UNIVERSITI PUTRA MALAYSIA

GROWTH PERFORMANCE AND SURVIVAL OF GIANT FRESHWATER PRAWN LARVAE MACROBRACLTIUNI ROSENBERGII (DE MAN) GROWN IN NATURAL AND ARTIFICIAL SEA WATER

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GROWTH PERFORMANCE AND SURVIVAL OF GIANT FRESHWATER PRAWN LARVAE *Macrobrachium rosenbergii* (de Man) GROWN IN NATURAL AND ARTIFICIAL SEA WATER

By

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TO MY LOVELY AND BELOVED PARENTS,
SISTERS AND BROTHERS,
ALL MY FRIENDS AND COURSEMATES.

I LOVE YOU ALL

ABSTRACT

A study was conducted to determine the feasibility of replacing sea water with salt water in the culture of Giant Freshwater Prawn larvae, *Macrobrachium rosenbergii* (de Man) by using "Freshwater System". The prawn larvae were culture in 3 treatments: 100% sea water (Control), 50% sea water and 50% artificial sea water (Treatment 1), and 100% artificial sea water (Treatment 2). Each treatment had 3 replicates at the stocking density of 40 larvae^{-1}. 5 larvae from each tank were examined daily to determine their stages. When about 90% of the larvae metamorphosed to post larvae (PL), the experiment was terminated. The average survival rate of larvae during the study period for control, 50% sea water and 50% artificial sea water and 100% artificial sea water were 1.34%, 0.98%, and 0.4% respectively. These results showed that the 50% salt water was able to sustain larvae until metamorphosis. There was a significant different ($p \leq 0.05$) in survival rate between both of the tanks. The mean rearing period of *Macrobrachium rosenbergii* prawn larvae to metamorphosis for Control was 53.33 ± 0.33 days while T1-50% and T2-100% took 55.0 ± 0.58 and 57.7 ± 1.45 days, respectively. The result from this culture suggested that the 50% artificial sea water can culture prawn larvae. Based on the body composition, the survival and growth may be improved if food supplement was included in diet.

ABSTRAK

Kajian telah dilakukan untuk menentukan kadar penggantian air laut dengan air garam dalam pengkulturan udang galah, *Macrobrachium rosenbergii* (de Man) dengan menggunakan "sistem air jernih". Larva udang dikultur dalam 3 jenis air iaitu 100% air laut (Kawalan), 50% air laut dan 50% air garam (Rawatan 1) dan 100% air garam (Rawatan 2). Setiap rawatan mempunyai 3 replikasi pada kadar kepadatan 40 larva per liter. 5 ekor larva dari setiap tangki diambil setiap hari untuk ditentukan peringkat larva. Apabila 90% daripada larva telah bermetamorfosis kepada post larva (PL), eksperimen ini dihentikan. Purata kadar hidup larva semasa kajian untuk 100% air laut, 50% air laut dan 50% air garam dan 100% air garam masing-masing adalah 1.34%, 0.98% dan 0.4%. Keputusan menunjukkan bahawa 50% air garam mampu untuk membawa larva sehingga bermetamorfosis kepada post larva (PL). Kajian menunjukkan terdapat perbezaan beerti ($p \leq 0.05$) di dalam kadar hidup di antara kesemua tangki. Min bagi masa pengkulturan larva *Macrobrachium rosenbergii* untuk bermetamorfosis kepada post larva (PL) bagi kawalan ialah 53.33 ± 0.33 hari manakala untuk Rawatan 1 dan Rawatan 2 masing-masing ialah 55.0 ± 0.58 dan 57.7 ± 1.45. Keputusan dari pengkulturan ini mencadangkan bahawa 50% air garam dapat mengkultur larva udang. Berdasarkan kepada keperluan, kadar hidup dan pertumbuhan mungkin boleh diperbaiki sekiranya makanan tambahan dimasukkan ke dalam diet makanan.

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I certify that this research project report entitled **"GROWTH PERFORMANCE AND SURVIVAL OF GIANT FRESHWATER PRAWN LARVAE *Macrobrachium rosenbergii* (de Man) GROWN IN NATURAL AND ARTIFICIAL SEA WATER"** has been examined and approved as a partial fulfillment of the requirement for the degree of Bachelor of Bioindustry Science in the Faculty of Agriculture and Food Science, Universiti Putra Malaysia Bintulu Campus.

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LIST OF ABBREVIATIONS/NOTATION/GLOSSARY OF TERMS

ANOVA - Analysis of Variance

AS - Artificial sea water

Cm - Centimeter

°C - Degree Celsius

DNMRT- Duncan Multiple Comparison Range Test

g - Gram

kg/m^{-2} - Kilogram per meter square

µm - Micrometer

ml - Millimeter

mgl^{-1} - Milligrams per liter

mm - Millimeter

pL - Post larvae

ppm - Part per million

ppt - Part per thousand

sp. - Species

SPSS - Statistical Package Social Science

SW - Sea water

CHAPTER 1

INTRODUCTION

Giant freshwater prawns are aquatic animals, is the world's favourite food and a major source of income to fisherman and entrepreneurs. The scientific name for the giant freshwater prawns is *Macrobrachium rosenbergii* (de Man), from the Palaemonidae family. It was the origin animal Indopasific area which is between India, Bangladesh, Republic of Mynmar, Sri Lanka to Indo-China, Thailand, Malaysia, Indonesia, Phillipines and South Pacific Island. These species are widely livestocks all over the world (Willis and Berrigan, 1977).

Development in *Macrobrachium rosenbergii* aquaculture began ever since July 1959 by Shoa Wen Ling who started the research on *Macrobrachium rosenbergii* in Penang Malaysia. In June 1961, Ling discovered that the larvae of *Macrobrachium rosenbergii* needed brackish water to continue surviving and growing. He produced the first post larvae through aquaculture. Yet research on giant freshwater prawns in their natural habitat is still small. Rajyalakshmi (1961) said that breeder prawn season in their natural habitat area are on March until May. According to the fisherman in river areas, prawn overflows are connected with the rainy season and dry season also high tide and low tide. But no research had been done to confirm this.

Even though *Macrobrachium rosenbergii* lives in freshwater (it also tolerates in high salinity rates), there were matured prawns which were captured with salinity rate more than 18 ppt (Raman, 1967) and it usually happens in Malaysia's brackish water (Ling and Merican, 1961). Broodstocks usually moved to brackish water area where they live until the eggs are hatched (George, 1969). *Macrobrachium rosenbergii* usually lives in freshwater areas that are connected with rivers and lakes even though juvenile and matured prawns were caught in area with high salinity. Prawn larvae needs brackish water for growth until it reaches the post larvae level and immature prawns will move to fresh water. After few weeks, this post larvae will be moved to fresh water environment where it's grown until maturity. All over the world, there are 49 species of *Macrobrachium rosenbergii,* which are beneficial for fisheries, and around 15 species is considerable in aquaculture field.

