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Effect of Salinity Stress on Growth of Three Strains of Egyptian Nile Tilapia *(Oreochromis niloticus)*

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ABSTRACT

Three strains of Egyptian Nile tilapia *Oreochromis niloticus* (Fayom (F), Kafr El-Sheikh (K) and Abbassa (AB) were used to study the effect of salinity stress on the growth performance. Yolk sac fries were collected from each strain to reduce the effect of age. The fish with mean initial weight 1.94 ± 0.06 (AB), 1.95 ± 0.06 (F) 1.93 ± 0.08 (K) were transferred directly from fresh water to three levels from salinity 0, 5 and 15 ppt in aquaria (three replicates for each strain and salinity) for 96 hrs. Ten fish per each aquarium were collected after the stress from each genotype to grow in saline water or freshwater. All tested fish in saline and freshwater fed twice daily with commercial feed pellets containing 32% protein. All strains demonstrated significant variation ($P<0.001$) in the growth rate and length at zero salinity. Even though AB strain had higher growth rate from day 10 up to day 50, it started to decrease at 60 days at 5 ppt. At the end of the experiment AB at 5 ppt. get the lowest growth rate without significantly difference than F and K at 5 ppt. All treated strain of tilapia at 15 ppt showed low growth rate which was lower than the zero and 5 ppt for growth rate. All stressed (5R ppt) tilapia strains grown in freshwater, exhibited significant variation ($P<0.001$) for both growth rate and length. On the other hand, stressed strains (15R ppt) in freshwater revealed significant variation ($P<0.001$) for length and growth rate. The highest weight was recorded for FR15 and the lowest for ABR15. The tested strains at 5 ppt and R15 revealed higher growth rate than the same strains in salinity and freshwater. This indicated that even though the tilapias were collected from different location, it has the ability to grow in low salinity. Fayoum strain get the highest growth rate at all tested environment. All strains tested at 15 ppt showed inhibition in the growth rate. It was recommended from this study

that the growth rate at 5 ppt saline water is better than freshwater. The recovered fish after 15 ppt salinity stress exhibited higher growth rate. The variation among tilapia strains to tolerate salinity stress provide the information that help in collecting and starting base population for selection program for salinity tolerance of tilapia. The results also indicated that tilapia has the ability to tolerate salinity fluctuation resulting from climate changes and drought.

Keywords: Salinity, stress, strains, tilapia, growth, tolerance

INTRODUCTION

Most of world fish production comes from freshwater species although saline lakes exist on every continent worldwide, and comprise a total volume of approximately $104{\cdot}000{\cdot}km^3$ (Williams, 1996). The shortage in freshwater in many countries with the competition for it with agriculture and other urban activities has increased the pressure to develop aquaculture in brackish water and seawater (El-sayed, 2006).

Tilapias are excellent growth rates on low protein diets whether cropping natural aquatic production or receiving supplementary feeds; tolerance of wide ranges of environmental conditions; comparatively free from serious disease and parasites infections; ease of handling and breeding in captivity and wide acceptance as food fish (Eknath, 1994). Tilapia species are generally tolerant a wide range of environmental conditions such as salinity. Tilapia, which euryhaline grows well in brackish water and fresh water, while in sea water its growth rate decreases (Assem, 1994; Payne, 1983).

Tilapias are important candidate species for brackish water aquaculture and are increasingly cultured in coastal ponds including in polyculture with shrimp, thus creating a demand for tilapia genotypes well suited to elevated salinities. (Lawson and Anetekhai, 2011; Kamal and Mair, 2005).

Also there is increasing commercial interest in tilapia species or hybrids that can tolerate salinity and still exhibit acceptable growth (Armas-Rosales, 2006). Various factors affect salinity tolerance in tilapia, such as natural history (Trewavas, 1982) species and strain, size, age (Watanabe *et al.*, 1985., Villegas, 1990 a&b, Suresh and Lin 1992; Avella *et al.*, 1993 & Ridah, 2008), salinity exposure time, rate of salinity increase (Watanabe *et al.*, 1985, Suresh and Lin, 1992, Lemaire *et al.*, 2004; Paz, 2004), temperature (Linkongwe *et al.*, 1996) and genetic effects (Lutz, 2006). In addition to, interaction between some of these factors may determine

salinity tolerance under different culture conditions.

