STUDIES ON WATER QUALITY, CULTURE PERFORMANCE AND HEALTH ASPECTS OF NILE TILAPIA (*OREOCHROMIS NILOTICUS*) IN FRESH AND BRACKISHWATER FISH FARMS

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ABSTRACT

The physico-chemical characteristics of water, nutrient status, plankton production, metals (Fe, Zn, Cu, Mn, Cd and Pb) accumulation in some organs of *O. niloticus*, fish growth conditions and health aspects were studied in fresh and brackishwater fish ponds during fish culture season 2007. The highest plankton production and fish biomass was observed in ponds which received fresh water, while nutrients remained slightly lower than in brackishwater fish ponds. Metals concentrations were negatively correlated with salinity, calcium, conductance and total hardness and positively correlated with chlorophyll "a". Brackishwater fish accumulates lower metals concentrations in fish organs than those reared in freshwater ponds. Metals concentrations in muscles were within the permissible levels. Concerning growth parameters, brackishwater fish had the highest values of condition factor (CF), hepatosomatic index (HSI), and male gonadosomatic index (GSI). The results of blood parameters that measured; glucose, total protein, albumine, creatinine, urea nitrogen, uric acid, aspartate amino transferase (ASAT) and alanine amino transferase (ALAT) revealed significant differences between fresh and brackishwater fish; however their values were in the reference limits. No pathological changes were observed in gills, liver, kidney and spleen in the studied fish. No differences were observed concerning the histological examination. It can be concluded that the health status of *O. niloticus* reared in brackishwater not affected by increasing in salinity and its culture in brackishwater has to expand.

INTRODUCTION

Tilapia species are economically important food source in tropical countries. They are primarily cultured in diverse farming systems like freshwater ponds, rice paddies and cages in lakes and reservoirs. There is an emerging demand to culture tilapia in brackishwater or sea water in areas or regions where freshwater resources are limited (George, 1997). Tilapia is characterized by a general tolerance to a wide range of environmental conditions including pH, temperature, salinity and pathogens. However, their cultured in high salinity were sensitive to handling and secondary infection (Chang & Plumb, 1996).

Production of world tilapia has increased steadily during the period of 1991- 2002. Its culture production reached to 1.5 million tones in 2002 when the global fish production was almost 51.4 million tons. The most quantity of tilapia in the world has been obtained from Asia (1 million ton/y) (Ramnarine, 2005).

The Nile tilapia (*O. niloticus*) is the main cultured species which responsible for increasing the global tilapia production. The worldwide production of tilapia cultured in brackishwater increased from 128458 metric tons (MT) in 1999 to 223248 MT in 2003. The share of Nile tilapia cultured in brackishwater has increased from 10.4% to 12.3% of total production of Nile tilapia (in fresh and brackishwater) during the same period, of which close to 99% of the production are from African countries (FAO, 2005).

Egyptian fish production has increased steadily over the last ten years reaching about 971,000 tons from all resources (river, seas, lakes etc.) in 2006, of which more than 61% (595,029 tons) was from aquaculture (GAFRD, 2007). The main cultured species are tilapia (*O. niloticus*), carps (*Cyprinus carpio*), mullets (*Mugil ramada* and *M. cephalus*) and the African catfish (*Clarias gariepinus*).

Due to the alarming growth rate for the Egyptian population, natural and artificial food must be increased in order to satisfy future domestic needs. Water is always a limiting factor in commercial fish production. However, water shortages for aquaculture required periodical investigations. The potential for horizontal expansion of stand-alone freshwater pond aquaculture appears to be poor, so development efforts should be focused on the expansion of brachishwater aquaculture to increase fish production.

Commercial farming of tilapia species is a rapidly expanded in Egypt and they are cultured in earthen ponds. Some of these ponds receive almost agricultural drainage water. Most of aquaculture studies on fresh water, while on brackish water were scarce.

The largest problem regarding aquaculture in irrigation drain water is the accumulation of heavy metals, pathogens and pesticides (Ingersoll *et al.*, 1992). The impact of these metals on fish has been of great concern for many authors. Their bioaccumulation in fish may critically influence the growth rate, physiological and biochemical status and consequently the meat quality of fish. Moreover, histopathological changes have been reported in gills, liver and kidney of fish reared in waste water (Zaghloul, 2000).

The aim of the present study is to evaluate the use of the brackish water for fish culture to overcome on the shortage of the River Nile water.

MATERIALS AND METHODS

Water and fish samples were collected from 12 shallow (1.25 m deep) earthen ponds; six in Al-Abbassa fish farm (freshwater) and six in a private farm (brackishwater) situated between Gamassa and Baltim city along the coastal international road (Al-Saloum-Damietta) during the 2007 fish culture season that extended from July to November. Fish in these farms feed on commercial pelleted feeds. The brackishwater ponds receive their water from under groundwater and agriculture drainage water.

1- Sampling

Water samples were taken from different places at each site by a PVC tube column sampler at depth of half meter from the water surface. The samples at each site were mixed in a plastic bucket and a sample of 1 liter was placed in a polyethylene bottle, kept refrigerated and transferred cold to the laboratory for analysis. Sixty *O. niloticus* fish (thirty from each farm) with total mean lengths of 17.42 cm and 18.47 cm and total mean weighs of 137.43 g and 186.99 g for freshwater and brackishwater fish ponds, respectively were collected and transferred to the laboratory in an ice box.

