

Review Article

LONG-TERM COMBINED EFFECTS OF SALINITY AND TEMPERATURE ON THE GROWTH OF JUVENILE RED TILAPIA (*OREOCHROMIS NILOTICUS*)

Abdullahi Dauda Kida,¹², Amir Shah Ruddin M.S¹

¹School of Biological Sciences Universiti Sains Malaysia Pulau Pinang

² Department of Fishery and Aquaculture Federal University Wukari, Taraba state, Nigeria

Corresponding Author: Abdullahi Dauda Kida abdulahidaudakida1@gmail.com

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Abstract

Over the last decades, there was growing evidence that the climatic change has greatly altered environmental conditions in many aquatic systems. Salinity and temperature are among the ecological factors that are specific to aquatic environment. Dominant environmental factors affecting marine finfish larvae are temperature and salinity that have a significant impact on growth rate, development and survival of marine fish. Red tilapia (*Oreochromis niloticus*) juveniles of two hundred and eighty fish were used in this study averaging 14.28±0.16g in weight. Each tank contains 10 fish in triplicate for a period of 120 days using 4x3 factorial design. Four temperature levels 28, 30 and 32 while salinity level of 5, 10, 15 and 20 respectively. There were significant differences in the growth among all treatment. At 28°C, the best value of body gain in weight was recorded with salinity of 5ppt treatment was 8.6=0.05g and 28°C with salinity of 5ppt treatment which was 7.20=0.22g. Salinity seems to have a stronger effect than temperature on the growth of red juvenile tilapia.

Key words: Red tilapia, Temperature, Salinity, Factorial Design, Growth Marine

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INTRODUCTION

Sensitive to temperature tilapias are at 28°C and 32°C optimum growth is usually achieved with decreasing temperature growth declines greatly and it growth is about 30% optimum at 20°C to 22°C (Teichert-Coddington *et al.*, 1997). At a temperature less than 16 or 17°C feeding usually stop and are lethal below temperature 10-11°C. The water temperature should be at least 20°C, in order to breed tilapias (Balarin, 1979). At 16°C certain species like Tilapia Sparrmanii are able to reproduce (Chimits, P., 1959). (Predominance of male phenotype) significant deviations of sex ratio were observed in both normal phenotypic (Baroiller *et al.*, 1995) and female genotypic monosex (Baroiller *et al.*, 1996) at 34-35°C is the fry of *Oreochromis niloticus* reared. Resulting from high temperature treatment functional masculinization was demonstrated in this species with XY sex determination (Baroiller *et al.*, 1995). In the related, *O. aureus*, the relevance of this mechanism was investigated, leaving under similar thermal regimes in natural environments (Trewavas, E., 1982). The effect of extreme temperatures (21-34°C) was investigated on the sex ration of *O. aureus* prohenies (Desprez and Melard, 1998).

Fingerlings are usually produced indoors during the colder months to maximize the grow-out season and stocked during the periods of warmer summer. Of most tilapia species the optimal temperature for the growth is between 25 and 28°C (Cnaani *et al.*, 1989) large components of the trait's variance was a result of dominance effects by studying some tilapia species and their hybrids. (Tave *et al.*, 1989), (Tave *et al.*, 1990) and (Behrends *et al.*, 1990) in Nile tilapia *O. niloticus* suggested that cold tolerance is controlled by additive genes.

(FAO, 2002) of the total global production report tilapia production in brackish water rose from 8.1% to 13.7% of tilapia strains well suited to brackish water salinity there is growing interest in the identification as a result.

MATERIALS AND METHOD

The fish were brought from a reputable fish farm located at kedah, Malaysia. The experimental fish were acclimatized in

fibre glass aquariums in the department of biological science laboratory of universiti sains Malaysia for 7 days. There were three treatment and a control. 4x3 factorial design was adapted temperatures (28,30 and 32) and salinity levels (5,10,15 and 20ppt) All the treatments including control experiment were triplicated. Treatment; T₁, T₂,T₃, T₄, and T₅ had salinity levels respectively, while control was normal bore hole water. The experiment was conducted in a fibre glass aquariums (30cm x 60cm x 62cm length x width x depth) for four months. All the aquariums indiscriminately distributed to each treatment group in a manner that each contained three aquariums distributed among the replicates of other treatments and to prevent repeatable error' Each aquarium has a stocking density of 10 fish weighing from 5g to 9g. Salinity levels were maintained throughout the period of the experiment by regular addition of salt by following its measurement with YSI meter 85 to ensure the salinity levels is maintain on daily basis. At the time of stocking, all the fish were measured and individual weighed. Water quality parameters like dissolved oxygen, temperature by DO meter YSI meter, pH was recorded using pH meter. Conductivity and total dissolved solids by salinity meter on daily basis every morning at exactly 11:00am.

