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

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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 grow 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 tilapia (Balarin, 1979). At 16°C certain species like Tilapia Sparmanni are able to reproduce (Chimits, P., 1959). Dominance effects of sex phenotype (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 provenies (Desprez and Melard, 1998).

Fingerlings are usually produced indoors during the colder months to maximize the grow out process 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 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 1:00am.

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.

| 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±0.10 | 10.8±0.14               | 10.5±0.71 | 10.8±0.28 | 11.0±1.41 | 11.3±0.99 | 11.9±0.14 | 12.4±0.78 | 14.3±0.42 |
| 10   | 12.6±0.56 | 15.5±1.14               | 15.6±0.17 | 16.4±0.57 | 16.6±2.26 | 16.9±1.27 | 17.2±3.11 | 17.6±0.57 | 17.9±0.14 |
| 15   | 12.7±0.27 | 14.0±1.41               | 13.5±2.12 | 14.4±0.57 | 14.5±0.71 | 14.8±1.13 | 15.5±0.71 | 15.9±0.14 | 15.9±0.85 |
| 20   | 11.9±0.13 | 12.2±1.13               | 13.1±1.27 | 14.3±1.84 | 14.7±0.42 | 15.7±0.99 | 18.3±0.42 | 19.1±2.69 | 19.5±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±0.11 | 11.1±1.56               | 11.3±0.99 | 11.4±0.57 | 11.8±0.28 | 12.5±2.12 | 13.9±0.28 | 14.4±0.85 | 15.9±1.77 |
| 10   | 12.2±0.78 | 11.2±0.28               | 11.2±1.13 | 12.1±0.14 | 12.3±0.42 | 13.0±2.12 | 13.8±1.27 | 14.1±1.27 | 16.7±0.42 |
| 15   | 12.4±0.58 | 14.0±2.83               | 14.6±0.85 | 15.2±1.13 | 15.3±0.42 | 15.2±3.82 | 15.9±1.27 | 16.4±0.57 | 17.0±1.41 |
| 20   | 12.3±0.96 | 14.8±0.28               | 15.1±1.27 | 15.9±2.69 | 16.5±2.12 | 17.2±2.97 | 18.1±2.83 | 18.2±1.13 | 18.5±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±0.45 | 14.2±1.13               | 14.9±0.14 | 15.8±1.13 | 16.0±0.00 | 16.4±2.26 | 17.2±1.56 | 17.3±3.25 | 17.4±3.39 |
| 10   | 12.5±0.11 | 12.5±0.71               | 12.8±1.13 | 12.6±0.85 | 13.3±1.13 | 14.1±1.27 | 15.0±0.71 | 15.5±0.71 | 16.0±1.41 |
| 15   | 11.9±0.10 | 11.0±0.71               | 11.1±1.27 | 11.5±2.12 | 12.0±1.41 | 12.9±0.14 | 13.9±1.57 | 15.5±0.71 | 16.3±1.98 |
| 20   | 12.3±0.35 | 13.6±0.75               | 13.9±0.14 | 14.1±1.27 | 14.7±0.42 | 14.8±1.70 | 15.5±0.71 | 16.2±0.28 | 18.3±0.99 |

Data are represented as mean± standard deviation

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

| Classification | Initial weight (g) | 2 | 4 | 6 | 8 | 10 | 12 | 14 | 16 |
|----------------|-------------------|---|---|---|---|----|----|----|----|
| Temperature (°C): N.S. | | | | | | | | | |
| 28  0  | 12.25±0.47 | 13.13±2.05 | 13.16±2.09 | 13.98±2.33 | 14.20±2.23 | 14.68±2.41 | 15.73±2.80 | 16.25±2.80 | 16.90±2.27 |
| 30  0  | 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  0  | 12.25±0.25 | 12.93±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
Table 3: Effect of salinity and temperature (individually) on the growth of red tilapia (*O. niloticus*) during the experimental periods (120 days)

| Classification | Temperature (°C): N.S | Salinity (ppt): N.S |
|----------------|------------------------|---------------------|
| 0              | 6.3±1.10               | 5.6±0.11            |
| 5              | 12.10±0.26             | 12.03±1.88          |
| 10             | 12.23±2.34             | 12.67±2.73          |
| 15             | 12.67±2.69             | 13.40±2.67          |
| 20             | 14.33±2.21             | 14.70±2.46          |

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) | Initial weight (g/fish) | Final weight (g/fish) | Body gain in weight (g) | Relative gain in weight % |
|--------|---------|-------------------------|-----------------------|-------------------------|---------------------------|
| 28     | 5       | 11.8±0.10               | 14.3±0.42             | 2.50±0.34               | 21.19±0.10                |
| 10     | 12.6±0.56 | 17.9±0.14             | 5.30±0.10             | 42.06±0.68              |
| 15     | 12.7±0.27 | 15.9±0.85              | 3.20±0.77             | 25.20±0.23              |
| 20     | 11.9±0.13 | 19.5±0.71              | 7.60±0.05             | 63.87±0.18              |
| 30     | 5       | 12.2±0.11               | 15.9±1.77             | 3.70±0.77               | 30.33±0.78                |

Data are represented as mean± standard deviation

N.S: (*P > 0.05*) *: Significant level (*P < 0.05*)
### Table 4: Summary of growth parameters (Mean ± SD) at different salinities and temperatures of red tilapia (O. niloticus)

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

*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**

| Classification | Initial weight (g) | Final weight (g) | 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±1.55       | 3.77±1.30               | 30.99±10.15                   | 0.07±0.03                        |

Data are represented as mean± standard deviation.
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 (%) were significantly 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).

Minimum condition factor value was recorded for (temperature 28°C and salinity 20ppt) treatment and the maximum values were recorded for (temperature 28°C and salinity 5ppt) treatment. It has been reported for many marine fishes as non-significant for several tilapia species and their hybrids has been reported (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 to lower temperature stress. (Atwood et al, 2003) size significantly 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 juvenile 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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