2- Laboratory analysis

a) Water

Hydrogen ion concentration (pH) was measured with pH meter (Model 25, Fisher Scientific). Salinity, electric conductivity (EC) and total dissolved solids (TDS) were determined using a salinity-conductivity meter (model, YSI EC 300). Dissolved oxygen was measured by using a digital oxygen meter (Model YSI 55). The concentration of total hardness, calcium hardness, carbonate and bicarbonate alkalinity (as $CaCO_3$), total phosphorus and chloride were estimated according to APHA (1985). Total nitrogen was measured according to Grasshoff *et al.* (1983). Concentration of all parameters were expressed as mg/l, except salinity, TDS and chloride as g/l and chlorophyll "a" content as µg/l. Transparency (m) was measured by using a Secchi Disc of 20 cm diameter (Boyd and Tucker, 1992). Heavy metals were extracted with conc. HCl and preserved in a refrigerator till analysis for Fe, Zn, Mn, Cu, Cd and Pb concentration as µg/l (Parker, 1972).

b) Fish

I- Metals residues

The different organs (muscles, gills and liver) were collected separately and the above metals were extracted by the method described in AOAC (1990). Atomic Absorption Spectrophotometer (Model Thermo Electron Corporation) instrument was used to detect metals concentrations which were expressed as µg/g. dry wt.

II- Growth parameters

-Fish condition

It was assessed by calculating condition factor (CF), hepato-somatic index (HSI) and gonado-somatic index (GSI) according to Schreck and Moyle (1990). These parameters were calculated as: $CF = (W_t/L^3) \times 100$; where W_t is the total gutted weight of the fish (g), and L is the total length (cm); HSI = (WL/Wt) x 100; where WL is the weight of the liver (g) and GSI =WG/Wt x 100; where WG is the weight of testes (g).

-The length-weight relationship

The length-weight relationship is usually expressed by the equation $W= aL^n$, (Le Cren, 1951) where, W=weight in grams, L= total length in cm. and "a" is a constant and "n" is the slope of the linear regression. The coefficients "a" and "n" were calculated after linearization by taking logarithms of both sides of the equation. This equation could be written as follows: $\log W=\log a + n \log L$.

III- Biochemical analysis

Blood samples were collected from the caudal veins and it was allowed to set for 30 min. at 4 °C to clot, and then centrifuged for 5 min at 1000 rpm. The serum samples were stored at -20 °C until later used to analyze glucose, total protein, albumine, creatinine, urea nitrogen, uric acid, aspartate amino transferase (ASAT) and alanine amino transferase (ALAT) according to the method described by Moss (1984). Blood samples were preserved in sodium fluoride for estimating blood glucose.

IV- Histological investigation

Tissue specimens were taken from fish, fixed in 10% neutral buffered formalin and processed for histological examination according to Roberts (2001). Sections were stained with hematoxyline-eosin (H & E) and examined under the light microscope (Luna, 1968).

3- Statistical analysis

One-way ANOVA and Duncan multiple range test were used to evaluate the significant difference of the concentration of different items that were studied with respect to fresh and brackishwater. Significant differences are stated at $P<0.05$ (Bailey, 1981). Correlation coefficients between the different parameters were computed.

RESULTS AND DISCUSSION

Physical characteristics of water

As shown in table (1), the pH values varied slightly in the two water types where it was 8.63 in freshwater ponds and 8.62 in brackishwater ones. The safe range of environmental pH for the survival of fish is approximately 5-9, but productivity is maximized in waters of pH 6.5-8.5 (Arrignon, 1999). So, the pH in water of studied ponds lies on the alkaline side and is suitable for growth of aquatic organisms.

Dissolved oxygen (DO) which is the most important chemical parameter in aquaculture attained higher values in brackishwater ponds (9.10 mg/l) and this may be attributed to the highly aeration rate in the area of brackiskwater ponds which lies near the sea shore. On the other hand, the lower values (5.07 mg/l) of DO recorded in freshwater ponds may be attributed to the high rate of activity (DO consumption in respiration and decomposition of high load of organic matter represented by die-off of phytoplankton by bacteria). However, no oxygen depletions were noticed in the two types of water. It is clear that DO content at the two pond groups lied within the limits (5 mg/l) that satisfy the needs of successful fish production as reported by Boyd (1990).

Table 1. Physical characteristics of water in fresh and brackishwater fish ponds.

Parameter	Freshwater farm		Brachishwater farm	
	Range	Mean±SE	Range	Mean±SE
pH	8.54-8.81	8.63^{a}±0.036	8.43-8.78	8.62^{a}±0.055
DO	4.5-6.0	5.07^{b}±0.22	8.2-10.2	9.10^{a}±0.35
SD	7.0-13.0	8.86^{b}±0.86	15-23	20.33^{a}±1.17
EC	0.78-1.05	0.88^{b}±0.032	9.28-19.57	15.57^{a}±2.10
Salinity	0.39-0.40	0.40^{b}±0.00	5.7-13.6	10.10^{a}±1.47
TDS	0.509-0.679	0.57^{b}±0.02	6.58-14.59	11.07^{a}±1.50
Chl "a"	183.14-253.83	211.70^{a}± 14.08	102.34-184.45	119.89^{b}±15.47

Superscript a and b notations denote significant differences between the same items (within rows).