Fish mortality was observed on daily basis. The data collected from the successful completion of the trial were subjected to analysis of variance (ANOVA). Pearson Correlation method was used to compare and find interaction effects between different parameters tested during the study. The level of significance (P<0.05) among means were compared by Duncan's new multiple range test (Duncan, D. B, 1955).

RESULT AND DISCUSSION

Effects of different temperature and salinity on red tilapia final weight(g) and average gain in weight(g) during the research are shown in Table 1, 2 and 3. There were no significant differences (P>0.05) in this initial body weight for the different temperatures and salinities tested at the beginning of the experiment.

Average final body weight was affected significantly (P<0.05) at the end of the experiment. Highest average final weight of the

fish was taken for (temperature 28°C and salinity 20ppt) treatment (Table 4). The lowest average final body weight of the fish was recorded for (temperature 28°C and salinity 15ppt) treatment. For the different temperature observed there was no significant differences in the final body weight.

(Domingues *et al.*, 2004) reported for rearing of *O. niloticus* the optimal temperature ranges from 25°C to 29°C. For the production of the circulating proteins there may be a particular temperature range which is suitable. Fish may be able although to tolerate in the condition of higher temperature of 32°C.

Decrease ability to react to physiological stress may be. Research have shown of thermal sensitivity is related to the fish growth rate. At a low temperature fish from higher latitude grow relatively faster than fish from low latitude (Angilletta *et al.*, 2002).

Performance growth parameters (Body gain in weight, relative gain in weight, initial weight, final weight, average daily body gain in weight, specific growth rate and condition factor) of red tilapia (*O. niloticus*) are shown in Table 4 and 5.