The Combined effect of temperature, salinity and density on the growth for *Oreochromis niloticus* juveniles showed highly statistically significant effects linear and quadratic of temperature, salinity on both growth and feed utilization (Jun *et al.,* 2011).

The effect of brackish water on growth performance of *Saratherdon melanotheron* from Senegal, Cote d'Ivoire, and Congo at 18 and 35 ppt showed that growth rate was the highest in the Senegal population (Gilles *et al.,* 1998). Genetically modified *O. niloticus* treated with sea bream-DNA reared at different levels of salinities up to 16 ppt showed significantly higher final body weight than the genetically modified *O. niloticus* treated with Artemia-DNA and the control fish group (El-Zaeem *et al.,* 2011). The effects of salinity on survival, growth of non-native Nile tilapia (*Oreochromis niloticus*) from southern Mississippi was reported (Schofield *et al.,* 2011).

Moreover, there are species and strain-specific showed variations with respect to the possible effect of salinity on growth performance (Suresh and Lin 1992; Garcia-Ulloa *et al.,* 2001). *Oreochromis niloticus* does not tolerate salinities above 20 ppt- and might not be suitable for culture in full-strength seawater (Baroiller *et al.,* 2000).

The development of reliable index for salt tolerance to evaluate stock is very important in the selection of strains that perform better under saline condition, and it provides a basis for accurate intraspecific comparison of tolerance limitation.

The objective of this investigation was to study the salinity stress on the growth performance of three strains of Egyptian Nile tilapia Fayom, Kafr El-Sheikh and Abbassa at different environment (saline and freshwater).

MATERIALS AND METHODS

The experiment was conducted in the genetics and breeding department at the Central Laboratory for Aquaculture Research Center (CLAR), Egypt.

Experimental fish

Three strains of Nile tilapia involved in this study were collected:

Fayom strain: from private hatchery at Fayom (F)

Kafr El-Sheikh strain: from private hatchery at Kafr El-Sheikh (K)

Abbassa strain: from CLAR experimental hatchery (AB)

Fry production

18 males and 54 females were chosen to produce offspring from each investigated of collection. Broodstock of each strain were stocked in a hapa net of (3 x 6 x 1m^3). Successful spawning and fry collection was observed in all hapas. Yolk sac fries were collected from each strain and transferred to CLAR. Rearing was done in three hapas of 18m^3 (3X6X1m). After three weeks in the hapas rearing, the fingerlings were stocked in the experimental tanks in wet laboratory in the Genetics and breeding department.

After the acclimatization, fish from each strain were divided into three groups. Each group from the strains was distributed randomly into nine replicated aquaria (40 L). The fish from each genotype was transferred directly from fresh water to each concentration of salinity for 96hrs (Table1).

Ten fish from each group were collected after the stress from each aquarium and continued in salinity or transferred to fresh water for studying. The initial weight was 1.94 ±0.06, 1.95 ±0.06, 1.93 ±0.08 for AB, F and K respectively. Three concentrations of salinity 0, 5 and 15 ppt were used in this study.

Table (1). *Strains and salinity concentrations usedin the first experiment and its abbreviations.*

Abbr.	Strain and concentration
F15	Fayom strain at 15ppt
K15	Kafr El-Sheikh strain at 15ppt
AB15	Abbassa strain at 15ppt
F5	Fayom strain at 5ppt
K5	Kafr El-Sheikh strain at 5ppt
AB5	Abbassa strain at 5ppt
FR15	Fayom strain at 15ppt returned to fresh water
KR15	Kafr El-Sheikh strain at 15ppt returned to fresh water
ABR15	Abbassa strain at 15ppt returned to fresh water
FR5	Fayom strain at 5ppt returned to fresh water
KR5	Kafr El-Sheikh strain at 5ppt returned to fresh water
ABR5	Abbassa strain at 5ppt returned to fresh water
F0	Fayom strain at fresh water
K0	Kafr El-Sheikh strain at fresh water
AB0	Abbassa strain at fresh water

