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RELATIONSHIP BETWEEN PROTEIN LEVEL AND STOCKING DENSITY TO GROWTH PERFORMANCE, FEED UTILIZATION OF TILAPIA (*OREOCHROMIS SPILURUS*) CULTURED IN HYPERSALINE WATER OF THE RED SEA

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ABSTRACT

A fourteen week (98 days) laboratory feeding trial was conducted to ascertain the effects of two dietary crude protein levels 32 and 48 CP%, and three stocking densities 10, 30 and 40 fish/80 liter buckets on marine tilapia (*Oreochromis spilurus*). Fingerlings (average body weight, 15.25 ±1.20 g/fish) were cultured under hyper saline conditions (43-44‰). The results showed that growth performance (weight gain, average daily gain, specific growth rate and protein efficiency ratio) of tilapia fingerling was significantly reduced ($P< 0.05$) at high dietary protein level and high stocking densities. The final weight of fish reared on 48% crude protein diet was 46.17, 35.19 and 26.15 g/fish at 10, 30 and 40 stocking densities, respectively. The feed conversion ratio was high at 48% protein for all stocking densities, while the feed intake, protein efficiency ratio, protein productive value and energy utilization were high at dietary protein 32% for all stocking densities. The results showed that dry matter and crude protein of fish body was higher at low stocking density (10 fish/bucket) than at 30 and 40 fish/bucket when fed on both 32% and 48% crude protein, whereas, ash content was higher for 40 fish/bucket stocking density than at 10 and 30 fish/bucket for different dietary protein levels of. The results of water quality analyses indicated that dissolved oxygen, pH, unionized ammonia and nitrite were within the optimum levels for fish stoked at low density (10 fish per bucket) and fed on low protein diet (32% CP). Values for water quality were (D.O, 6.74 mg/L; pH, 6.59; unionized ammonia, 0.02; and nitrite, 0.024. The results showed that fish growth was best at low stocking density and low dietary protein level tested (32%).

1. INTRODUCTION

Tilapia is among the most successful cultured finfish species all over the world. This has been largely due to their fast growth rate, ability to feed low protein diet, simple reproduction techniques, and resistance to disease and handling. In addition, tilapia has a good tolerance to a wide range of environmental conditions. In 2002, Asia produced 1.5 million tonnes of tilapia which was equal to 80% of the total world production; it is believed that there is a potential for further tilapia culture development in the Asia and the Pacific, as well as in Africa and South America. The market for tilapias is being steadily expanded in the United States, Japan and even Europe; this situation might provide an added impetus to increased tilapia culture in developing countries in the immediate future.

The diversity of tilapia culture practices is also borne by the fact that tilapias are tolerant to high salinity species and could be cultured

in brackish waters and in sea cages. Cruz and Ridha, (1990) stated that *O. spilurus* is suitable for sea cage culture. During recent years, it has become necessary to provide complete rations to meet the dietary nutrient requirements for tilapia species. Numerous studies have been conducted to ascertain the dietary protein requirements of tilapia, *Oreochromis niloticus*, (Rezk, *et al*., 2002, El-Sayed, 2003, Hakim, 2006). Studies concerning the relationship between stockings density and growth of tilapia have shown that optimal stocking density for obtaining the highest possible fish yields depend upon the amount and the quality of food available (Zonneveld and Fadholi, 1991). However, the use of high stocking density as a technique to maximize water usage and thus increase stock production has also been shown to have an adverse effect on growth (Essa & Nor, 1988). Furthermore, the relation between stocking density and growth is not distinct. Tilapia culture in Saudi Arabia is still a new industry; few studies have been carried out in the Kingdom (Amoudi and Rasim, 2003). These studies did not study the dietary nutrient requirements for tilapia species. Hence, there is a need to investigate the feed quality and composition as well as breeding system to promote sustainable culture of Saudi Arabia major production of *Oreochromis spilurus*.

Little attention has been paid to *Oreochromis spilurus* culture in comparison to other species (e.g. *O. niloticus*, *O. mossambicus* and red tilapia), while *O. spilurus* is suitable for culture in salt water (Cruz and Ridha, 1990), especially in countries like Saudi Arabia. Saudi Arabia is a country surrounded by sea water and there is very little fresh water. Therefore, it was desirable that studies should be carried out on such type of species.