Table 1: Effect of salinity and temperature on the growth of red tilapia

| | | Body weight changes through the exp. (weeks)* | | | | | | | | |
|--------|---------|---|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|-------------------------|
| T (°C) | S (ppt) | Initial weight (g/fish) | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 |
| 28 | 0 | 6.3±1.10 | 5.6±0.11 | 5.4±0.46 | 5.8±0.81 | 5.7±0.91 | 5.8±1.01 | 5.9±1.08 | 5.8±1.20 | 5.9±1.28 |
| | 5 | 11.8 ^a ±0.10 | 10.8 ^f ±0.14 | 10.5 ^e ±0.71 | 10.8 ^e ±0.28 | 11.0 ^f ±1.41 | 11.3 ^e ±0.99 | 11.9 ^e ±0.14 | 12.4 ^d ±0.78 | 14.3 ^e ±0.42 |
| | 10 | 12.6 ^a ±0.56 | 15.5 ^a ±1.41 | 15.6 ^a ±0.17 | 16.4 ^a ±0.57 | 16.6 ^a ±2.26 | 16.9 ^a ±1.27 | 17.2 ^b ±3.11 | 17.6 ^b ±0.57 | 17.9 ^b ±0.14 |
| | 15 | 12.7 ^a ±0.27 | 14.0 ^c ±1.41 | 13.5 ^b ±2.12 | 14.4 ^b ±0.57 | 14.5 ^c ±0.71 | 14.8 ^b ±1.13 | 15.5 ^c ±0.71 | 15.9 ^c ±0.14 | 15.9 ^c ±0.85 |
| | 20 | 11.9 ^a ±0.13 | 12.2 ^e ±1.13 | 13.1 ^b ±1.27 | 14.3 ^b ±1.84 | 14.7 ^c ±0.42 | 15.7 ^b ±0.99 | 18.3 ^a ±0.42 | 19.1 ^a ±2.69 | 19.5 ^a ±0.71 |
| 30 | 0 | 6.3±1.10 | 5.6±0.11 | 5.4±0.46 | 5.8±0.81 | 5.7±0.91 | 5.8±1.01 | 5.9±1.08 | 5.8±1.20 | 5.9±1.28 |
| | 5 | 12.2 ^a ±0.11 | 11.1 ^e ±1.56 | 11.3 ^d ±0.99 | 11.4 ^d ±0.57 | 11.8 ^e ±0.28 | 12.5 ^d ±2.12 | 13.9 ^d ±0.28 | 14.4 ^c ±0.85 | 15.9 ^c ±1.77 |
| | 10 | 12.2 ^a ±0.78 | 11.2 ^e ±0.28 | 11.2 ^d ±1.13 | 12.1 ^c ±0.14 | 12.3 ^e ±0.42 | 13.0 ^d ±2.12 | 13.8 ^d ±1.27 | 14.1 ^c ±1.27 | 16.7 ^c ±0.42 |
| | 15 | 12.4 ^a ±0.58 | 14.0 ^c ±2.83 | 14.6 ^a ±0.85 | 15.2 ^a ±1.13 | 15.3 ^b ±0.42 | 15.2 ^b ±3.82 | 15.9 ^c ±1.27 | 16.4 ^b ±0.57 | 17.0 ^b ±1.41 |
| | 20 | 12.3 ^a ±0.96 | 14.8 ^b ±0.28 | 15.1 ^a ±1.27 | 15.9 ^a ±2.69 | 16.5 ^a ±2.12 | 17.2 ^a ±2.97 | 18.1 ^a ±2.83 | 18.2 ^a ±1.13 | 18.5 ^a ±0.71 |
| 32 | 0 | 6.3±1.10 | 5.6±0.11 | 5.4±0.46 | 5.8±0.81 | 5.7±0.91 | 5.8±1.01 | 5.9±1.08 | 5.8±1.20 | 5.9±1.28 |
| | 5 | 12.3 ^a ±0.45 | 14.2 ^b ±1.13 | 14.9 ^a ±0.14 | 15.8 ^a ±1.13 | 16.0 ^a ±0.00 | 16.4 ^a ±2.26 | 17.2 ^b ±1.56 | 17.3 ^b ±3.25 | 17.4 ^b ±3.39 |
| | 10 | 12.5 ^a ±0.11 | 12.5 ^e ±0.71 | 12.8 ^c ±1.13 | 12.6 ^c ±0.85 | 13.3 ^d ±1.13 | 14.1 ^c ±1.27 | 15.0 ^c ±0.71 | 15.5 ^c ±0.71 | 16.0 ^c ±1.41 |
| | 15 | 11.9 ^a ±0.10 | 11.0 ^e ±0.71 | 11.1 ^d ±1.27 | 11.5 ^d ±2.12 | 12.0 ^e ±1.41 | 12.9 ^d ±0.14 | 13.9 ^d ±1.57 | 15.5 ^d ±0.71 | 16.3 ^c ±1.98 |
| | 20 | 12.3 ^a ±0.35 | 13.6 ^d ±0.75 | 13.9 ^b ±0.14 | 14.1 ^b ±1.27 | 14.7 ^c ±0.42 | 14.8 ^c ±1.70 | 15.5 ^c ±0.71 | 16.2 ^c ±0.28 | 18.3 ^a ±0.99 |

- Data are represented as mean± standard deviation

* Value in columns having the same superscript letters are not significant different ($P = 0.05$)

Table 2: Effect of salinity and temperature (individually) on the growth of red tilapia (*O. niloticus*) during the experimental periods (120 days)

| | | Body weight changes through the exp. (weeks)* | | | | | | | | |
|-----------------------|--------------------|---|------------|------------|------------|------------|------------|------------|------------|--|
| Classification | Initial weight (g) | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 | |
| Temperature (°C): N.S | | | | | | | | | | |
| 28 | 12.25±0.47 | 13.13±2.05 | 13.18±2.09 | 13.98±2.33 | 14.20±2.23 | 14.68±2.41 | 15.73±2.80 | 16.25±2.88 | 16.90±2.27 | |
| 30 | 12.28±0.10 | 12.78±1.91 | 13.05±2.09 | 13.65±2.33 | 13.98±2.29 | 14.48±2.16 | 15.43±2.03 | 15.78±1.91 | 17.03±1.09 | |
| 32 | 12.25±0.25 | 12.83±1.41 | 13.18±1.63 | 13.50±1.87 | 14.00±1.73 | 14.55±1.46 | 15.40±1.37 | 16.13±0.85 | 17.00±1.06 | |
| Salinity (ppt): N.S | | | | | | | | | | |