The individual weight and total length of each fish were measured before stocking. The fish were fed twice daily with commercial feed pellets containing 32% protein at the rate of 7% biomass per day for the first 20 days, 6% for the next ten days and after at 5% till the end of experiment. All the fish were sampled every 10 days, individual weight (A METTLERR balance model PC 4400 accurate to within 0.01 g was used to weigh the fish.) and total length of each fish was measured. The feed was adjusted according to the data of each

sample. Fish were grown in these systems for 60 days. The water temperature was 25 ^{o}C ± 1, dissolved oxygen range was 3 - 5 mg/L, pH range was 7.2 - 8.3, nitrite range was 0.0 - 0.05 mg/L, and unionized ammonia range was 0.09 - 0.2 mg/L. These parameters are inside the suitable ranges for fish farming (Boyd 1990).

Water Salinity Preparation

Stock solution of 15 and 5 ppt of saline was prepared by adding salt to dechlorinated tap water using salinity meter apparatus (YSI Model 33, S-C-T meter) to adjust the accurate concentration.

Statistical Analysis

The data was analyzed statistically by using SPSS program (Version11) to calculate the ANOVA for means. Stander error and significant for all treatment were calculated.

RESULTS

Growth in saline water

All strains demonstrated significant variation ($P<0.01$) in the growth rate and length at zero salinity during this study (Figure 1 a & b).

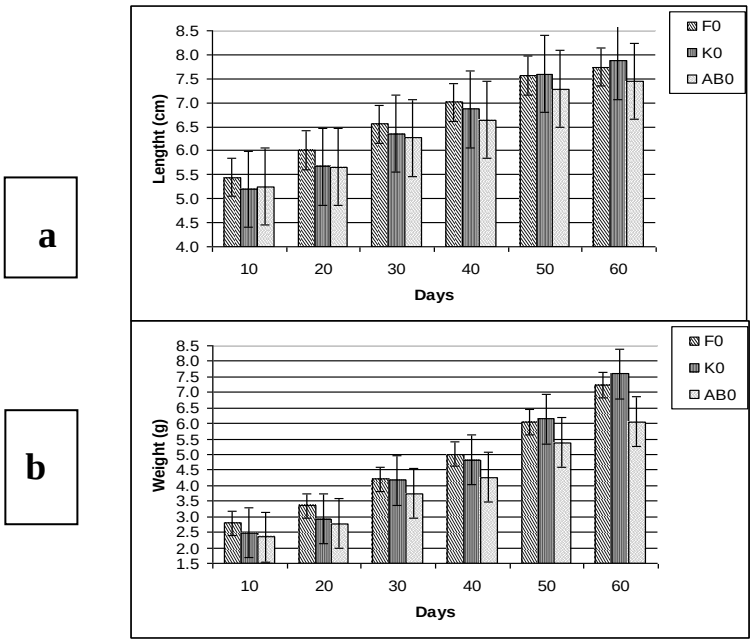

Figure 1. ***Mean growth rate (±SE) for Nile tilapia Oreochromis niloticus from Fayom (F), Kafr El-Sheikh (K) and Abbassa (AB) for 60 days at zero salinity, (a) length and (b) weight***

There was variation in the length for all tested strain of tilapia but not significantly different (Figure 2a) at 5ppt salinity. After ten days from growth both F5 and K5 were in the same line for growth rate (Figure 2a) while AB5 had higher growth rate with no significant differences ($P<0.01$). Even though AB strain was higher growth rate from the tenth days up to the day 50 it started to decrease at day 60 at 5 ppt. At the end of the experiment AB5 was the lowest growth rate but not significantly difference than F5 and K5.