The objective of the present study is to evaluate the effect of two levels of dietary protein (32%and 48% CP) and three degree of stocking densities (10, 30 and 40 fish/80 liter bucket) on growth performance and feed utilization of fingerlings of tilapia (*Oreochromis spilurus*) cultured in hypersaline condition.

2. MATERIALS AND METHODS

A total number of 640 healthy marine tilapia (*Oreochromis spilurus*) fingerlings were used in this experiment. The experimental fish were of almost equal size with an average body weight (15.25±1.20 g/fish) and they were collected from the ponds of the fish farming centre, Jeddah, Saudi Arabian, in June 2005.

Fish were held in fully prepared plastic aquaria of an 80 liter water capacity each. Two experiments were conducted using 24 buckets. Each bucket was supplied with hypersaline seawater (43-44‰) and continuous aeration. Three stocking densities were used in this experiment 10, 30 and 40 Fishes/bucket. The experiment was repeated 4 times for each stocking density. Fish were weighed at the start of the experiment and after every 2 weeks during the experimental period.

Two diets containing 32% and 48% crude protein (manufactured by ARASCO feed mill) were used (Table 1). Fishes were fed till satiation two times daily at 8.00 and 16.00 h, for 98 days. The amount of feed consumed by the fish within each bucket was recorded daily. Faeces and uneaten feed residues were siphoned out of the buckets daily together with about one third of the aquarium's water volume was replaced with fresh seawater in the morning before feeding time.

Mean fish weight, average weight gain, average daily weight gain (ADG), specific growth rate % (SGR% Fish day), feed conversion ratio (FCR), protein utilization (protein efficiency ratio, PER, productive protein value PPV %) and energy utilization (EU %) were calculated as described by Omar, (1984).

Dissolved oxygen (DO), unionized ammonia (NH_3) nitrite (NO_2) and pH determined weekly at 7.30 am before siphoning of the water. Temperature and

salinity were recorded daily and its average values were 30±2°C and 43-44(g/L), respectively.

At the end of the feeding experiment, representative fish from each bucket were sacrificed and frozen for subsequent proximate analyses of fish body composition. Initial carcass was performed on a pooled sample of 10 fingerlings which were weighed and frozen prior to the study. Proximate analysis of moisture, protein, lipid and ash in both of the experimental diet and body carcass were performed according to the official method of AOAC (1984). Moisture content was determined by drying and weighing a pre-weighed sample in a drying oven for 24 hours at 105°C. Total crude protein was determined using the kjeldahl method. Lipid contents were extracted by Soxhlet method. Ash content was determined by weighing and ashing a dry sub-sample in a pre-weighed porcelain crucible in a muffle furnace for 8 hours at 600°C. Three determinations per each sample were run and the values reported represented the means.

Collected data were analyzed by the method of variance (Snedecor and Cochran, 1973). Means were compared according to Duncan's multiple range test (Duncan, 1955).

Table (1): Feed ingredient and nutrient composition of the two diets containing 32% and 48% crude protein as provided by ARASCO feed mill.

Item	**Dietary protein level**	
Crude protein	**32%**	**48%**
Feed ingredient %		
Fish meal	26	40
Soya bean meal	34	42
Yellow corn	34	11
Fish oil	2	3
Lysine (mg)	4000	4000
Methionine (mg)	3000	3000
Choline chlonde (mg)	9000	9000
Vitamin premix*	1	1
Mineral premix**	1	1
Fungiade	1	1
Antioxidant	1	1
Proximate Analysis(% dry weight)		
Crude protein (CP)	31.73	47.33
Ether extract (EE)	5.44	9.25
Crude fiber (CF)	3.84	1.78
Ash	5.71	6.21
Nitrogen free extract (NFE)	51.13	46.33
Calculated gross energy (kcal GE /g DM)***	4.51	5.06
Calculated energy to protein Ratio (kcal GE/g CP)	13.70	10.78

* Vitamin mixture/kg premix containing the following: 30000IU Vitamin A, 30000IU Vitamin D3, 400IU Vitamin E, 2500 mg Vitamin B1, 135 mg Vitamin B2, 590 mg Vitamin B6, 440 mg Vitamin B12, 50 mg biotin, 9350 mg choline chloride, 4000 mg Vitamin C, 2670 mg Inositol, 340 mg benzoic acid, 9350 mg niacin, and 2700 mg pantothenic acid.

