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Meagre (*Argyrosomus regius*) culture in high salinity conditions

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Abstract

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Diversifying aquaculture in Saudi Arabia with finfish species formerly reared in the Mediterranean Sea requires a sufficient understanding of the preferences and limits of cultured fishes under local conditions. We conducted experiments in triplicate on 41 meagre (*Argyrosomus regius*) juveniles of 116 g in Saudi Arabia, testing four locally available commercial feeds (42.2–48.1% crude protein, 11.8–19.9% crude fat) for 79 days to determine the growth performance of fish in local high salinity (42–45‰) and 27°C conditions. The average final weight, specific growth rate, and feed conversion ratio differed significantly among treatments. The trial achieved a feed conversion ratio of 1.09–1.52 and a specific growth rate of 1.00–1.40. The growth performance appeared to be in line with related research. We anticipate that improvement of nutritional characteristics of the feed will improve the performance of the fish. Our results indicate the feasibility of successfully rearing meagre under high salinity conditions.

Keywords: Argyrosomus regius; nutrition; growth rate; feed conversion ratio; aquaculture; high salinity

Introduction

Meagre (*Argyrosomus regius*) was selected by the fisheries authority as the target species of mariculture development projects, before the development of commercial meagre culture in Saudi Arabia (Dickson, 2022). Mariculture in Saudi Arabia faces several challenges, including extreme salinity of seawater which is 42–45‰ during the meagre productive period (Young & Al Moutiri, 2022; Young & Shaikhi, 2022b).

Meagre thrives along the Mediterranean Sea, the Black Sea, and east Atlantic Ocean from Scandinavia down to equatorial Africa (Kružić et al., 2016). The eurythermal and euryhaline fish grows best at temperatures around 21°C (Lazo et al., 2010), showing optimal characteristics for aquaculture exploitation – relatively easy broodstock management and larval rearing similar to those of European seabass (*Dicentrarchus labrax*) and gilthead seabream (*Sparus aurata*), with fast growth and a short farming period, high food efficiency, adaptability to different environmental conditions, and market size (Monfort, 2010; Duncan et al., 2013). In 2020, global aquaculture production of meagre was 53.5 thousand tonnes in 2020, with highest production in Egypt, Turkey, Spain, and Greece (Food and Agriculture Organization of the United Nations, 2022). Moreover, meagre is a potential cage culture species, where the fish generally stocked begin as juveniles with an initial size of approximately 1–2 g, and are then grown to marketable size (400 g) for 13–14 months (Young et al., 2022).

Saudi Arabia is particularly well placed to develop mariculture in warmer waters to improve productivity – especially in the winter. However, most Mediterranean Sea species farms are located in cooler northern Saudi Arabia (Figure 1), and the farming of meagre in high salinity and temperatures conditions is poorly understood. Most related research has been at lower salinity (24–32‰), lower temperatures (17–24°C) and in fingerling sizes (< 50 g) (Chatzifotis et al., 2012; García-Mesa et al., 2014; Abdel-Rahim et al., 2019). We therefore, endeavored to better understand the culture of meagre under high salinity condition (42–45‰).

Materials and Methods

We tested different commercial feeds during consecutive meagre cycles (December 18, 2018– March 07, 2019) at the King Abdullah University of Science and Technology, Saudi Arabia.

We obtained meagre fingerlings from a commercial farm in Saudi Arabia. We kept the fish in indoor holding tanks of 2.2 thousand L, feeding them the same commercial feed until the fish reached juvenile size. At the beginning of each trial, we stocked the fish in 1-ton capacity round tanks (1.2 m diameter: 0.9 m height), each holding 850 L of water. We weighed each fish, and verified the nonsignificant variability of the fish size among tanks statistically.

We stocked 41 juveniles with an average weight of 115.90 ± 21.07 g (mean ± SD) in triplicate, supplying the tanks with filtered and sterilized seawater (42–45‰) with a flow-through system (flow rate 5 l/min^{-1}), with continuous aeration in each tank to maintain dissolved oxygen close to saturation, and daily flushing of drain valves and siphoning of wastes at the tank bottom and fortnightly cleaning during sampling. We maintained a 12 h:12 h light/dark regime, conducting the experiments over 79 days.