LONG-TERM COMBINED EFFECTS OF SALINITY AND TEMPERATURE ON THE GROWTH OF JUVENILE RED TILAPIA
(*OREOCHROMIS NILOTICUS*)

| | | | | | | | | | |
|------|------------|------------|------------|------------|------------|------------|------------|------------|--------------------------|
| 0 | 6.3±1.10 | 5.6±0.11 | 5.4±0.46 | 5.8±0.81 | 5.7±0.91 | 5.8±1.01 | 5.9±1.08 | 5.8±1.20 | 5.9±1.28 |
| 5 | 12.10±0.26 | 12.03±1.88 | 12.23±2.34 | 12.67±2.73 | 12.93±2.69 | 13.40±2.67 | 14.33±2.68 | 14.70±2.46 | 15.87 ^b ±1.55 |
| 10 | 12.43±0.21 | 13.07±2.21 | 13.20±2.23 | 13.70±2.35 | 14.07±2.25 | 14.67±2.01 | 15.33±1.72 | 15.73±1.76 | 16.87 ^b ±0.96 |
| 15 | 12.33±0.40 | 13.00±1.73 | 13.07±1.79 | 13.70±1.95 | 14.27±1.86 | 14.30±1.23 | 15.10±1.06 | 15.93±0.45 | 16.40 ^b ±0.56 |
| 20 | 12.17±0.23 | 13.53±1.30 | 14.03±1.01 | 14.77±0.99 | 15.30±1.04 | 15.90±1.21 | 17.30±1.56 | 17.83±1.48 | 18.77 ^a ±0.64 |
| TxS: | N.S | * | * | * | * | * | * | * | * |

- Data are represented as mean± standard deviation

N.S: ($P > 0.05$) *: Significant level ($P < 0.05$)

Table 3: Effect of salinity and temperature (individually) on the growth of red tilapia (*O. niloticus*) during the experimental periods (120 days)

| Body weight changes through the exp. (weeks)* | | | | | | | | | |
|---|--------------------|------------|-----------|-----------|-----------|-----------|-----------|-----------|-----------|
| Classification | Initial weight (g) | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 |
| Temperature (°C): N.S | | | | | | | | | |
| 28 | 12.25±0.47 | 0.88±0.80 | 0.05±0.58 | 0.80±0.37 | 0.22±0.12 | 0.48±0.35 | 1.05±0.04 | 0.52±0.18 | 0.65±0.85 |
| 30 | 12.28±0.10 | 0.50±0.72 | 0.27±0.24 | 0.60±0.38 | 0.33±0.22 | 0.50±0.40 | 0.95±0.31 | 0.35±0.29 | 1.25±0.03 |
| 32 | 12.25±0.25 | 0.58±0.42 | 0.35±0.10 | 0.32±0.41 | 0.50±0.08 | 0.55±0.36 | 0.85±0.12 | 0.73±0.64 | 0.87±0.87 |
| Salinity (ppt): N.S | | | | | | | | | |
| 0 | 6.3±1.10 | 5.6±0.11 | 5.4±0.46 | 5.8±0.81 | 5.7±0.91 | 5.8±1.01 | 5.9±1.08 | 5.8±1.20 | 5.9±1.28 |
| 5 | 12.10±0.26 | -0.07±0.74 | 0.20±0.06 | 0.44±0.40 | 0.26±0.20 | 0.47±0.23 | 0.93±0.40 | 0.37±0.23 | 1.17±0.95 |
| 10 | 12.43±0.21 | 0.64±0.03 | 0.13±0.15 | 0.50±0.59 | 0.37±0.29 | 0.60±0.26 | 0.66±0.32 | 0.40±0.10 | 1.14±0.27 |
| 15 | 12.33±0.40 | 0.67±0.37 | 0.07±0.54 | 0.63±0.38 | 0.57±0.23 | 0.03±0.50 | 0.80±0.17 | 0.83±0.67 | 0.47±0.41 |
| 20 | 12.17±0.23 | 1.36±0.12 | 0.50±0.07 | 0.74±0.13 | 0.53±0.11 | 0.60±0.10 | 1.40±0.50 | 0.53±0.10 | 0.94±0.14 |
| TxS: | N.S | * | * | * | * | * | * | * | * |

- Data are represented as mean± standard deviation

N.S: ($P > 0.05$) *: Significant level ($P < 0.05$)