All the three treated strain of tilapia at 15ppt showed low growth rate which was lower than the both zero and 5ppt salinity for growth rate. No significant variation was recorded during the study for the three tested fish for both length and growth rate through the 60 days (Figure 3 a and b)

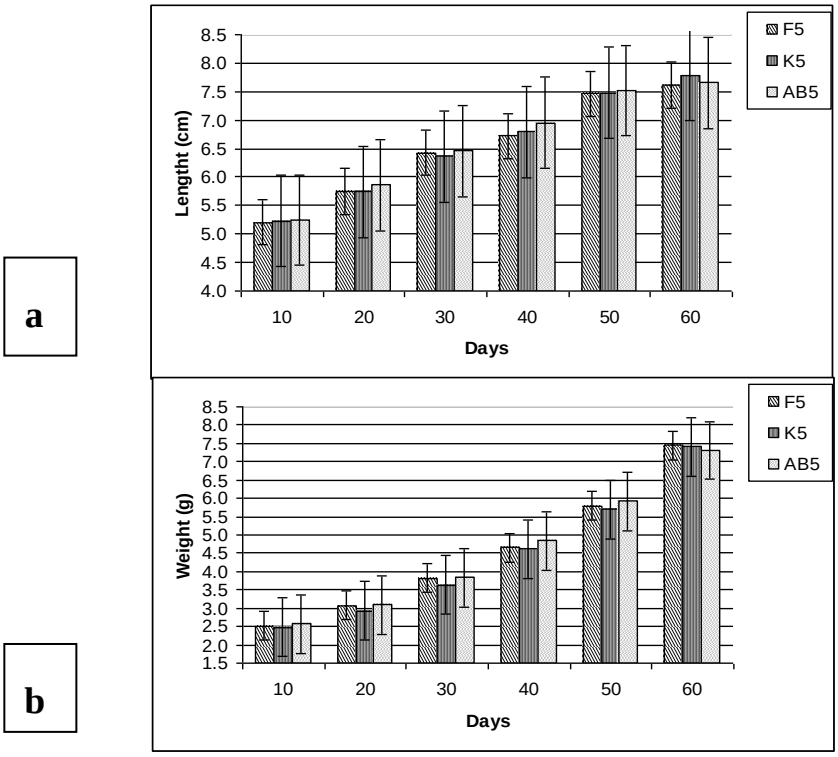

Figure 2. ***Mean growth rate (±SE) for Nile tilapia Oreochromis niloticus from Fayom (F), Kafr El-Sheikh (K) and Abbassa (AB) for 60 days at 5ppt salinity, (a) length and (b) weight.***

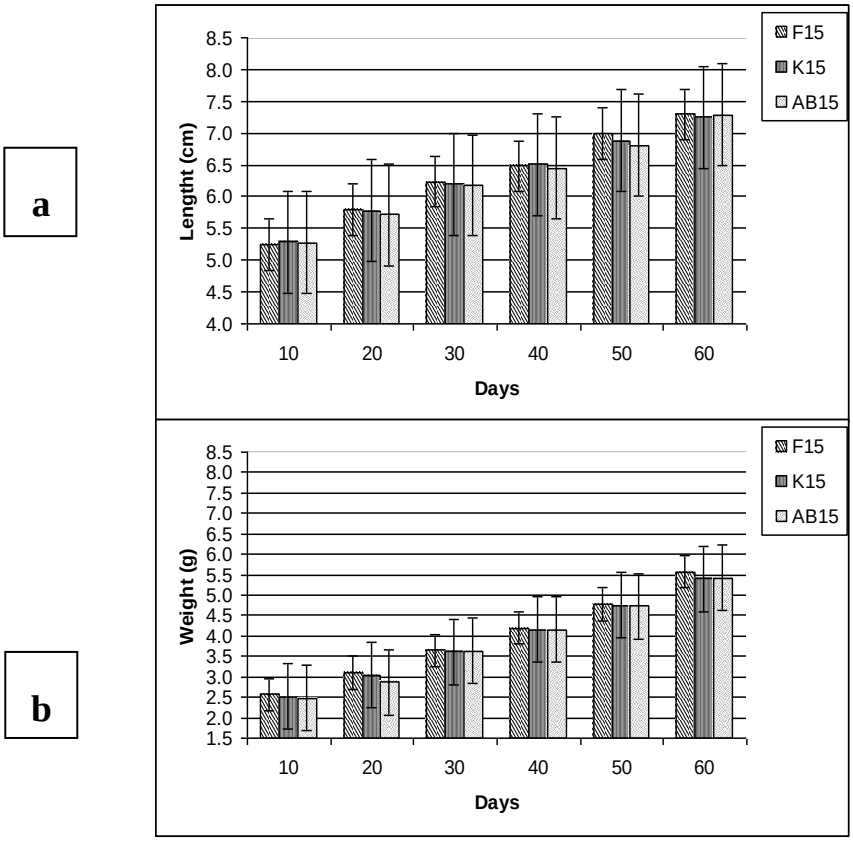

Figure 3. ***Mean growth rate (±SE) for Nile tilapia Oreochromis niloticus from Fayom (F), Kafr El-Sheikh (K) and Abbassa (AB) for 60 days at 15ppt salinity, (a) length and (b) weight***