We fed the fish four different commercial feeds commonly marketed in Saudi Arabia: Maram 6 mm (Maram Feed Plant for Concentrates and Cubes, Saudi Arabia), Biomar-1 4.5 mm (Biomar Group, Denmark), Arasco 6 mm (Arasco Feed Company, Saudi Arabia), and NAQUA 6 mm (National Aquaculture Group, Saudi Arabia). We used the same feeds for both trials. We randomly named feeds Diet 1, Diet 2, Diet 3, and Diet 4 to conceal their identity. In Table 1 we show the composition profile of the commercial diets used in the experiment.

Fish were hand-fed *ad libitum* twice daily (9:00 and 15:00), except for the days of sampling. We released the pellets slowly to allow the fish to feed evenly, recorded consumption daily, and air-dried and weighed uneaten pellets to calculate the actual feed intake of the fish.

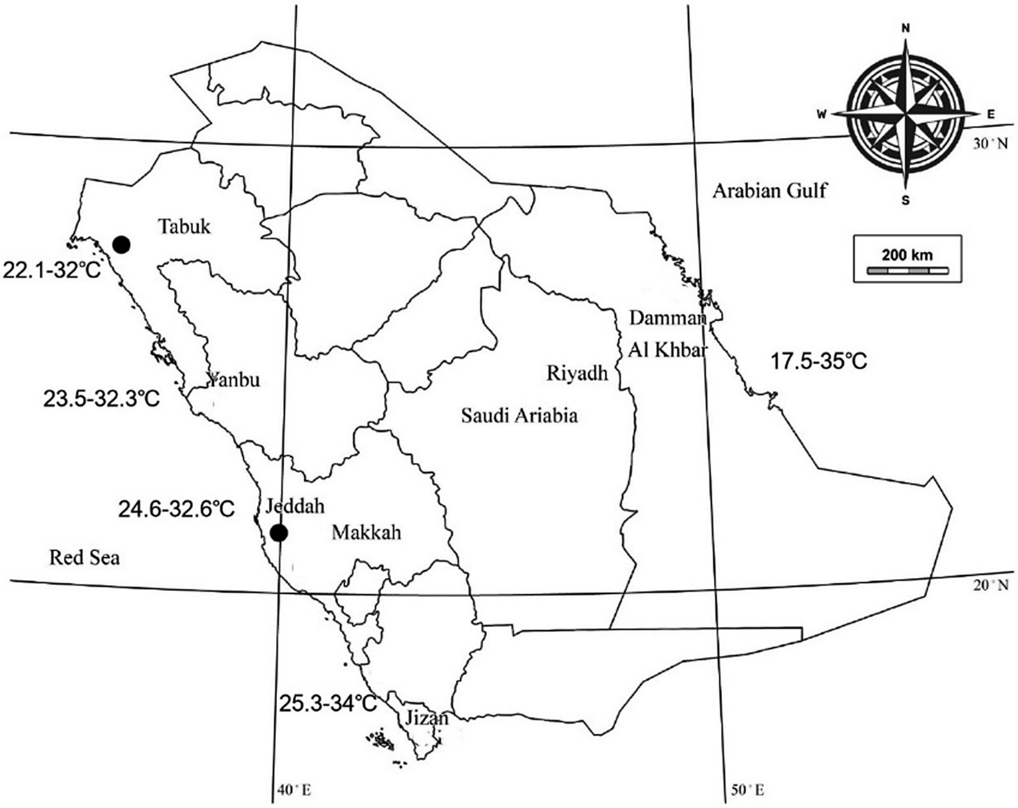

Fig. 1. Water temperature range of aquaculture regions in Saudi Arabia, black circles showing the locations of the Mediterranean Sea species farming locations
Source: Young and Shaikhi 2022b