** Mineral mixture/kg premix containing the following: 330 mg Manganese, 200 mg Iron, 25 mg copper, 5 mg Iodine and 5 mg cobalt.

*** Gross energy (GE Kcal/g diet) calculated according to NCR, (1993) using the following calorific values: 5.64, 9.44 and 4.11 kcal/g diet of protein, fat and carbohydrate respectively.

3. RESULTS

3.1. Growth performance

Results in Table 2 show the effect of different protein levels and different stocking densities on growth performance of *O. spilurus* fingerlings cultured in hypersaline conditions. The values of the total weight gain (g/fish), average daily weight gain (ADG: g/fish/ day) and specific growth rate (SGR %) were positively correlated with lowering protein level in the diet from 32% up to 48% CP accompanied with lowering stocking density from 10 up to 40 fish/80 l with a significant value of ($P<0.05$). From the data presented it can be seen that the effect of the interaction between dietary protein levels and stocking density increased the average of weight gain (33.81 g), ADG (0.345 g/fish/day) and SGR % (1.14) at 10 fish/ bucket, while at 40 fish/bucket, the averages reached to 12.87 g, 0.132 g/fish/day and 0.60% for weight gain, ADG and SGR% respectively. On the other hand, the parameters of growth performance at 32% CP was 26.46g, 0.27 g/fish/day and 0.9% for weight gain, ADG and SGR% respectively, whereas these average at 48% CP was 19.7 g, 0.20 g/fish/day and 0.79% for weight gain, ADG and SGR% respectively.

Table (2): Growth*performance of fish fed on the experimental diets for 14 weeks.

Protein level%	**Stocking Density (fish/bucket)**			**Mean****
	10	**30**	**40**	
Initial Fish Weight (g/fish)				
32	16.45	15.95	16.48	16.29
48	16.38	16.35	15.68	16.14
Average**	16.42	16.15	16.08	16.22
Final Weight (g/fish)				
32	54.28	42.23	31.75	42.75^{a}
48	46.17	35.19	26.15	35.84^{b}
Average**	50.23^{a}	38.71^{b}	28.95^{c}	
Weight Gain (g/fish)				
32	37.83	26.28	15.27	26.46^{a}
48	29.79	18.84	10.47	19.7^{b}
Average**	33.81^{a}	22.56^{b}	12.87^{c}	
Average Daily Gain (ADG)(g/fish/day)				
32	0.386	0.268	0.156	0.27^{c}
48	0.304	0.192	0.107	0.20
Average**	0.345^{a}	0.230^{b}	0.132^{c}	
Specific Growth Rate (SGR %)				
32	1.22	0.99	0.67	0.96^{a}
48	1.06	0.78	0.52	0.79^{b}
Average	1.14^{a}	0.89^{b}	0.60^{c}	

* Each value indicates the mean of four replicates.
** Means in the same row with different superscripts are significantly ($P<0.05$) different.

The effect of the interaction between dietary protein levels and stocking density on the feed intake dry matter (g DM/fish), feed conversion ration (FCR) and protein efficiency ratio (PER) of *O. spilurus* is shown in Table 3. The data cleared that the increasing protein levels and increasing stocking density resulted in a significant ($P<0.05$) reduction of feed intake and protein efficiency ratio, while it resulted in other side to a significant ($P<0.05$) increase of feed conversion ratio. The average feed intake was 50.61 g at 10 fish /bucket, while it was 35.62 g at 40 fish /bucket, while these averages were 44.66 g at 32% CP and 40.32 g at 48% CP. In contrast, the FCR showed best result when fish reared at the lowest stocking density (10 fish /bucket) 1.51 and fed the 32% CP 1.83, but the average of FCR at high stocking density (40 fish/bucket) was 2.85 and 2.32 at 48%CP fed diet.

Results in Table 3 showed the effect of different protein levels and stocking density on feed and nutrient utilization of *O. spilurus*. Protein efficiency ratio (PER) and protein productive value (PPV %) decreased significantly ($P<0.05$) with increasing of protein level and stocking density. The average PER and PPV% were 0.9 and 27.67% at 10 fish /80 l and 0.35 and 12.21% at 40 fish /bucket, while these average at 32% and 48% CP were 0.83, 0.41 for PER and 22.43% and 14.55% for PPV % respectively. However, energy utilization (EU%) were significantly ($P<0.05$) increased with increasing the protein level in the diet from 32% to 48% CP were reached to 11.71% and 15.51% respectively, but its average was 18.77%, 11.51% and 9.80% during 10, 30 and 40 fish stocking density respectively.

