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Survival and Growth of *Tilapia zillii* and *Oreochromis urolepis urolepis* (Order Perciformes; Family Cichlidae) in Seawater

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Abstract—The potential for *Tilapia zillii* and *Oreochromis urolepis urolepis* culture in seawater was evaluated by determining their survival and growth in seawater at 35‰. Fingerlings were collected from Pangani River using seine nets and reared in 1 m^3 concrete ponds after acclimatization from salinity of 2‰ to 35‰. Fingerlings were also reared in freshwater as controls. Fingerlings were fed twice daily using commercial fish feeds (White Rose floating pellets), initially at a rate of 5% of their total body weight (TBW) and 10% of their TBW after two weeks. Their growth rate (length and weight) was recorded weekly except controls for handling, their growth being recorded at the beginning and end of the experiment. The average weight gain ($g.week^{-1}$), percentage weights gain ($week^{-1}$) and specific growth rate (SGR, $\%.day^{-1}$) were determined in freshwater and seawater. There was no significance difference ($p > 0.05$) in the SGR between the two species in seawater. The survival rates of *O. urolepis urolepis* were 100% in freshwater and seawater and 89% and 96% respectively for *T. zillii*. This study showed that *T. zillii* and *O. urolepis urolepis* can survive and grow in seawater but the former is a better candidate for mariculture.

INTRODUCTION

As >25% of its surface is submerged under fresh and marine water, Tanzania has one of the highest levels of natural tilapiine fish diversity (Trewavas, 1983). Efforts to artificially rear tilapia in Tanzania can be traced back to the 1950s when successful experimental farming was carried out at Korogwe (Tanga) and Malya (Mwanza). In the mid-1950s about 1000 ha (8000-10000 ponds) were farmed, producing about 2000 tons annually (Maar *et al*., 1996). Lack of proper management, use of inappropriate technology, drought, inadequate

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extension efforts, poor infrastructure to facilitate marketing, as well as competing sources of tilapia from capture fisheries in Tanzania's great lakes, resulted in a decline in production. In the mid-1970s, 2000 tons were produced per annum, which had decreased to 1,000 tons by the 1980s (Rice *et al*., 2006).

At present, aquaculture is largely a subsistence activity practiced by poor households in Tanzania. Rural people that are far from major freshwater bodies depend on aquaculture as a source of income, animal protein and occasional employment. However, since the output of capture fisheries is decreasing (Akimbo *et al*., 2001) Tanzania will depend increasingly on aquaculture for its aquatic protein resources, not only in the inland but more so in coastal areas, due to the ample availability of seawater.

Some tilapias have higher survival and growth rates in saline waters than in freshwater. For instance, Liao and Chang (1983) reported faster growth in Taiwanese red tilapia, a crossbreed between mutant reddish-orange female *Oreochromis mossambicus* (Peters, 1852) and normal male *O. niloticus* (Lovshin, (1998), in brackish and salt water than in freshwater. Canagaratnam (1966) demonstrated that *O. mossambicus* grew better in saline water, with the highest growth rate recorded in 50:50 sea and freshwater. This is close to the isotonic equilibrium for the fish and, therefore, it expends only a little energy to maintain its osmotic balance (Febry & Lutz, 1987). As a result, there is a lower demand on the thyroid gland at this salinity and faster growth. Job (1969) stated that, as salinities approached isotonicity in *O. mossambicus* (12.5‰), there was a reduction in osmotic load and a lower osmoregulation cost, which allowed more energy to be spent on growth with a corresponding increase in oxygen uptake. This corresponded to the isotonic equilibrium between the fish and its surrounding environment but was found to be size dependent.

This study was thus devised to establish whether *Tilapia zillii* (Linnaeus, 1758) and *Oreochromis urolepis urolepis* (Norman, 1922) from Pangani River can survive and grow in seawater, and whether their survival and growth would differ between seawater and freshwater.