The larvae was fed with a type of zooplankton that can be bought in shops in the form of cysts. *Macrobrachium rosenbergii* will fed on the third day after it hatches. In the beginning, *Macrobrachium rosenbergii* larvae was fed with zooplankton known as *Artemia salina* or called it *Artemia* sp. is the only ideal food especially for *Macrobrachium rosenbergii.* GSL or "Great Salt Lake" is one of the *Artemia* sp. which has a high quality and it is produced in Utah, USA. Usually the larvae is fed with complementary food by workers. Egg custard is a part of their complementary diet during the larvae level or post larvae level. As the prawn is matured and grown its is fed with pellet food that can sink into the water. This is because during the matured phase prawns usually live or find their food at the base of the pond.

Besides that the quality of water for prawn's larvae livestock has to be maintained well because good quality water will ensure good health and fertile livestock. If the water is acidic (<pH 6.5) or more alkaline (>pH 9.5) in a long-term period, reproduction and growth will decline. The toxicity of ammonia will increase when the concentration of the dissolved oxygen is low. Ammonia will also increase the usage of oxygen throughout the body. Ammonia can also cause histology changes in kidneys of the fish, tiroid tissues and blood are also exposed to ammonia concentration that can kill the aquatic organism. Exposure to high concentration of ammonia can cause the fish or prawn to be more vulnerable to disease due to lower immunity system.

Giant freshwater prawn, *Macrobrachium rosenbergii* is one of the crustaceans that have been cultured successfully in pond whether with a polyculture or a monoculture system. Farmed freshwater prawns, mainly *Macrobrachium rosenbergii* have been produced totally around 130 000 metric tonne per year. Worldwide production of this freshwater prawn, *Macrobrachium rosenbergii,* increased 636% between 1989 and 1998 while its value increased 957% during the same period (New, 2000). It is a very desirable species for freshwater pond culture because of its much attribution. Even though tropical freshwater prawns production less than of shrimp production, freshwater prawns remains of significant interest in many countries. Farmers are also preferred *Macrobrachium rosenbergii* though *Macrobrachium malcomsonii* and others *Macrobrachium* sp. is widely cultivated. A fast growth rate and can reach marketable size within three to four month compared to other freshwater prawns under a favorable pond conditions. Omnivorous is the

feeding habit for this species and can feed readily on vegetable matter or commercially available chicken feeds and etc.

There are 4 'breeding systems' of the *Macrobrachium rosenbergii* (de Man) that have been carried out; Fresh Water Open System (Ling, 1962), Green Water Open System (Fujimura, 1966), Intensif System "AQUACOP" (Aquacop, 1979) and Green Water Without Exchange the Water Open System nown as "Modified Static Green Water"(Ang and Cheah, 1986). Through the intensive breeding system nown as Intensif Closed System "AQUACOP" (Aquacop, 1979) as much as 60 post larvae per litre has been produced at a rate of 100 larvae per litre. On the other hand, the 3 types of "green water breeding system" produced more than 30 larvae per litre with the larvae releasing rate of less than 50 larvae per litre. The techniques to produce prawn breeding used by researchers before the 80's needed a great amount of maintenance such as cleaning the tanks and often changing water. These techniques demand a higher cost mainly with the heavy usage of sea water and man power. It becomes even more complicated when the hatchery is situated so far from the seaside. This is because hatcheries situated far from the seaside require huge tanks and big transports vehicles to transport sea water which will take a long time and increase the production cost.

According to a past experiment carried out at the 'Hatchery of Freshwater', UPM Serdang, using the "Green Water System Without Exchange the Water" the sea water can be obtained from manufacturers at a price of RM30 per tonne. Sea water obtained from the Faculty of Fisheries UPM Port Dickson, cost RM3.75/tonne. This

shows how costly it is to get sea water supply for the culture process of prawns. As we all know, the cost of salt is much less as compared to sea water usage.

Through the outcome of this research, we hope that all the problems to obtain sea water for the purpose of breeding prawns might be overcome especially for breeders who are setting up hatcheries inland. Among the objectives of this research are:

1.1 Objectives

1.1.1. Doing research on the effectiveness through different type of water toward the growth and survival rate larvae of *Macrobrachium rosenbergii.*

1.1.2. To decrease cost for the commercial growing of *Macrobrachium rosenbergii.*

CHAPTER 2

LITERATURE REVIEW

2.1 Morphology of *Macrobrachium rosenbergii*

Taxonomy

Kingdom : Animalia
Phylum : Arthropoda
Sub Phylum : Mandibulata
Class : Crustacea
Sub Class : Malacostraca
Order : Decapoda
Sub order : Natantia
Family : Palaemonidae
Genus : *Macrobrachium*
Species : *Macrobrachium rosenbergii*
(Source: De Man, 1879)

Macrobrachium rosenbergii is known via its bluish grey body and has claws that are blue. The body of this prawn is divided into 3 main parts, namely the sefalotoraks, abdomen and uropoda. Sefalotoraks is the head of the prawn which covers the head and chest whereby it is surrounded by a hard skin called karapas. The front of the prawn's head forms a long, sharp and jagged shape called the rostrum. The jagged shape along this rostrum is extremely important to identify freshwater prawn's species (Fincham and Wickins, 1976). The number of jagged parts found on the rostrum of *Macrobrachium rosenbergii* is 11-13 at the dorsal and 8-14 at its ventral.

Besides the rostrum, a five paired crawling legs known as the periopod can be found at the chest part. The second crawling leg is rather different from other periopod whereby its blue, has claws and strong (Fincham and Wickins, 1976).

The abdomen part is the body of the prawn which is surrounded by five hard segments which protect the body from being injured. *Macrobrachium rosenbergii* can be identified because the third segment covers the second and fourth segments compare the marine prawns whereby each segment covers each other (Motah, 1981). A pair of swimming legs, which is the pleupoda, is situated below each segments. Its five paired pleopods are used efficiently to swim fast. For the female prawns, the below body part is known as pleura. Pleura are the abdomen where the eggs are kept during the incubation and hatching process. The tail of the prawn is called the uropoda and is used to help in its swimming. Lastly, the tail of the prawn has a sharp part known as the telson.

2.2 Biology of *Macrobrachium rosenbergii*

Macrobrachium rosenbergii lives in fresh water (it also tolerates in high salinity rates and as approved, there were matured prawns cached with salinity rate more than 18 ppt (Raman, 1967) and it usually happens in Malaysians brackish water (Ling and Merican, 1961). Broodstocks usually moved to brackish water area where they live until the eggs are hatched (George, 1969). *Macrobrachium rosenbergii* larvae needs brackish water to grow until it reaches its post larvae, in which these immature prawns moved to freshwater area (Ling, 1969).

Macrobrachium rosenbergii is the largest freshwater prawn and the male prawn can grow up to the size of 320 mm and weight more than 200 g (Ling, 1969). Sandifer

et al (1975), by using the artificial sea water, the post larvae shows good tolerance until salinity reaches 25 ppt and the blood of *Macrobrachium rosenbergii* is in the osmotic state from 17-18 ppt of salinity. Popper and Davidson (1982) said that the growth and survival rate larvae of *Macrobrachium rosenbergii* is good at the level of salinity more than 16 ppt.

2.3 Hatching technique of *Macrobrachium rosenbergii*

In Thailand, the rate of prawn's larvae dispensation should be at stocking density of 30-50 prawns larvae per liter (New and Singholka, 1985). In Taiwan, hatchery tanks are be equipped with safe equipment such as PVC pipe and large content of primary stock such as female prawns with the weight of 20-40 g and has the "rate of disseminate" around 13kg/m^{-2} (Chien, 1990). At many hatchery centres, average salinity is between 8-20 ppt but 12 ± 2 ppt is usually used (New and Singholka, 1985).