Table (3): Feed intake, feed conversion ratio, and protein/ energy utilization* of fish fed the experimental diets for 14 weeks.

Protein level%	Stocking density (fish/bucket)			Mean**
	10	30	40	
Feed Intake (g DM/fish)				
32	35.62	43.71	36.65	44.66^{a}
48	47.59	38.78	34.58	40.32^{b}
Average**	41.61^{b}	41.25^{b}	35.62^{c}	
Feed Conversion Ratio (FCR)				
32	1.42	1.66	2.40	1.83^{b}
48	1.60	2.06	3.30	2.32^{a}
Average**	1.51^{c}	1.86^{b}	2.85^{a}	
Protein Efficiency Ratio (PER)				
32	1.18	0.82	0.48	0.83
48	0.62	0.39	0.22	0.41
Average**	0.9^{a}	0.61^{b}	0.35^{c}	
Protein Productive value (PPV %)				
32	33.71	19.37	14.21	22.43
48	21.63	11.82	10.19	14.5
Average**	27.67^{a}	15.60^{b}	12.21^{c}	
Energy Utilization (EU %)				
32	16.63	9.53	8.96	11.71^{b}
48	20.91	13.49	10.96	15.10^{a}
Average**	18.77^{a}	11.51^{b}	9.80^{c}	

* Each value indicates the mean of four replicates.

** Means in the same row with different superscripts are significantly ($P<0.05$) different.

3.2. Survival rates

No mortalities were reported among the experimental fish throughout the experimental period.

3.3. Carcass Composition

Results in Table 4 showed that the difference between the initial and the final carcasses were significantly ($P<0.05$) increased in DM% with increasing the protein level in the diet and decreasing the stocking density. The DM% average was reached to 24.17, 23.99 and 24.00 in case of stocking density10, 30 and 40 fish/80 L water, respectively, while it's mean was 23.58 and 24.52 for all stocking densities in case of 32% and 48% CP. In addition to the average of CP% was recorded as 57.93%, 56.47% and 55.20% during the stocking densities 10, 30 and 40 fish respectively. However, analyses of variance on the interaction between dietary protein level and stocking density per bucket were not statistically significant in case of CP% and Ether extract (EE%). The results showed that body composition of *Oreochromis spilurus* increased in ash% by increased the stocking density only. Difference among the six tested groups were not significant ($P<0.05$) in CP%, EE% and Ash%, but they were significant ($P<0.05$) in DM%.

Table (4): Body composition* of fish fed the experimental diets.

Protein level%	Stocking density (fish/bucket)			Mean**
	10	30	40	
Dry Matter (DM %)				
32	32.83	23.81	23.11	23.58 [b]
48	24.51	24.17	24.89	24.52[a]
Average**	24.17[a]	23.99[b]	24.00[c]	
Crude Protein (CP %) ***				
32	58.73	56.53	54.79	56.68
48	57.13	56.41	55.6	56.38
Average**	57.93[a]	56.47[b]	55.20[c]	
Ether Extract (EE %) ***				
32	19.58	19.33	19.16	19.36
48	19.43	19.46	19.29	19.39
Average**	19.51	19.40	19.23	
Ash %***				
32	21.69	24.14	26.05	32.96
48	23.44	24.13	25.11	24.23
Average**	22.57[c]	24.14[b]	25.58[a]	

*Chemical composition of fish at the start of the experiment was as follows, 24.11 DM%, and on DM basis containing (55.78% CP, 19.83% EE and 24.39% ash, each value being the mean of four replicates).
** Means in the same row with different superscripts are significantly ($p<0.05$) different.
*** % on dry matter basis.

