



**UNIVERSITI PUTRA MALAYSIA**

***THE GROWTH PERFORMANCE AND SURVIVAL RATES OF  
RED TILAPIA OREOCHROMIS SP. GROWN IN DIFFERENT  
WATER SALINITIES***

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TILAPIA *Oreochromis* sp. GROWN IN DIFFERENT WATER SALINITIES**



By

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**A Project Report Submitted in Partial Fulfillment of the Requirement  
for the Degree of Bachelor of Bioindustry Science in the  
Faculty of Agriculture and Food Sciences  
Universiti Putra Malaysia Bintulu Campus**

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*DEDICATION*

*The most graceful and the most merciful*

*Especially dedicated to my beloved parents*

*Jetie ak Unja And Duazw ak Sarwoh*

*And other family members:*

*Kulih, Achong, Jaya, Anthoneo, Lily and Lamang*

*for their love, care and support*

*Special thanks to Jacklyne John and Claudia licca.*

## ABSTRACT

The experiment was conducted at the hatchery unit of University Putra Malaysia Bintulu to investigate the growth performance and survival rates of Red Tilapia *Oreochromis* sp. Grown in 4 levels of water salinities. The four-salinities levels are 0‰, 5‰, 10‰, and 15‰. Red Tilapia fingerlings weighing 0.12 to 6.8 g were cultured in tanks for 56 days. The growth of Red Tilapia was better in freshwater than brackishwater. The highest mean increase in total length and body weight of Red Tilapia was achieved by 0‰ with 5.20 cm increase in length and 2.23 g in weight compared to other salinity levels and the survival rates of red tilapia was highest in brackishwater (15‰) with (25.04%) compared to 0‰ (24.48%). The growth of Red Tilapia is found to be better in untreated water (0‰)

## ABSTRAK

Percubaan ini dijalankan untuk melihat tumbesaran dan kadar hidup ikan Tilapia Merah *Oreochromis* sp, dalam nisbah yang berbeza. Ianya dilakukan di hatceri Universiti Putra Malaysia Kampus Bintulu. Empat saliniti yang digunakan dalam percubaan ini ialah 0‰, 5‰, 10‰ and 15‰. Penelitian ini dibuat dalam jangka masa 56 hari dengan menggunakan bibit berat antara 0.12 - 6.8 g. Hasil percubaan ini menunjukkan ikan yang ditenak dalam air tawar telah memberikan peningkatan panjang ikan iaitu 5.20 cm dan 2.23 g untuk berat keseluruhan ikan Tilapia. Didapati kadar hidup adalah terbaik dalam air payau (15‰) iaitu (25.04%) berbanding dengan air tawar 0‰ (24.48%). Pertumbuhan tumbesaran dan kadar hidup bagi ikan Tilapia Merah yang terbaik dicapai pada saliniti 0‰.

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I certify that this research project report entitled "***The Growth Performance and Survival Rates of Red Tilapia (*Oreochromis* sp.). Grown in Different Water Salinities.***" Has been examined and approved as a partial fulfillment of the requirement for the degree of Bachelor of Bioindustry Sciences, University Putra Malaysia Bintulu Campus.

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## LIST OF ABBREVIATIONS

|       |                                   |
|-------|-----------------------------------|
| AGR   | Absolute Growth Rate              |
| D.O   | Dissolved Oxygen                  |
| DM    | Dry Matter                        |
| FAO   | Food Association and Organization |
| FRT   | Florida Red Tilapia               |
| GLM   | General Linear Model              |
| HSD   | Tukey's Studentized Range         |
| MT/yr | Metric Tone per Year              |
| mt    | Metric Tone                       |
| Mg/L  | Milligram per Liter               |
| ppt   | Part Per Thousand                 |
| %     | Percent                           |
| SAS   | Statistical Analysis Software     |
| ‰     | Salinity                          |
| SGR   | Specific Growth Rate              |
| TAN   | Total Ammonia-Nitrogen            |
| USA   | United States of America          |
| $W_2$ | Final Weight                      |
| $W_1$ | Initial Weight                    |

## CHAPTER 1

### INTRODUCTION

Many tilapia species are euryhaline and can grow in saline water after proper acclimation (Suresh and Lin, 1992). Varieties of red tilapia has been successfully cultured in saline waters (Watanabe, 1991). However, most of those tilapia culture trials were conducted in intensive systems with pelleted feeds, requiring frequent water exchanges. Compared to the voluminous literature available for semi-intensive culture of tilapia in freshwater, literature on semi-intensive culture in saline condition is almost nonexistent. In that experiment fish production was extremely low, resulting from high mortality due to uncontrolled high salinity. We are assuming that feeding rates for brackish water tanks are similar to those for freshwater tanks. Tilapias appear to be the most appropriate choice for such a culture system because there are few domesticated finfish species that feed on low-cost natural foods such as detritus and plankton. This interest in brackish water culture is particularly strong in Thailand and Vietnam where shrimp culture is now commonly reduced to one crop per year, leaving the ponds empty for half a year. Tilapia culture is also attractive to shrimp farmers as a by-product to utilize abundant phytoplankton in either shrimp condition or their effluents. Thai strain red tilapia (*Oreochromis* sp.) has been becoming more and more popular in Thailand, and there is a great potential to culture this species in brackish water. The purposes of this study were to determine an appropriate the suitable salinity level to culture red tilapia for survival and to investigate the growth performance.

## STATEMENT OF THE PROBLEM

The red tilapia is the least saline tolerant of the commercially important species, but grows well at salinities below to 15 ppt. Therefore, the tilapias are preferred for saltwater culture. Some Tilapias reportedly have full strength in seawater, but its reproductive performance begins to decline at salinities above 10 to 15 ppt. whereas perform better at salinities below 5 ppt. In this study, four salinities range being respectively 0‰, 10‰, 20‰, and 30‰. Based on field observation, the fingerling able to survive at range 0‰ to 15‰ and at 20‰ salinity mortalities occur for whole tanks especially at 30‰. The experiment was conducted at salinity levels 0‰, 5‰, 10‰, and 15‰ to observe the growth performance and survival rates at that salinities level.

**OBJECTIVES:**

1. Study the growth performance of *Oreochromis* sp. in different water salinities
2. To determine the survival rates Red Tilapia at four water salinities.



## **CHAPTER 2**

### **LITERATURE REVIEW**

#### **2.1 Overview of Red Tilapia**

Tilapias, originally from Africa, have been cultivated for centuries. During the last 50 years, interest in their aquaculture potential has led to a nearly worldwide production and distribution. Because of its contribution to world food production through aquaculture operations, tilapias generated much enthusiasm in many developing countries during the 1940's and 1960's. In some of these nations, tilapia production was a strategic element in the expansion of local aquaculture, and as a way to obtain animal protein at a low cost for massive consumption, while in other countries they were introduced mainly for recreation and restocking purposes. In the 1960's and 1970's, tilapia culture was geared towards the production of food for local consumption and for the diversification of rural activities related to agriculture and animal husbandry. Tilapia culture soon after its first insurgence became an unprofitable commercial activity because excessive reproduction resulted in small harvest sizes. However, during the past 20 years commercially viable techniques have been developed to control overcrowding in the different production systems, thereby permitting faster and uniform growth to larger sizes. Commercial production has again become popular in many countries around the world, and the traditional markets of Asia and Africa have expanded too many countries in the Americas and Europe.

## 2.2 Asia Production

In Asia, aquaculture has expanded sevenfold during the past eleven years and has contributed substantially to the region's food security, employment generation and foreign exchange earnings. According to FAO statistics, production of tilapia increased from 619,000 mt in 1994 to 800,000 mt in 1996. The phenomenal growth of aquaculture in the Asia region during the last two decades was market-driven. Appropriate technologies were developed and adopted. Governments in the region developed with policies supportive of the industry, such as tax incentives, infrastructure development, and exemption of fish farms from land reform programs. The production and export of high-value species have been in high gear since the 1980s; however, problems related to environmental degradation, particularly water pollution, the high cost of imported feeds, and the destruction of mangroves decelerated production and drastically eroded profits (Charles *et al.*, 1997). Tilapia production is based on a combination of many factors, including social, political, economical, technological, and environmental, which will vary depending on the prevailing conditions and expectations of each producing entity or country. In most cases, governments involved with aquaculture development, as well as the private sector, have identified tilapia farming as an important activity, which generates employment and hard foreign currency, and provides an opportunity to diversify local production with a new commodity. Therefore, the investing climate, access to public and private financial resources and legal framework, are only a few government policy issues that will determine the production system to be used by the potential tilapia

grower. In addition, in each producing country, economic and environmental factors are structural elements that cause considerable impact on tilapia production.

### **2.3 Species and Strains for Culture**

Pullin (1983) compared various tilapia species with culture potential and suggested that research efforts be concentrated on *O. niloticus* and *O. aureus*. Shelton, (2002) claimed that while the latter is still used to produce the hybrids, it has been effectively left behind as *O. niloticus* has taken the lead as the principal species for culture in many parts of the world. This species is the most favored by farmers due to its suitability for farming in a wide array of culture environments/systems, ranging from extensive, low-input pond culture to intensive recirculating systems. The other species that are gaining recognition because of their adaptability to certain conditions.

### **2.4 Tolerance Limits of Red Tilapia**

The Red tilapia hybrids, produced first time in Taiwan through the interspecific cross of *O. mossambicus albino* and *O. niloticus*, are providing the '3rd generation of tilapias' combining favored colors with other desirable features of tilapias (Anon. 1984). This fish has gained increasing preference of commercial farmers in some countries because of their reddish color liked by consumers and their resemblance to premium marine species such as sea bream (*Chrysophrys major*) and red snapper (*Lutjanus campechanus*). Red tilapias are suitable for brackishwater and seawater culture because of salinity tolerance of the parental species, known to be moderately (*O. niloticus* and *O. aureus*) to highly euryhaline (*O. mossambicus* and *O. hornorum*).

Red tilapia hybrids are most commonly used in intensive aquaculture operations but recent reports indicate that they also have potential for culture under low-input farming. While tilapias in general are known for their relative ease of cultivation and other attributes, their growth and other production traits are largely influenced by genetics. Popma and Lovshin. (1996) reported that males of pure strains of *O. niloticus* and hybrids with *O. niloticus* as a parent, especially *O. niloticus* x *O. aureus* hybrids, are considered the fastest growers. Male *O. mossambicus* has much lower growth than other species. *Oreochromis* spp. hybridize readily in fishponds. Contamination with less desirable species, such as *O. mossambicus*, and years of inbreeding among pure strains can lead to slower growth (Popma and Lovshin, 1996). The use of the recently developed improved tilapia strains represents a means by which the fish yields in ponds and other culture systems can be increased.

## **2.5 Global Productions from Aquaculture**

The world's total tilapia aquaculture production in 2000 was 1.27 million mt and contributed about 3.6% of global total aquaculture production. The top five producing countries during 2000 are China, Egypt, Thailand, Philippines and Indonesia, each accounting for 49.7, 12.4, 7.8, 7.3 and 6.7%, respectively, of world's total aquaculture production of tilapia (FAO, 2002). China has remained the number one producer both within Asia and globally; it produced 629 182 mt in 2000 which is more than 6 times the 1990 production. Egypt also made an impressive increase in tilapia production, from 24 916 mt in 1990 to 157 425 mt in 2000. On the other hand, production in Thailand only slightly increased while those in Philippines and Indonesia have almost

remained stable during the period. In 2000, of the 1.27 million mt of tilapia produced from aquaculture, 85% was grown in freshwater environment, while 14.1% in brackish water (FAO, 2002). For the year 2002, estimated global tilapia production was 1,374,239 MT (Fitzsimmons, 2003). Major producers were China (629,182 MT/yr), Mexico (102,000 MT/yr), Thailand (100,000 MT/yr), the Philippines (92,284 MT/yr), Taiwan province (85,000 MT/yr), Brazil (65,000 MT/yr) and Indonesia (50,000 MT/yr) (Fitzsimmons, 2003).