The average values of transparency were generally higher in brackishwater ponds (20.33 cm), whereas in freshwater ones showed the lower Secchi disc readings (8.86 cm). This may be attributed to the higher primary productivity (phytoplankton growth) as well as high turbidity due to the high content of suspended materials (especially clay particles) in freshwater ponds. The sediment texture in these ponds is clayey loam (fine soils), whereas that of the brackishwater area is a sandy loam sediment (which contains the lowest percent of clay particles and less suspended in water column). This agrees with Boyd (1990 & 1992).

The concentration of ions that represented by electric conductivity (EC), salinity and total dissolved solids (TDS) was significantly different between fresh and brackishwater fish ponds as shown in table (1). The increased of salinity in brackishwater ponds can be due to the high levels of dissolved salts in agriculture drainage water together with increased soil salinity in this region. However, salinity in both types of ponds was suitable for fish growth and survival as mentioned by Basiao *et al.* (2005).

Primary productivity (chlorophyll "a") in ponds are one of the most important steps in the complex analysis of aquatic ecosystems as these constitute important component of fish food and thus, act as an index of trophic status of the water body (Abel, 1998). Chlorophyll "a" concentration which is an indication for the primary productivity (phytoplankton) was low in brackishwater ponds compared to freshwater ones. This can be attributed to the artificial feeding which is the main food source for fish in brackishwater. Also, the freshwater ponds are very productive owing to the feeding and presence of inorganic fertilizers.

Chemical characteristics of water

Alkalinity (carbonates and bicarbonates), total hardness and calcium hardness varied between the two types of water. The higher values were recorded in brackishwater ponds (Table, 2). However, alkalinity was high in both fresh and brackishwater, indicating that pond waters were well buffered. Water hardness and calcium hardness increased in brackishwater ponds as salinity level increased. These results coincide with Garg and Bhatnagar (1996) who mentioned that brckishwater contains high concentrations of Ca^{++} and Mg^{++} along with chlorides, phosphates and bicarbonates.

Table 2. Chemical properties of water in fresh and brackishwater fish ponds.

Parameter	Freshwater farm		Brachishwater farm	
	Range	Mean ± SE	Range	Mean ± SE
$CO3^{--}$	18.0-37.5	$27.21^a \pm 3.35$	22.50-27.00	$26.75^a \pm 1.95$
HCO_3^-	262.5-330.0	$288.0^a \pm 9.93$	232.5-390.0	$315.0^a \pm 27.32$
TH	200.0-260.0	$228.57^b \pm 7.69$	2000-3600	$2733.33^a \pm 304.05$
Ca-H	72.0-136.0	$100.29^b \pm 9.15$	950-1175	$1043.33^a \pm 34.20$
OP	0.008-0.143	$0.049^b \pm 0.02$	0.014-0.198	$0.140^a \pm 0.027$
TP	0.29-0.663	$0.435^b \pm 0.044$	0.395-0.975	$0.678^a \pm 0.09$
Cl^-	115.0-0.150	$0.13^b \pm 0.007$	7.75-9.00	$8.31^a \pm 0.21$
T. NH_4-N	0.2-0.4	$0.343^a \pm 0.037$	ND	ND
NO_2-N	0.016-0.030	$0.020^a \pm 0.002$	0.016-0.055	$0.037^a \pm 0.006$
NO_3-N	0.175-0.553	$0.321^a \pm 0.059$	0.116-0.636	$0.305^a \pm 0.074$
TN	22.4-27.85	$24.81^a \pm 0.71$	15.02-20.48	$18.66^b \pm 1.05$
ON	21.69-26.88	$24.07^a \pm 0.67$	14.63-21.62	$18.32^b \pm 1.02$

ND: Not determined.

Maximum values of orthophosphate (OP) (0.140 mg/l), total phosphorous (TP) (0.678 mg/l) and nitrite-nitrogen (0.037 mg/l) were recorded in brackishwater ponds (Table, 2). The higher values of total phosphorus in fresh and brackishwater ponds result from the high content of chlorophyll "a". This agrees with Garg and Bhatnagar (1996) who mentioned that saline waters contain higher values of phosphorus than freshwater. The total ammonia-nitrogen values that recorded in the present study were in the safe levels for fish. As shown in table (2), the less values of total ammonia NH_4-N, NO_2-N, NO_3-N and PO_4-P) can be related to the high content of primary productivity (chlorophyll "a") which consumed these ions as a nutrient.

From this work it is conclude that, the values of total and organic nitrogen in freshwater ponds increase than that of brackishwater ones. This can be attributed to the higher values of chlorophyll "a" that were recorded in freshwater ponds. Also, the continuous addition of agricultural drainage water (rich in nutrients) to compensate the shortage in water column in brackishwater ponds lead to increase total phosphorus (TP). In addition, the water column in freshwater ponds is more stagnant which lead to increasing chlorophyll "a" concentration.

