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EFFECT OF SALINITY ON GROWTH, FEED UTILIZATION AND HAEMATOLOGICAL PARAMETERS OF FLORIDA RED TILAPIA FINGERLINGS.

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***Key words:* Red tilapia; Salinity; Growth performance; Haematological responses.**

ABSTRACT

*The present study was designed to investigate the effect of different salinities on survival rate, growth performance, carcass composition, feed and nutrient utilization and some physiological responses of Florida red tilapia (**Oreochromis urolepia** hornorum X **Oreochromis mossambicus** hybrid). The results showed that the mean survival rate of fish reared in fresh, brackish and sea water were 100%, 97.5% and 90%, respectively. Significant increases in growth performance and feed intake were observed when the fish were reared in sea water. Carcass composition and nutrient utilization increased significantly when the fish were reared in brackish water than those reared in fresh or sea water. On the other hand, the most prominent feature of the physiological response of red tilapia to different salinities were a significant increase in plasma sodium concentration, haemoglobin content and cholesterol values with increasing salinity. Changes in the plasma total protein, glucose and potassium were insignificant. It could be concluded that fish can be reared in salt water up to 36.21 ‰ salinity (sea water) without based on the quality product. The optimal salinity was about 17.81 ‰ (brackishwater).*

INTRODUCTION

Red tilapia (***Oreochromis*** sp.) is a hybrid produced by the inter-breeding between ***O. niloticus*** and the mutant of ***O. mossambicus***. The habit of red tilapia is extremely similar to that of the common mouth-brooding tilapia. This fish is euryhaline, omnivorous, reproductive and highly resistant to diseases, (Liao & Chang, 1983) .

Due to the fact, fresh water resources in Egypt, nowadays is not plentiful, there is an inclination to use saline water in fish farming specially in arid areas where fresh water are at a premium. In such circumstances, water salinity should have a significant effect on the activity of the fish. Salinity has been shown to influence growth, metabolism and ion regulation of different fish (Morgan and Iwama, 1991; Dutil ***et al.***, 1992 and Munro ***et al.***, 1994). However, there is little information on the influence of salinity on fresh water species, under culture (farming) conditions.

Culturing of red tilapia has recently gained increasing interest in many countries. It's attractive coloration (a blend of pink, red, yellow and gold) and the absence of black coloration in the peritonium makes red tilapia highly appreciated by the consumers. Furthermore, red tilapia has several characters which make it an important farm fish i.e. the fast growth rate, good conversion and ability to grow in fresh, brackish and salt waters and low susceptibility to diseases (Liao and Chang, 1983). All these factors combine to make optimistic the prospect of red tilapia culture in Egypt.

The tilapia spp. are generally tolerant to a wide range of salinity variation, but this tolerance does not necessarily indicate conditions for maximum production. Assem (1995) indicated that, when the fish are reared in saline water, some indications of the influence of salt concentrations upon growth are required. Payne ***et al.*** (1988) recorded that, it is important to determine these thresholds for salt water tilapia culture to establish the other factors which influence them, such as temperature and feeding. Paloheimo and Dickie (1966a) cleared that, salinity may affect growth of fish by influencing food intake, conversion efficiency and osmoregulatory mechanism. The aims of this experiment are to evaluate the feasibility of red tilapia culture in the sea water as well as studying some haematological responses.

MATERIALS AND METHODS

Fry of red tilapia hybrid, obtained from Mariut Fish Farm in Alexandria, (average weight 0.73 ± 0.01 g) were brought to the Rearing laboratory of N.I.O.F. Kayed Bay, Alexandria at 12th July, 1996. Fry were acclimated for one week under appropriate experimental conditions into three groups: fresh water [Tap water after dechlorinated (salinity = 1.51‰)], brackish water [50% tap water + 50% sea water (salinity = 17.81 ‰)] and sea water [100% sea water (salinity 36.21 ‰)]. The experiment began at 19th July, 1996, each treatment consisted of three glass aquaria. Ten fish were reared in each aquarium (100 x 40 x 30 cm). The concentration of dissolved oxygen was maintained at or close to 100% of air saturation by aeration. Ambient water temperature ranged from 25 to 28 °C during the experimental period. The fish were fed on a diet containing 30% crude protein (CP) and 472 kcal/100g. The ingredients and composition of the pellet feed which have diameter of about 2 mm are shown in Table (1). Fish were fed three times daily (9.00, 13.00 and 17.00 h) for 6 days a week. Daily feed allowance was determined as percentage of fish live body weight and readjusted bi-weekly. Feeding rates were 4% of total body weight (Feed intake = Feeding weight during the experimental period x dry matter (%) in the experimental diet). Accumulated wastes were removed and a fixed amount of water (one third of the aquaria water) was exchanged daily over the experimental period (84 days).