Table 1. Proximate composition and amino acid profile of the commercial diet used in the experiment

g 100g^{-1} dry matter	Diet 1	Diet 2	Diet 3	Diet 4
Crude protein	46.88	48.13	47.50	42.23
Crude fat	13.80	14.03	11.83	19.88
Ash	10.20	9.80	10.30	7.00
Dry matter	90.50	97.50	95.70	92.90
Starch	7.60	7.95	8.15	8.97
Amino acid				
Arginine	2.26	2.30	1.28	2.86
Histidine	1.22	2.14	n.d.	1.40
Isoleucine	1.99	2.03	1.83	1.58
Leucine	3.63	5.48	3.80	2.81
Lysine	3.10	3.93	2.44	3.73
Methionine	1.16	2.05	1.16	1.15
Phenylalanine	2.16	2.69	1.91	1.75
Threonine	1.94	2.0	1.69	1.74
Valine	2.23	2.30	2.22	1.84
Alanine	2.68	3.22	2.58	2.02
Aspartic acid	6.67	6.38	5.58	5.11
Cystine	0.43	0.27	0.34	0.51
Glutamic acid	9.0	11.12	8.19	6.43
Glycine	2.93	2.32	2.24	2.56
Proline	1.67	3.21	1.87	1.79
Serine	2.25	2.70	1.91	1.62
Tyrosine	n.d.	2.05	n.d.	1.42
Calculated				
Gross energy[1]	21.55	21.75	21.14	23.16
P/E ratio[2]	21.75	22.13	22.47	18.23

In each column, different letters indicate a significant difference ($P < 0.05$).

[1] Estimated using the following caloric values: CHO = 17.3 MJ kg^{-1}; Protein = 23.6 MJ kg^{-1}; lipid = 39.5 MJ kg^{-1}.

[2] MJ kg^{-1}

n.d.: not detected

We monitored the main water parameters – temperature, dissolved oxygen, pH, and salinity – twice daily during all trial periods, maintaining values (mean ± SD) of 27.34 ± 0.7°C, 7.73 ± 0.37 mg/l^{-1}, and 7.97 ± 0.08, respectively.

We sampled every two weeks to determine growth and survival. We anesthetized the fish using clove oil (25 µl/l) before sampling, allowed their recovery in a holding tank, and returned them to their allocated tanks. During the sampling, we withheld feeding until the following day. In the final sampling, we also measured body length to determine the condition of each fish. We used sampling data to calculate growth parameters.

We determined the percentage survival rate by the number of survivors at the end of the experiment × 100/initial number stocked.

Weight gain: (Final body weight) − (initial body weight).

We determined the specific growth rate (SGR) using the following equation: specific growth rate (% body weight per day) = [(ln (W2−W1)) × 100]/Δt, where W1 represents the initial wet fish weight at stocking, W2 represents the final wet fish weight, and t represents the grow-out period.

We determined the feed conversion ratio (FCR) by the feed weight/fish weight gain.

Protein efficiency ratio (PER) = (weight gain)/ (protein intake).

With Predictive Analytics Software version 18.0 (IBM, Armonk, New York), we used analysis of variance and Duncan's multiple range test for post hoc comparison of the means. We considered $P < 0.05$ significant.

Results and Discussion

Across all groups, final body weight differed significantly (Table 2). We observed a significantly higher total weight gain in Diet 1 compared to those of Diet 2, Diet 3, and Diet 4 (Table 2). We detected no significant differences in the survival rate across all groups (98.37–100%), with a significantly higher SGR in Diet 1 (1.4) as compared to those of Diet 3 (1.04) and Diet 2 (1.0). The results demonstrated a significantly lower FCR in Diet 1 (1.18) and Diet 4 (1.09) as compared to those of Diet 2 (1.52) and Diet 3 (1.41). The feed intake of the meagre was significantly

Table 2. Survival and growth performance of juvenile meagre fed the different commercial diets for ten weeks under 42–45‰