## **2.6 Age, Size and Fecundity**

In most cases, tilapia reaches sexual maturity in less than six months (Fitzsimmons, 1997). However, under certain conditions of light, temperature, food and social factors, sexual maturity can be reached as early as three months (Jalbert and Zohar, 1982 and Balarin and Haller, 1988). For example, inadequate food supplies have been shown to promote early maturation with lowered fecundity and stunted fry. This is assumed an adaptation for species survival during food limited periods (Balarin and Haller, 1988). When food supply is good both in quantity and in quality, fry production is stimulated. Broodstock fish require a high protein diet. Fish fed a diet of 35-40% protein produce the most fry (Balarin and Haller, 1988). Once mature, spawning can occur every 10-14 days, with females producing an average of nearly 600 eggs and fry per spawn depending on size and age at the time of spawning (Rosati *et al.*, 1997).

## 2.7 Temperature and Reproduction

Temperatures above 20°C-23°C are required for spawning and for the growth of secondary sexual characteristics. Prolonged temperatures below 20°C results in the failure of juveniles to mature and in the reabsorption of mature gonads in older fish (Balarin and Haller 1988; Jalbert and Zohar, 1982). Tilapia are generally characterized by a temperature preference in the range of 12°C - 42 °C (Avella *et al.*, 1992), and optimal water temperature for tilapia growth is about 29°C-31°C (Popma and Masser, 1999). In addition, duration of exposure at low temperatures (Hargreaves, 2000) appear to affect tilapia survival significantly. Blue tilapia is considered the most cold tolerant of the major tilapia species (Rakocy *et al.*, 1993). In areas outside their natural range, the major limiting factor determining the possibility for establishment of tilapia populations is the normal minimum temperature during the coldest period of the year (Hargreaves, 2000). Based on normal winter temperatures, it has been generally accepted that tilapia survival in the southeastern USA would be limited to coastal habitats along the Gulf and Atlantic coasts from Texas to South Carolina, and in more inland waters only in southern regions of Florida and Texas (Hargreaves, 2000).

Apart from several studies of pure species many years ago little recent information is available to evaluate which species, strains and hybrids possess natural characteristics that will allow them to perform well in brackish or seawater production systems. Some characteristics of tilapia, including fast growth, make it a very invasive fish that can establish populations outside of its natural range under the proper conditions (Pillay, 1990). There are two common types of recirculating systems in tilapia production,

usually defined by the color of the water: green water and clear-water (Hargreaves, 2000). Green water systems allow phytoplankton to proliferate, allowing tilapia to filter feed on the bloom. Differences in salinity tolerance within tilapia species are typically related to strain, age, and body size (Villegas, 1990). Nile Tilapia (*O. niloticus*) is the least salt tolerant commercial species with lethal salinities of 12.5 ppt reported in experimental conditions (Watanabe 1985; Avella *et al.*, 1993), although it has been cultured at salinities of 15 ppt (Popma and Masser, 1999)

In addition, Mozambique tilapia may opportunistically feed on a number of different food items. Where common, such as in the estuarine waters of Florida, they may lower local biodiversity, through competition for trophic resources and direct predation. Hubbs *et al.* (1971) expressed special concern for native faunas of stenothermal springs in Bexar County, Texas. Tilapia was originally considered for aquaculture as a means of producing cheap protein and because of the readiness of the species to breed in almost any type of water body, being omnivorous and hardy enough for fish farming (Pillay, 1990). Today, tilapia has become one of the most common farm raised fish in the world, second only to carps in terms of total production (Watanabe *et al.* 2002).

## **2.8 Environmental Complexity and Reproduction**

The influence of behavior on growth at different salinities the apparent density-dependent differences in growth response to salinity observed in these studies suggested that behavioral factors influenced these results. Further investigations

revealed that agonistic encounters among fish as well as percentages of fish with damaged fins (due to agonistic encounters) declined with salinity, suggesting that growth response to salinity was influenced by inhibitory effects of territorial aggression, which was mitigated by increasing salinity (Watanabe *et al.*, 1988). This suggested that aggression impairs growth by lowering feed consumption (appetite) and increasing conversion ratios. Hence, as aggression was mitigated by increasing salinity, growth was improved. That behavioral interaction may exert inhibitory effects on growth, which vary with salinity. It was previously suggested for Taiwanese red tilapia (Liao and Chang, 1983). In another experiment, growth of juvenile progeny spawned and sex reversed at salinities of 2 ppt and 1.8 ppt was compared in 24 m<sup>3</sup> outdoor pools at 36 ppt. When water temperatures exceeded 27°C, growth and survival were not significantly different between these groups. However, when temperatures abruptly fell below 25°C, growth and survival remained significantly higher among progeny spawned at 18 ppt (Watanabe *et al.*, 1989).

## CHAPTER 3

### METHODOLOGY

#### 3.1 Experimental Design and Facility Setup

This experiment was carried out at University Putra Malaysia Campus Bintulu at Hatchery unit, from July 2006 through October 2006 to study for growth performance of red tilapia at four salinity levels (0‰, 5‰, 10‰, and 15‰) and culture of red tilapia in different salinity level. The experiments were conducted with factorial arrangement to test effects of four salinity levels (0‰, 5‰, 10‰, and 15‰) for growth of Red Tilapia. Approximately 360 fingerling of *Oreochromis* sp. were collected from pond hatchery unit to introduce experimental to tanks in triplicate. The growth experiments, each lasting for nine weeks, were designed and study the effect of varying salinity on growth and survival rates. All experiments were conducted in tanks at the hatchery unit supplied freshwater with dilution with seawater each tank was adequately aerated using air stones. There were twelve combinations (treatments). In fresh water (0‰) that served as a control. Three replicates were used per treatment. The site selection and placement of tanks was conducted in twelve tanks filled with 25 liters volume of water at different salinity level. The tanks were grouped into four blocks, and treatments were allocated randomly to tanks in each block. Tilapia stock was seined, counted for total length and weighed weekly for each tank using digital scale (Figure 1 and 2). All tanks were checked weekly to measurement quality of water content to achieve salinity level.



Figure 1: Measurement of total length using a measuring scale



Figure 2: Measurement of body weight using digital scale microbalance (Model B303-S Mettler Toledo)

Salinity levels in all tanks were monitored weekly. Water depth in all tanks was maintained at 14 centimeter throughout the experiment by adding water of appropriate salinity levels weekly to replace evaporation and seepage losses. All tanks were aerated for 24 hours daily using air bubble in each tank. At the time of collecting water samples, while temperature and dissolved oxygen (DO) were measured at the time of collecting water samples with an YSI model 63 and YSI model 200 oxygen meters (Appendix 5). Design and construction for culture red tilapia should be constructed

from materials such as resistant to biology fouling and easier to clean. Water temperature, DO, salinity, total ammonia and pH were measured at 0800 h daily prior to changing water. During the experimental period, fishes were checked everyday for mortalities. Salinity, temperature and pH of water were checked once a week. Total Ammonia-Nitrogen was monitored every two weeks. Dissolved oxygen was checked everyday the experimental period. Fishes were sampled every week to monitor any changes in weight and total length. Time of measurement and observed values recorded; good record keeping is essential to a successful aquaculture.

### **3.2 Statistical Analysis**

Statistical analysis was performed using the SAS system version 9.1 for Windows™ (SAS Institute Inc., 2002-2003 Cary North Carolina USA) Significance was set at  $P \leq 0.05$ . The GLM procedure was used to perform an analysis of variance and to determine the significant differences between salinity levels and trial effects on individual fish weight, Total length of growth performance, survival rates and effect on parameter of water quality in tanks culture. The Tukey's Studentized Range (HSD) compares difference among mean. The characteristic of this method is simple and most popularly for comparison. Statistics were used to understand the problems and to process the result of discussion.

### **3.3 WORK ROUTINE IN HATCHERY UNIT**

#### **3.3.1 Preparation of Feed**

Red Tilapia readily accept artificial diets such as powder mash, crumbled pellets and pelleted feeds, if they are sized appropriately to fit into their mouth. The most important aspect of tank culture is providing good quality feed in the correct amounts to fish. The diet should be nutritionally complete containing vitamins and minerals. Protein content should be 35 percent for 0.12 to 6.8 gram Red Tilapia. Fish were fed twice daily by using 10% of body weight (starter feed)(Table 1). The correct amount of feed must be weighed daily. Feeding rate tables or programs are required to make periodic increments in the daily ration. The fish were sampled once weeks to determine their average weight and the feeding rate were corrected for calculating adjustments in the daily ration. Adjustments can be made between sampling periods by estimating fish growth based on an assumed feed conversion ratio (feed weight divided by weight gain). Red tilapia (0.12 to 0.32 g size) fed twice daily with the same quantity (dry matter, DM). Two bags of starter, which cost RM 80 each and four bags of grower cost RM 60 each, were use in this experiment. The Red Tilapia growth was determined by bulk-weight at the beginning and at the end of the culture period.

#### **3.3.2 Feeding Rates**

Recommended feeding rates for tilapia are a function of fish size, water temperature, fish biomass density, and abundance of natural food organisms. As with other fish species, optimum-feeding rate is inversely related to fish weight. At 26°C to 29°C common feeding rates using high-quality feeding ratio given in (Table 1)

**Table 1: Feeding rates scheme of Red Tilapia**

| <b>Weight (g)</b> | <b>Feeding Rates % Weight gain/Day</b> |
|-------------------|--|
| 1-5               | 8-10                                   |
| 5-20              | 4-6                                    |
| 20-100            | 3-4                                    |
| 100-200           | 2-3                                    |
| 200-400           | 1.5                                    |

Source: Lovshin, 1996.

Appetite decreases rapidly at temperatures below 25°C and above 30°C. The use of floating feeds and checking the tank bottom for unconsumed feed at the feeding site help reduce overfeeding.

### **3.3.3 Growth assessment**

Tilapias were fed according to the feeding scheme described earlier and the growth trial was continued for 2 month two weeks. The tanks were siphoned one a week to maintain water quality. Every one week, 30 fingerlings were taken out and the total length was measured using a scale with minimum stress. They were then weighed on a microbalance. Weight gains were calculated by subtracting initial mean weight from the final mean weight. Specific Growth Rate (SGR) and Absolute Growth Rate (AGR) were calculated using the formula as reported by Hopkins. (1992).(Appendix 1 and 2)

Specific Growth Rate (SGR) = Food fed / Weight gain

Absolute Growth Rate (AGR) =  $L_n(W_2) - L_n(W_1) \times 100 / t$

Where,  $W_2$  = final weight in mg,  $W_1$  = initial weight in mg

### **3.3.4 Water Quality Exchange**

Water quality, as well as quantity, is one of the most important factors affecting the success of a hatchery operation. If water quality is good, then good results can be achieved easily. In hatcheries, water quality should be managed to regulate environmental conditions so that they are within the desirable range for survival, growth and reproduction of fish. Water from river, stream, lake or groundwater can be used in hatcheries. Water temperature be in the range of 26.6–28.2°C and pH be 7.3–8.45. Growth rate is very rapid during fry and fingerling stages. During these stages, they have different biological characteristics especially in terms of feeding habits, growth and habitat preferences. Water quality determines not only how well fish will grow in an aquaculture operation, but whether or not they survive. Fish influence water quality through processes like nitrogen metabolism and respiration. The knowledge of testing procedures and interpretation of results are important to the fish farmer.

### **3.3.5 Fish Handling**

The fishes must be handling either in afternoon or under the shade, make sure the water is clean, has air bubbling trough or has a running water flowing through the container. Fry are delicate and squash easily. Keep them in the water so that they can swim. Avoid leaving them piled up together in a net or at the bottom of container containing no water for them to swim. Scoop nets should be soft material that will not bruise or hurt the fry. Nets should be fine-mesh, as the coarse-mesh net will catch the fish by the gills that could cause injury. Avoid dropping the fish on ground or making

them panic that make them to putting on gloves are advised when holding or carrying a fingerling in hands so that the fish will remain calm.