From a rough guidance, at every cycle of release the total content of food should be from 1.2-1.6 kg for every meter of culture (Stock should be to 30-40 per litre) (New and Singholka, 1985). In Thailand, the stock of post larvae is placed in concrict tanks with the densities of 1000-5000 larvae m^{-2} (New and Singholka, 1985). Care of ground ponds is the same in many countries and is conserved at low stocking density around 20-25 post larvae m^{-2} and harvested after long term period that is around 75-90 days (New, 1988).

2.4 Water quality managements

Water quality is useful term to describe the ability of water to support the cultivated species. The majority parameters include oxygen, temperature, total ammonia, nitrogen, pH and turbidity. But priority will differ to species, life cycle stage and culture system. Salinity, alkalinity, nitrite, nitrogen, carbon dioxide, minerals ions and dissolved organic materials are the less importance factors in established systems. Poor water quality is one of the major reasons for the failure of many hatcheries (Wickins and Lee, 2002). A good water quality management will lead to a better ranching of *Macrobrachium rosenbergii.* Ideal water quality parameters for larvae of *Macrobrachium rosenbergii* culture are stated at Table 1.1:-

Table 2.1: Ideal water quality parameters for larvae of *Macrobrachium rosenbergii* culture.

Water quality	Range
Temperature	25-32°C
Ph	7-8.5
Hardness	30-150mgl^{-1}
Alkalinity	20-60mgl^{-1}
Dissolved oxygen	3-7mgl^{-1}
Un-ionized ammonia	< 1ppm

Recomanded by EIFAC (1998), daily cycle of metabolite level in culture water should be determined at least one in order to locate the periods of maximum and minimum of vital components. Measuring selected factors to obtain information relevant to water management is also important.

2.5 Salt Water Usage

Till now, there are not many reports on the usage of salt water in rearing *Macrobrachium rosenbergii.* Most research done on the rearing of this prawn's larvae are conducted using natural sea water. Generally, there is an advantage and disadvantage on the usage of natural sea water compared to artificial sea water and salt water. In sea water, it is found that the content of chemical substances is more complete. It contains trace elements in it. Beneficial bacteria are also present in natural sea water. However, in artificial sea water and salt water, the content of chemical substances and trace elements are incomplete. Beneficial bacteria are also not present in these both solutions (Howkins, 1981).

Here it gives a rough picture on the effect towards the survival rate and the growth of the prawn's larvae if salt water is used as rearing medium. Salt solution has characteristics which are categorized between natural and artificial sea water. Salt which is produced through salt water evaporation contains a small amount of minor elements and trace elements because a few elements might have been lost through the evaporation process while preparing the salt. These concentrated elements are hard to stabilize. It becomes a problem to add elements into the salt water so that its concentration is as the same as the concentration in natural salt water. In addition, it will increase the cost (Kinne, 1976).

Research on the effect of substitution sea water with salt water (40%, 50%, 60%, salt water) in prawn's larvae cultured has been conducted in UPKK Serdang Faculty of Fishery. The result of this research proved that part of the sea water could be substituted with salt water in prawn's larvae culture. However the increase of salt

water hatchery to 60% could slower the changing period of larvae into post larvae (Ang,1992).

In 1983, research on larvae of *Macrobrachium rosenbergii* using salt water has been conducted in Thailand. Tansakul (1983) had used Herbst's modified salt water which is consisted of 0.13 g of calcium chloride and 3 g of salt water in 100 ml of freshwater which has been added with chlorine. This research was done in a glass bottle with a capacity of 8 liters (12 cm in diameter and 22 cm in height). No water exchange was done. Three different treatments were conducted. Control 1 was a mixture of salt water (12 ppt) and sea water (12 ppt) at the ratio of 3:1. The bottles were not cleaned throughout the whole research. Control 2, had a same ratio of water mixture as Control 1 and extra food was channeled out. One liter of the rearing water was executed every 5 days in the period of 15 days and was substituted with 1 liter of freshwater. Control 3, as a control using sea water without water exchange. Discharge rate is 10 larvae per liter. Five replications was done on each control. The result of this research showed that Control 2 produced the larvae stage in the period of 49 days with the average of stocking larvae and standard deviation and the survival rate was 15%. Control 3 produces post larvae in the period of 42 days with the average of stocking larvae per liter and the survival rate was 15%. Control 1 had shown to have 100% mortality in the period of 21 days. It was concluded that Control 2 whereby the exchange of water every five days in the period of 15 days had produced a better result and the survival rate could be increased if rearing was done in a larger container by using the ratio which is proposed, only ¼ of sea water (12 ppt) is used from this whole rearing medium.

From the entrepreneur aspect, it is most suitable to be run by farmers who are far from rural areas.

Yambot and Verza Cruz (1986) had conducted a research on *Macrobrachium rosenbergii* using brine solution, salt water and sea water. They have used 3 different treatments. Treatment 1 is combination between brine solution, freshwater without chlorine and green water. Treatment 2 is combination between salt water, freshwater without chlorine and green water. Treatment 3 is combination between sea water, freshwater without chlorine and green water. This research was conducted in 6 cones shaped fiber tanks with the capacity of 250 liter which were equipped with 2 air pipes in each side of the tanks. The bottom of the tanks were cleaned everyday. After the fifth day the larvae was reared, 5 % of the rearing medium was channeled out and substituted with the same treated water for each treatment so that the medium stayed at the level of 250 liter. The salinity was fixed at the amount of 12-14 ppt. From this research, it was shown that T1 has the highest survival rate (25.74 %), followed by T3 (17.95 %) and T2 (6.71 %). There was a significantly difference between T1 and T2 and between T2 and T3. Moreover, during the first day the larvae changed into post larvae, it was led by T1 (28.33 days), T3 (30.0 days) and T2 (32.33 days). T1 took a period of 43 days for one rearing cycle from larvae to post larvae, followed by T3 which took 46.33 days and lastly T2 which took 61.67 days.

Silverthorn and Reese (1978) had conducted a research on *Macrobrachium rosenbergii's* larvae rearing using artificial salt produced by "Instant Ocean" which was dissolved with distilled water. They found out that there were no difference

between the survival rate at the salinity of 5 ppt, 8 ppt, and 14 ppt using this medium. The prawn's larvae were reared successfully in an artificial sea water medium through a water cycle system (Minamirzawa and Morizone, 1970). Artificial salt produced by "Instant Ocean" (Aquarium System) is very suitable to be used as a prawn's larvae rearing medium through the water cycle system. Smith *et al* (1976), found that through trials done on the discharge rate of 67-138 larvae per liter could produce 30-34 post larvae by using this artificial salt as the rearing medium.

Based on those statements, most prawn's larvae rearing is done using natural or artificial sea water. No clear research was reported on prawn's larvae rearing using salt water though we know that the cost of usage is far cheaper especially if the hatching unit is far from the sea coast area. Since there is an importance in the usage of salt water, therefore research is conducted to see how far salt water can save cost and eventually substitute sea water in prawn's larvae rearing.