MATERIALS and METHODS

Collection and stocking of fingerlings

Oreochromis urolepis urolepis fingerlings weighing 5.3-42 g (4.8-12.3 cm) and *Tilapia zillii* weighing 11.9-15.4 g (7.4-11.0 cm) were collected from the Pangani River using seine nets and transported to the Institute of Marine Sciences-Mariculture Center (IMS-MC) at Pangani in Tanga, Tanzania. The two species were identified according to Eccles (1992) and Pullin (1988). Fingerlings were acclimated for the experimental procedures by adding seawater to their holding tanks in daily increments of 2% to 35%.

Pond design and experimental set up

Twelve 1.0 m^3 concrete ponds were randomly stocked with ten fingerlings of both *O. urolepis urolepis* and *T. zillii*, of about the same weight for the growth experiments at the IMS-MC. The experiment was undertaken in two replicates with two controls, the first at zero salinity (freshwater) in which the fingerlings were weighed weekly. The second comprised pre-weighed, seawater-acclimated fingerlings left undisturbed without reweighing until the end of the experiment. This was done to evaluate the effect of handling on fingerling survival and growth. The treatment ponds were stocked with seawater-acclimated fingerlings and weighed weekly to the end of the experiment.

Assessing fingerling survival and growth

Growth rates were measured by recording total body length using a measuring board and body weight using a digital balance (Cen-Tech model no: 95364) reading to 0.01 g. Survival was monitored at regular intervals by counting the number of surviving fingerlings. All dead fish found in the ponds were removed using a scoop net and recorded. Growth performance was determined in terms of average weight gain, percentage weight gain and specific growth rate (SGR):

Average weight gain (g) = [Σ (final weight – initial weight)] ÷ N fingerlings

% weight gain.fish^{-1} = [(final weight – initial weight) ÷ initial weight] x 100

Specific growth rate (%.day^{-1}) = [(l_n final weight – l_n initial weight) ÷ no of days] x100

Feeding

Fingerlings were fed manually using commercial feed (White Rose floating pellets) twice every day (morning and afternoon) at a designated end of the pond. The pellets contained a minimum of 20% protein and 4% fat, and a maximum of 5, 12 and 10% fibres, ash and moisture respectively. The fingerlings were initially fed 5% of their total body weight (TBW) weekly and 10% of their TBW weekly thereafter.

Data analysis

Data analysis was conducted using Microsoft Excel, ver., 2007 and Origin pro 7 software. Results were presented as means with standard deviations. The statistical significance of differences between measured parameters was calculated using one-tailed T-tests at a P level of <0.05.

RESULTS and DISCUSSION

Growth rate of *Tilapia zillii* in seawater

The specific growth rates (SGR), average and percentage weight gain of *Tilapia zillii* in seawater are presented in Tables 1 and 2 and Figure 1. Yidirim *et al*. (2009) found that *T. zillii* attained a daily SGR ranging from 2.12-2.98%.day^{-1} in brackish water with a salinity of 11% when fed with feeds with crude protein ranging from 16.57-18.49%.day^{-1}. El-Sayed (1989) recorded an SGR of 0.54-0.87%.day^{-1} for this species, while Abdel-Tawwab (2008) recorded an SGR of 0.10-0.82%.day^{-1}. The SGR values obtained in this study (Table 5) ranged from 0.9%.day^{-1} in the handling control ponds to 1.13%.day^{-1} in the treatment ponds and are close to those obtained by Abdel-Tawwab (2008) and El-Sayed (1989) but lower than those of Yidirim *et al*. (2009). They indicate that *T. zillii* can grow as well in seawater as in brackish water.

Growth rate of *Tilapia zillii* in freshwater

The specific growth rates, percentage weight gain and the average weight gain of the freshwater *T. zillii* control fingerlings are presented in Table 1 and Figure 2. Polat (1998) found *T. zillii* had an SGR ranging from 2.26-3.04%.day^{-1} in freshwater and

Table 1. Mean weekly weight of *Tilapia zillii* in the seawater treatment and freshwater control ponds (± SD).