Growth in freshwater

The stressed fish when return again to fresh water for studying the effect of stress on growth rate in this environment. The tested strains of tilapia exhibited significant variation ($P<0.0001$) for both growth rate and length (Figure 4 a&b)

For the first twenty days F5 strain showed higher growth rate than those the other strains. In the same time AB5 had the lowest growth rate during the whole experiment period (60 days) and significantly difference from all tested fish.

At recovery to fresh water from 15ppt, all tested fish revealed significant variation ($P<0.001$) for length and growth rate (Figure 5 a&b). The highest mean weight was recorded for FR15 and the lowest for ABR15.

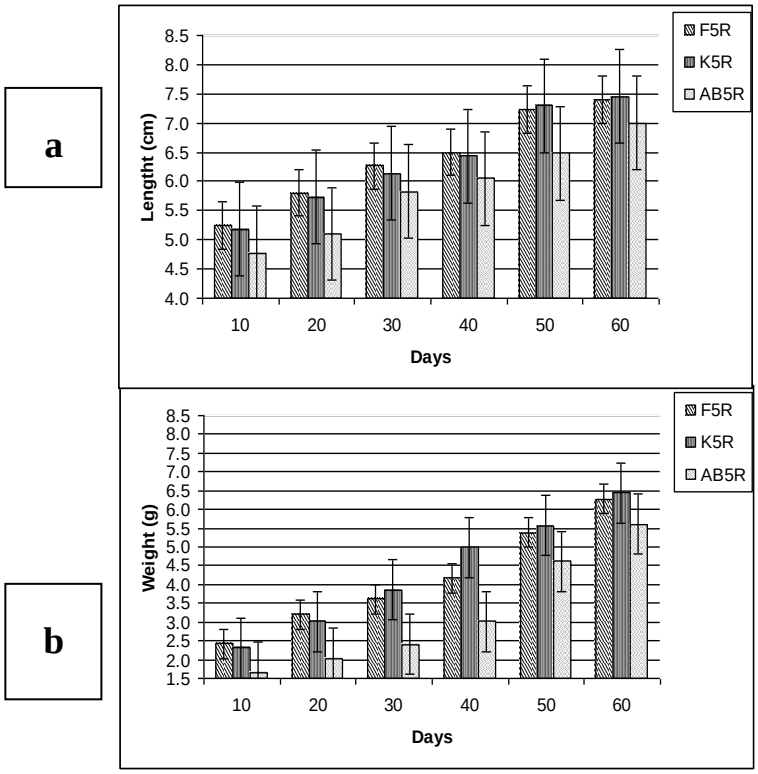

Figure 4. ***Mean growth rate (±SE) for Nile tilapia Oreochromis niloticus from Fayom (F), Kafr El-Sheikh (K) and Abbassa (AB) for 60 days at fresh water after salinity stress at 5ppt salinity, (a) length and (b) weight***

DISCUSSION

The results of this investigation showed variation in related to the weight and length.

Changes in weight are relatively grater than changes in length. The present investigation revealed that the introduced strains from Egyptian Nile tilapia *Oreochromis niloticus* from Fayom, Kafr El-Sheik had higher growth rate than those from Abbassa at zero salinity. The variation among the strain which were collected from different hatches in Egypt was due the genetic variation among tilapia strains as reported by Kamel 1999. This result in the same line with Rezk and Kamel, 2010 who reported that The mean body weight for four strain of *O. niloticus* and their crosses at harvest were significantly different ($P<0.01$).