CHAPTER 3

MATERIALS AND METHODS

3.1 Broodstocks

Prawns used during this research were broodstocks giant freshwater prawns were bought from the Pasar Tamu Bintulu Sarawak (Figure 3.1). The eggs of freshwater prawns are carried in the lower side of the abdomen whereby they are easily dispatched. These broodstocks can be obtained from rivers, ponds or from breeding stock maintained and mated in the aquaria. They should be selected carefully for this research. Samples that are obviously healthy, active and well pigmented with large egg masses should be chosen. Huge female prawns have larger amount of eggs. A rough guide is often used to assume that 1000 larvae are produced from each 1g of broodstock females' weight. The broodstock females of 10-12 cm (rostrum to telson) typically carry about 10 000-30 000 eggs. Often, these eggs are lost or damaged due to physical damages or even during the management of transportations process.

The total stocking larvae based on the production after the eggs hatched is 30-50 larvae per liter. Prawns chosen ought to be grey or dark in color. These eggs will hatch in a period of 2-3 days. It must be made sure that each tank has larvae of the same age (within 1-3 days) to avoid cannibalism and to ease the food-giving job. These samples was kept inside a 40 liters aquarium tank that is filled with 32 liters of water at the salinity of 16 ppt. Each tank was given oxygen and samples will be given ½ fish balls per prawn every morning.

Figure 3.1: Broodstock species of *Macrobrachium rosenbergii*

3.2 Measurement for Stocking Larvae

To count the total larvae that were taken, a sampling process was done. 3 divisions of sampling at the surface area, in the middle, and at the lower area were chosen and average of 3 divisions sample was done. A 50ml biker is used to conduct the sampling.

Example of sampling:

Result a = at the surface = 200,206,211 (mean 205.7)

Result b = in the middle = 213,215,218 (mean 215.3)

Result c = at the lower = 205,201,204 (mean 202.3)

Total larvae collection:

$$= \frac{\text{Mean number of larvae X Volume of tank}}{\text{Beaker sampling}}$$

$$= \frac{207.8 \text{ larvae X } 50\,000 \text{ ml}}{50 \text{ ml}}$$

= 207,766 larvae

3.3 Distribution of Larvae into Experimental Tanks

The larvae of *Macrobrachium rosenbergii* that has already hatched will be placed into 9 tanks according to different types of water. Each water treatment has three replications. In a liter of water, the stocking density is about 40 larvae. Therefore, for 32 liters of water, the stocking density would be 2000 larvae per tank and were be placed into every tank for each part.

3.4 Preparation for Experimental Tank

The tanks used are a 40 liter fiberglass tanks. These tanks are divided to three different types of water with the same salinity of 16 ppt. 80% of each type of water was added into the tank, which is 32 liter out of 40 liter. The water in the tank is left overnight for 24 hours. The purpose is to ensure that the solid matter or any other unwanted matter is dissolved below the tank. Besides that, it also to increase the water quality used in this research. A large amount of water is needed to support the larvae and it is to ensure that the larvae is not so compacted, as it would cause stress. The tank is given good aeration to make certain that the dissolved oxygen is at a good level. Larvae are added into 9 tanks that are arranged randomly according to three different water replications (Figure 3.2).

Figure 3.2: Position of the tank's larvae in random distribution

3.5 Sea Water

Sea water was taken from Pantai Bintulu Port, Bintulu Sarawak. Two tonnes of sea water with a salinity of 30 ppt were taken using a pump generator and were transported using a lorry that was prepared by Universiti Putra Malaysia Bintulu Campus. The sea water is left overnight or for 24 hours. The reason is to ensure that the solid matter or any unwanted matter is dissolved below the tank. Besides that, it is also to increase the water quality in this research. Two uses of sea water:

1. Preparation for brackish water
2. Preparation for the hatching process of *Artemia* sp.

In this research, the sea water with a salinity of 16 ppt was found from the dilution between sea water and fresh water.

3.6 50% Sea Water and 50% Artificial Sea water

As the second treatment (T1), 50% of sea water was added to 50% of artificial sea water. This means that in 32 liters of water are a mixture of 16 liters of sea water and 16 liters of artificial sea water. 298.56 g of synthetic salt water was diluted to obtain a salinity of 16 ppt. Before that, both of the water was sieved by a censor size of 5um before can be used.

3.7 Artificial Sea Water

As a third treatment (T2), 100% of synthetic salt was prepared at the Hatchery of Fresh Water in Universiti Putra Malaysia Bintulu Campus for the students' research. To produce artificial sea water, the "Instant Ocean" synthetic salt is mixed with fresh water. In this research, a liter of water uses 18.66 g of synthetic salt to obtain

water at the salinity of 16 ppt. In order to attain an accurate reading, hot water is used to dilute the synthetic salt. Therefore, for 32 liters of water, 597.12 g of synthetic salt was used.

3.8 Preparation of Food for Larvae

The preparation of food for larvae is the most important aspect in order to attain success in this research. This is because; food is the most significant factor to promote growth, good quality and the survival of the larvae. Food for the larvae is *Artemia* sp., egg custard, rotifer and copepodite.

The *Artemia* sp. is prepared by inserting cyst of the *Artemia* sp. into bikers that are filled with water at the salinity of 16 ppt. These bikers are also given a good aeration and are placed at a bright site to increase the level of hatching of the *Artemia* sp. in a short period of time. After 24 hours, around 70% to 80% of *Artemia* sp. have already hatched and are prepared to be fed to the larvae (Figure 3.6).

3.9 Monitoring Water Quality

Water quality analysis is conducted once a week to examine the condition of the water throughout the research. It is to ensure that the quality of the water is good in order to increase the survival and growth of the larvae. The water analysis that was done includes the temperature, salinity, pH, dissolved oxygen and ammonia. Refractometer is used to evaluate salinity (ppm). Before it is measured, the tools must be set to 0 ppt using distilled water (Figure 3.3).

For the pH and temperature, Hanna Portable Meter was used (Figure 3.4). The D.O. meter brand of Y.S.I D.O 200 (Figure 3.5) should always do the calibration to attain good and accurate results.

3.10 The Statistical Analysis

All the data produced within the 63 days of research have been tabled and analyzed. The data collected were analyzed using the Statistical Procedure ANOVA (Analysis of variance) and the Duncan Multiple Comparison Range Test. The SPSS (Statistical package for the social science) was used to analyze the data (Zar, 1974).

