing appropriate nutrition in the feed. In the present study, the protein proportion of the commercial feed was around 48%. This is slightly less than the recommended value of 48.80% for Sobaity (*S. hasta*) in Kuwait (Hossain et al, 2014). Fingerlings of the same species were reared on a diet of 52% crude protein (Yousif et al, 2003) in the UAE. In the present mariculture setup, the proportions of different components of the feed were very similar to that reported in Mozanzadeh et. al., (2017) concluding that diets containing about 48% protein, 15% lipid, 15% carbohydrates, and 20 KJ g–1 gross energy are best for an on-growing *S. hasta*. The larval stage is very crucial and requires both high quality and plenty of live feeds to avoid any mass mortality. Yousif et al, (2003) reported that hormonal injection to induce spawning is not necessary at a temperature of above 20ºC for Sobaity. Monitoring of the feeding condition and whether any growth hormones were given during the culturing practice is, therefore, important.

The abiotic factors monitoring showed that on occasions, these factors can change slightly, perhaps due to the flushing system, temperature, or unconsumed feed, which can affect the oxygen level in the holding tanks temporary. The DO occasionally was 3 mg/l. Obviously, survival would be limited if DO drop further. It has been reported, however, that S. hasta can tolerate lower oxygen levels in aquariums (Zainal, 2016). The current observation is consistent with the findings obtained on adult Sobaity monitored for oxygen consumption rate. *S. hasta* exhibited a tolerance of hypoxic conditions down to 1 mg per liter of dissolved oxygen (Zainal, 2016).

In general, both species can tolerate wide ranges of temperature, salinity, and dissolved oxygen, but sudden changes in these environmental parameters may lead to an increased risk of poor health and mortality, especially in the juvenile stages of any cultured fish (EFSA, 2008). The overall average temperature in the tanks of the two groups was very similar with the minimum-maximum-average as (23.20 - 42.00- 29.62) and (22.40-42.50- 28.91) for the tank of *S. aurata* and *S. hasta*, respectively. The temperature range reflects the natural ambient conditions moving down from the end of summer temperature slowly towards springtime.

Aquatic systems are complex and common hazards in fish circulating water tanks can occur. Organic matter in the form of wastes such as dead fish; uneaten food and fish excretions can build up occasionally prior to the flushing process. The pH average as recorded with minimum-maximum-average values in the consecutive weeks for the tank of S. aurata were (6.28-7.81-7.13) and for the tanks of S. hasta were (5.61-7.98-7.15). Occasionally, pH might decline indicating slight acidic conditions. However, it was noticed that the fish survival has not been affected by the temporary drop in the pH level. Regular pH testing is, therefore, important to avoid toxicity and a mass kill of the fish. The pH of the water and acidity related to the buildup of CO_2 may cause hazards, but these problems can be avoided by appropriate husbandry (EFSA, 2008). Many fishes can tolerate pH changes ranging from 6.5 to 8.4, but a pH of 8 to 8.4 is preferred (Boxton and Allouse, 1982). These species can breed successfully at an extreme salinity (50 ppt) as reported by Yousif et al, (2003). Under mariculture conditions, it is important to keep the cultured fishes at optimum levels to avoid mortality or parasitic infection.

In aquaculture, different methods have been used to estimate the growth of fish in terms of their increase in size with time. This could be represented by the absolute growth rate (weight/day), the relative growth rate (percentage increase in weight), the specific growth rate (percentage per day) and the von Bertalanffy function. The relationship between length and weight is also a useful indicator of fish health because these variables can be entered into an equation for assessing the relative condition factor (K). The relative condition factor can be calculated as K = weight x 100/L3.

In the year 2008, similar results of preliminary study (unpublished data), indicated that age group 49 to 56 days of *S. hasta* grew at a higher rate in terms of length ($P< 0.05$). For example, at 56 days, the average total length of *S. hasta* was 42 mm ± 0.2, n = 270 compared to 28.5 mm ± 0.14, n = 270 for *S. aurata*.

The linear form of the length-weight relationship is characterized by high fitness (R2) indicating proportional growth for the length against weight. The growth rate is not usually exponential over a very long period of the life of a fish, but any growth curve can be treated in this way if it is divided up into shorter intervals (Ricker, 1975). Hossain et al, (2014) revealed that daily SGR% for a 6-month-old juvenile of *S. hasta* weighing 51.39 g was estimated to range between 0.76 and 0.62. The current results agree with these values, as individuals of lower weights show higher SGR% levels.

The specific growth rates are negatively correlated with the weights of both species. Although the regression equation shows slightly towards the lower limit of R2, especially in the case of *S. aurata*, it does nevertheless, show an inverse correlation between the two variables. The inverse correlation between SGR% and initial weight has been reported in other fish species such as salmon, *Salmo salar* (Cook et al, 2000) and in red spotted grouper *Epinephelus coioides* (Lin et al. 2008). Further, Crane, et al., (2019) reviewed the literature on SGR% and noted an increase in the number of published works using SGR% as an indicator of fish growth.