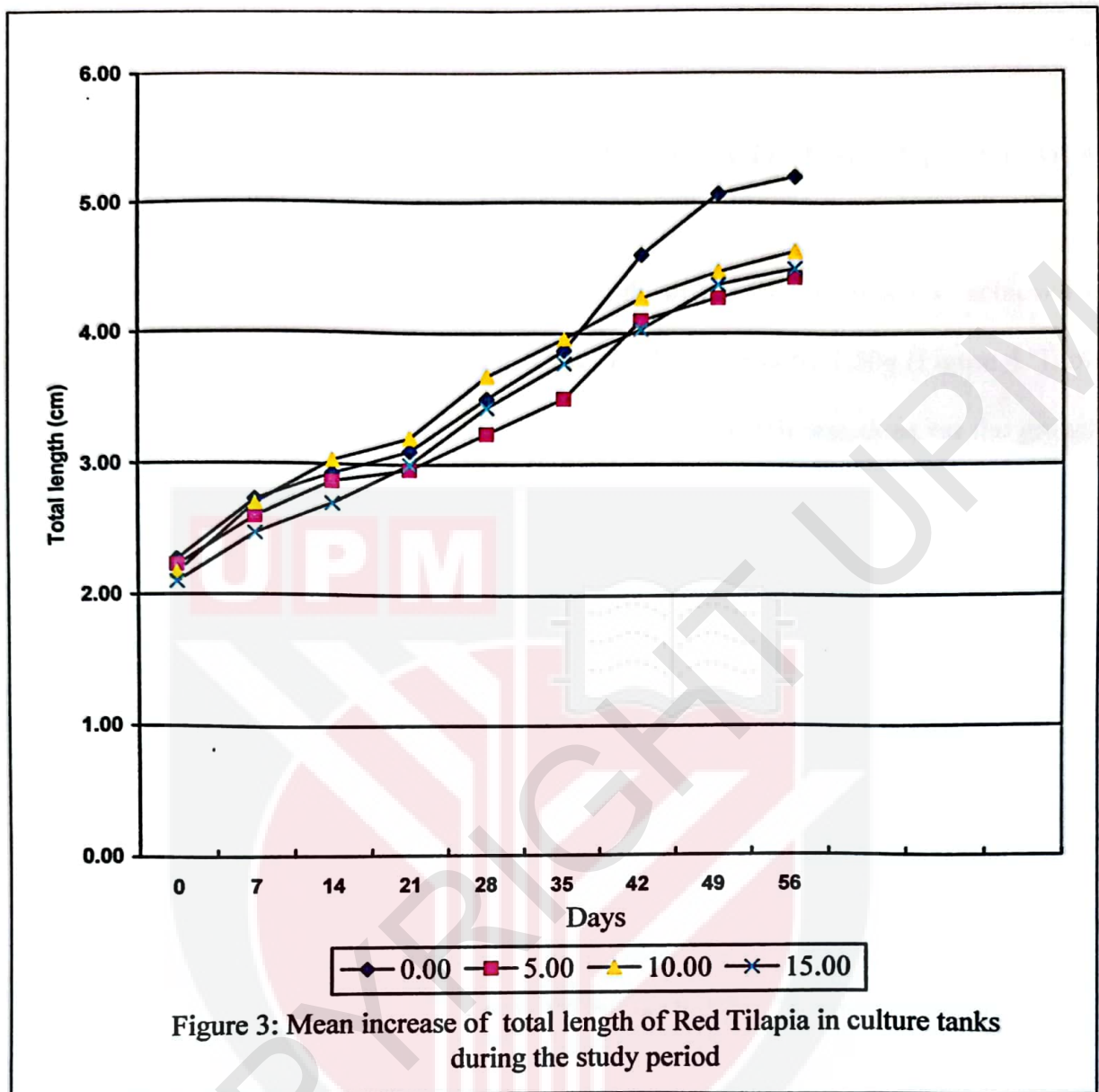
## CHAPTER 4

### RESULTS

Tilapias are more tolerant than most commonly farmed freshwater fish to high salinity, high water temperature, low dissolved oxygen, and high ammonia concentrations. Parameters monitored and their ranges recorded were temperature (26°C -29°C), pH (6.0-7.5), dissolved oxygen (5.0-6.5 mg/L) and total ammonia-nitrogen (0-0.04 mg/L). The water quality at four-salinity levels (0‰, 5‰, 10‰ and 15‰) were obtained, 0‰ served as a control and the growth performance and survival rates of Red Tilapia were monitored during experimental period for 56 days.

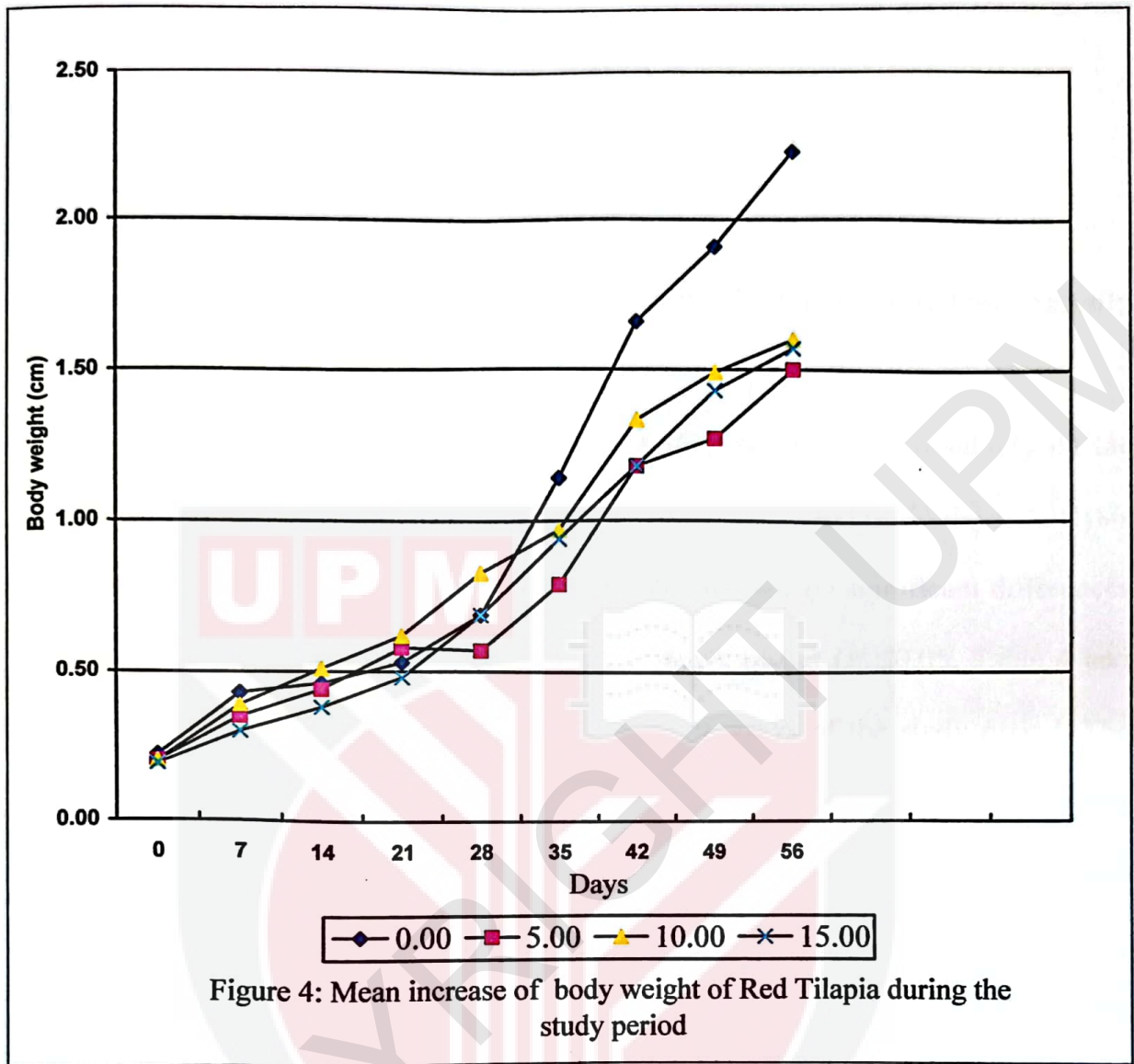
#### 4.1 Comparison of Growth (Increase in Length) of Red Tilapia Grown at four Salinity Levels

The highest increase mean in the total length of the Red Tilapia was achieved at 0‰ by 5.20cm (Figure 3). This is significantly different from the other salinity levels. Statistical analysis of variance (ANOVA) performed on the results for the total length of red tilapia *Oreochromis* sp. showed significant difference for the main factor and the interaction using the Tukey's test at  $P \leq 0.05$ . This was followed at 10‰ with the mean of 4.63cm, while 15‰ salinity gives 4.50cm increase in total length. Table 2 shows the comparison of the means of the total length in the culture tanks of 0‰, 5‰, 10‰ and 15 ‰ during the study period while figure 11, 12, 13 and 14 shows the growth performance among 4 salinity levels during the study period.



#### **4.2 Comparison of the Increase in Body Weight for Red Tilapia Grown at Four Salinity Levels**

The highest increase in the mean of body weight of the Red Tilapia was achieved at 0‰ by 2.23g, followed by 10‰, 1.60g, 15‰, 1.57g and 5‰ by 1.50g (Figure 4, Table 3). The Statistical analysis of variance (ANOVA) test which was done on the growth data showed significant difference for main factor and the interaction using the Tukey's test at ( $P \leq 0.05$ ). There was a tendency that the growth will decrease as the salinity increase. The increase in the mean of body weight of Red Tilapia at 0‰ was significantly different from the other salinity levels, which was tested.



#### 4.3 Comparison of the Survival Rates (%) for Red Tilapia at Four Salinity Levels

Survival rates were recorded for each tank to assess the influence of salinity on the growth performance and survival rates of Red Tilapia for period of 56 days. Analysis of variance, (ANOVA) performed for survival rates showed no significant differences for main the factor and the interaction using Tukey's test at ( $P \leq 0.05$ , Table 4 and Figure 5) rates of Red Tilapia *Oreochromis* sp for 9 weeks of the study period. The best survival rates of Red Tilapia was achieved at 15‰ with 25.04 %, followed by 0‰ 24.49%, 5‰ 23.11 and 10‰ 22.78%. The percentage of Survival is highest at 0‰ and 15‰ during the experiment period.

Table 2: Increase in Total Length (cm) during experimental period

| Salinity | Day period         |                    |                    |                   |                    |                    |                   |                    |                    |
|----------|--------------------|--------------------|--------------------|-------------------|--------------------|--------------------|-------------------|--------------------|--------------------|
|          | 0                  | 7                  | 14                 | 21                | 28                 | 35                 | 42                | 49                 | 56                 |
| S0       | 2.27 <sup>a</sup>  | 2.73 <sup>a</sup>  | 2.93 <sup>ab</sup> | 3.10 <sup>a</sup> | 3.50 <sup>a</sup>  | 3.87 <sup>a</sup>  | 4.60 <sup>a</sup> | 5.07 <sup>a</sup>  | 5.20 <sup>a</sup>  |
| S5       | 2.23 <sup>a</sup>  | 2.60 <sup>ab</sup> | 2.87 <sup>ab</sup> | 2.97 <sup>a</sup> | 3.23 <sup>b</sup>  | 3.50 <sup>b</sup>  | 4.10 <sup>a</sup> | 4.27 <sup>b</sup>  | 4.43 <sup>b</sup>  |
| S10      | 2.17 <sup>ab</sup> | 2.70 <sup>ab</sup> | 3.03 <sup>a</sup>  | 3.20 <sup>a</sup> | 3.67 <sup>a</sup>  | 3.97 <sup>a</sup>  | 4.27 <sup>b</sup> | 4.47 <sup>ab</sup> | 4.63 <sup>ab</sup> |
| S15      | 2.10 <sup>b</sup>  | 2.47 <sup>b</sup>  | 2.70 <sup>b</sup>  | 3.00 <sup>a</sup> | 3.43 <sup>ab</sup> | 3.77 <sup>ab</sup> | 4.03 <sup>a</sup> | 4.37 <sup>ab</sup> | 4.50 <sup>b</sup>  |

Note: Same alphabets are not significantly different using Tukey's test at  $P \leq 0.05$ .