At the termination of the study, fish in each aquarium were netted, counted and weighed. Body composition analyses were performed using standard AOAC (1980) methods. Crude protein was determined as a nitrogen content in the diet or in the fish x 6.25. Gross energy of the diet as well as carcass energy content were estimated according to NRC (1993). To study the effect of salinity on some haematological parameters of red tilapia, blood was collected directly from the caudal artery into heparinized capillary tubes. Haemoglobin content was measured using Sahli haemometer. Plasma protein, glucose and cholesterol were measured using standard Kits. Plasma ion concentrations of sodium and potassium were measured using flame analyzer.

Table (1): Formulation (%) and composition (%) in dry matter of the experimental diet.

Items	Diet (% inclusion)
Feed Ingredients	
Fish meal	25
Soybean meal	33
Yellow corn flour	38
Corn oil	2
Vitamin mixture*	1
Mineral mixture**	1
Nutrients % (as DM basis)	
Crude protein (CP)	30.33
Ether extract (EE)	5.44
Crude fiber (CF)	3.84
Ash	6.35
Nitrogen free extract (NFE)	54.04
Calculated gross energy*** (GE kcal /100 g)	444.52
Calculated energy to protein ratio (kcal/GE/g CP)	14.66

* Vitamin mixture/ kg Premix containing the following: 3300 IU vitamin A, 3300 IU vitamin D_3,410 IU vitamin E, 2660 mg vitamin B_1, 133 mg vitamin B_2, 580 mg vitamin B_6, 410 mg vitamin B_{12}, 50 mg biotin, 9330 mg coline chloride, 4000 mg vitamin C, 2660 mg inositol, 330 mg para-aminobenzoic acid, 93330 mg niacin and 26.60 mg pantothenic acid.

** Mineral mixture/kg Premix containing the following: 325 mg manganese, 200 mg Iron, 25 mg copper, 5 mg iodine and 5 mg cobalt.

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

Statistical analysis of results were conducted by using randomized design for the analysis of variance, the Duncan Multiple Rang test and the least significant difference test according to Snedecor and Cochran (1967).

RESULTS

The mean survival rate of red tilapia reared in fresh water (Salinity = 1.51‰); brackish water (17.8‰) and sea water (36.2‰) were 100%, 97.5% and 90%, respectively.

As shown in Table (2), the differences in growth performance of red tilapia reared in different salinities were statistically significant ($p<0.01$). It is evident that, fish reared in sea water grew better than those reared in brackish water or fresh water e.g. total weight gain for fish reared in sea water was 20.1 g/fish while for those in brackish and fresh water, gain were 14.4 g/fish and 7.6 g/fish, respectively.

Chemical composition of red tilapia showed a significant differences ($P<0.01$) when they reared at different degrees of salinity (Table 3). Fish reared in brackish water had the highest value of dry matter (23.8%), Crude protein (59.8%), ether extract (27.4) and gross energy (596.2 kcal/100 g). Ash content on the other hand, showed the lowest value (12.8%), for the fish reared in brackish water.

Feed and nutrient (protein and energy) utilization (Table 4) showed significant variations ($P<0.01$) between treatments. Although highest feed intake was observed for fish reared in sea water, good responses to feed, proteins and energy utilization were at fish reared in brackish water. The lowest feed intake, feed conversion ratio and nutrient (protein & energy) utilization were observed for fish reared in fresh water.

Table (2): Growth performance and survival rate of Florida red tilapia fingerlinges reared in three sources of salinity.

Water sources	Initial weight (g/fish)	Final weight (g/fish)	Body gain (g/fish)	Average daily gain (mg/fish/day)	Specific growth rate* SGR (%)	Survival rate (%)
Sea water	0.72 ± 0.01	20.80^{a} ± 0.05	20.08^{a} ± 0.06	239.05^{a} ± 0.69	4.00^{a} ± 0.02	90.00
Brackish water	0.72 ± 0.01	15.15^{b} ± 0.08	14.43^{b} ± 0.09	171.79^{b} ± 1.03	3.63^{b} ± 0.02	97.50
Fresh water	0.73 ± 0.01	8..34^{c} ± 0.04	7.61^{c} ± 0.04	90.60^{c} ± 0.45	2.90^{c} ± 0.04	100.00
L.S.D (p<0.01)		0.3175	0.3316	3.999	0.0957	

* Specific growth rate %= 100 (Ln final weight - Ln initial weight) / days.

** Average in the same column having different superscripts are different (p<0.01).

Table (3): Carcass composition of Florida red tilapia reared in three sources of salinity (values are expressed as % of Dry Matter DM basis).