Table 4: Summary of growth parameters at different salinities and temperatures of red tilapia (*O. niloticus*)

| T (°C) | S (ppt) | Growth performance | | | |
|--------|---------|-------------------------|-------------------------|--------------------------|---------------------------|
| | | Initial weight (g/fish) | Final weight (g/fish) | Body gain in weight (g) | Relative gain in weight % |
| 28 | 5 | 11.8 ^a ±0.10 | 14.3 ^e ±0.42 | 2.50 ^g ±0.34 | 21.19 ^h ±0.10 |
| | 10 | 12.6 ^a ±0.56 | 17.9 ^b ±0.14 | 5.30 ^{cd} ±0.10 | 42.06 ^c ±0.68 |
| | 15 | 12.7 ^a ±0.27 | 15.9 ^c ±0.85 | 3.20 ^f ±0.77 | 25.20 ^f ±0.23 |
| | 20 | 11.9 ^a ±0.13 | 19.5 ^a ±0.71 | 7.60 ^a ±0.05 | 63.87 ^a ±0.18 |
| 30 | 5 | 12.2 ^a ±0.11 | 15.9 ^c ±1.77 | 3.70 ^e ±0.77 | 30.33 ^e ±0.78 |

| | | | | | |
|----|----|-------------------------|-------------------------|--------------------------|---------------------------|
| | 10 | 12.2 ^a ±0.78 | 16.7 ^c ±0.42 | 4.50 ^{de} ±0.59 | 36.89 ^{de} ±0.36 |
| | 15 | 12.4 ^a ±0.58 | 17.0 ^b ±1.41 | 4.60 ^{de} ±0.06 | 37.10 ^{de} ±0.98 |
| | 20 | 12.3 ^a ±0.96 | 18.5 ^a ±0.71 | 6.20 ^b ±0.21 | 50.41 ^b ±0.78 |
| 32 | 5 | 12.3 ^a ±0.45 | 17.4 ^b ±3.39 | 5.10 ^{cd} ±0.10 | 41.46 ^c ±0.11 |
| | 10 | 12.5 ^a ±0.11 | 16.0 ^c ±1.41 | 3.50 ^f ±0.33 | 28.00 ^f ±0.78 |
| | 15 | 11.9 ^a ±0.10 | 16.3 ^c ±1.98 | 4.40 ^{de} ±0.27 | 36.97 ^d ±0.12 |
| | 20 | 12.3 ^a ±0.35 | 18.3 ^b ±0.25 | 6.00 ^c ±0.06 | 48.78 ^{bc} ±0.75 |

- Data are represented as mean± standard deviation

*Value in columns having the same superscript letters are not significantly different ($P = 0.05$)

Continue of Table 4: Summary of growth parameters (Mean ± SD) at different salinities and temperatures of red tilapia (*O. niloticus*)

| | | Growth performance | | | |
|--------|---------|----------------------------------|------------------------------------|--------------------------|--------------|
| T (°C) | S (ppt) | Average daily gain in weight (g) | Specific growth rate (%growth/day) | Condition factor (K %) | Survival (%) |
| 28 | 5 | 0.04 ^f ±0.01 | 0.34 ^g ±0.10 | 1.93 ^a ±0.13 | 80 |
| | 10 | 0.09 ^c ±0.05 | 0.63 ^c ±0.25 | 1.75 ^c ±0.25 | 90 |
| | 15 | 0.06 ^e ±0.04 | 0.40 ^f ±0.35 | 1.53 ^c ±0.87 | 80 |
| | 20 | 0.14 ^a ±0.03 | 0.88 ^a ±0.48 | 1.38 ^g ±0.49 | 40 |
| 30 | 5 | 0.07 ^{de} ±0.05 | 0.47 ^{de} ±0.57 | 1.81 ^b ±0.25 | 80 |
| | 10 | 0.08 ^d ±0.05 | 0.56 ^d ±0.45 | 1.57 ^{de} ±0.48 | 100 |
| | 15 | 0.08 ^d ±0.02 | 0.56 ^d ±0.12 | 1.62 ^{de} ±0.47 | 90 |
| | 20 | 0.11 ^b ±0.01 | 0.73 ^b ±0.36 | 1.98 ^b ±0.68 | 90 |
| 32 | 5 | 0.09 ^c ±0.02 | 0.62 ^c ±0.89 | 1.57 ^e ±0.45 | 100 |
| | 10 | 0.06 ^e ±0.05 | 0.44 ^e ±0.78 | 1.28 ^f ±0.75 | 60 |
| | 15 | 0.08 ^d ±0.08 | 0.56 ^d ±0.12 | 1.66 ^d ±0.22 | 100 |
| | 20 | 0.11 ^b ±0.10 | 0.71 ^{bc} ±0.11 | 1.25 ^g ±0.45 | 70 |