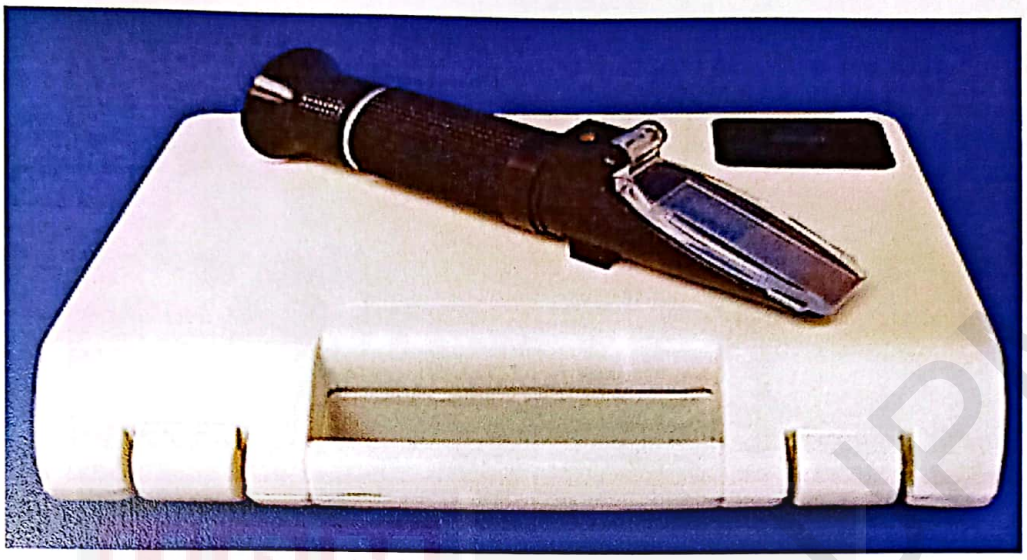

Figure 3.3: Refractometer

Figure 3.4: pH meter model Hanna Portable Meter

Figure 3.5: D.O Meter model Y.S.I 200

Figure 3.6: The process of producing *Artemia* sp. for larvae's consumption

CHAPTER 4

RESULTS

4.1 Survival Rates of Larvae *Macrobrachium rosenbergii* in Tank of Sea Water (Control), 50% of Sea Water and 50% of Artificial Sea Water (T1), and 100% of Artificial Sea Water (T2) Throughout the 63 Days of Culture.

The comparison on the mean of the prawn larvae's survival rate inside the tank of Control, Treatment 1 and Treatment 2 in 63 days of culture are shown in Figure 4.1 and Appendix A. The survival rate which was taken from the test conducted shows a development from the test on the usage of 100% sea water (Control), 50% of sea water and 50% of artificial sea water (T1), and 100% of artificial sea water (T2). From this research, it was shown that Control tank has the highest survival rate was 15 ± 1.53 is about 0.73%, it was led by tank No.2 and mean of the lowest survival rate is 2.7 ± 0.58 is about 0.13% comes by tank No.4. For the Treatment 1, the highest survival rate is 11.67 ± 0.58 is about 0.58% comes by tank No.9 and mean of the lowest survival rate is 3.67 ± 0.58 is about 0.18% comes by tank No.7. For the Treatment 2, the highest survival rate is 3 ± 0 is about 0.15% was found in tank No.6 and mean of the lowest survival rate is 1 ± 0 is about 0.15% comes by tank No. 3.

Overall, the Control tank gave the highest percentage of survival, that is, 1.34%, contrarily, the treatment tank with 100% of salt water gave the lowest rate of percentage, that is, 0.43%. The survival rate of larvae *Macrobrachium rosenbergii* that was reared via clear water for 63 days has a different percentage of survival rate. The graph of the prawn larvae's survival rate can be seen in Figure 4.1. Table 4.1 shows the high percentage of survival rate in the sea water tank which is 1.34%. This

is caused by the using of sea water which have good nutrient for reproduction of larvae. The other factor is concentration of larvae inside the tank which is not so compacted. Therefore, larvae does not have to compete for food, oxygen, and do not face an apparent pressure.

The total rate of death happened at the highest rate during the first 3 weeks of the research. This can be seen during the day and night, where the larvae are at the surface to get oxygen and the larvae which is at the ground and is bluish signifies that they are unhealthy and that there are pieces of food at the ground of the tank. On the following week, the death rate decrease whereby the apparent death of larvae happens throughout the research conducted. There was significant differences ($p \leq 0.05$) inside the tank of Control, Treatment 1 and Treatment 2 in survival rate throughout the 63 days of culture are shown in Table 4.2.

Table 4.1: Percentage of mean survival rate of larvae *Macrobrachium rosenbergii* in Control tank , 50% sea water and 50% artificial sea water -T1 and 100% artificial sea water- T2.

Experiment	Percentage of survival rate (%)								
	Control			Treatment 1			Treatment 2		
	T1	T2	T4	T5	T7	T9	T3	T6	T8
Percentage	0.48	0.73	0.13	0.22	0.18	0.58	0.15	0.15	0.1

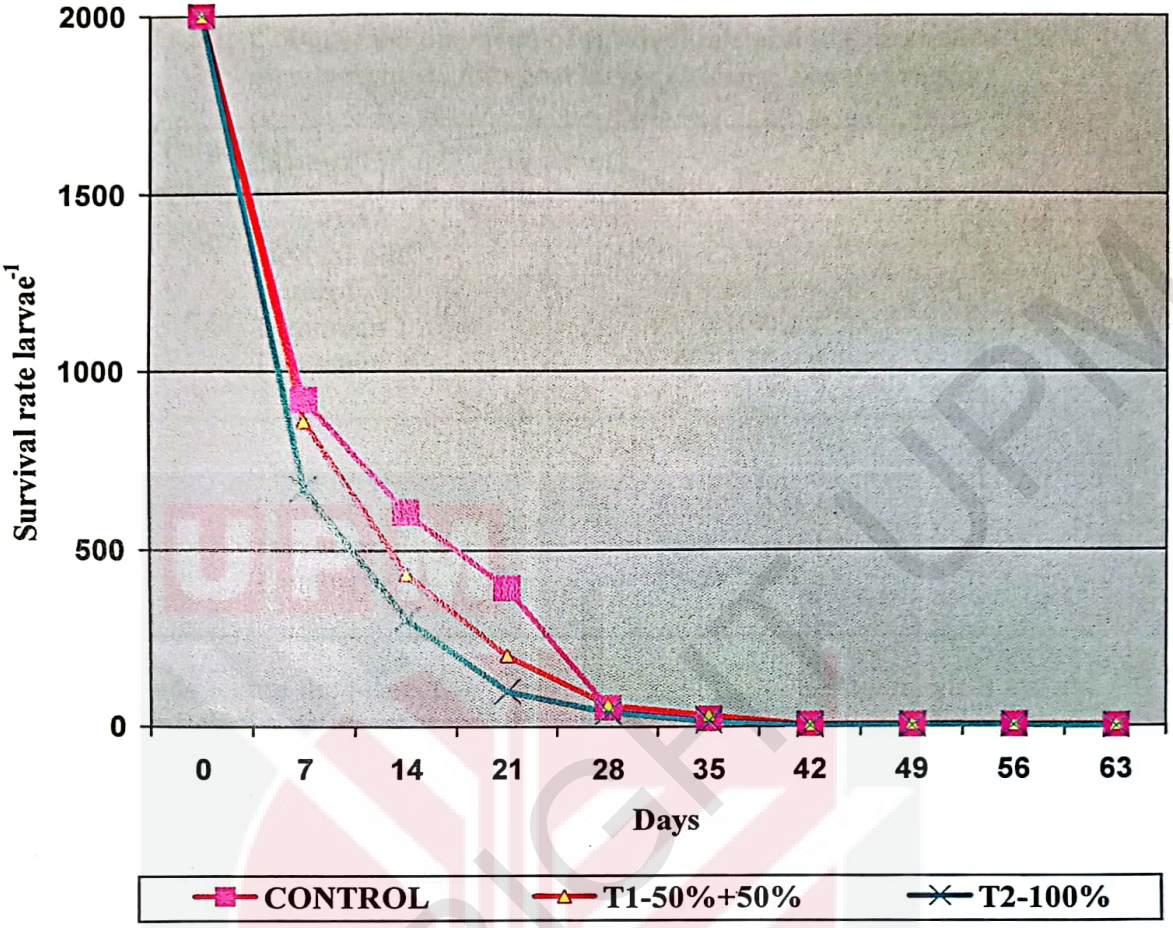

Figure 4.1: Mean survival rate of larvae *Macrobrachium rosenbergii* in Control , 50% sea water and 50% artificial sea water -T1 and 100% artificial sea water- T2.