Table 3: Increase in Body Weight (g) during experimental period

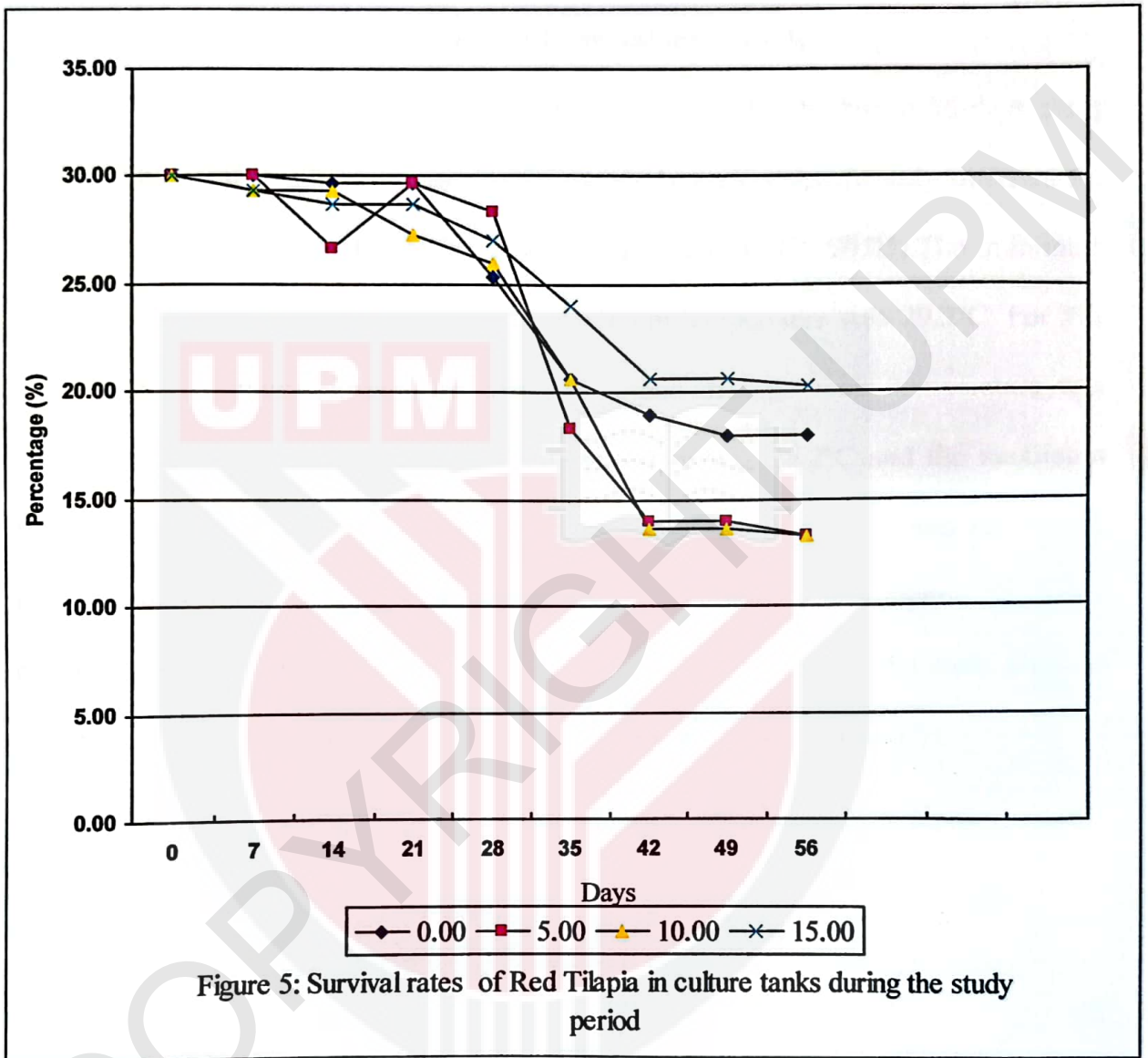
| Salinity | Day period        |                   |                    |                   |                   |                   |                   |                   |                    |
|----------|-------------------|-------------------|--------------------|-------------------|-------------------|-------------------|-------------------|-------------------|--------------------|
|          | 0                 | 7                 | 14                 | 21                | 28                | 35                | 42                | 49                | 56                 |
| S0       | 0.22 <sup>a</sup> | 0.42 <sup>a</sup> | 0.46 <sup>ab</sup> | 0.53 <sup>a</sup> | 0.69 <sup>a</sup> | 1.14 <sup>a</sup> | 1.66 <sup>a</sup> | 1.91 <sup>a</sup> | 2.23 <sup>a</sup>  |
| S5       | 0.20 <sup>a</sup> | 0.35 <sup>a</sup> | 0.44 <sup>ab</sup> | 0.58 <sup>a</sup> | 0.57 <sup>a</sup> | 0.79 <sup>a</sup> | 1.18 <sup>a</sup> | 1.27 <sup>a</sup> | 1.50 <sup>b</sup>  |
| S10      | 0.20 <sup>a</sup> | 0.39 <sup>a</sup> | 0.51 <sup>a</sup>  | 0.62 <sup>a</sup> | 0.83 <sup>a</sup> | 0.79 <sup>a</sup> | 1.13 <sup>a</sup> | 1.49 <sup>a</sup> | 1.60 <sup>ab</sup> |
| S15      | 0.19 <sup>a</sup> | 0.30 <sup>a</sup> | 0.38 <sup>b</sup>  | 0.48 <sup>a</sup> | 0.69 <sup>a</sup> | 0.94 <sup>a</sup> | 1.18 <sup>a</sup> | 1.43 <sup>a</sup> | 1.57 <sup>ab</sup> |

Note: Same alphabets are not significantly different using Tukey's test at  $P \leq 0.05$ .

Table 4: Survival Rates (%) of Red Tilapia at 4 Salinity Levels

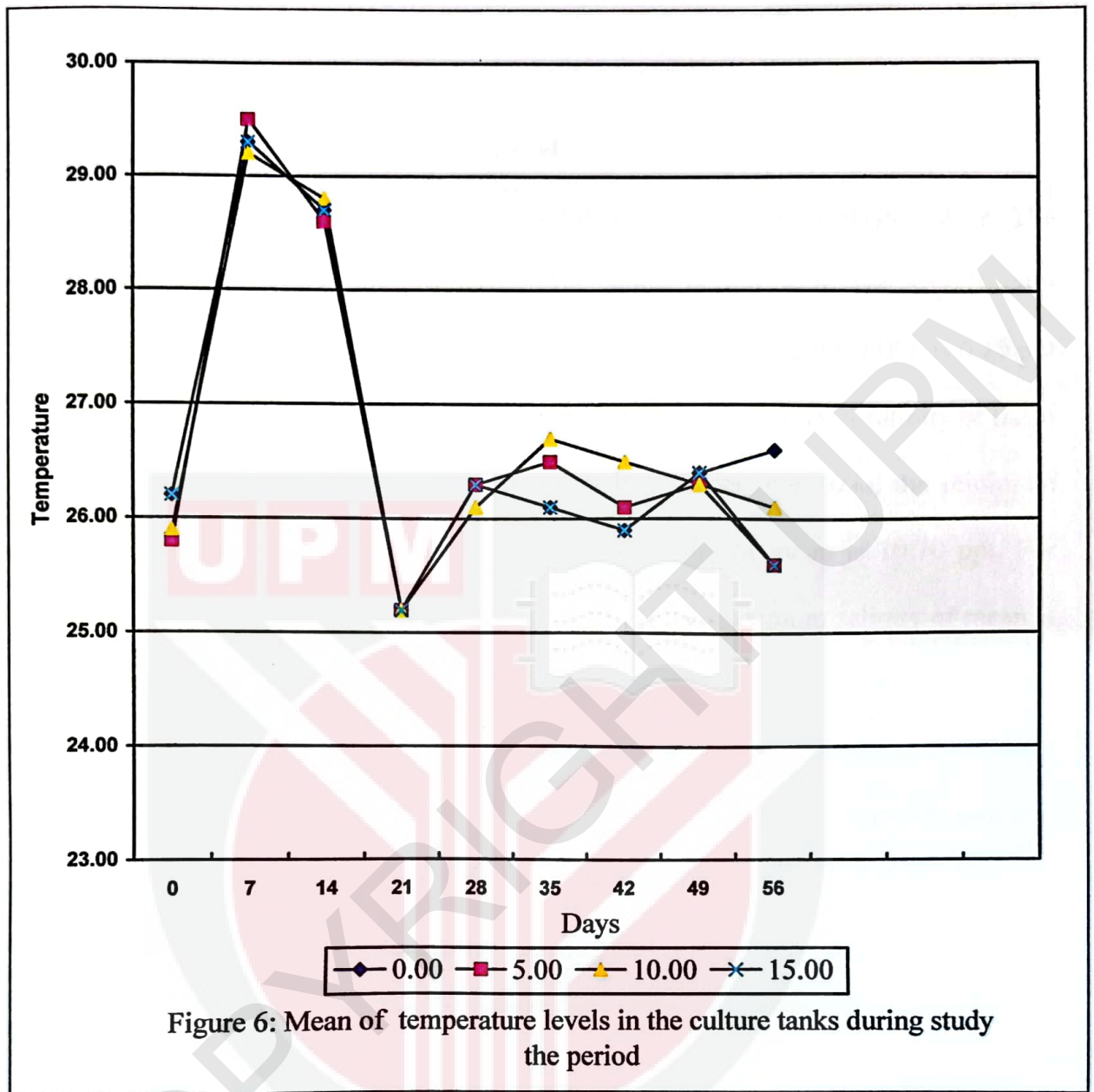
| Salinity | Day period         |                    |                    |                    |                    |                    | Mean                |                     |                    |                    |
|----------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|---------------------|---------------------|--------------------|--------------------|
|          | 0                  | 7                  | 14                 | 21                 | 28                 | 35                 |                     | 42                  | 49                 | 56                 |
| S0       | 30.00              | 30.00              | 29.67              | 29.67              | 25.33              | 20.67              | 19.00               | 18.00               | 18.00              | 24.48 <sup>a</sup> |
| S5       | 30.00              | 30.00              | 29.67              | 29.67              | 28.33              | 18.33              | 14.67               | 14.00               | 13.33              | 23.11 <sup>a</sup> |
| S10      | 30.00              | 29.33              | 29.33              | 27.33              | 26.00              | 20.67              | 15.33               | 13.67               | 13.33              | 22.78 <sup>a</sup> |
| S15      | 30.00              | 29.33              | 28.67              | 28.67              | 27.00              | 24.00              | 21.67               | 20.67               | 20.33              | 25.04 <sup>a</sup> |
| Mean     | 28.75 <sup>a</sup> | 29.67 <sup>a</sup> | 29.33 <sup>a</sup> | 28.83 <sup>a</sup> | 26.67 <sup>a</sup> | 20.92 <sup>b</sup> | 17.67 <sup>bc</sup> | 16.58 <sup>bc</sup> | 16.25 <sup>c</sup> |                    |

Note: Same alphabets are not significantly different using Tukey's test at  $P \leq 0.05$ .



#### 4.4 Comparison of Temperature at Four Salinity Levels

Figure 6 showed the mean temperature in four-salinity levels during 56-days study period. The result for temperature during the study period significantly different for main factor and interaction using the Tukey's test at ( $P \leq 0.05$ ). The minimum temperature for 0‰ was 25.2°C and the maximum temperature was 29.3°C. For 5‰ salinity the minimum temperature was 25.2°C and the maximum temperature was 29.5°C. For salinity, 10‰ the minimum temperature was 25.2°C and the maximum temperature was 29.2 °C. For salinity, 15‰ the minimum temperature was 25.2°C and the maximum temperature was 29.3°C. Table 5 summarizes the temperature ranges during the experimental period. The temperatures observed during the study showed that they significantly different during the study period ( $P \leq 0.05$ , Table 5).



#### 4.5 Comparison of Four-Salinity Level

Figure 7 shows mean of salinity in four-salinity levels during 56-days culture. The results for salinity-level changes during the study period were not significantly different (Tukey's test at  $P \leq 0.05$ ). The minimum salinity of mean for 0‰ is 0.10 ppt and the maximum salinity of mean is 0.20 ppt. For 5‰, the minimum salinity of mean is 5.10 ppt and the maximum salinity of mean is 5.50 ppt. For 10‰, the minimum salinity of mean is 10.10 ppt and the maximum salinity of mean is 10.70 ppt. For 15‰, the minimum salinity of mean is 15.30 ppt and the maximum salinity of mean is 15.90 ppt, Table 6 summarizes the salinity ranges during the experimental period. The salinity observed during the study showed that they do not differ significantly during the study period ( $P \leq 0.05$ , Tables 6). That cause by the location at hatchery unit and environment changing. The statically analysis to show are significantly different among the four salinity level during the experimental period for 56 days.