Number of weeks	Growth parameters					
	Mean weight (g)		Mean weight in following week (g)		Mean weight gain (g.fish^{-1})	
	Seawater	Freshwater control	Seawater	Freshwater control	Seawater	Freshwater control
1	15.4±2.2	7.10±1.6	19.1±4.9	9.0± 6.3	3.7±1.3	1.9±2.6
2	19.1±4.9	9.0± 6.3	20.0±2.3	10.4±1.4	0.9±0.1	1.38± 0.5
3	20.0±2.3	10.4±1.4	22.3±3.3	11.9±2.0	2.3±1.8	1.48±1.9
4	22.3±3.3	11.9±2.0	22.4±1.8	12.3±2.2	0.1±0.1	0.4±0.3
5	22.4±1.8	12.3±2.2	24.9±2.1	12.9±3.1	2.5±0.7	0.5±0.5
6	24.9±2.1	12.9±3.1	27.7±2.5	14.6±3.0	2.8±1.1	1.8
7	27.7±2.5	14.6±3.0	28.3±2.5	14.8±3.3	0.6	0.2
8	28.3±2.5	14.8±3.3	28.9±2.2	15.2±3.3	0.6±0.3	0.4±0.3

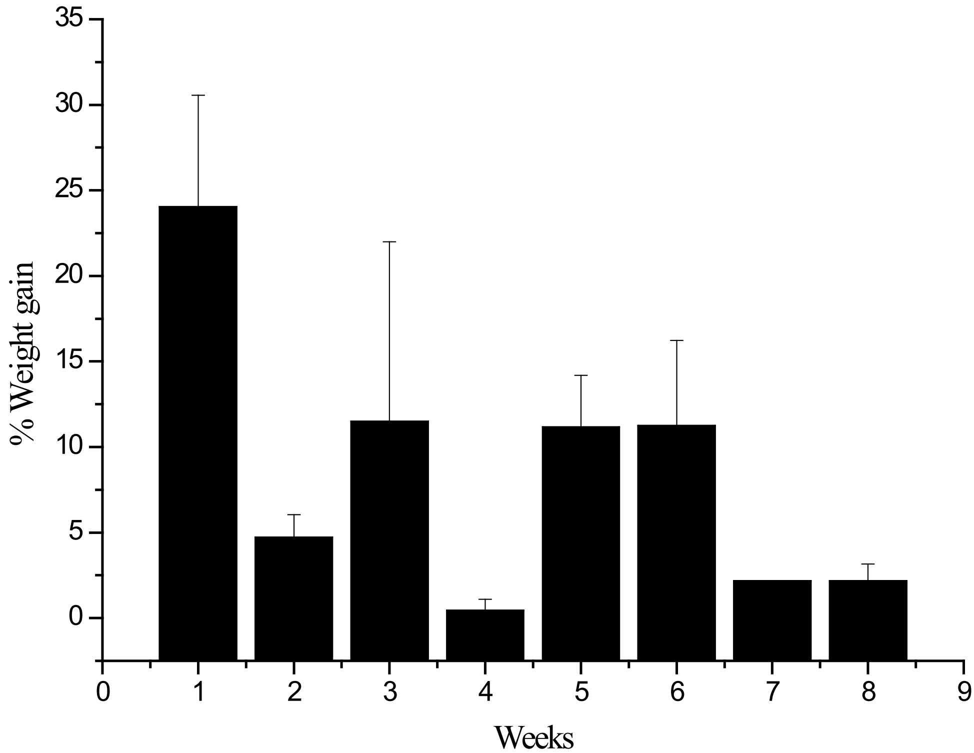

Figure 1. Percentage weight gain of *Tilapia zillii* in seawater.