3.4. Water Quality

The results in Table 5 show the effect of different protein levels and different stocking densities on water quality of *O. spilurus* fingerling cultured under hypersaline condition. The pH, unionized ammonia (NH_3) mg/L and nitrite (NO_2) mg/L significantly ($P<0.05$) decreased with decreasing dietary protein levels and stocking densities. The average of pH, NH_3 and NO_2 were 6.96, 0.04 mg/L and 0.158 mg/L in case of 32% CP, while these averages in case of 48% CP were 7.36, 0.07 and 0.333 mg/L, respectively. On the other hand the average of pH, NH_3 and NO_2 were 6.83, 7.27, 7.37; 0.024 mg/L, 0.055 mg/L, 0.09 mg/L and 0.025 mg/L, 0.176 mg/L, 0.537 mg/L in case of 10, 30 and 40 fish /bucket respectively. However, dissolved oxygen (mg/L) was significantly ($P<0.05$) increased with decreasing dietary protein and stocking density. The average of DO was 5.61 and 4.70 mg/L in case of 32% CP and 48% CP respectively.

Table (5): Effect of protein level and stocking on water quality of *Oreochromis spilurus*.

Protein level%	Stocking Density (fish/bucket)			Average
	10	30	40	
Dissolved Oxygen (mg/L)				
32	6.74^{a}	5.87^{b}	4.21^{c}	5.61^{a}
48	6.23^{a}	5.16^{b}	2.72^{c}	4.70^{b}
Mean	6.49^{A}	5.52^{B}	3.47^{C}	5.16
pH				
32	6.59^{b}	7.11^{a}	7.17^{a}	6.96^{b}
48	7.09^{b}	7.34^{a}	7.56^{a}	7.36^{a}
Mean	6.83^{B}	7.27^{A}	7.37^{A}	7.16
unionized ammonia (NH_3) mg/L				
32	0.02^{c}	0.04^{b}	0.06^{a}	0.04^{a}
48	0.027^{c}	0.07^{b}	0.12^{a}	0.07^{a}
Mean	0.024^{C}	0.055^{B}	0.09^{A}	0.055
Nitrite (NO^2) mg/L				
32	0.021^{c}	0.125^{b}	0.328^{a}	0.158^{b}
48	0.029^{c}	0.226^{b}	0.745^{a}	0.333^{a}
Mean	0.025^{C}	0.176^{B}	0.537^{A}	0.246

Letters in the same row with different superscripts (small and capital) mean significantly different ($P<0.05$).

4. DISCUSSION

In the present investigations, the results indicated that growth performance of *Oreochromis spilurus* fingerlings reared in hypersaline water and fed a diet containing 32% crude protein was better than fish fed a diet containing 48% crude protein in all tested stocking densities in hyper saline water. These results are in disagreement with many studies which demonstrated that growth increased with the increasing dietary protein level in the diet (El-Sayed, *et al*., 2003; Fasakin, *et al*., 2005; Hakim, *et al*., 2006), but these results are in agreement with the findings of Omar, *et al*., 1997 who presented that increasing protein level from 30 to 40% CP resulted in a significant reduction in growth performance of *O. niloticus* sp. Magouz, (1990) reported that the dietary protein level for *O. niloticus* could be reduced from 40% to 30% without any significant effect on growth of fish. Also similarly, more Nile tilapia females tended to spawn at intermediate dietary protein levels (25% and 30%) and the spawning frequency decreased, with increasing dietary protein content (DeSilva and Radampola, 1990 cited in El-Sayed, *et al*., 2003). This controversy in the results may be due to difference in the experimental conditions (salinity), host, locality and species of tilapia; this agrees with El-Sayed, *et al*., 2003 who attributed discrepancies in tilapia gowth results to fish species, water quality and culture systems adopted.

The effect of salinity on growth performance has been investigated for tilapia sp. (Fiess, *et al*., 2007; El-Sayed *et al*., 2003; Sparks, *et al*., 2003). Suresh, and Kwei Lin, (1992) cited in Eguia, and Eguia, (1999) stated that tilapia tolerate, grow and even reproduce in saline waters, although this capacity offset under high salinity condition. (El-Sayed, *et al*., 2003), was found that the protein requirement of brood stock Nile tilapia (reared in the same system) was affected by water salinity. According to Sardella *et al*. (2004) cited in Tine, *et al*., (2007) tilapia may survive acute exposures to increased salinity but they suffer from physiological disturbances. This suggests that the reduced growth rates observed for fish reared at high protein level may be attributed to higher salinity.