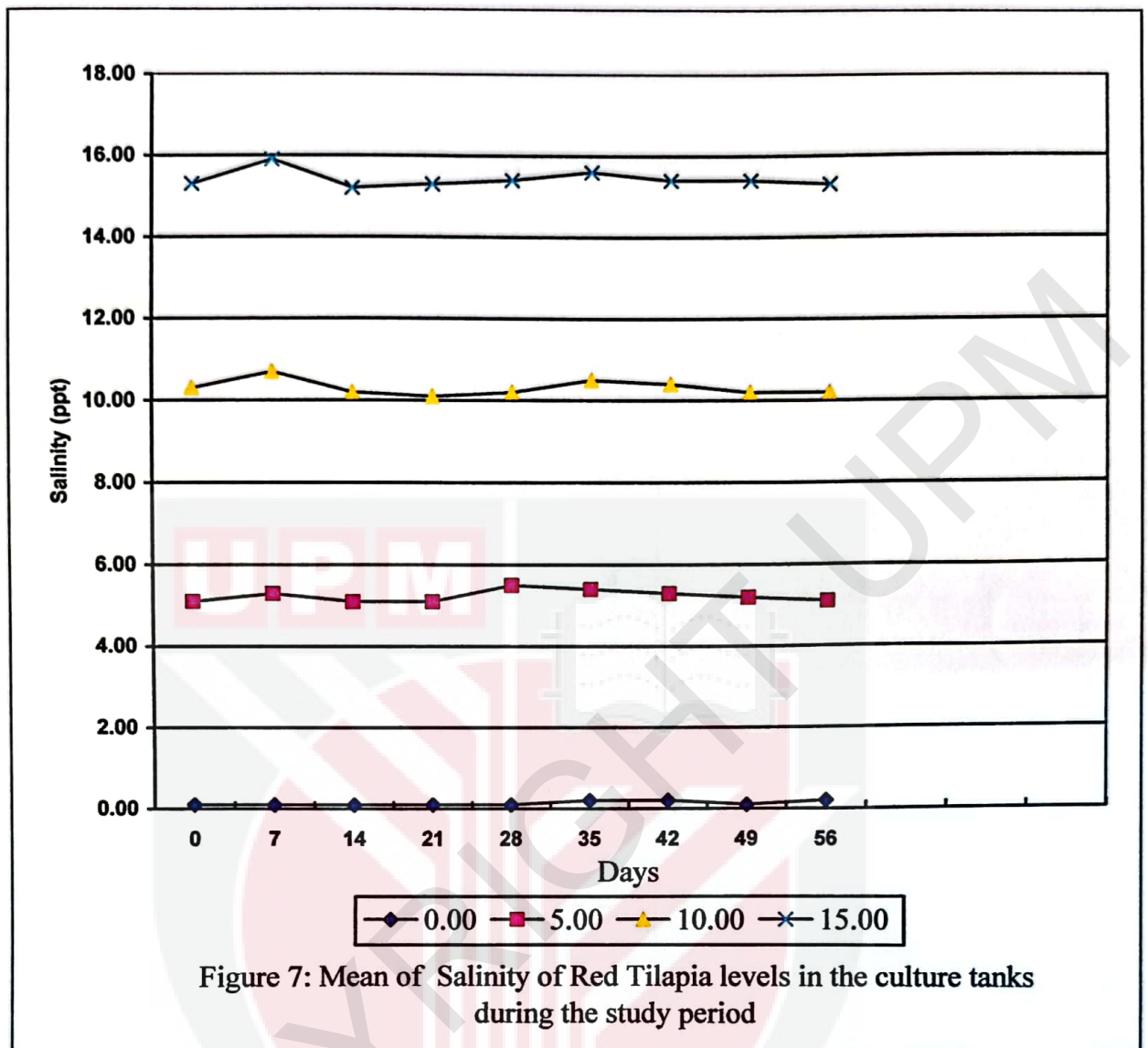


Table 5: Temperature (°C) during experimental period

| Salinity | Day period        |                    |                   |                    |                    |                    |                    |                    |                    |
|----------|-------------------|--------------------|-------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
|          | 0                 | 7                  | 14                | 21                 | 28                 | 35                 | 42                 | 49                 | 56                 |
| S0       | 26.2 <sup>b</sup> | 29.3 <sup>ab</sup> | 28.7 <sup>c</sup> | 25.20 <sup>a</sup> | 26.30 <sup>a</sup> | 26.10 <sup>c</sup> | 25.90 <sup>c</sup> | 26.40 <sup>a</sup> | 26.40 <sup>a</sup> |
| S5       | 25.8 <sup>c</sup> | 29.4 <sup>b</sup>  | 28.6 <sup>d</sup> | 25.20 <sup>a</sup> | 26.30 <sup>a</sup> | 26.50 <sup>b</sup> | 26.10 <sup>b</sup> | 26.30 <sup>b</sup> | 25.60 <sup>c</sup> |
| S10      | 29.5 <sup>a</sup> | 29.2 <sup>b</sup>  | 28.8 <sup>b</sup> | 25.20 <sup>a</sup> | 26.10 <sup>b</sup> | 26.70 <sup>a</sup> | 26.50 <sup>a</sup> | 26.30 <sup>b</sup> | 26.10 <sup>b</sup> |
| S15      | 26.2 <sup>b</sup> | 29.3 <sup>ab</sup> | 28.9 <sup>a</sup> | 25.20 <sup>a</sup> | 26.30 <sup>a</sup> | 26.10 <sup>a</sup> | 25.90 <sup>c</sup> | 26.40 <sup>a</sup> | 25.60 <sup>c</sup> |

Note: Same alphabets are not significantly different using Tukey's test at  $P \leq 0.05$ .

Table 6: Salinity (ppt) during experimental period

| Salinity | Day period         |                    |                    |                    |                    |                    |                    |                    |                    |
|----------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|--------------------|
|          | 0                  | 7                  | 14                 | 21                 | 28                 | 35                 | 42                 | 49                 | 56                 |
| S0       | 0.10 <sup>d</sup>  | 0.10 <sup>d</sup>  | 0.10 <sup>d</sup>  | 0.10 <sup>d</sup>  | 0.20 <sup>d</sup>  | 0.20 <sup>d</sup>  | 0.20 <sup>d</sup>  | 0.10 <sup>d</sup>  | 0.20 <sup>d</sup>  |
| S5       | 5.10 <sup>c</sup>  | 5.30 <sup>c</sup>  | 5.30 <sup>c</sup>  | 5.10 <sup>c</sup>  | 5.50 <sup>c</sup>  | 5.40 <sup>c</sup>  | 5.30 <sup>c</sup>  | 5.20 <sup>c</sup>  | 5.10 <sup>c</sup>  |
| S10      | 10.30 <sup>b</sup> | 10.70 <sup>b</sup> | 10.70 <sup>b</sup> | 10.10 <sup>b</sup> | 10.20 <sup>b</sup> | 10.50 <sup>b</sup> | 10.40 <sup>b</sup> | 10.20 <sup>b</sup> | 10.20 <sup>b</sup> |
| S15      | 15.30 <sup>a</sup> | 15.90 <sup>a</sup> | 15.20 <sup>a</sup> | 15.30 <sup>a</sup> | 15.40 <sup>a</sup> | 15.60 <sup>a</sup> | 15.40 <sup>a</sup> | 15.40 <sup>a</sup> | 15.30 <sup>a</sup> |

Note: Same alphabets are not significantly different using Tukey's test at  $P \leq 0.05$ .

#### 4.6 Comparison of pH at Four Salinity Levels

Figure 8 shows the ranges of pH in four-salinity levels during 56-days study period. The results for pH during the study period differed significantly (Tukey's test at  $P \leq 0.05$ ). The minimum of pH for 0‰ was 7.37 and the maximum pH was 8.66. The means of 0‰ showed significant differences with 15‰. For 5‰, the minimum pH was 7.62 and the maximum pH was 9.00. The mean salinity 5‰ was significantly different when compared with 15‰. For 10‰, the minimum pH was 7.70 and the maximum pH was 8.81. For 15‰, the minimum pH was 7.15 and the maximum pH was 8.41. For all the 4 salinity levels, the pH for waters significantly different at 15‰. For the control the range controls (0‰) pH ranges from 7.36-8.66. Statistical analysis (Table 7) showed significant difference ( $P \leq 0.05$ ) among four-salinity levels during the experimental period of 56 days.

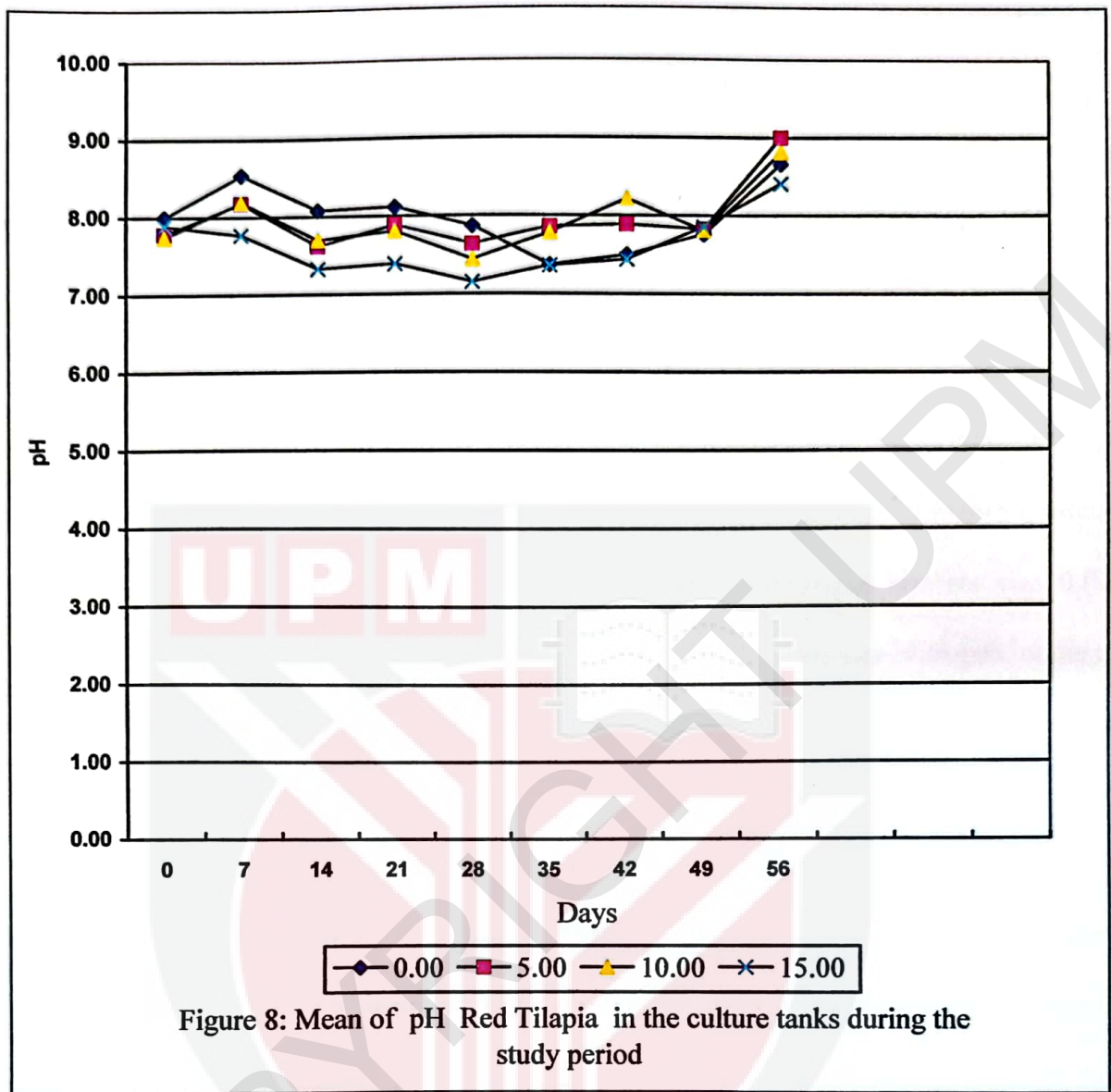


Figure 8: Mean of pH Red Tilapia in the culture tanks during the study period

#### 4.7 Comparison of Total Ammonia-Nitrogen at Four Salinity Levels

The total ammonia-nitrogen content in experiment tanks significantly different ( $P \leq 0.05$ ) in the study. Figure 9 showed the total ammonia-nitrogen content in four-salinity levels during 56-day study period. The minimum Total Ammonia-Nitrogen content for 0‰ was 0.01 mg/L and the maximum Total Ammonia-Nitrogen content was 0.02 mg/L. At 5‰, the minimum Total Ammonia-Nitrogen content was 0.01 mg/L and the maximum was 0.03 mg/L. At 5‰ the Total Ammonia-Nitrogen, content did not differ from 10‰ and 15‰. At 10‰, the minimum Total Ammonia-Nitrogen content was 0.10 mg/L and the maximum Total Ammonia-Nitrogen content was 0.17 mg/L. At 15‰ salinity, the minimum Total Ammonia-Nitrogen content was 0.13 mg/L and the maximum Total Ammonia-Nitrogen content was 0.31. Table 8 shows the Total Ammonia-Nitrogen at four-salinity levels for the experiment tanks. Statistical analysis showed significant difference among the four salinity levels in the experimental tanks. Total Ammonia- Nitrogen was not stable and kept on changing during the experimental period.