Correlation parameters of water quality revealed a positive correlation between pH and CO_3^{--} (r=0.7423, P<0.01), TN and ON (r=0.9994; P=0.00), DO and SD (r=0.9048, P=0.00), and a negative correlation of chlorophyll "a" with nutrients (NO_2–N, r=0.6534; PO_4-P, r = 0.6122, P<0.05) and a positive correlation with total Kjeldahl nitrogen (r=0.7606, P<0.05). No correlation with DO and NH_3 concentration to any other water quality parameter. No correlation was observed with chlorophyll "a" and NO_3–N, (r=0.4727, P>0.05). This clearly proved that pond productivity was not positively correlated with nutrient concentrations. This could be explained that nutrients were consumed by phytoplankton. From table (1&2), it is shown that, all water quality parameters remained within the optimal growth range for *O. niloticus.*

Heavy metals accumulation in water

Concentrations of metals followed the order: Fe > Mn > Zn > Cu > Pb > Cd in pond water. Freshwater ponds have higher levels of all studied metals than in brackishwater ones as shown in table (3). This may be due to the role of salinity in decreasing the water load of metals and the high contents of chlorophyll "a" in freshwater ponds where metals were adsorbed and consumed by phytoplankton (Saleh, 1982; Saleh *et al.* 1988). They also added that, the concentration of heavy metals in plankton (phyto & zoo) were 4000 to 10000 times higher than those in water. In this study, metals concentrations were positively correlated with chlorophyll "a". However, concentration of these metals are still under the permissible limits (Fe: 1.0, Zn: 1.0, Cu: 1.0, Mn: 0.05, Cd: 0.01 and Pb: 0.0.05 mg/l) according to US EPA (1986).

Table 3. Heavy metals concentrations in water (mg/l) of freshwater and brachishwater fish farms

Parameter	Freshwater farm		Brachishwater farm	
	Range	Mean±SE	Range	Mean±SE
Fe	0.34-2.62	1.32^{a}±0.35	0.21-0.38	0.28^{b}±0.022
Zn	0.047-0.128	0.080^{a}±0.012	0.013-0.049	0.028^{b}±0.005
Cu	0.013-0.023	0.017^{a}±0.002	0.0013-0.0043	0.0031^{b}±0.001
Mn	0.193-0.672	0.436^{a}±0.079	0.015-0.083	0.056^{b}±0.009
Cd	0.001-0.005	0.002^{a}± 0.00	0.00-0.004	0.002^{a}±0.00
Pb	0.00-0.027	0.007^{a}±0.004	ND	ND^{a}±0.00

ND: Not detected

Heavy metals accumulation in fish organs

Tables (4, 5 & 6) showed the results of heavy metals that accumulated in organs of *O. niloticus* collected from the two types of fish farms. It was noticed that, the concentrations of all studied metals (except Mn) in fish reared in freshwater ponds were higher than those reared in brackishwater. This may be explained by the fact that freshwater ponds having lower water hardness as compared with brackishwater ones. Hardness cations (divalent cations, such as Ca^{2+} and Mg^{2+}) are well known to decrease aqueous metal uptaking at uptake sites (Jobling, 1995 & Pyle *et al.*, 2005). In the present study, metal concentrations in muscles were considerably lower than those in gills and liver, which are consistent with many authors (Pyle *et al.* 2005; Saeed and Sakr, 2008). They mentioned that, the high metal concentrations in liver reflect its multifunctional role in detoxification and storage.

Table 4. Heavy metals concentrations (μg/g dry wt.) in muscles of *O. niloticus* reared in freshwater and brachishwater fish farms

Parameter	Freshwater farm		Brachishwater farm	
	Range	Mean SE	Range	Mean SE
Fe	51.43-66.53	56.56^{a}±4.98	57.65-60.93	51.79^{a}±3.93
Zn	62.6-103.47	83.52^{a}±11.81	23.85-35.42	29.64^{b}±3.34
Cu	1.93-3.61	2.75^{a}±0.49	1.36-1.38	1.37^{a}±0.01
Mn	1.10-1.63	1.29^{a}±0.17	1.95-4.43	3.19^{a}±0.72
Cd	0.022-0.068	0.049^{a}±0.014	ND	ND^{b}±0.00
Pb	0.230-0.283	0.265^{a}±0.018	ND	ND^{b}±0.00

ND: Not detected

The high accumulation of metals in the liver could be due to the greater tendency of the elements to react with the oxygen carboxylate, amino group, nitrogen and/or sulphur of the mercapto group in the metallothionein protein, whose concentration is highest in the liver (Jobling, 1995). He also added that, the high accumulation of metals in metabolic organs as gills and liver is related to the metallothioneins proteins which are synthesized in these organs when fishes are exposed to heavy metals and detoxify them. From the present results, it is conspicuous that, Fe was the highest accumulated metal in fish tissues while Cd was the lowest one. Iron recorded the highest concentrations in all fish organs. This can be due to iron-containing enzymes and the extensive vascular system of the liver, as the hemoglobin in the blood binds approximately three quarters of the Fe in the body. The haeompoietic function of the liver and the organ's abundant blood supply explain the accumulation of Fe (Voynar, 1960). The haeompoietic function of the liver and the organ's abundant blood supply explain the accumulation of Fe (Voynar, 1960). On the other hand, the high accumulation of Zn and Cu in the liver could be related to the specific metabolism process and enzyme catalyzed reaction involving Zn and Cu taking place in the liver. On the other hand, the high accumulation of Zn and Cu in the liver could be related to the specific metabolism process and enzyme catalyzed reaction involving Zn and Cu taking place in the liver.