	Diet 1	Diet 2	Diet 3	Diet 4
Survival, %	98.37 ± 0.00^{a}	100 ± 2.53^{a}	97.56 ± 1.46^{a}	100 ± 0.00^{a}
Final body weight, g	323.60 ± 25.20^{c}	246.29 ± 18.15^{a}	248.47 ± 15.89^{a}	294.58 ± 16.74^{b}
Weight gain, g	208.69^{c}	129.12^{a}	133.50^{a}	178.04^{b}
Specific growth rate, %/day	1.4 ± 0.05^{c}	1.0± 0.06^{a}	1.04 ± 0.07^{a}	1.25 ± 0.04^{b}
Feed conversion ratio	1.18 ± 0.19^{a}	1.52 ± 0.23^{b}	1.41 ± 0.21^{b}	1.09 ± 0.18^{a}
Feed intake, g/day	3.32 ± 0.09^{b}	2.63 ± 0.08^{a}	2.54 ± 0.03^{a}	2.62 ± 0.06^{a}
Protein efficiency ratio	1.82 ± 0.05^{b}	1.43 ± 0.04^{a}	1.49± 0.02^{a}	2.17 ± 0.02^{c}

In each column, different letters indicate a significant difference ($P < 0.05$)

higher in Diet 1 (3.32 g/day) than those of the other diets (1.09–1.52 g/day). PER was significantly higher in Diet 1 and Diet 4 (1.82–2.17) as compared to those of Diet 2 and Diet 3 (1.43–1.49).

Our findings suggest that high salinity condition (42‰–45‰) is appropriate for meagre farming. This study shows that the growth performance of meagre under conditions of high salinity is comparable to those from previous research. Here, our feed had similar protein content (42.23–48.13%) to those in related meagre research. Moreover, the crude fat contents of the diets used in the current trials (11.83–19.88%) appeared slightly lower than those reported in previous research, which were 15–20.5% (Martínez-Llorens et al., 2011; Velazco-Vargas et al., 2013; Gültepe et al., 2016).

Our results, suggest that meagre may successfully be farmed in 27°C condition—a different result from those among Mediterranean finfish species (meager, European seabass and greater amberjack (*Seriola dumerili*) juveniles (135–155 g), which reported a lower survival rate (11.3–30%) in 28–34°C conditions after three months (Young & Shaikhi, 2023a). Temperature is considered as one of the most important environmental factors affecting growth and metabolism of cultured fish (Lutterschmidt & Hutchison, 1997). From a production point of view, extreme salinity and temperature mainly affect the survival rate, growth potential, feed requirements and feed utilization efficiency of farmed fish in Saudi Arabia's aquaculture industry (Young et al., 2021; Young & Al Moutiri, 2022; Young & Shaikhi, 2023b).

In our study, meagre performed particularly well with Diet 1 and Diet 4, resulting in an FCR of 1.18 and 1.09, respectively, while those for Diet 2 and Diet 3 had higher values of 1.52 and 1.41, respectively. Furthermore, Velazco-Vargas et al. (2014) reported better FCRs achieved in diets containing higher levels of proteins (53–55%). In terms of growth rates measured in this study, the best performing rates among the four groups (SGR 1.40 and 1.25) achieved similar or higher SGR than related research results (Velazco-Vargas et al., 2014; Couto et al., 2016). Furthermore, the FCR results in this study (1.09–1.52) for meagre were also observed in the FCR results reported by Young & Shaikhi (2023a), wherein their FCR was around 1.02–1.31.

The FCR of this study showed similar results to those of related research results. Fountoulaki et al. (2017) obtained an FCR of 2.37 in small cages. Moreover, Gültepe et al. (2016), by growing meagre with commercial pellets (44% crude protein, 12.5% crude fat) obtained an average FCR of 1.84. Young & Shaikhi (2022a) reported similar results, with 125 g juvenile European seabass attaining an FCR of around 1.72–1.97 at 42‰ salinity conditions.

Conclusions

Here, we found that the maximum salinity endured during the survival and growth of meagre was 42–45‰. Our results indicate that meagre farming is feasible under high salinity conditions. However, growth performance showed significant differences between diets in final weight, weight gain (g), SGR, and FCR in culture periods under different commercial diets, which were affected by water temperature (lower 27°C), crude protein, and crude fat contents of the diets. Our findings can be used to improve the growth performance and feed efficiency of meagre farming in highly saline waters (42‰). Future research should focus on the longer-term outdoor farming trials and cost analysis of meagre aquaculture development in highly saline conditions.

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