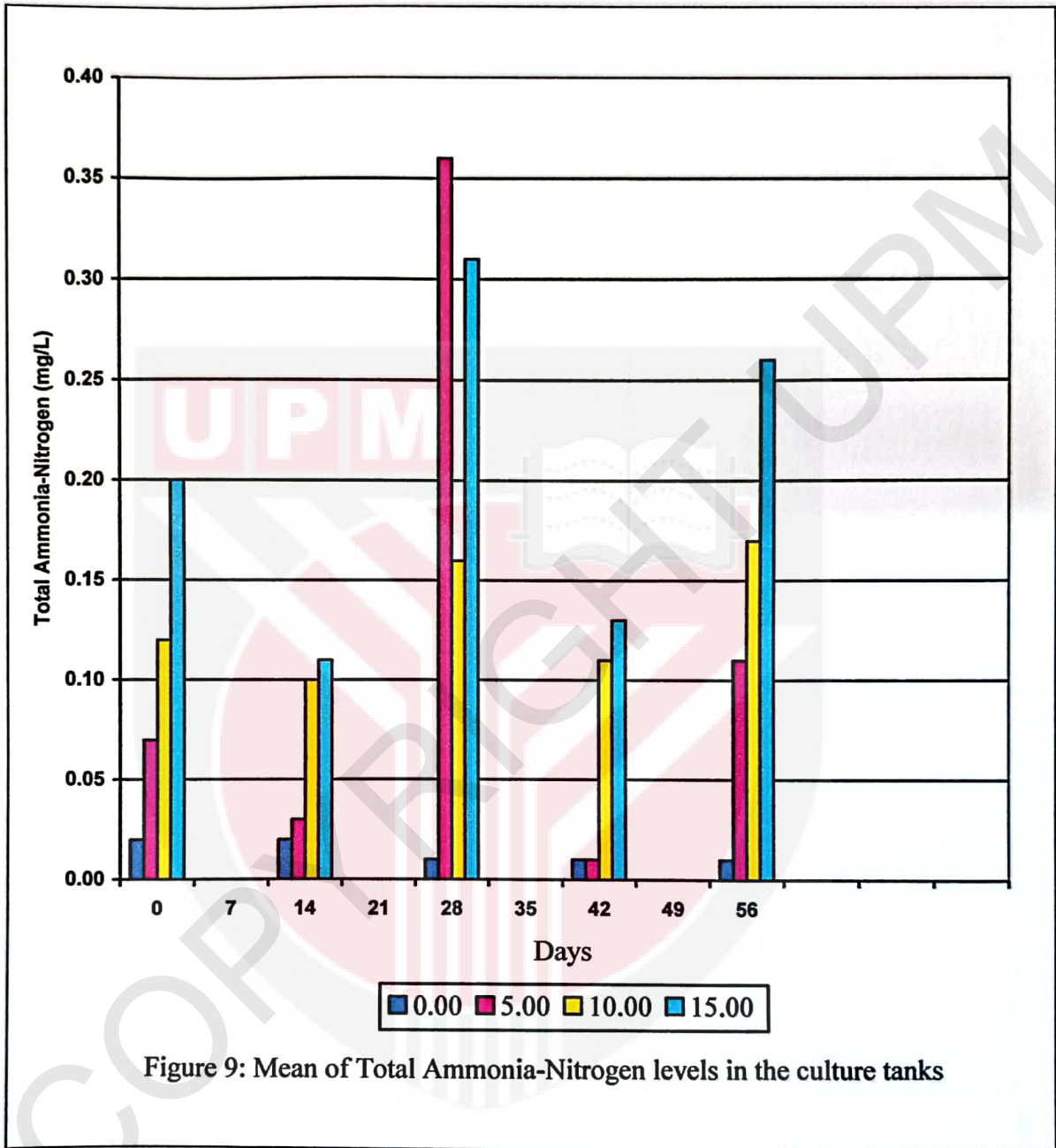


Figure 9: Mean of Total Ammonia-Nitrogen levels in the culture tanks

Table 7: pH during experimental period

| Salinity | Day period        |                    |                    |                   |                   |                    |                    |                    | Mean              |                   |
|----------|-------------------|--------------------|--------------------|-------------------|-------------------|--------------------|--------------------|--------------------|-------------------|-------------------|
|          | 0                 | 7                  | 14                 | 21                | 28                | 35                 | 42                 | 49                 |                   | 56                |
| S0       | 8.00              | 8.54               | 8.08               | 8.12              | 7.87              | 7.37               | 7.50               | 7.76               | 8.66              | 7.99 <sup>a</sup> |
| S5       | 7.80              | 8.18               | 7.62               | 7.89              | 7.64              | 7.86               | 7.89               | 7.83               | 9.00              | 7.96 <sup>a</sup> |
| S10      | 7.74              | 8.19               | 7.70               | 7.81              | 7.44              | 7.78               | 8.22               | 7.81               | 8.81              | 7.94 <sup>a</sup> |
| S15      | 7.89              | 7.77               | 7.33               | 7.39              | 7.15              | 7.36               | 7.44               | 7.86               | 8.41              | 7.61 <sup>b</sup> |
| Mean     | 7.83 <sup>b</sup> | 8.17 <sup>ab</sup> | 7.68 <sup>bc</sup> | 7.8 <sup>bc</sup> | 7.53 <sup>c</sup> | 7.60 <sup>bc</sup> | 7.76 <sup>bc</sup> | 7.86 <sup>bc</sup> | 8.72 <sup>a</sup> |                   |

Note: Same alphabets are not significantly different using Tukey's test at  $P \leq 0.05$ .

Table 8: Total Ammonia-Nitrogen (mg/L) during experimental period

| Salinity | Day period        |                   |                   |                   |                   |                   |                   |                    | Mean               |                   |
|----------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|--------------------|--------------------|-------------------|
|          | 0                 | 7                 | 14                | 21                | 28                | 35                | 42                | 49                 |                    | 56                |
| S0       | 0.02              | 0.02              | 0.02              | 0.01              | 0.01              | 0.01              | 0.01              | 0.01               | 0.01               | 0.01 <sup>b</sup> |
| S5       | 0.07              | 0.03              | 0.03              | 0.36              | 0.36              | 0.01              | 0.01              | 0.11               | 0.11               | 0.15 <sup>a</sup> |
| S10      | 0.12              | 0.10              | 0.10              | 0.16              | 0.16              | 0.11              | 0.11              | 0.17               | 0.17               | 0.20 <sup>a</sup> |
| S15      | 0.20              | 0.11              | 0.11              | 0.31              | 0.31              | 0.13              | 0.13              | 0.26               | 0.26               | 0.11 <sup>a</sup> |
| Mean     | 0.01 <sup>b</sup> | 0.06 <sup>b</sup> | 0.06 <sup>b</sup> | 0.21 <sup>a</sup> | 0.21 <sup>a</sup> | 0.08 <sup>b</sup> | 0.08 <sup>b</sup> | 0.14 <sup>ab</sup> | 0.14 <sup>ab</sup> |                   |

Note: Same alphabets are not significantly different using Tukey's test at  $P \leq 0.05$ .

#### 4.8 Comparison of Dissolved Oxygen in the Culture Tanks

Figure 10 shows the mean of Dissolved Oxygen of the water in the culture tanks during 56-day of study. Dissolved oxygen content during the study period showed no significant difference. Minimum Dissolved Oxygen for 0‰ was 8.61 mg/L and the maximum Dissolved Oxygen was 9.58 mg/L. At 5‰, the minimum Dissolved Oxygen was 8.29 mg/L and the maximum Dissolved Oxygen was 9.01 mg/L. At 10‰, the minimum Dissolved Oxygen was 8.44 mg/L and the maximum Dissolved Oxygen was 9.33 mg/L. At 15‰, the minimum Dissolved Oxygen was 8.35 mg/L and the maximum Dissolved Oxygen was 9.73 mg/L. From the observation during the study period, the mean Dissolved Oxygen was not significantly different at the four salinity levels (Table 9). Based on the data obtained, the Dissolved Oxygen content in four-salinity levels were not the same. The statistical analysis showed no significant difference ( $P \leq 0.05$ ) among the four salinity levels during the experimental period.