Table 5. Heavy metals concentrations (µg/g dry wt.) in gills of *O. niloticus* reared in freshwater and brachishwater fish farms

Parameter	Freshwater farm		Brachishwater farm	
	Range	Mean SE	Range	Mean SE
Fe	171.03-231.16	198.15^{a}± 25.38	153.17-255.64	164.91^{a}± 36.22
Zn	168.94-203.27	186.11^{a}± 14.02	49.12-74.27	61.7^{b}±7.26
Cu	5.30-7.14	5.43^{a}± 0.95	2.69-2.79	2.74^{a}± 0.029
Mn	17.80-31.31	26.63^{a}± 4.41	30.53-34.96	32.75^{a}± 1.28
Cd	0.011-0.025	0.016^{a}± 0.005	0.00-0.017	0.015^{a}± 0.00
Pb	0.076-0.594	0.279^{a}± 0.160	ND	ND^{b}± 0.00

ND: Not detected

Table 6. Heavy metals concentrations (µg/g dry wt.) in liver of *O. niloticus* reared in freshwater and brachishwater fish farms

Parameter	Freshwater farm		Brachishwater farm	
	Range	Mean ± SE	Range	Mean ± SE
Fe	214.64-274.38	248.66^{a}± 17.74	138.3-196.29	167.3^{b}± 16.74
Zn	126.82-327.10	209.77^{a}± 60.26	39.39-52.99	46.19^{b}± 3.93
Cu	21.82-143.50	74.34^{a}± 36.1	5.17-5.30	5.24^{b}± 0.038
Mn	2.41-2.90	2.72^{b}± 0.16	9.50-10.54	10.02^{a}± 0.30
Cd	0.065-0.486	0.205^{a}± 0.140	0.00-0.133	0.067^{b}± 0.038
Pb	0.097-0.497	0.269^{a}± 0.12	ND	ND^{b}± 0.00

ND: Not detected

Cu accumulation can be also explained by its relation to low-molecular weight proteins (metallothionein), which are concentrated in hepatic tissue as mentioned by (Pyle *et al.* 2005). They also mentioned that, the lower muscle Zn and Cu may be related to the increased deposition of the two metals in the liver fish.

The highest concentration of Mn was found in gills tissue of cultured fish. This may be attributed to the complex formation between both metal ions and the protein structure in gills which contain nitrogen, oxygen and sulfur as previously reported by Cotton and Wilkinson (1980). Gills also considered as the main route of uptake of Mn, which show little absorption through the gut from food (Katz *et al.* 1972).

Our data revealed that fish in brackishwater ponds accumulate lower values of Cd in gills and liver tissue, while Pb not detected. Increased of Pb in freshwater farm (in Abbassa) may be due to water burden of Pb result from irrigation pumps that used gasoline for long time, whereas brackishwater ponds are new and present in a virgin area near the sea. Cd exhibited higher values in different organs in fish reared in freshwater than those in brackishwater ponds. This can be attributed to increase of water hardness in brackishwater. Pyle *et al.* (2005) mentioned that water hardness was an important factors that decreasing hepatic Cd accumulation. They also added that branchial Ca^{2+} uptake in hard water probably contribute to a decrease in dietary Cd uptake in fish. Ingersoll *et al.* (1992) reported that both Ca and Mg concentrations control the water exchange rate of fish held in saline water. However, Ca has greater effect than Mg in reducing water permeability. Baldisserotto *et al.* (2004) noticed that rainbow trout fed a Ca-supplemented diet took up less waterborne Cd (to gills, liver, and kidney) than fish fed a normal diet. They reasoned that dietary Ca may be transported to the gills where it blocks waterborne Cd uptake.

Saleh (1982) stated that fishes live in freshwater accumulate more concentrations of heavy metals than those living in brackish or saline water. Also, the bioaccumulation of these metals in plankton affects its levels in fish. In this study, metals concentrations were negatively correlated with salinity, calcium, conductance and total hardness. The recommended daily intake for an adult is 48, 60, 2.0-9.0, 3.0, 0.1 and 0.214 mg/day (except Cd µg/day) wet weight for Fe, Zn, Cu, Mn, Cd and Pb respectively according to FAO/WHO (1999). So, a normal daily diet including this fish species from both fresh and brackishwater poses no health risk to consumer.

Growth parameters

Condition factor (CF), hepato-somatic index (HSI), gonadosomatic index (GSI) and length-weight relationship is essential biological parameters needed to appreciate the suitability of the environment for any fish. CF is a measure of somatic energy reserves associated with recent feeding activity, HSI is associated with liver energetic reserves and metabolic activity, and GSI is a measure of reproductive potential.

Culture of *O. niloticus* showed well-being in both fresh and brackishwater. However, the fish biomass remained slight lower in freshwater (K=1.62) than brackishwater (K=1.70) ponds as shown in table (7). This could be explained by the higher productivity, good nutritive conditions and greater feeding activity in fish from the two types of water. Basiao *et al.* (2005) mentioned that Nile tilapia grew well in brackishwater and there were no significant differences in the growth of fish raised in brackish and in freshwater ponds. Villegas (1990) found that the optimum salinity range for the growth of Nile tilapia was 0-10 ppt. He stated that, growth and survival declined as salinity increased from 15 to 32 ppt. Garg and Bhatnagar (1996) mentioned that culture of common carp showed that the fish biomass remained significantly higher in brackishwater ponds than in freshwater ponds. Abu Hena *et al.* (2005) indicated that *O. niloticus* showed a better option for culture at salinities above 10 ppt, based on growth performance and survival.