- Data are represented as mean± standard deviation

*Value in columns having the same superscript letters are not significantly different ($P = 0.05$)

Table 5: Effect of salinity and temperature on initial weight, final weight, body gain in weight, relative gain in weight and average daily weight gain of studied red tilapia

| | | Growth performance | | | |
|-----------------------|--------------------|--------------------------|-------------------------|---------------------------|----------------------------------|
| Classification | Initial weight (g) | Final weight (g/fish) | Body gain in weight (g) | Relative gain in weight % | Average daily gain in weight (g) |
| Temperature (°C): N.S | | | | | |
| 28 | 12.25±0.47 | 16.90±2.27 | 4.65±2.30 | 38.08±19.43 | 0.08±0.04 |
| 30 | 12.28±0.10 | 17.03±1.09 | 4.75±1.05 | 38.68±8.43 | 0.09±0.02 |
| 32 | 12.25±0.25 | 17.00±1.06 | 4.75±1.06 | 38.80±8.69 | 0.09±0.02 |
| Salinity (ppt): N.S | | | | | |
| 0 | 6.3±1.10 | 5.6±0.11 | 5.4±0.46 | 5.8±0.81 | 5.7±0.91 |
| 5 | 12.10±0.26 | 15.87 ^b ±1.55 | 3.77 ^d ±1.30 | 30.99 ^d ±10.15 | 0.07 ^c ±0.03 |

| | | | | | |
|------|------------|--------------------------|-------------------------|--------------------------|-------------------------|
| 10 | 12.43±0.21 | 16.87 ^b ±0.96 | 4.43 ^b ±0.90 | 35.65 ^b ±7.11 | 0.08 ^b ±0.02 |
| 15 | 12.33±0.40 | 16.40 ^b ±0.56 | 4.07 ^c ±0.76 | 33.09 ^c ±6.83 | 0.07 ^c ±0.01 |
| 20 | 12.17±0.23 | 18.77 ^a ±0.64 | 6.60 ^a ±0.87 | 54.35 ^a ±8.28 | 0.12 ^a ±0.02 |
| TxS: | N.S | * | * | * | * |

- Data are represented as mean± standard deviation

N.S: ($P > 0.05$) *: Significant level ($P < 0.05$)

Continue of Table 5: Effect of salinity and temperature on survival, initial length, final length, specific growth rate and condition factor red tilapia

| Classification | Growth parameters | | | | |
|-----------------------|---------------------------|-------------------------|---------------------------|------------------------------------|-------------------------|
| | Survival (%) | Initial length (cm) | Final length (cm) | Specific growth rate (%growth/day) | Condition factor (K %) |
| Temperature (°C): N.S | | | | | |
| 28 | 72.50±22.17 | 9.49±0.44 | 10.09±0.90 | 0.56±0.25 | 1.65±0.24 |
| 30 | 90.00±8.16 | 9.45±0.18 | 10.04±0.33 | 0.58±0.11 | 1.75±0.19 |
| 32 | 82.50±20.62 | 9.20±0.46 | 10.53±0.68 | 0.58±0.11 | 1.44±0.21 |
| Salinity (ppt): N.S | | | | | |
| 0 | 6.3±1.10 | 5.6±0.11 | 5.4±0.46 | 5.8±0.81 | 5.7±0.91 |
| 5 | 86.67 ^a ±11.55 | 9.39 ^a ±0.39 | 9.61 ^b ±0.58 | 0.48 ^b ±0.14 | 1.77 ^a ±0.18 |
| 10 | 83.33 ^a ±20.82 | 9.46 ^a ±0.39 | 10.35 ^{ab} ±0.36 | 0.54 ^b ±0.10 | 1.53 ^d ±0.24 |
| 15 | 90.00 ^a ±10.00 | 9.05 ^a ±0.34 | 9.93 ^b ±0.15 | 0.51 ^b ±0.09 | 1.60 ^b ±0.07 |
| 20 | 66.67 ^b ±25.17 | 9.62 ^a ±0.28 | 10.97 ^a ±0.55 | 0.77 ^a ±0.09 | 1.54 ^c ±0.39 |
| TxS: | * | * | * | * | * |