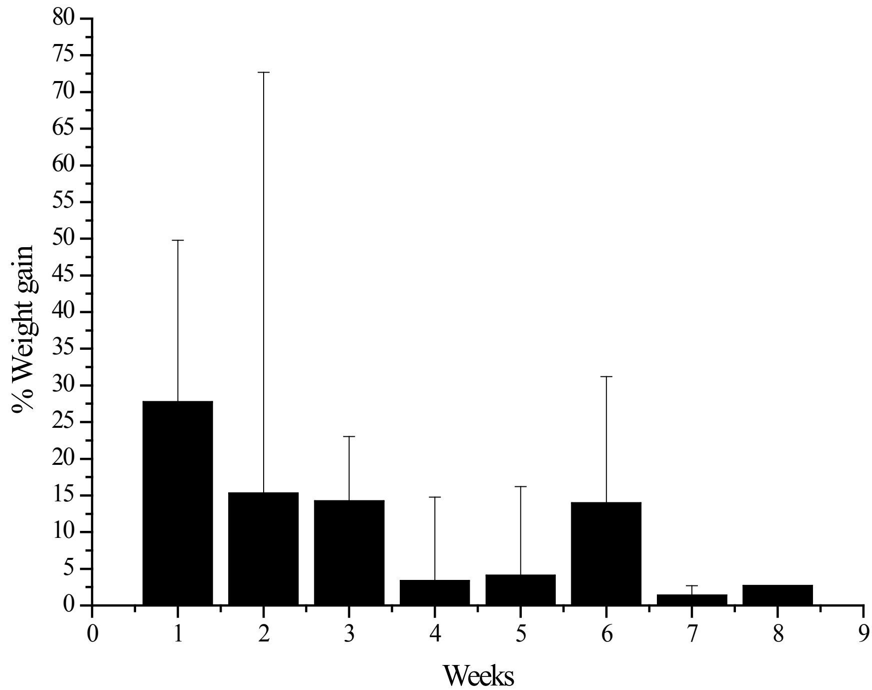

Figure 2. Percentage weight gain of *Tilapia zillii* in freshwater.

Table 2. Growth rate of *Tilapia zillii* in seawater of 35% (handling control) (± SD).

Growth parameters	Value
Mean weight day 1 ($g.fish^{-1}$)	15.9 ±2.5
Mean weight after 8 weeks ($g.fish^{-1}$)	26.4±5.7
Mean weight gain after 8 weeks ($g.fish^{-1}$)	10.5 ±7.4
Percentage weight gain (%)	66.0±8.3

the values recorded by Rana *et al*. (1996) ranged from 6.1-7.65%.day^{-1}, while Jegede and Olusola (2010) recorded a range of 0.72-1.17%.day^{-1}. The mean value of 1.37%.day^{-1} obtained in this study (Table 5) was close to the range obtained by Jegede and Olusola (2010) but less than the findings of Rana *et al*. (1996) and Polat (1998). These differences may be attributable to different experimental conditions.

Growth rate of *Oreochromis urolepis urolepis* in seawater

The growth rates attained by *Oreochromis urolepis urolepis* in seawater are presented in Tables 3 and 4 and Figure 3. The growth performance of Florida red tilapia (FRT; *Oreochromis mossambicus* x *Oreochromis niloticus*) has been assessed in brackish and seawater. Watanabe *et al*. (1989) established that its SGR was 3.34%.day^{-1} when reared in cages at salinities ranging from 34-41‰ and 3.46%.day^{-1} in seawater pools of 37‰ salinity; the value obtained by Paz (2004) for its SGR in brackish water was 3.9%.day^{-1}. The SGR results for *O. urolepis urolepis* in seawater in this study (Table 5) were 0.71%.day^{-1} in the treatment ponds and 1.2%.day^{-1} in the handling control ponds, poor values when compared to the cited studies. This may be due to better growth performance by the hybrid cross. *O. urolepis urolepis* also manifested negative growth during the first week of acclimatization to saline conditions, probably due to delayed adaptation to the new environment and food.