HSI and GSI have the same trends for CFs, in that fish from brackishwater ponds had the higher values (2.92 & 0.35, respectively), than those in freshwater ponds (1.39 & 0.16, respectively). A significant difference exists between fish HSI and GSI in the two types of water. GSI was assessed only for mature male fish. The higher values of HSI can be attributed to the physiological changes which take place in the digestive system resulting in the enlargement of the liver due to increase capacity of hepatocytes to glycogen content. Also, Roberts (2001) showed that such increase in the HSI can be due to the increase in the activities of the sexual hormones.

Table 7. Condition factor (K), hepato-somatic index (HSI), Gonado-somatic index (GSI) and length-weight relationship of *O. niloticus* reared in freshwater and brachishwater fish farms

Factor		Freshwater	Brackishwater
Condition factor (k)	Range	1.44-1.76	1.43-2.01
	Mean	$1.62^a \pm 0.01$	$1.70^a \pm 0.04$
HSI	Range	0.79-2.22	1.31-3.57
	Mean	$1.39^b \pm 0.06$	$2.92^a \pm 0.13$
GSI	Range	0.11-0.41	0.12-0.82
	Mean	$0.16^b \pm 0.01$	$0.35^a \pm 0.04$
L-W relationship		Log W = -1.8525+3.0481 Log L	Log W = -1.9389+3.1212 Log L
Exponent "n"		3.0481	3.1212

However, males from freshwater ponds showed significantly decreased GSIs as compared with males from brackishwater ponds. This can be a reflection of metal induced impairment of reproductive potential in these fish. This observation agrees with Pyle *et al.* (2005) who speculated that liver Cd was negatively associated with reproductive condition in males (GSI), suggesting that dietary Cd may contribute to decreased reproductive potential in male yellow perch.

The computed equations representing the relation between length and weight for *O. niloticus* in fresh and brackishwater ponds are illustrated in table (7) and figs. (1 & 2). The value of "n" in the equation "Log W = Log a + n Log L", reflect the condition of the fish. From these equations, the values of the exponent "n" indicate that the rate of increase in weight of *O. niloticus* were close to the cube (3) of length in the freshwater ponds (n= 3.0481), and brackishwater ponds (n= 3.1212). Since the value of exponent "n" is so close to 3.0 for fish in the two types of water, it could be stated that the weight of *O. niloticus* increased approximately as the cube of the length and follow the cube of the length and follow the cube law in the two types of water. The highest fish biomass that observed in the present study coincided with the highest plankton production. Thus, this study shows a positive correlation between plankton production and the fish biomass that observed in the present study coincided with the highest plankton production. Thus, this study shows a positive correlation between plankton production and the fish biomass.

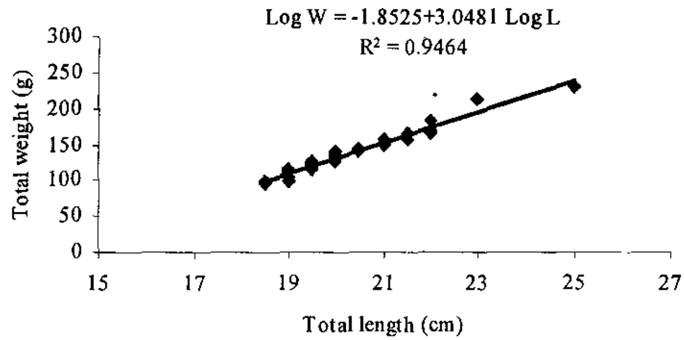


Figure 1. Regression line illustrating the length-weight relationship of *O. niloticus* reared in freshwater fish farms

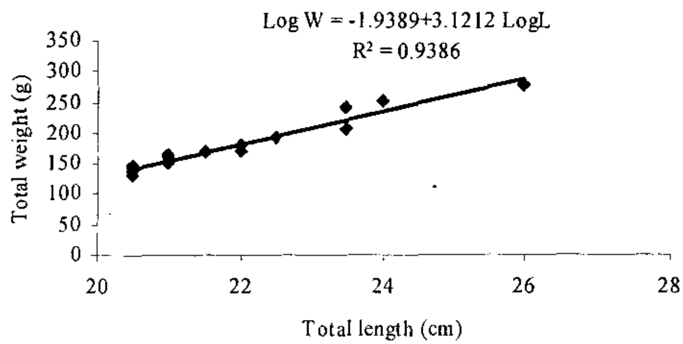


Figure 2. Regression line illustrating the length-weight relationship of *O. niloticus* reared in brackishwater fish farms

Knud-Hansen and Batterson (1994) mentioned that net fish yield is strongly related to primary productivity. Thus, the higher production of *O. niloticus* under fresh and saline water conditions can be attributed to the high abundance of plankton in these waters. Higher fish biomass under saline conditions can also be attributed to the slower and more sustained release of nutrients in saline waters. Sustaining the fertility of a water body over a longer period of time perhaps depends more on the comparatively faster rate of degradation, as observed in non-saline or in fresh waters (Bhatnagar *et al.* 1994).