The growth rate at 5ppt was higher which in parallel with Villegas (1990) reported that its highest growth is achieved at 0-10 ppt. The Nile tilapia

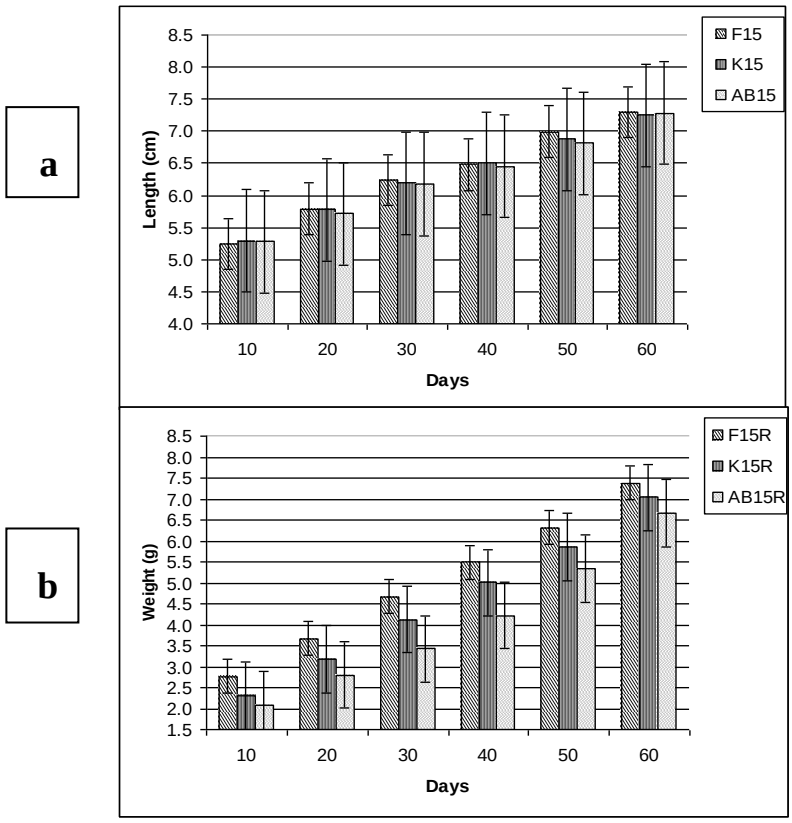

Figure 5. ***Mean growth rate (±SE) for Nile tilapia Oreochromis niloticus from Fayom (F), Kafr El-Sheikh (K) and Abbassa (AB) for 60 days at fresh water after salinity stress at 15ppt salinity, (a) length and (b) weight***

exhibits a moderate tolerance to salinity with 60 d fish surviving direct transfer up to 25 ppt (Watanabe *et al.*, 1985).

On the other hand, 5ppt and R15 (returned to fresh water after direct transfer to salinity stress at 15 ppt) tested strain revealed higher growth rate than other salinity and recovery. This indicated that even though the tilapias were collected from different location tilapia has the ability to grow in low salinity as well as freshwater. Fayoum strain had the highest growth rate at 5ppt and F15R. Overall, growth was higher for all genotypes at elevated salinities with O. niloticus relatively faster growing at low salinity (Kamel and Mair, 2005). The tilapia, even the less saline tolerant *O. niloticus*, appeared to grow as well as or better at moderate salinities than in freshwater (Kamel and Mair, 2005;

Suresh and Lin, 1992). Differences in growth for Tilapia observed between environments with varying salinity (Massou *et al.,* 2004)

Growth rate of the Thai strain ranked second in both fresh- and saline water

All strain tested at 15ppt showed inhibition in the growth rate. Nile tilapia acutely transferred from freshwater to salinities up to 20 ppt showed that salinity significantly affected growth of Nile tilapia (Schofield *et al.,* 2011). Also Villegas (1990 a&b) observed a continued decline in weight gain in 45-day old *O. niloticus* fry stocked in 0.5 m3 cages as salinity increased from 0 to 32 ppt. The tolerance to salt water is often negatively correlated with the growth capacity. For example, *Oreochromis niloticus* is considered to be a species which grows particularly well but has a very low tolerance to salinity. Conversely, species such as *Sarotherodon melanotheron* and *O. mossambicus* which have naturally low growth capacities tolerate a salinity of 80–117 g- ^{1} in the wild, which is considered to be among the highest levels known in tilapia species (Green, 1997).