Growth rate of *Oreochromis urolepis urolepis* in freshwater

The growth of *O. urolepis urolepis* in freshwater is presented in Figure 4. Lamtane *et al*. (2008) found that its SGR of in fresh water was 1%.day^{-1} while Paz (2004) reported an SGR of 3.9%.day^{-1}. We obtained an SGR for *O. urolepis urolepis* of 2.9%.day^{-1} in freshwater; differences from the cited works may be attributable to differences in stocking density and environmental conditions. Again this species showed negative growth rate in one of the replicate during the first week in freshwater, indicating that it took time to adapt to the new environment and food.

Table 3. Mean weekly weight of *Oreochromis urolepis urolepis* in the seawater treatment and freshwater control ponds (± SD).

Number of weeks	Growth parameters					
	Mean weight (g)		**Mean weight in following week (g)**		**Mean weight gain ($g.fish^{-1}$)**	
	Seawater	Freshwater control	Seawater	Freshwater control	Seawater	Freshwater control
1	34.5±6.2	2.92±0.2	33.8±5.9	2.7±0.3	-0.7±1.3	-0.22
2	33.8 ±5.9	2.7±0.3	37.3±6.2	3.9±0.5	3.5±2.7	1.9±0.1
3	37.3±6.2	3.89±0.5	42.0±7.3	5.3	4.7±2.1	1.5±1.5
4	42.0±7.3	5.3	44.3±6.5	6.5	2.3±2.1	1.2±0.4
5	44.3±6.5	6.5	45.3±6.8	9.4±3.7	1.0 ±0.9	2.9±0.6
6	45.3±6.8	9.4±3.7	46.9±4.6	11.2±2.1	1.6±0.8	1.8±0.6
7	46.9±4.6	11.2±2.1	49.2±4.6	13.3±1.4	2.1±0.7	2.1±0.1
8	49.2±3.9	13.3±1.4	51.3±4.6	14.7±1.5	2.1±0.7	1.4±0.9

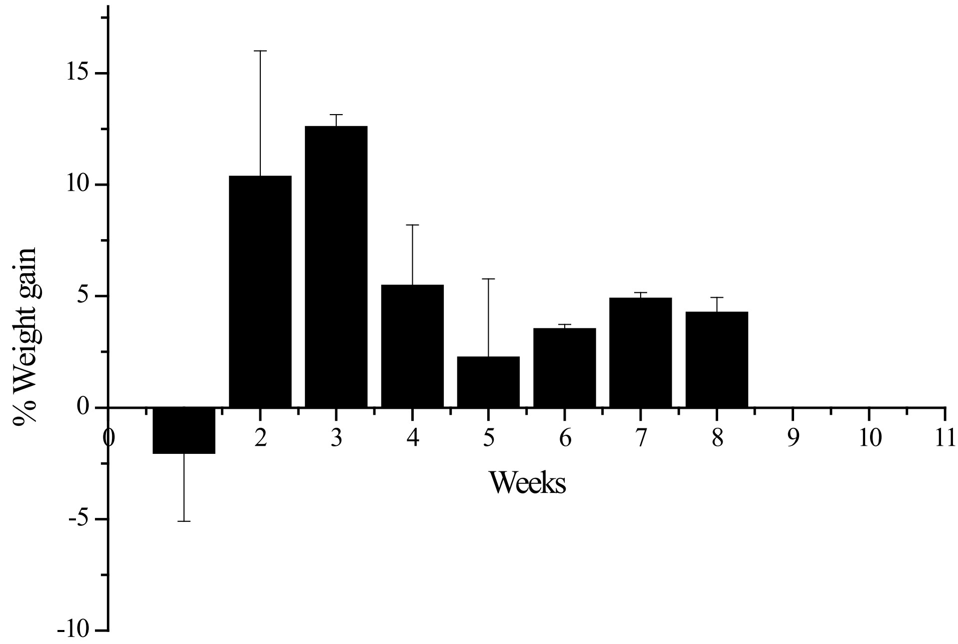

Figure 3. Percentage weight gain of *Orechromis urolepis urolepis* in seawater.