Control : Sea Water
Treatment 1 : 50% Sea Water + 50% Artificial Sea Water
Treatment 2: 100% Artificial Sea Water

Table 4.2: Comparison the mean of survival rate and time complete 100% metamorphosis into post larvae (Mean ± Standard Error)

Parameter / Tank	Mean ± Standard Error
Survival rate:	
Control	$415.43^{c} \pm 9.29$
Treatment 1	$379.17^{b} \pm 2.79$
Treatment 2	$329.33^{a} \pm 6.78$
Time to PL:	
Control	$53.33^{a} \pm 0.33$
Treatment 1	$55.50^{ab} \pm 0.58$
Treatment 2	$57.71^{b} \pm 1.45$

Means within the respective parameters with the same superscripts are not significantly different at p=0.05. (DNMRT)

4.2 Period Of Metamorphosis From Larvae To Post Larvae (PL)

The comparison on the period of metamorphosis from larvae to post larvae (PL) inside the Control tank, Treatment 1 and Treatment 2 in 63 days of culture are shown in Figure 4.2 and Table 4.3. The larvae took different times to metamorphosis into post larvae. In this study, the first day the larvae metamorphosis into post larvae (PL) was 49 days by the Control tank, it was led by tank No.1 and tank No.4. These larvae took 54 days to complete all their metamorphosis into PL. Treatment 1 tank's took of 49 days to produce first PL and took 54 days to complete all their metamorphosis into PL, it was led by the tank No.9. The slow rate of larvae metamorphosis by Treatment 2 took about 58 days to complete all their metamorphosis, it was led by the tank No.8 and tank No.6. There were significant differences ($p \leq 0.05$) in time to metamorphosis into pL inside Control tank and Treatment 2 throughout the 63 days of culture are shown in Table 4.2.

Table 4.3: Time period of metamorphosis from larvae to post larvae (PL) inside the Control tank, Treatment 1 and Treatment 2 in 63 days of culture.

EXPERIMENT	Average of survival rate (%)								
	Control			50% SW + 50% AS			100 % AS		
	T1	T2	T4	T5	T7	T9	T3	T6	T8
Number of days to metamorphosis into post larvae	49	49	49	50	51	49	50	51	51
Mean sum of days to complete 100% metamorphosis into post larvae	53	53	54	55	56	54	60	55	58

SW-SeaWater
AS- Artificial Sea Water

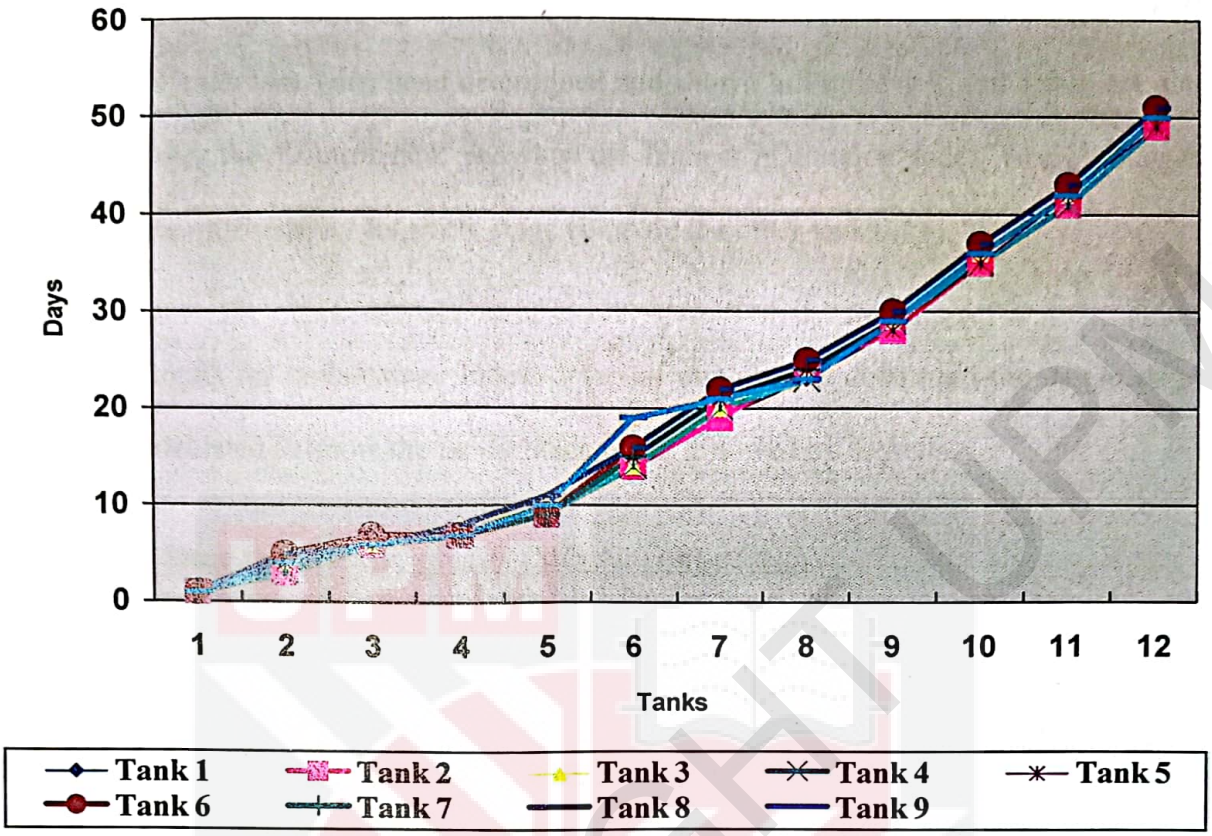

Figure 4.2: Period of metamorphosis from larvae to post larvae (PL) inside the Control, Treatment 1 and Treatment 2 throughout the 63 days of culture.

Control : Sea Water (Tank 1,2 and 4)
Treatment 1: 50% Sea Water + 50% Artificial Sea Water (Tank 5,7,and 9)
Treatment 2: 100% Artificial Sea Water (Tank 3,6 and 8)

4.3 Larvae Stage Index

The larvae stage index on the 7th, 14 th, 21 st, 28 th, 35 th, 42 nd, 49 th, 56 th, and the 63rd days for each tank have been determined and shown in Figure 4.3 and Table 4.4. On the whole, the Control tank showing the highest maturation index where changes occur the most rapidly for every stage compare the other tanks.