Clinical findings

The fishes are immediately cached from several ponds of fresh and brackishwater showed normal and healthy soundness markers except the brackishwater fish were covered with profused slime or mucus more than the freshwater one. This increased mucus is attributed to that mucus plays an important role in maintenance of osmoregulation via electrolyte regulation as mentioned by Handy & Eddy (1991), who found that the mucus of freshwater fish has a considerable high concentration of Na^+ & Cl^- ions than dose the water. This reduces the gradient between the blood and water. Thus the increase in the mucus layer in fish experiencing pollutant stress would reduce the passive diffusive loss of electrolytes. Also, Handy et al. (1989) stated that mucus has a low permeation coefficient for metals and thus may help protect the tissue from its action on the sensitive gills epithelium.

The serum biochemical analysis

The health status of fish was determined by estimation of different blood chemical parameters as shown in table (8). Elevation in blood glucose in fish may reflect a generalized stress response to a variety of environmental conditions and is brought about by increasing levels of adrenaline and cortisol (Thomas, 1990). So, increased glucose levels in brackishwater (98.0 mg/dl) fish than freshwater one (74.33 mg/dl) can be attributed to increase levels of adrenalin which plays an important role in osmoregulation. The complex mixture of proteins found in the blood largely originates from liver where it is broadly divided into fibrinogen and albumin (immunoglobulins come from β lymph).

Measurement of serum albumin is of a considerable diagnostic value as it relates to general nutritional status, integrity of the vascular system and liver functions. In our study we observed normal levels of albumin with no significant difference between fresh and brackishwater fish (Table, 8).

Table 8. Concentration of blood serum constituents of *O. niloticus* reared in freshwater and brachishwater fish farms

Parameter	Freshwater	Brachishwater	Correlation with salinity	
			r	P
Glucose (mg/dl)	$74.33^{b} \pm 3.53$	$98.0^{a} \pm 4.04$	0.8477	0.0330
T. protein (g/dl)	$3.32^{a} \pm 0.11$	$3.65^{a} \pm 0.27$	0.5625	0.2453
Albumine (g/dl)	$1.70^{a} \pm 0.09$	$1.32^{a} \pm 0.00$	0.4882	0.1180
Creatinine (mg/dl)	$0.76^{a} \pm 0.05$	$0.16^{b} \pm 0.00$	-0.9690	0.0014
Urea (mg/dl)	$7.67^{a} \pm 0.17$	$5.87^{b} \pm 0.43$	-0.9146	0.0106
Uric acid(mg/dl)	$2.13^{b} \pm 0.03$	$2.87^{a} \pm 0.13$	0.8915	0.017
AST (u/l)	$21.0^{b} \pm 1.15$	$38.33^{a} \pm 1.45$	0.9659	0.0017
ALT (u/l)	$17.67^{a} \pm 0.88$	$5.27^{b} \pm 0.18$	-0.9724	0.0011

P: Significance level at ($P < 0.05$), r: Correlation coefficient.

Concerning creatinine, urea nitrogen and uric acid, there are significant variations between fresh and brackishwater fish (Table, 8). These results express the kidney function which plays the main factor in regulation of osmosis (osmoregulation) via the guxtaglomerular apparatus, urine excretion via the secretion of many hormones as interrenal corticoid hormones and this variation may returned to the hyperactivity of kidney to maintain the normal osmoregulation in the new media in brackishwater.

Obviously, the hormonal control mechanisms of electrolyte levels in fish are complex and interrelated with other functions; for example, cortisol and adrenalin are important stress hormones which affect a wide variety of functions under various environmental conditions can be in response to altered blood ionic compositions and/or to other homeostatic challenges. Little is known about how the secretion rate of the various osmoregualatory hormones is regulated (Heath, 1995).

In an investigation by Casillas *et al.* (1983), histopathological lesions in the liver were correlated with change in plasma enzymes especially (AST&ALT). In our study, there are no elevations in these enzymes (Table, 8) than the reference limits and no histopathological lesions were detected in liver in fishes of both comparative media. This give us a primary indication that brackishwater may be a good media for growing up and culture of Nile tilapia.