The salinity influence on the growth in the early life of three West African fish species (*Ethmalosa fimbriata, Sarotherodon melanotheron*, and *Tilapia guineensis)*. The results showed that salinity has different influence on the growth of each species. *Ethmalosa fimbriata* has the highest growth during the first 180 days in the freshwaters, indicating growth inhibition in the hyperhaline areas. For Tilapia and *Sarotherodon* species no growth difference were found (Labonne *et al.,* 2009).

In brackishwater, Mississippi commercial strain tilapia (MCS), and Florida red tilapia (FRT) all yields and mean weights were lower than in freshwater While in brackishwater, blue tilapia had a yield of 0.07 ±0.13 kg/m² and a mean weight of 72 ±124 g, which were significantly higher (Patricio, 2004)

Fish performed better in freshwater than in the saline water environment Among the pure strains, the red tilapia originating from Malaysia had the greatest growth rate in freshwater, whereas the strain from Taiwan ranked highest in saline water. In both fresh- and saline water, growth of red tilapia from Stirling was lowest. Growth of red tilapia strains was significantly lower in saline than in freshwater environments Pongthana *et al.,* (2010). Tilapia hybrids that contain a genetic component of *O. mossambicus. hornorum* are perceived to have a high euryhaline capacity, thus

exhibiting greater growth and better feed utilization efficiency in saltwater than those of *O. niloticus* derived origins (Watanabe *et al.*, 2006). The GIFT strain in the three experiments had higher mean body weight than non selected fish (Ridah, 2008).

The tolerance to salt water is often negatively correlated with the growth capacity. For example, *Oreochromis niloticus* is considered to be a species which grows particularly well but has a very low tolerance to salinity (Green, 1997). Genetically modified *O. niloticus* treated with sea bream-DNA reared at different levels of salinities up to 16 ppt had significantly higher ($P > 0.05$) final body weight than the genetically modified *O. niloticus* treated with Artemia-DNA and the control fish group (El-Zaeem *et al.*, 2011). Generally, with increasing salinity of up to 32 ppt, the growth performance decreased. This may be attributed to the increase in energy cost of osmoregulation at high salinity level. Morgan and Iwama (1991), Toepfer and Barton (1992) and Grau *et al.*, (1994) reported that, there is an increasing metabolic rate of osmoregulatory activitiesat high salinity. Furthermore, Rao (1968) noted that, osmoregulation appears to use a high proportion of the available energy ranging from 20 to 50% of total energy expenditure, depending on the environmental salinity.

In some tilapia species grown in 50% seawater, the growth performance was better or similar to that obtained in the same species reared in freshwater (Suresh and Lin 1992). Its highest growth is achieved at 0-10 ppt (Villegas, 1990 a&b). The growth performance of red tilapia was significantly lower in saline than in freshwater environments ($P<0.01$) the red tilapia originating from Malaysia had the greatest growth rate in freshwater, whereas the strain from Taiwan ranked highest in saline water. Growth rate of the Thai strain ranked second in both fresh- and saline water (Pongthana *et al.*, 2010)

CONCLUSION

It was recommended from this study that the growth rate at 5 ppt saline water is better than freshwater. The recovered fish after 15ppt salinity stress exhibited higher growth rate. The variation between tilapia strains to tolerate salinity stress provide information that help in collecting and starting base population for selection program for salinity tolerance of tilapia. The results also indicated that tilapia has the ability to tolerate salinity fluctuation resulting from climate changes and drought.

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تأثير الإجهاد الملحى على نمو ثلاث سلالات من البلطى النيلى المصرى