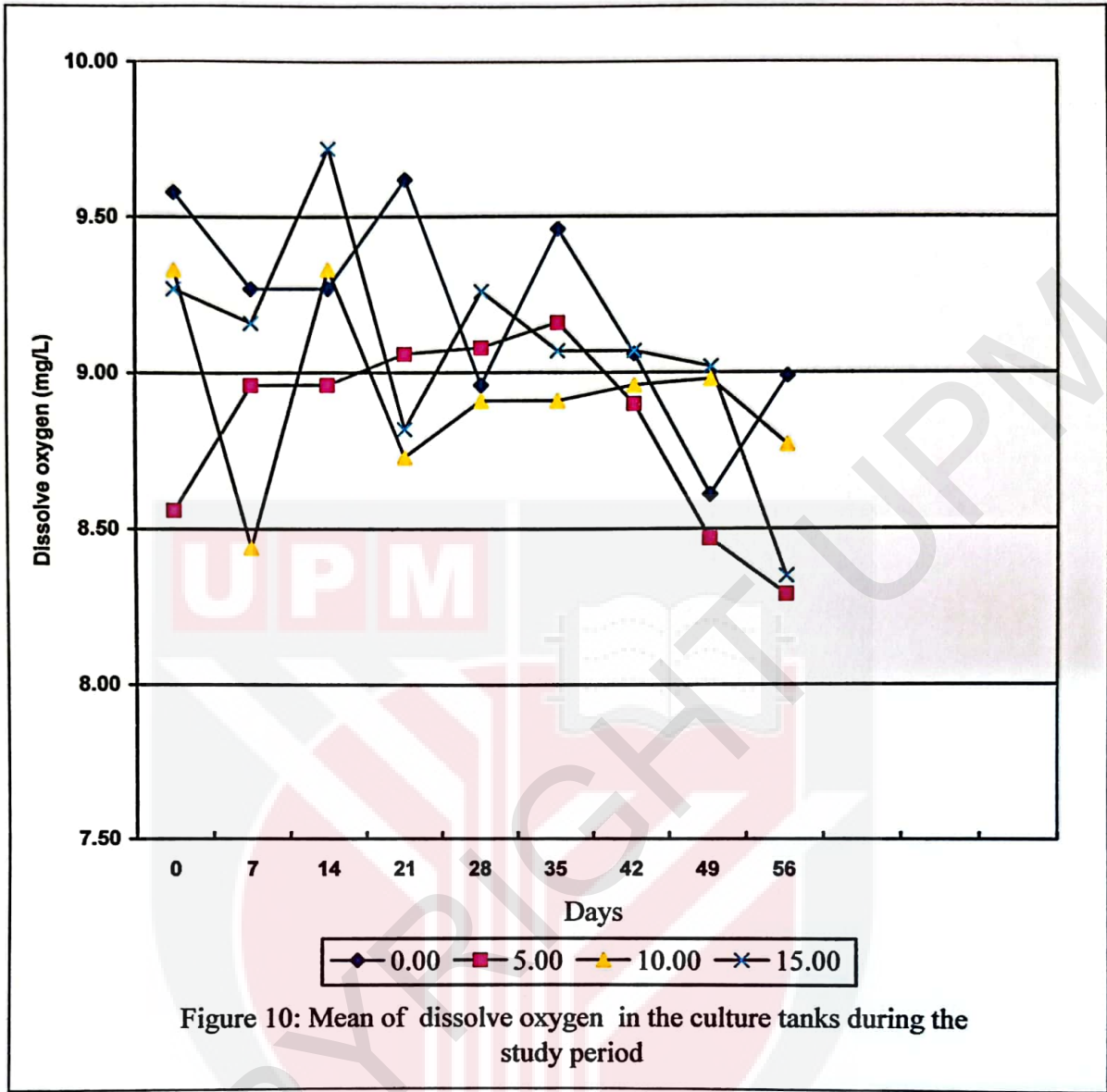


Table 9: Dissolved oxygen (mg/L) during experimental period

| Salinity | Day period       |                   |                   |                   |                   |                   |                   |                   |                   |                   |  | Mean |
|----------|------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|-------------------|--|------|
|          | 0                | 7                 | 14                | 21                | 28                | 35                | 42                | 49                | 56                |                   |  |      |
| S0       | 9.58             | 9.27              | 9.27              | 9.62              | 8.96              | 9.46              | 9.06              | 8.61              | 8.99              | 9.20 <sup>a</sup> |  |      |
| S5       | 8.56             | 8.96              | 8.96              | 9.06              | 9.08              | 9.16              | 8.90              | 8.47              | 8.29              | 8.83 <sup>a</sup> |  |      |
| S10      | 9.33             | 8.44              | 9.33              | 8.73              | 8.91              | 8.91              | 8.96              | 8.98              | 8.77              | 8.93 <sup>a</sup> |  |      |
| S15      | 9.27             | 9.16              | 9.72              | 8.82              | 9.26              | 9.07              | 9.07              | 9.02              | 8.35              | 9.08 <sup>a</sup> |  |      |
| Mean     | 9.1 <sup>a</sup> | 8.97 <sup>a</sup> | 9.32 <sup>a</sup> | 9.06 <sup>a</sup> | 9.05 <sup>a</sup> | 9.15 <sup>a</sup> | 8.99 <sup>a</sup> | 8.77 <sup>a</sup> | 8.60 <sup>a</sup> |                   |  |      |

Note: No significant different for main factors and interaction.

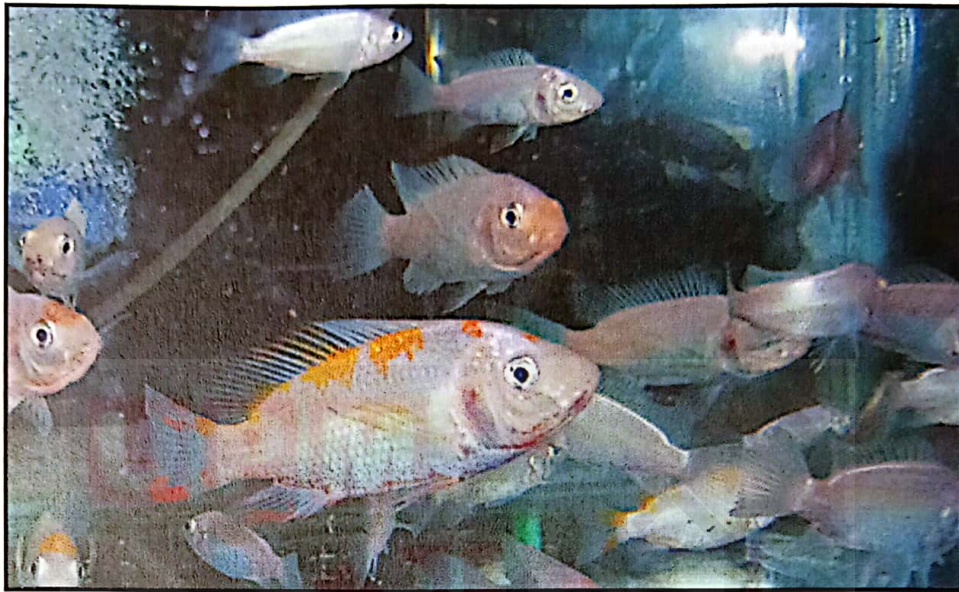


Figure 11: Growth performance of Red Tilapia at 0‰ (Control)



Figure 12: Growth performance of Red Tilapia at 5‰

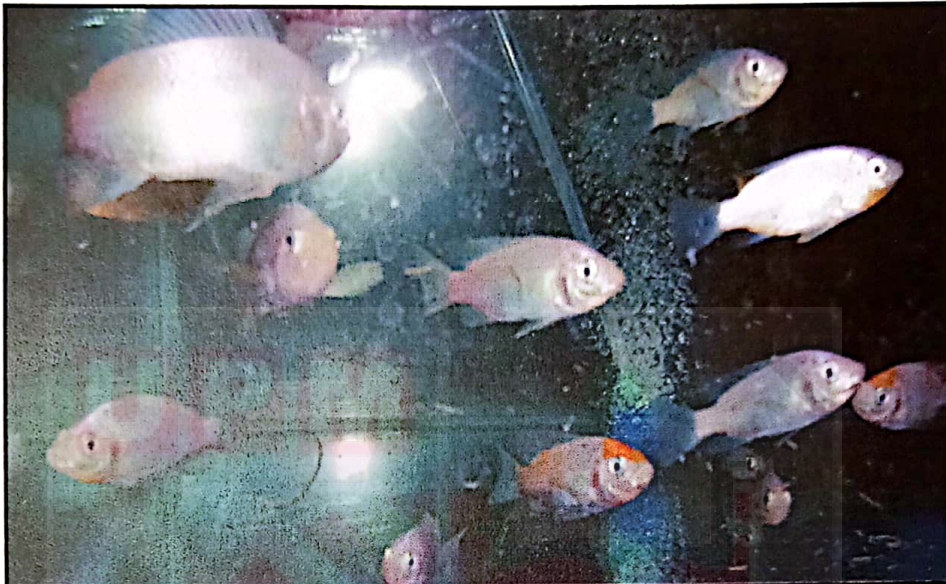


Figure 13: Growth performance of Red Tilapia at 10‰



Figure 14: Growth performance of Red Tilapia at 15‰

## CHAPTER 5

### DISCUSSION

The result in this study shows that the fastest growth performance was observed in 0‰ ( $P \leq 0.05$ ) compared with 5‰, 10‰, and 15‰ salinity levels. However, the highest survival rate of red tilapia was observed at 15‰. The results obtained in this study are consistent with the results by Watanabe *et al.* (1988).

#### 5.1 Effect of Salinity on Red Tilapia

Comparisons were made between salinity in each tank used in this study. These comparisons were based on important growth performance and survival rates of Red Tilapia, as well as environmental tolerances. For different salinity level systems, performance in growth, survival, total length and measurement in body weight were ranked separately for each salinity. From this study, it can be suggested that *Oreochromis* sp. grows faster in fresh water than in a saline environment. However, (Lio and Chang, 1983) had made contrary findings, i.e. the fishes grows faster in saline waters. Some of these salinity preferences may have been influenced by water temperature preferences. It had become clear that most of the fish studied could not tolerate above 30‰ salinity for a period of more than two hours at room temperature that was recorded. The exact levels of tolerance would have to be redefined at each temperature within a species temperature tolerance range. The results presented in this study involving acclimation to increase the salinity indicate a compensatory response that enables survival at an environmental salinity of 15‰. After the period of

acclimation in increasing the salinity (up to 5‰) and after the fish remained for 56 days in this salinity, it showed that the Red Tilapia were able to survive at different salinity levels. This is in consistence with the result obtained by (McGeachin, 1987) for Blue Tilapia. Further studies on culture of Red Tilapia are needed to determine the point at which maintenance of an environmental salinity level enables survival and growth performance compatible with the possibility of raising this fish species in brackishwater and freshwater condition.

## 5.2 Effect of Salinity on Growth Performance

Red Tilapia will grow faster in freshwater than brackishwater in this study period which is not consistent with the result obtained by Watanabe *et al.* (1988). The results obtained in this study were almost the same as the results from Taiwanese Red Tilapia exhibited faster growth in fresh water than in salt water (Liao and Chang, 1983), and similar results were found in *O. niloticus* (Villegas, 1990). The results obtained in this study on the effects of salinity on fish growth are controversial. In under saline water conditions, the growth of Red Tilapia decreased with increased salinity levels above 15‰. The present study indicates that the growth of Red Tilapia may reach the peak at 0‰ level. The best growth of Red Tilapia is at high density in freshwater. In countries with temperate climates, where ambient weather temperatures make Red Tilapia survive in different salinity levels.

### 5.3 Effect of Salinity on Survival Rates

Statistical analysis shows that the data obtained in this study was significantly different ( $P \leq 0.05$ ) in four salinity levels used during the study period. Red Tilapia is the least saline tolerant of the commercially important species, but can survive well at salinities of 15 ppt. *Oreochromis* sp grow well in brackishwater up to 15 ppt salinity. The survival rates of Red Tilapia in this study highest at 15‰ by 25.04% and was significantly better than salinity levels. The Red Tilapias survival is best in brackishwater than freshwater condition. A survival rate of Red Tilapia was not inversely related to salinity levels.

### 5.4 Effect of Salinity on Body Weight and Total Length of Tilapias

Tilapias are tolerant to brackish water. The Red Tilapia is the least saline tolerant of the commercially important species, but grows well at salinities below to 15‰. Therefore, the Tilapias were preferred for saltwater culture. Some lines of the Red Tilapia reportedly have full strength seawater, but its growth performance begins to decline at salinities above 10‰ to 15‰. Nevertheless, they perform better at salinities below 5 ‰. Fry numbers decline substantially at 10 ppt salinity. Tilapias are much more tolerant of salt water than most other freshwater fishes Found in (Watanabe *et al.*, 1985). Fry and small juveniles were dying if salinity goes above 20‰. Daily weight gains were significantly different among four salinity levels during this study. The highest growth performance is in freshwater (0‰) and is significantly higher than the other salinity levels used. The results obtained in this study showed that, growth of Red Tilapia in brackishwater is slower than freshwater.

### **5.5 Effect of Temperature on Red Tilapia**

The suitable temperatures used to culture Red Tilapia are 26°C to 30°C. The value of temperature at four salinity depends on the environment changes. In this study, the temperature for 0‰ was 26.4°C among the other salinity levels used. The temperature values at tanks were not stable by environment of heat effect during this study period. The results are approximately the same reported by Avella *et al.* (1992) preference in the range of 12°C to 42°C. Mortalities occur at extreme temperatures. Tilapias do not thrive in low water temperatures but are very tolerant to high temperatures. Note, though, that too much handling at high temperature could result in high mortality. Activity and feeding of Tilapias are reduced below 20°C. The data obtained in this study are similar to the results reported in Nile Tilapia (Trewavas, 1983.). Preferred water temperatures for Tilapias growth are approximately between 25.2°C to 29.5°C. Tilapias are reportedly tolerable to temperatures up to 40°C, but stress-induced disease and mortality are problematic when temperatures exceed 37°C or 38°C.

### **5.6 Effect of Dissolved Oxygen on Red Tilapia**

Low dissolved oxygen reduced the food intake and the growth performance of Red Tilapia. The suitable value must be above 5.0 mg/L. In this study, the dissolved oxygen for 0‰ is 9.20mg/L and is not significantly different among the other salinity levels used. When the dissolved oxygen is low, the total ammonia-nitrogen can be harmful to Red Tilapia. The results obtained in this study showed that, salinity is very important to the culture of Red Tilapia. The minimum dissolved oxygen level that fish

can safely tolerate depends on the temperature effect. Volubility of oxygen increases as temperature decreases. In tanks conditions, dissolved oxygen can change dramatically over a 24-hour period. Low dissolved oxygen is usually the first water quality constraint to the growth Red Tilapia. In spite of tilapias ability to survive in acute low dissolved oxygen, tanks should be managed to generally maintain levels, which is between 8.29 to 9.72 mg/L because metabolism and growth are depressed when dissolved oxygen is low.