- Data are represented as mean± standard deviation

N.S: ($P > 0.05$) *: Significant level ($P < 0.05$)

The effect of salinity level (5, 10, 15 and 20) and temperature levels (28°C, 30°C and 32°C) on growth parameters of red tilapia after 16 weeks are presented on table 4. Results of the body gain in weight (g), specific growth rate (%growth/day), final weight (g/fish) and condition factor (K %) were significantly ($P < 0.05$) different. Minimum values of body gain in weight, final weight and relative gain in weight was recorded for (temperature 28°C and salinity 5ppt) treatment and the maximum value for (temperature 28°C and salinity 20ppt). The maximum values of average specific growth rate and daily gain in weight for (temperature 28°C and salinity 20ppt) treatment and the maximum values were recorded for (temperature 28°C and salinity 20ppt treatment).

Minimum condition factor value was recorded for (temperature 32°C and salinity 20ppt) treatment and maximum value recorded for (temperature 30°C and salinity 20ppt) treatment. In Table 5, there was significant different ($P < 0.05$) between salinity treatment but there was no significant different ($P < 0.05$) between temperature treatments. The interaction between temperature and salinity in all the parameters of growth were significant different ($P < 0.05$).

Red tilapia *Oreochromis niloticus* Survival (%) at different temperature and salinities during experimental period of 120 days was shown in Table 5 and at the end of experiment Table 6. Findings indicated that significant difference ($P < 0.05$) were seen in ammy red tilapia studied and improvement in survival was observed in (temperature 30°C and salinity 10ppt)

treatment, (temperature 32°C and salinity 5ppt) treatment and (temperature 32°C and salinity 10ppt) treatment and unimproved survival was in (temperature 26°C and salinity 30ppt) treatment. It has been reported for many marine fishes and freshwater. The existence of size-dependent over-winter mortality with smaller individuals being more susceptible than larger conspecifics (Sogard, 1997). Size effect on cold tolerance as non-significant for several tilapia specie and their hybrids has been reposted (Cnaani *et al.*, 2000) and (Cnaani *et al.*, 2003). However, Hofer and Watts (Hofer, S.C and S.A Watts, 2002) observed that smaller juveniles below 6g were more acute exposure and susceptible to lower temperature stress. (Atwood *et al.*, 2003) size significant affected cold tolerance in *O. niloticus* larger fish as indicated.

Major economic concern is the inability of tilapia to tolerate low temperature as it reduces their growing season and leads mortality in winter. Egyptian tilapia strain mortality has been reported from 13°C to 10°C (Lahav, E. and Z. Raanan, 1998) and from 11°C to 9°C (Khater, A.A and R.O Smitheman, 1998). However, (Sifa *et al.*, 2002) first mortality with better cold tolerance reported at 11°C and total mortality at 7.4°C of *O. niloticus* Egyptian strain used in China.

(Verdegen *et al.*, 1997) and (Mena-Herrera *et al.*, 2002) reported contrary to those by (Watanabe *et al.*, 1998) postulated that in high salinity environments red tilapia is capable of reaching a maximal growth rate. Growth pattern is related to an increase in the consumption of feed disregarding

the influence of growth performance on salinity. Among the studies difference may be explain partly by the fact that (Watanabe *et al.*, 1998). In a developmental stage when their growth much faster and feeding energy is greater than at later stages in small fish is used.

Salinity, among the ecological factors is specific to aquatic environment. On the growth capacities in fish many authors have demonstrated the influence of external salinity. For a lot of species this is true, including both freshwater fish and marine. Species, in fact not influenced by changes in salinity during their growth and development are rare. Many juveniles prefer intermediary salinities as it is also well known as found, e.g tidal coastal areas, estuaries or coastal lagoons.

CONCLUSION

At a higher salinities up to 30ppt with retention at temperature between 28°C and 32°C the red tilapia fish can be reared. Therefore temperature and salinity are two important factors affecting the culture of red tilapia *Oreochromis niloticus* but salinity is made to influence more of the growth and survival compared to temperature.

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