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أجريت هذه الدراسة فى المعمل المركزى لبحوث الثروة السمكية (العباسة – مصـــر) لتحديد كفاءة معدل النمو لثلاث سلالات من البلطى النيلى فى مصر (الفيـــوم ، كفـــر الشيخ والعباسة) وذلك بعد الإجهاد الملحى فى ثلاث مستويات من الملوحة (صفر ، ٥ و ١٥ جزء فى الألف). تم تجميع زريعة فى مرحلة كيس المح من كل سلالة وذلـــك لتفادى وتقليل تأثير العمر على الاسماك المستخدمة فى هذه الدراسة وتم تحضينها فـــى هابات منفصـــلة حتـــى وصـــلت الـــى متوســـط وزن ١,٩٤ ± ٠,٠٦ للعباســـة و ١,٩٥±٠,٠٦ للفيوم و ١,٩٣± ٠,٠٨ جرام لكفر الشيخ تم نقل اسماك السلالات المستخدمة فى هذه الدراسة من المياه العذبة الى الميـــاه المالحـــة مباشـــرة لـــثلاث مستويات من الملوحة بثلاث مكررات لكل منها فى احواض زجاجية لمدة ٩٦ ساعة . تم تجميع عشر سمكات عشوائيا من كل سلالة بعد الاجهاد لكل حوض رجاجى وذلك لدراسة النمو اما فى نفس الملوحة المستخدمة للاجهاد او مياة عذبة (ثلاث مكـــررات لكل معاملة) . وتم قياس الوزن والطول للأسماك وتم تغذية الأسماك على علف ٣٢% بروتين لمدة ٦٠ يوم. بمعدل مرتين يوميا وتم اخذ عينات الأسماك كـــل عشـــرة أيـــام وتعديل العلف تبعا للوزن.

أوضحت النتائج أن جميع السلالات اظهرت فروقا معنوية إحصائيا بالنسبة للـــوزن والطول فى المياة صفر فى الألف ملوحة.

وبالرغم ان العباسة اظهرت معدلات اعلى فى النمو حلال الفترة من اليوم العاشر حتى اليوم الخمسين فى ٥ جزء فى الالف ملوحة الا انها بدأت فى الانخفاض بعد ذلك وفى نهاية التجربة كانت العباسة اقل السلالات نموا ولكنه كان فرقا غير معنويا .

بالنسبة للملوحة ١٥ جزء فى الالف كل السلالات المستخدمة اظهرت نموا ضعيفا بالمقارنة بالصفر و٥ جزء فى الألف ملوحة. لم يلاحظ اى فروقا معنويا بالنسبة للطول أو الوزن بين السلالات فى هذة المعاملة.

أما بالنسبة لأسماك التى تم نموها فى مياه عذبة بعد إجهاد ملحى ٥ جزء فى الألف ملوحة فقد اظهرت فروق معنوية بالنسبة للوزن والطول فى السلالات الثلاث المستخدمة.

أما بالنسبة لاسماك التى تم نموها فى مياه عذبة بعد إجهاد ملحى ١٥جزء فى الالف ملوحة فقد اظهرت فروق معنوية بالنسبة للوزن والطول فى السلالات الثلاث المستخدمة وأعلى معدل نمو كان فى سلالة الفيوم بينما أقل نمو كان فى سلالة العباسة.

يتضح من هذه الدراسة ان السلات أظهرت نموا أعلى فى ٥ جزء فى الألف ملوحة وكذلك الأسماك التى تم نموها فى مياه عذبة بعد إجهاد ملحى ١٥جزء فى الألف بالمقارنة بالمعاملات الأخرى فى المياه المالحة والعذبة.

وبالرغم أن السلالات تم تجميعا من مناطق مختلفة الإ أنها لديها المقدرة أن تنمو فى ملوحة ٥ جزء فى الالف. كما كان هناك تثبيط للنمو لكل السلالات فى ١٥جزء فى الالف ملوحة.

تخلص هذه الدراسة إلى أن الملوحة ٥ جزء فى الألف ملوحة هى الأفضل لنمو سلالات البلطى الثلاث المستخدمة فى هذه الدراسة عن المياه العذبة وأن الإجهاد الملحى ١٥جزء فى الألف ملوحة ثم عودة الأسماك للمياه العذبة ليس له تأثير على

معدلات النمو الإختلافات فى تحمل سلالات البلطى للملوحة يعطى معلومات ويساعد فى تجميع أسماك من البلطى لبدء برنامج تحسين وراثى لتحمل أسماك البلطى النيلى للملوحة وأيضا النتائج اوضحت أن سلالات البلطى لديها المقدرة على النمو وتحمل التذبذب فى درحات الملوحة الناتجة من التغيرات المناخية والجفاف.