#### **5.7 Effect of Total Ammonia-Nitrogen on Red Tilapia**

A good water quality management programmed will result in fewer fish disease problems. Total Ammonia-Nitrogen should be tested every two weeks, when ammonia levels are found to be high; the frequency of testing should be increased until the problem is solved. Ammonia is responsible for more unexplained losses in aquaculture than any other water quality parameter. At concentrations typically found in tanks, it is colorless and odorless, so the only way to know if it is present is to test for it. Total Ammonia-Nitrogen is closely correlated with pH and to a lesser extent by water temperature and dissolved oxygen. The toxicity of Total ammonia-nitrogen increase at higher temperatures; the ranges in percentage-unionized form given above reflect conditions at 24°C to 32°C. Low dissolved oxygen also increases the total ammonia-nitrogen. Prolonged exposure (56 days) to unionized total ammonia-nitrogen concentration greater than 1 mg/L causes losses, especially among fry and juveniles in water with low dissolved oxygen. The first mortalities from prolonged exposure begin at unionized total ammonia-nitrogen concentrations as low as 0.2 mg/L unionized

ammonia begins to depress the appetite of Tilapias at concentrations as low as 0.08 mg/L.

### 5.8 Effect of pH on Red Tilapia

When the range of pH is above 9.0 to 9.5 for a long-term period, the growth of Red Tilapia were reduced. The suitable pH range used to culture the Red Tilapias is from 6.5 to 8.5. The concentration of bases and acids in the water determines its pH. In general, Tilapias can survive in pH ranging from 5 to 10, but the recommended pH for good growth of tilapias is 6.5 to 9. If pH readings are outside this range, fish growth will reduce. pH values below 4.5 or above 10, mortalities will occur. pH typically fluctuates one or two units daily. In the morning, carbon dioxide levels are high and pH is low because of the respiration during the night session. From the data obtained in this study, the value of pH ranged from 7.15 to 9.00. The pH at 0‰ was 7.99, which are significantly different from waters at 15‰, which were 7.61. Another reason for low growth rates and survival in brackishwater could be explained by Chervinski's *et al.*(1976) and Villegas, (1990) who observed that Tilapias fingerlings are less salt tolerant than larger fish in salt water. Tilapias culture is limited primarily to freshwater and low salinity brackishwater, but some varieties can be cultured in higher salinity brackishwater and marine systems (Watanabe *et al.*, 1985). Similar results in this study were observed for the pH effect and the survival rates on Red Tilapia. Differences in salinity tolerances within Tilapias species are typically related to strain, age and body sizes (Villegas, 1990). Red Tilapia reared in brackishwater grow slower than freshwater progeny at salinities less than 18 ppt. Brackishwater culture, when

practiced, usually begins in either the nursery phase or with advanced fingerling production.



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## CHAPTER 6

### CONCLUSION

The best growth performance was achieved in freshwater at 0‰. The survival rates of Red Tilapia are higher at 15‰ compared to 0‰, 5‰ and 10‰. The survival rates were high because the Tilapias were able to grow and adapt to different salinities while the growth in brackishwater was poor but could approached the normal level. It is generally observed that tilapias exhibit poor growth in tanks. The same source red tilapia grew very well if the position of tanks near or direct to the sunlight. However, it would be useful to compare the Red Tilapia for growth characteristics under different water salinity conditions to have better understanding for both growth performance and survival rates. One surprising result in this study was that the survival of Red Tilapia in freshwater was far below the survival at 15‰, the comparison of water quality for 0% (control) is suitable to culture red tilapia compared to other salinity levels. This study demonstrates that the Red Tilapia grow better in freshwater tanks than brackishwater tanks. It also shows that the Red Tilapia culture is profitable in freshwater depend on climate of the specific country. Studies are required to assess the effects of salinity on water quality parameter for tolerance in Red Tilapia. It is difficult to distinguish the survival rates of the Red Tilapia at differences due to treatment effect. However, that fish require a great expenditure to withstand a saline environment.

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APPENDIX 1

Specific Growth Rate (SGR) =  $L_n(W_2) - L_n(W_1) \times 100 / t$

Table 10: Increase in Body Weight (g) during experimental period

| Salinity       | Day period        |                   |                    |                   |                   |                   |                   |                   |                    |  |
|----------------|-------------------|-------------------|--------------------|-------------------|-------------------|-------------------|-------------------|-------------------|--------------------|--|
|                | 0                 | 7                 | 14                 | 21                | 28                | 35                | 42                | 49                | 56                 |  |
| S0             | 0.22 <sup>a</sup> | 0.42 <sup>a</sup> | 0.46 <sup>ab</sup> | 0.53 <sup>a</sup> | 0.69 <sup>a</sup> | 1.14 <sup>a</sup> | 1.66 <sup>a</sup> | 1.91 <sup>a</sup> | 2.23 <sup>a</sup>  |  |
| S5             | 0.20 <sup>a</sup> | 0.35 <sup>a</sup> | 0.44 <sup>ab</sup> | 0.58 <sup>a</sup> | 0.57 <sup>a</sup> | 0.79 <sup>a</sup> | 1.18 <sup>a</sup> | 1.27 <sup>a</sup> | 1.50 <sup>b</sup>  |  |
| S10            | 0.20 <sup>a</sup> | 0.39 <sup>a</sup> | 0.51 <sup>a</sup>  | 0.62 <sup>a</sup> | 0.83 <sup>a</sup> | 0.79 <sup>a</sup> | 1.13 <sup>a</sup> | 1.49 <sup>a</sup> | 1.60 <sup>ab</sup> |  |
| S15            | 0.19 <sup>a</sup> | 0.30 <sup>a</sup> | 0.38 <sup>b</sup>  | 0.48 <sup>a</sup> | 0.69 <sup>a</sup> | 0.94 <sup>a</sup> | 1.18 <sup>a</sup> | 1.43 <sup>a</sup> | 1.57 <sup>ab</sup> |  |
| Feed intake(g) | 6.3               | 10.8              | 13.5               | 15.6              | 20.7              | 28.7              | 40.2              | 45.6              | 53.4               |  |

Note: Same alphabets are not significantly different using Tukey's test at  $p \leq 0.05$ .

Where,  $W_2$  = final weight in g,  $W_1$  = initial weight in g

$$\begin{aligned}
 0\%c &= L_n(W_2) - L_n(W_1) \times 100 / t &= L_n(W_2) - L_n(W_1) \times 100 / t &= 5\% \\
 &= L_n(2.23) - L_n(0.22) \times 100 / 56 &= L_n(1.50) - L_n(0.20) \times 100 / 56 &= 3.30g \\
 &= 3.51g &= &= \\
 10\%c &= L_n(W_2) - L_n(W_1) \times 100 / t &= L_n(W_2) - L_n(W_1) \times 100 / t &= 15\% \\
 &= L_n(1.60) - L_n(0.20) \times 100 / 56 &= L_n(1.57) - L_n(0.19) \times 100 / 56 &= 3.42g \\
 &= 3.34g &= &=
 \end{aligned}$$

APPENDIX 2

**Absolute Growth Rate (AGR) = Feed / Weight gain**

|                   |   |                    |   |                   |   |                    |
|-------------------|---|--------------------|---|-------------------|---|--------------------|
| 0% <sub>cc</sub>  | = | Feed / Weight gain | = | 5% <sub>cc</sub>  | = | Feed / Weight gain |
|                   | = | 53.4/2.01          | = |                   | = | 53.4/1.30          |
|                   | = | 26.60%             | = |                   | = | 41.07%             |
| 10% <sub>cc</sub> | = | Feed / Weight gain | = | 15% <sub>cc</sub> | = | Feed / Weight gain |
|                   | = | 53.4/1.40          | = |                   | = | 53.4/1.38          |
|                   | = | 38.14%             | = |                   | = | 38.70%             |

APPENDIX 3

Significant Main Factor and Interactions

Tukey's Studentized Range (HSD) Test for Body weight

| Source          | DF  | Sum of Squares | Mean Square | F Value | Pr > F |
|-----------------|-----|----------------|-------------|---------|--------|
| Model           | 35  | 31.22987685    | 0.89228220  | 26.10   | <.0001 |
| Error           | 72  | 2.46146667     | 0.03418704  |         |        |
| Corrected Total | 107 | 33.69134352    |             |         |        |

Tukey's Studentized Range (HSD) Test for Total Length of Red Tilapia during study period

| Source          | DF  | Sum of Squares | Mean Square | F Value | Pr > F |
|-----------------|-----|----------------|-------------|---------|--------|
| Model           | 35  | 78.22629630    | 2.23503704  | 62.53   | <.0001 |
| Error           | 72  | 2.57333333     | 0.03574074  |         |        |
| Corrected Total | 107 | 80.79962963    |             |         |        |

Tukey's Studentized Range (HSD) Test for Temperature

| Source          | DF  | Sum of Squares | Mean Square | F Value | Pr > F |
|-----------------|-----|----------------|-------------|---------|--------|
| Model           | 35  | 204.6787963    | 5.8479656   | 15789.5 | <.0001 |
| Error           | 72  | 0.0266667      | 0.0003704   |         |        |
| Corrected Total | 107 | 204.7054630    |             |         |        |

Tukey's Studentized Range (HSD) Test for Salinity

| Source          | DF  | Sum of Squares | Mean Square | F Value | Pr > F |
|-----------------|-----|----------------|-------------|---------|--------|
| Model           | 35  | 3501.666667    | 100.047619  | 1.98E15 | <.0001 |
| Error           | 72  | 0.000000       | 0.000000    |         |        |
| Corrected Total | 107 | 3501.666666    |             |         |        |

APPENDIX 4

Interaction not significant for main factor and interactions

Tukey's Studentized Range (HSD) Test for Survival Rate of Red Tilapia during study period

| Source          | DF  | Sum of Squares | Mean Square | F Value | Pr > F |
|-----------------|-----|----------------|-------------|---------|--------|
| Model           | 35  | 3780.296296    | 108.008466  | 8.99    | <.0001 |
| Error           | 72  | 865.333333     | 12.018519   |         |        |
| Corrected Total | 107 | 4645.629630    |             |         |        |

Tukey's Studentized Range (HSD) Test for pH

| Source          | DF  | Sum of Squares | Mean Square | F Value | Pr > F |
|-----------------|-----|----------------|-------------|---------|--------|
| Model           | 35  | 18.63129167    | 0.53232262  | 2.58    | 0.0004 |
| Error           | 72  | 14.88353333    | 0.20671574  |         |        |
| Corrected Total | 107 | 33.51482500    |             |         |        |

Tukey's Studentized Range (HSD) Test for Dissolved Oxygen

| Source          | DF  | Sum of Squares | Mean Square | F Value | Pr > F |
|-----------------|-----|----------------|-------------|---------|--------|
| Model           | 35  | 12.06610000    | 0.34474571  | 0.77    | 0.8030 |
| Error           | 72  | 32.31286667    | 0.44878981  |         |        |
| Corrected Total | 107 | 44.37896667    |             |         |        |

Tukey's Studentized Range (HSD) Test for Total Ammonia- Nitrogen

| Source          | DF | Sum of Squares | Mean Square | F Value | Pr > F |
|-----------------|----|----------------|-------------|---------|--------|
| Model           | 19 | 0.58502667     | 0.03079088  | 4.06    | <.0001 |
| Error           | 40 | 0.30366667     | -0.00759167 |         |        |
| Corrected Total | 59 | 0.88869333     |             |         |        |

## APPENDIX 5

### Equipment to Monitor Water Quality



Figure 15: pH Hanna Portable Meter

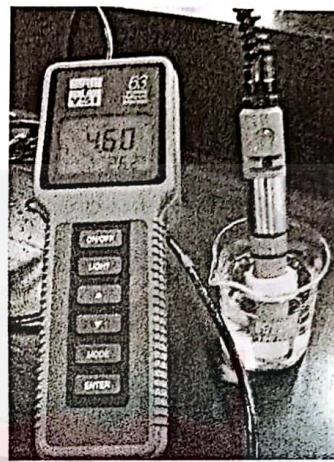


Figure 16: SCT meter (63-YSI Environment)



Figure 17: YSI medel 200 Meter Oxygen Meter



Figure 18: Hach Test Kits Model 1400

## PUBLICATION OF THE PROJECT UNDERTAKING

This is to certify that I have no objection to publish the project entitled “**The Growth Performance and Survival Rater of Red Tilapia *Oreochromis* sp. Grown in Different Water Salinities.**” by the supervisor in a joint authorship. However, it has to be evaluated by the Faculty of Agriculture and Food Sciences, Universiti Putra Malaysia Bintulu Campus and published in form approved by the Faculty.

  
Augustin Ak Jetie

Date: 30 April 2007