Calculations for larvae stage index: 5 larvae was already determind the larvae stage were calculated to know the larvae stage index followed by formula:

$$\text{Larvae Stage Index} = \frac{(Sa \times Na) + (Sb \times Nb) + (Sc \times Nc)}{Na + Nb + Nc}$$

Where:

Sa, Sb, Sc = Stage of larvae
Na, Nb, Nc = Total larvae to calculate

From the experiment, mean average larvae stage index at the first 3 rd week for the Control tank was 3.56, 5.67 and 6.67 followed by the Treatment 1, 3.11, 5.44 and 6.33 whereby the Treatment 2 was 2.78, 4.89, and 6.22 respectively. For the last 3rd week, mean average larvae stage index for the Control tank was 9.56, 10.56 and 11.56 followed by the Treatment 1 was 9.67, 10.33 and 11.11 whereby the Treatment 2 was 9, 10.11 and 10.78 respectively. There are significant differences ($p \leq 0.05$) inside the tank of Control and Treatment 2 during the study period are shown in Table 4.5.

Table 4.4: The mean of larvae stage index

Experiment	Larvae Stage Index		
Day	Control	Treatment 1	Treatment 2
7	3.56 ± 0.19	3.11 ± 0.19	2.78 ± 0.19
14	5.67 ± 0.34	5.44 ± 0.51	4.89 ± 0.38
21	6.67 ± 0.34	6.33 ± 0.34	6.22 ± 0.19
28	8.44 ± 0.51	8.33 ± 0.34	8.22 ± 0.19
35	9.56 ± 0.19	9.67 ± 0.34	9 ± 0.88
42	10.56 ± 0.19	10.33 ± 0.10	10.11 ± 0.51
49	11.56 ± 0.19	11.11 ± 0.38	10.78 ± 0.51

Table 4.5: Comparison the mean of larvae stage index (Mean ± Standard Error)

Larvae stage index:	
Control	8.00^{b} ± 0.08
Treatment 1	7.76^{ab} ± 0.07
Treatment 2	7.43^{a} ± 0.14

Means with the same superscripts are not significantly different at p=0.05 (DNMRT)

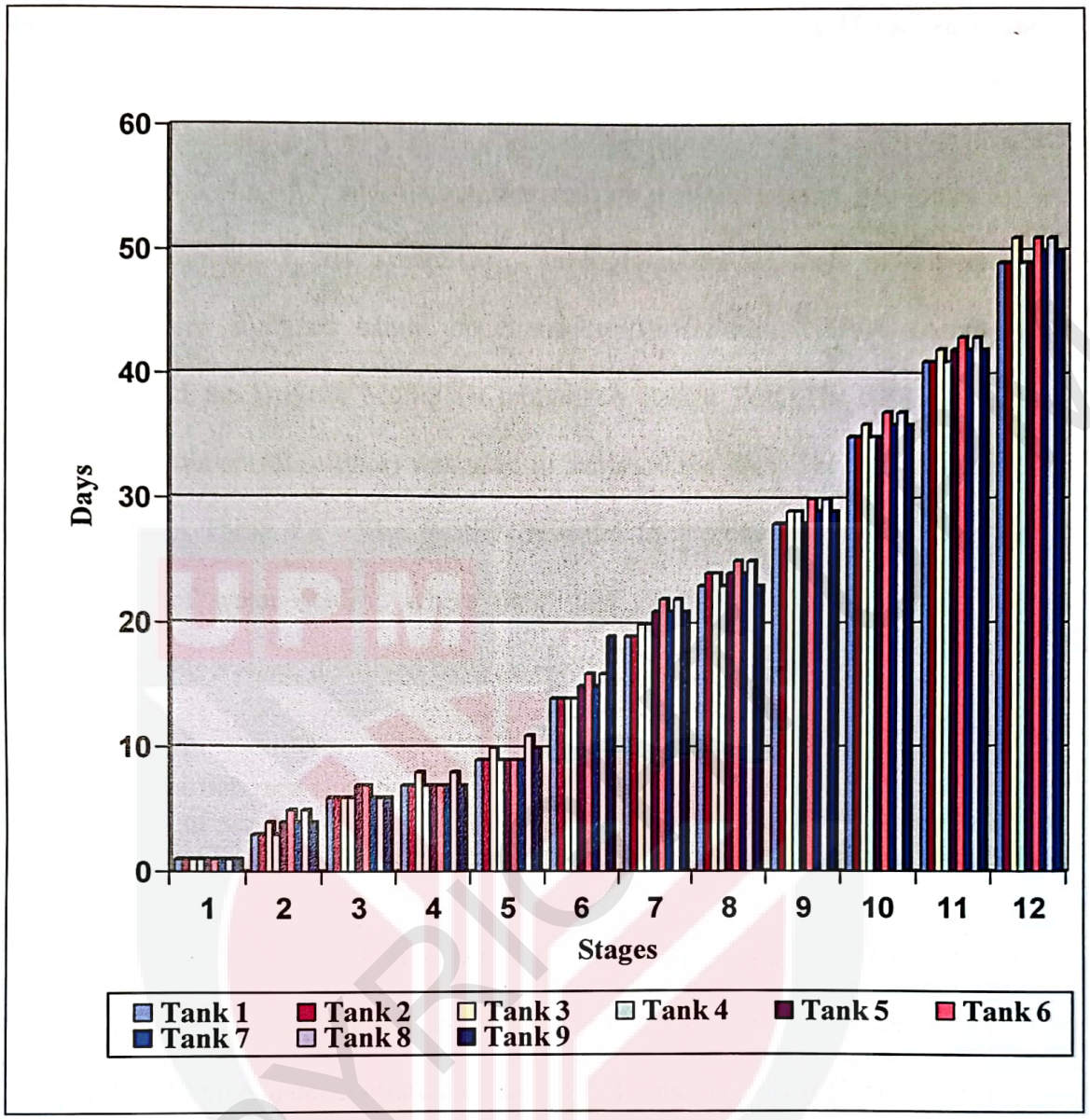

Figure 4.3: Larvae stage index of *Macrobrachium rosenbergii* inside the tank of Control, Treatment 1 and Treatment 2 in 63 days of culture.

Control : Sea Water (Tank 1,2 and 4)
Treatment 1: 50% Sea Water + 50% Artificial Sea Water (Tank 5,7,and 9)
Treatment 2: 100% Artificial Sea Water (Tank 3,6 and 8)

4.4 Effect of Water Quality Parameters in Larvae Rearing *Macrobrachium rosenbergii.*

Water quality is very important in larvae rearing of *Macrobrachium rosenbergii.* Figure 4.4, 4.5, 4.6, 4.7, and 4.8 summarized the results of water parameter for the Control, Treatment 1 and Treatment 2 throughout the 63 days of culture. Data collected were analyzed using the Statistical Procedure ANOVA (Analysis of variance) and the Duncan Multiple Comparison Range Test. The SPSS (Statistical package for the social science) was used to analysed the data. The statistical analysis are shown in Table 4.6 . The quality of water is acceptable whereby there are 5 parameters of water quality, where their data are taken, namely; the un-ionized ammonia, temperature, dissolved oxygen, rate of salinity and pH.