Histological findings

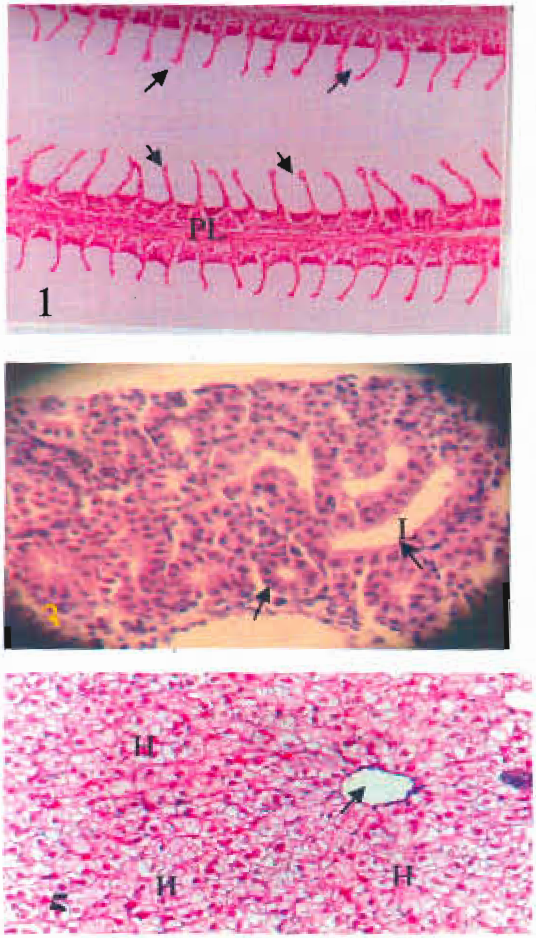
Light microscopic examination of gills, liver, kidney and spleen of fish reared in brackishwater ponds showed no lesions. The gills showed primary lamellae with its arrays of delicate secondary lamella (Fig. 1). The gills in freshwater fish have a few chloride cells. Although, the chloride cells in marine fish plays a main role in osmoregulation, the endocrine control of osmoregulation stay have the master role as mentioned by Lagler *et al.* (1962). They also added that, osmoregulation is mainly under endocrine control via the posterior pituitary interrenal corticoid hormones and possibly caudal neuro-secretary system and juxtaglomerular apparatus of the kidney. Eddy (1981) said that, cortisol promots the gain of salt in freshwater fish and it's lost in sea water. So, the acclimatization of freshwater *O. niloticus* in brackishwater contributed to the reach of such fishes to certain stages of development involving drastic endocrine changes to become smolt before being capable of living in brackishwater.

Also the histological study revealed a well vascularized glomemli of kidneys (Fig. 2) where the glomerular filtration is of great importance in osmoregulation where in freshwater environment large volumes of dilute urine was produced by the kidney while, in marine one small quantity. is produced. Furthermore, they drink a significant amount of water to replace water lost by osmosis (Roberts, 2001).

As mentioned before the values of transaminases (ALAT & ASAT) which express the health status of the liver were in normal limits and the results were confirmed by the histological sections stained with H & E, where the processed specimens of liver showed cords of hepatocytes their apices directed toward the central vein which empty from the RBCs (Fig. 5). The spleen showed melano macrophage centers (MMC) in stroma of hemopiotic elements (Fig. 6).

CONCLUSION

From the present results, it can be concluded that the health status of tilapia fish reared in brackishwater not affected.by increasing in salinity and the significant variation in biochemical values still within the reference limits. So, culture of tilapia in brackishwater has to promote.



Figs. 1- 6. photomicrographs for sections of gills, kidney, liver and spleen of *O. Niloticus* reared in brackishwater earthen ponds.

Fig.1. Gills showing primary lamellae (PL) were supported by cartilaginous rods with its arrays of delicate secondary lamella (arrows) H& E., X 300.

Fig.2. Kidneys showing well vascularized glomemli (arrows) H& E., X 300.

Fig.3. Kidney showing intact renal tubules of excretory kidney (arrows) with its lumen (L) H& E., X 300.

Fig.4. Kidney showing intact archrinephric duct (arch.D) lined by epithelial cells with vesicular nuclei (arrow) H& E., X 300.

Fig.5. Liver showing cords of hepatic cells (H) their apices directed toward the central vien (arrow) which empty from the RBCs H& E., X 150.

Fig.6. Spleen showing melano macrophage (M) in stroma of hemopiotic elements H& E., X 300.

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دراسة جودة المياه والأداء والصحة العامة لأسماك البلطى النيلى المستزرعة فى المياه العذب والشروب

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1- قسم الليمنولوجى 2- قسم أمراض الأسماك

نظرا لندرة المياه العذبة في مصر فقد إتجهت الدراسات الحالية إلى إستخدام المياه الشروب في تربية الأسماك، مدى ملائمة هذه المياه للإستزراع السمكي من ناحية الجودة وتأثيرها علي صحة الإنسان. تم إختيار مجموعتين من الأحواض الترابية، حيث تستخدم المجموعة الأولى المياه العذبه (العباسة/شرقية) والمجموعة الثانية تستخدم المياه الشروب (بلقاس الطريق الساحلى بور سعيد/مطروح).ولقد تم دراسة مواصفات المياه وبعض العناصر مثل الحديد، الزنك،النحاس، المنجنيز، الكادميوم والرصاص إلى جانب بعض القياسات البيوكيميائية والدراسات الهستولوجية للأسماك. وقد أظهرت النتائج أن المياه الشروب مناسبة لتربية الأسماك وغنية فى محتواها بالكائنات الأولية النباتية (الفيتوبلانكتون)، وقد تم تسجيل قيم عالية من معامل الحالة، المعامل الكبدى، المعامل التناسلى ومعامل النمو للأسماك. وكان تركيز بعض العناصر الثقيلة فى المياه و عضلات الأسماك أقل من النسب المسموح بها عالميا. كما أوضحت الدراسة أن الحالة الصحية للأسماك جيدة. وقد سجلت فروق ذات دلالة معنوية فى بعض القياسات البيوكيميائية ولكنها فى حدود المسموح بها عالميا كما لم تسجل آية فروق هستولوجية فى الأعضاء التى تم دراستها بين الأسماك المرباة فى المياه الشروب والمياه العذبة. وتوصى الدراسة بتعظيم دور الإستزراع فى المياه الشروب.