In aquaculture, several attempts have been made to maximize the growth-reducing cost of fish production. Transgenic salmon were observed to grow at a rate 2.62-2.85 times faster than non-transgenic salmon (Cook et al. 2000). Fingerlings of Gilthead Seabream injected with bovine or human growth hormone were 1.15 times larger than control fish (Cavarie et al. 1993). Other hormonal experiments on juveniles of coho salmon injected with bovine growth hormone showed 2.18 times in weight gain (Higgs et al, 1977), whereas the weight of transgenic coho salmon was ten times larger than control fish of the same age (Devlin et al. 1995). Mclean et al, (1993) found that the diet supplemented by fish growth hormone for juvenile black seabream (*Acanthopagrus schlegli*) resulted in 1.5-1.6 times increase in weight. Therefore, in aquaculture, the growth rate can be manipulated to save time from production to marketing. Knowledge of the SGR% of the cultured fish may considerably improve the feeding efficiency. A pattern of growth can also be established using length-at-age data or the usage of RNA-DNA ratio as an index of growth rate (Mathers et al, 1994), involving protein synthesis rate and enzymatic activities.

Presently, the mariculture was of the type that is known as a land-based re-circulating system. It may avoid potential contamination of the marine environment by organic pollutants. This system can be compared with another type of floating cage, which may also have some advantages. Floating cages help in supplying the system with a continuous renewal of oxygenated water without fuel consumption or even an occasional decrease in the dissolved oxygen concentration. The present results provided an insight into the growth rate of two important commercial species of seabream raised in mariculture.

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معدل النمو اللحظي لاستزراع الأحياء البحرية
Sparus aurata و Sparedentix hasta, Valenciennes 1830
Linnaeus 1758

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المُستَخلَص

تم رصد معدل نمو نوعين من الدنيس خلال عام 2017. تم جمع الدنيس Sparedentix hasta و Sparus aurata من عمر 26 إلى 159 يومًا وعند 47 إلى 173 يومًا لنوع S. hasta و S. aurata على التوالي. تم استخدام البيانات التي تم الحصول عليها للفئات العمرية من 47 إلى 159 يومًا للمقارنة بين النوعين مع إعطاء 600 و510 فردًا لكل نوع. تم تربيتها من البيض في ظل ظروف بيئية محيطة خاضعة للرقابة في الاستزراع البحري الوطني في مملكة البحرين. وتم تغذية اليرقات المبكرة على أغذية حية مثل الأرتيميا بينما كانت الإصبعيات تتغذى على الأعلاف التجارية. أشارت المراقبة اللاأحيائية الأسبوعية إلى أن هذه الأنواع يمكنها تحمل التقلبات الطفيفة في تلك العوامل. أحيانا تراوحت تركيزات الأكسجين المذاب ، على وجه الخصوص ، بين 3.4 و6 مجم / لتر مما يشير إلى تحملها لتوافر الأكسجين المنخفض العرضي. كان معدل النمو أسيًا خلال فترة المراقبة. كانت الارتباطات الخطية بين كتلة الجسم وطول الجسم ذات دلالة إحصائية. بالرغم من أن بعض البيانات أشارت إلى أن الدنيس الأوروبي ، S. aurata ، يمكن أن ينمو بشكل أسرع ($P \leq 0.05$) من S. hasta ، في فئات عمرية معينة. بشكل عام ، كان لـ S. hasta معدل نمو فوري أعلى (معدل النمو النوعي ، SGR ٪). على سبيل المثال ، كانت نسبة SGR٪ 20.29 من 54 إلى 61 يومًا ، في حين أن S. aurta كانت قيمتها 4.48٪. وبشكل عام ، تراوحت نسبة SGR من 0.1 إلى 20.3٪ في S. hasta ومن 0.2 إلى 19٪ في S. aurata. يبدو أن S. aurata لها جسم أكثر استدارة وأقصر ، لكن الأنواع المحلية ، S. hasta ، تنمو أطول وأثقل بشكل ملحوظ. تتناقص الفروق في معدلات النمو مع مرور الوقت ومع زيادة كتلة الجسم. أيضا ، توجد علاقة عكسية بين كتلة الجسم ومعدل النمو المحدد في كلا النوعين. تعتبر مراقبة النمو المحدد اللحظي باستخدام كتلة الجسم أو طول الجسم من أكثر مؤشرات الإنتاج فائدة في تربية الأحياء البحرية. ومع ذلك، يجب الانتباه إلى تربية ورفاهية تلك الأنواع المستزرعة.

الكلمات الدالة:النمو، السبيطي، الدنيس ، الإصبعيات ، الخليج العربي ، البحرين.