Item / Water sources	DM* %	Crude protein	Ether extract	Ash	Gross energy** kcal/100 g
At the beginning	21.55 ± 0.43	55.12 ±0.01	15.90 ±0.12	27.96 ±0.18	460.93±1.15
At the end of the experiment					
Sea water	23.36^{b} ±0.01	57.50^{b} ±0.05	26.71^{b} ±0.01	15.79^{ab} ±0.06	576.44^{b}±0.32
brackish water	23.79^{a} ±0.01	59.79^{a} ±0.06	27.43^{a} ±0.12	12.78^{b} ±0.16	596.15^{a}±1.38
Fresh water	23.08^{c} ±0.01	56.37^{c} ±0.02	26.18^{c} ±0.09	17.45^{a} ±0.11	565.07^{c}±0.94
L.S.D (p<0.01)	0.097	0.253	0.096	3.012	1.188

* Calculated based on 5.64, 9.44 and 4.11 (kcal/g) of protein, lipid and carbohydrate, respectively.

** DM : Dry Matter.

- Average in the same column having different superscripts are different (p<0.01).

Table (5). Effects of salinity on some haematological parameters of red tilapia*.

Parameter	Fresh water	Brackish water	Sea water	F	L.S.D (p<0.05)	L.S.D (p<0.01)
Haemoglobin (%)	50.3[c] ±5.0	53.0[b] ±4.4	56.2[a] ±5.4	4.26*	4.13	5.55
Glucose (mg/100 ml)	39.1 ±8.1	47.6 ±12.7	45.8 ±12.9	1.84	insignificant	insignificant
Total protein (mg/100 ml)	4.55 ±0.3	4.63 ±0.3	4.74 ±0.5	0.83	insignificant	insignificant
Cholesterol (mg/100 ml)	77.5[c] ±29.5	135.6[b] ±44.7	152.9[a] ±43.6	3.74*	58.81	79.04
Sodium (mmol/l)	148.7[c] ±22.6	177.3[b] ±26.2	195.3[a] ±18.7	12.94*	18.82	25.31
Potassium (mmol/l)	16.0 ±12.0	18.1 ±3.4	18.4 ±3.8	2.03	insignificant	insignificant

* Average of 12 fish.
$F_{2,33}$ at 5% level = 3.290.
$F_{2,33}$ at 1% level = 5.315.

The concentration of protein in the plasma has changed but insignificantly, in response to various salinities (4.55, 4.63, 4.74 mg/100 ml), respectively.

Changes in plasma glucose level as an indicator of fish metabolic rate, showed highest level in brackish water (47.6 mg/100 ml), followed by sea water (45.8 mg/100 ml) then fresh water (39.1 mg/100 ml). These variations were statistically tested to be insignificant.

Finally, plasma cholesterol values for red tilapia increased with the increase in salinity and were significantly higher (p<0.05) in sea water (152.9 mg/100 ml) than in brackish water (135.6 mg/100 ml) or fresh water (77.5 mg/100 ml).

Plasma cholesterol values for red tilapia increased also with the increased salinity and the differences among treatments were significantly higher ($p<0.05$) in sea water than in brackish or fresh water. This observation indicates that in red tilapia lipid metabolism may play a part in osmotic and ionic regulation. Spaargaren and Mors (1985) reported that, cholesterol concentration attain maximal values around normal sea water salinities and attributed this type of response to the function of this substance in regulating membrane permeability. On the other side, in low salinity, cholesterol may be removed from the blood to the tissue where they may play a role in the reduction of membrane permeability.

Plasma protein level of red tilapia increased with increasing salinity and shown to be a function of percentage of salt in the medium. Function of plasma protein concentrations with changes of physical and chemical properties of the environment are well documented and always be regarded as index of fitness (Assem ***et al.***, 1992). Plasma protein level was also reported to increase in sea water adapted eel (Huggins and Colley, 1971); ***Tilapia zillii*** (Farghally ***et al.***, 1973); ***Tilapia mossambica*** (Venkatachari, 1974) and ***Oreochromis niloticus*** (Assem, 1995). However, plasma protein concentration varied in a narrow limit in response to salinity changes. These results are in agreement with those of Munro ***et al***. (1994).

It is confirmed that, the exposure of fish to different salinities could not be considered as stressful since changes in blood glucose level was insignificant ($p>0.05$) which indicated fish adaptation to the new environment. In general, the increased glucose concentrations for brackish and sea water adapted fish may be resulted from their increased metabolic requirements or it may be imported for the adjustment of the internal milieu to higher salinities making use of the osmotic pressure of the glucose molecules (Assem, 1995). On the other hand, the decreased of glucose concentrations for fresh water fish might be explained due to the decrease in the general condition of the fish [condition factors of red tilapia reared in fresh, brackish and sea water were 1.139, 1.475 and 1.521, respectively. (Mourad, unpublished data).