Comparison of growth between *Tilapia zillii* and *Oreochromis urolepis urolepis*

The growth rate of *T. zillii* in the treatment ponds in terms of its percentage weight gain and SGR was higher (Table 5, Figure 5) than that of *O. urolepis urolepis*. The latter responded poorly to seawater in the first week and *T. zillii* was more tolerant and adapted earlier to its new environment and food than *O. urolepis urolepis*; this may be due to genetic differences in their adaptation to saline conditions. However, the differences between the growth of *T. zillii* and *O. urolepis urolepis* in seawater were not significant ($P > 0.05$) but, in freshwater, *O. urolepis urolepis* manifested significantly higher growth ($P = 0.005$).

Table 4. Growth rate of *Oreochromis urolepis urolepis* in seawater of 35% handling control) (± SD).

Growth parameters	Value
Mean weight on day 1 ($g.fish^{-1}$)	12.5±2.1
Mean weight after 56 days ($g.fish^{-1}$)	24.2±2.8
Mean weight gain ($g.fish^{-1}$)	11.7±1.0
Weight gain (%)	93.6±9.9

Table 5. Mean specific growth rates (± SD) of *Tilapia zillii* and *Oreochromis urolepis urolepis* over eight weeks.

	Specific growth rates
T. zillii in 35% seawater (treatment)	1.13%
T. zillii in freshwater (control)	1.37%
T. zillii in seawater (handling control)	0.9%
O. urolepis urolepis in seawater (treatment)	0.71%
O. urolepis urolepis in freshwater	2.9%
O. urolepis urolepis in seawater (handling control)	1.2%

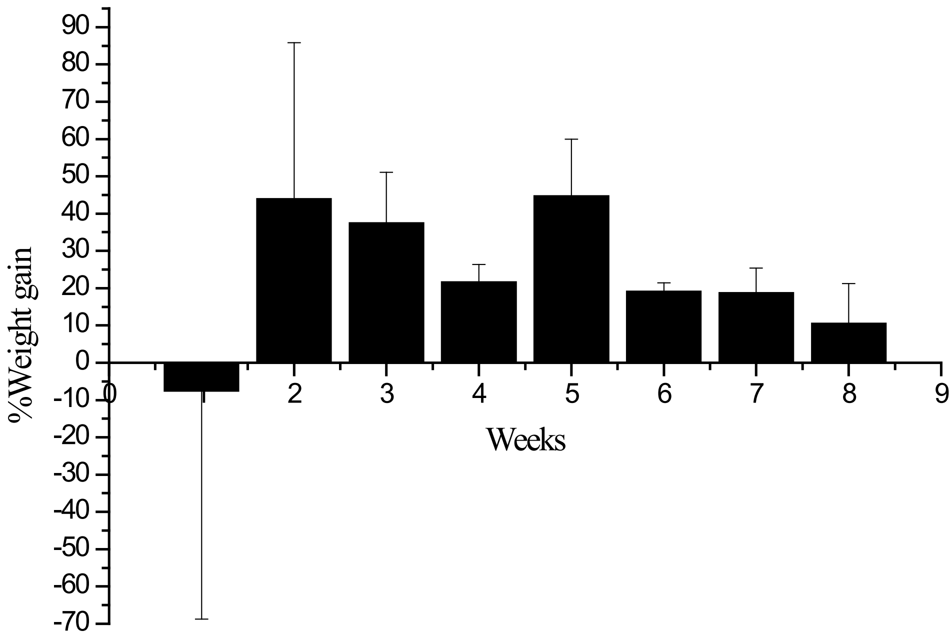

Figure 4. Percentage weight gain of *Oreochromis urolepis urolepis* in freshwater.