Growth performance in this study present that fish stocked at 10 fish water and fed a diet containing 32% CP was better than the other stocking densities 30 and 40 fish/80 l, and tested diet containing 48% CP in hypersaline water, these results are in agreement with the study of Omar *et al*., (1997), which showed that increasing the stocking density above 10 fish/aquarium resulted in a significant lower dry matter, crude protein and lipid content. Feed intake was high when fish reared at lower 40 fish/tank, similar result were obtained by Omar *et al*., (1997) who observed that growth rates were reduced for fish reared at high density.

No mortality was observed in the reared tilapia *Oreochromis spilurus* during the whole period of experiment. Many studies on rearing of tilapia sp. at different protein levels get a survival rate close to 100% (Yi and Lin 2001; Ulloa Rojas and Verreth, 2003; Huanga, and Huang, 2004; Peres, *et al*., 2004 and Hakim, *et al*., 2006)

Feed conversion ratio (FCR) in the present study increased with increasing dietary protein level in the diets and stocking density. Similar results were obtained by Ulloa Rojas and Verreth (2003) when fed *Oreochromis aureus* with diets containing different levels of coffee pulp from 0 to 390 g/kg. The mean FCR of 1.83 of fish fed 32% CP in this study is comparable with Al-Hafedh, *et al*., (2003), and 1.98 reported by Ridha and Cruz (2001) for Nile tilapia. Omar, *et al*., (1997), observed the best FCR with fish reared at the lowest stocking density and fed the 30% protein diet.

The observed dietary feed intake was highest for tilapia fish reared at the lowest dietary protein and lowest density (Table 3), these results being in agreement with Omar *et al*., 1997) who reported a higher feed intake with fish reared at the lowest density. Similar results showed by Ulloa Rojas and Verreth (2003) when fed *O. aureus* different levels of coffee pulp.

In the present study, protein efficiency ratio (PER) and protein productive value (PPV %) were decreased with increasing dietary protein level and stocking density. These trends are the same with those reported by Omar *et al*., (1997) and Ulloa Rojas and Verreth (2003) for *O. nilaoticus* and *O. aureus* respectively. Also, El-Sayed, (1991) reported that PER and PPV % were negatively correlated with dietary protein level and stocking density for *L. Ramada* fry. Therefore, it is expected that the protein requirement of *O. spilurus* decrease with age. In addition, fishes in their early life stages have higher metabolic rate than late juvenile stages, which would be reflected in a higher protein and energy demand. The results showed that the highest values of feed and protein utilization were obtained at the lower crude protein level. However, energy utilization (EU %) improved significantly with increasing the protein level in the diet from 32% to 48% crude protein.

Chemical composition of tilapia carcass was altered significantly ($P<0.05$) by the levels of dietary protein and stocking density. The carcass protein increased with decreasing the stocking density, it was not affected by the level of protein in the diet till 48%. In contrary, the dry matter increasing with increasing the level of protein in the diet and lower stocking density. These results agree with Omar *et al*., (1997) who showed that increasing the stocking density of *O. niloticus* above 10 fish/aquarium resulted in a significant ($P<0.05$) lower dry matter, crude protein and lipid content. On the other hand, this result had disagreement with Nour *et al*., (1993) who reported that the carcass protein of *M. cephalus* increase with increasing the level of protein in the diet till 35%.

Dissolved oxygen (DO) and pH, unionized ammonia (NH_3) mg/l values were within the favorable levels for tilapia sp. However, nitrite (NO_2) values were slightly higher when fish fed high protein level and reared in higher densities, which attribute the lower growth of these fishes. Similar trends were found by Al-Hafedh, *et al*., (2003) when rear *O. niloticus* in different tanks using different filters. TAN concentrations of 1 to 3 mg/l were common in aerated ponds with high feeding rates, and sublethal effects of ammonia probably affected growth of fish adversely (Boyd, 1990 sited in Yi and Lin, 2001). According to Lawson, 1995 and Van Rijn and Rivera, 1990 both sited in Al-Hafedh, *et al*., (2003), it should always be kept at less than 1 ppm in intensive recirculating systems.

In conclusion, this study revealed that growth performance for *O. spilurus* reared under hypersaline water was best at the lowest stocking density and low dietary protein level tested. *O. spilurus* has a potential to be a candidate for fish in Saudi Arabia where fresh water aere very scarce. More studies are needed to reach a better growth with more stock densities and suitable diet in hypersaline water such in Saudi Arabia.

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