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DISCUSSION

Tilapia species are generally tolerant to a wide range of environmental condition, including the salt content of the water (Assem, 1994). Tilapia, which is euryhaline, grows best in brackish water and its growth rate decreases at freshwater or at sea water (Payne, 1983). ***Tilapia zillii*** can survive even in salinity up to 42.81 ‰ and water temperature 24°C in Suez Bay (Bayoumi, 1969) and can breed at salinity of 29 ‰ in Lake Qarun (El-Zarka, 1956). The mortality rate of the fry stages of red tilapia indicate that these stages can be adapted gradually to salinities up to sea water (36.21 ‰). However, some tilapia species e.g. ***Oreochromis mossambicus*** and ***O. niloticus*** still show a fair growth rate in sea water (Hepher, 1988).

The results of the present study showed that, growth performance as measured by total weight gain, average daily gain and specific growth rate, significantly increased ($p<0.01$) when fish were reared in sea water than in brackish or fresh water. These results are in accordance with those of Liao and Chang (1983) who found that Taiwanese red tilapia reared in sea water grow faster than fish reared in brackish or fresh water. The significant increase of growth performance with increasing salinity may be related to the increase in food intake. Increased food consumption with increasing salinity was also reported in ***Cyprinodon macularius*** (Kinne, 1960); ***Mugil cephalus*** (De Silva and Perrera, 1976) and ***Dicentrachus labrax*** (Dendrinos and Thorpe, 1985).

Significant differences in chemical body composition ($p<0.01$) were evidenced for fish reared at different salinities. The highest values of dry matter, crude protein and ether extract were recorded for fish reared in brackish water. This may be attributed to the huge amount of energy that lost during osmoregulation process either in sea or fresh water. Therefore, the highest gross energy was noticed for body constitutes of fish reared in brackish water (596 kcal/100 g) followed by that of sea water (576 kcal/100 g) and the lowest was for that of fresh water (565 kcal/100 g).

The results of feed and nutrient utilization indicated that, although the highest growth rate was achieved for fish reared in sea water, the best feed and nutrient utilization were recorded for fish reared in brackish water. This may be due to that, in sea and fresh water, as mentioned above, more energy demand was diverted into ion-osmoregulation and water exchange processes. Under this situation, fish may put-on body weight, however it had or despite the poor quality of their flesh. A similar pattern was demonstrated for ***O. niloticus*** X ***O. aureus*** hybrids and common carp ***Cyprinus carpio*** when common carp fingerlings reared at salinity 10 g/l accumulated excessive amounts of water, possibly due to some disruption of their osmoregulatory system. The negative growth observed at 12 g/l may be due to an inhibition of appetite but also to a less efficient utilization of food for growth as energy is directed to osmoregulation (Payne, 1983), he also recorded that carp grow better at 4 g/l than in fresh water. To examine the response of (***O. niloticus*** X ***O. aureus*** hybrids) to different salinities, the growth rate of the hybrids remained more or less constant to a salinity of 6 g/l but declined sharply at higher concentrations. The growth rate apparently increased at 16 g/l but, when growth was converted to increases in dry weight, the decline in growth rate with increased salinity was maintained. The situation appears similar to that noted at 10 g/l in the carp with increase in corporation of water at higher salinities giving the appearance of a high growth rate (Payne, 1983). Therefor, it is essential that, dry weight must be used as an index of growth performance.

In this study, the most prominent feature of the physiological response of red tilapia exposed to different salinities was a significant increase ($p<0.01$) of plasma sodium concentrations for fish reared in brackish or sea water as compared to that of fish reared in fresh water. These results are in accordance with Ahokas and Duerr (1975) whereas for Potassium levels in the plasma of red tilapia did not differ significantly among treatments. Therefore, red tilapia tolerance to brackish or sea water probably reflects their ability to withstand the increased osmotic pressure of internal fluids.

Haemoglobin content in red tilapia blood increased with the increased salinity and the differences were significantly higher ($p<0.05$) for sea water than brackish or fresh water. The response of haemoglobin concentration to salinity variations observed in the present study may be explained by the differential changes in red cells and plasma volume due to the loss of water from the blood to the hypertonic environment in the process of homeostasis. Another explaination is that, it may be a physiological response in an attempt to increase the oxygen-carrying capacity of the blood to support the higher metabolic demand associated with preventing dehydration in the hypertonic environment.