Table 6. Survival rates of *T. zillii* and *O. urolepis urolepis*

	Survival rate
T. zillii in 35% seawater (treatment)	96%
T. zillii in freshwater (control)	89%
T. zillii in 35% salinity (handling control)	82%
O. urolepis urolepis in 35% seawater (treatment)	100%
O. urolepis urolepis in freshwater (control)	100%
O. urolepis urolepis in 35‰ seawater (handling control)	90%

Survival rates

The survival of *T. zillii* and *O. urolepis urolepis* is presented in Table 6; the latter manifested better survival (100%, except in the handling control) in both fresh and seawater. This suggests that it is more tolerant of seawater, once adapted, despite its slower acclimatization. The mortalities in *O. urolepis urolepis* in the handling control ponds may have been due to accumulated wastes as the ponds, though flushed, were minimally disturbed.

Nugon (2003) reported that *Oreochromis aureus*, *O. niloticus* and FRT exhibited survival rates of ~81% in salinity regimes of up to 20‰, and lower survival rates for O. aureus (54%) and FRT (33%) at 35‰ salinity. The present *T. zillii* and *O. urolepis urolepis* studies yielded better survival rates and indicated that the environmental parameters were suitable for rearing the two species.

CONCLUSIONS

Based on the results of this study, both *T. zillii* and *O. urolepis urolepis* can be reared in seawater but *O. urolepis urolepis* is more suitable for fresh water aquaculture. The development of brood stock of both species would appear advisable and, if possible, they should be crossbred for trials of the fingerlings in seawater hatcheries. The fingerlings could be grown out or used for feedstock in the numerous milkfish mariculture ponds in the Tanga Region where there is scarcity of such food. DNA analysis should be conducted on both species to confirm their identification as interbreeding among tilapia species has been known to produce intermediate characteristics (Moralee, 2000).

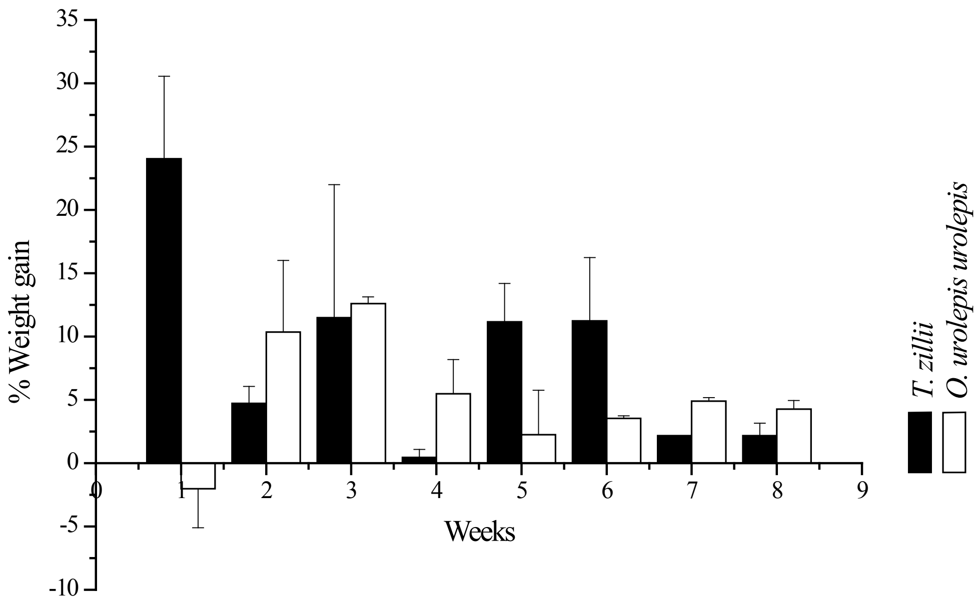

Figure 5. Percentage weight gain of *Tilapia zillii* and *Oreochromis urolepis urolepis* in seawater.

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