4.4.1 Effect between the concentration of un-ionized ammonia (mgl^{-1}) inside the tank of sea water (Control), 50% of sea water and 50% of artificial sea water (T1), and 100% of artificial sea water (T2) throughout the 63 days of culture.

The comparison concentration of un-ionized ammonia (mgl^{-1}) inside the tank of Control, Treatment 1, and Treatment 2 throughout the 63 days of culture are shown in Figure 4.4. The mean concentration of un-ionized ammonia in the Control tank is 0.09 ± 0.01 mgl^{-1}. Whereas the value of concentration un-ionized ammonia for the Treatment 1 is 0.06 ± 0.01 mgl^{-1} whereby the mean concentration un-ionized ammonia of Treatment 2 is 0.07 ± 0.01mg^{-1}. Table 4.6 shown have significant differences ($p \leq 0.05$) inside the tank of Control and Treatment 1 throughout the 63 days of culture.

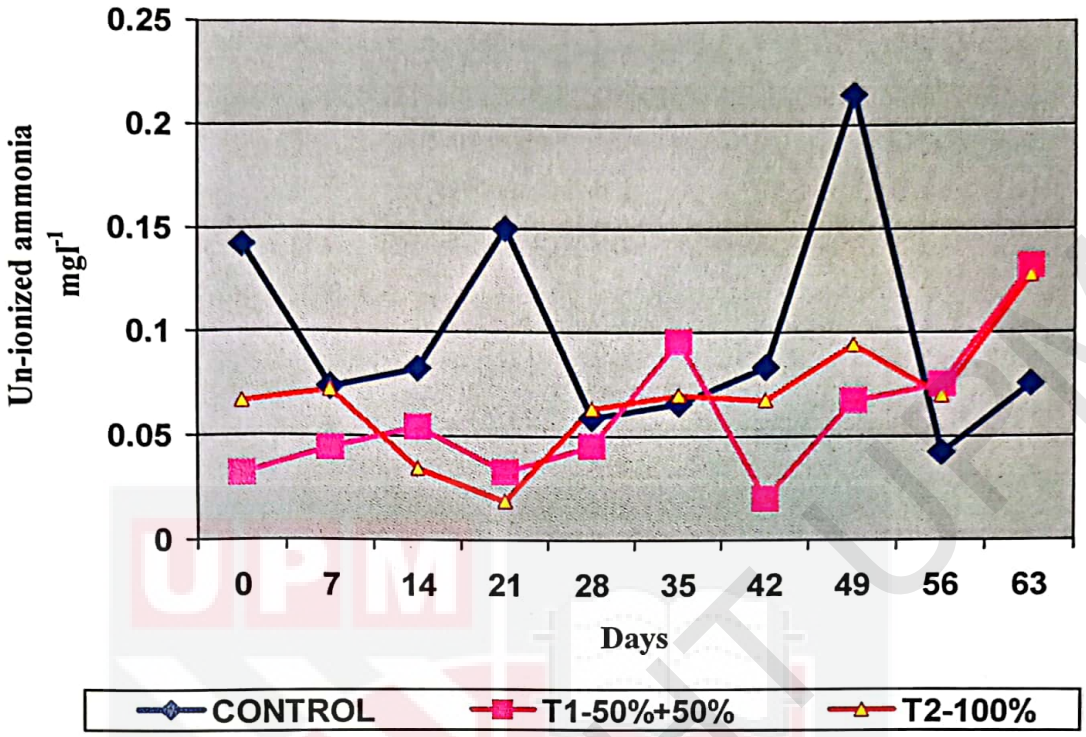

Figure 4.4: Mean un-ionized ammonia (mgl^{-1}) in 63 days of culture *Macrobrachium rosenbergii* larvae for the Control, Treatment 1 and Treatment 2.

Control : Sea Water
Treatment 1 : 50% Sea Water + 50% Artificial Sea Water
Treatment 2 : 100% Artificial Sea Water

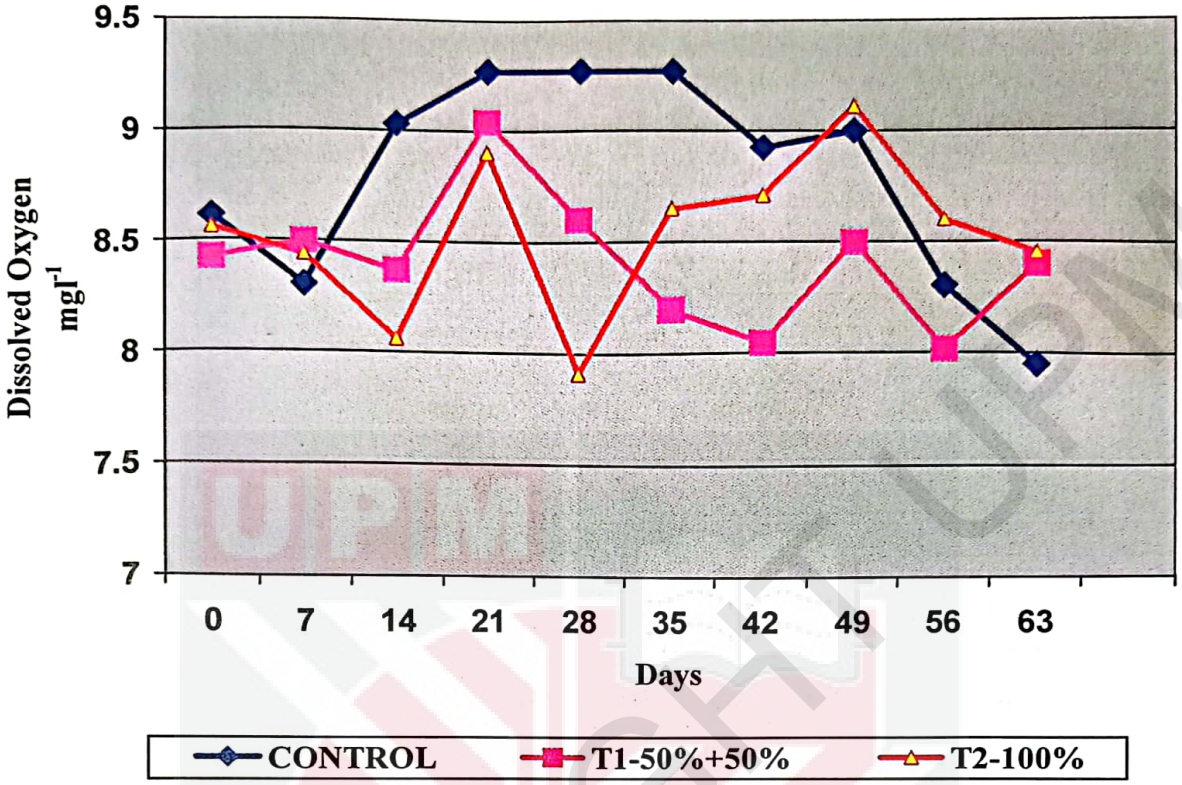

Figure 4.5: Mean dissolved oxygen (mgl^{-1}) in 63 days of culture *Macrobrachium rosenbergii* larvae for the Control, Treatment 1 and Treatment 2.

Control : Sea Water
Treatment 1 : 50% Sea Water + 50% Artificial Sea Water
Treatment 2 : 100% Artificial Sea Water

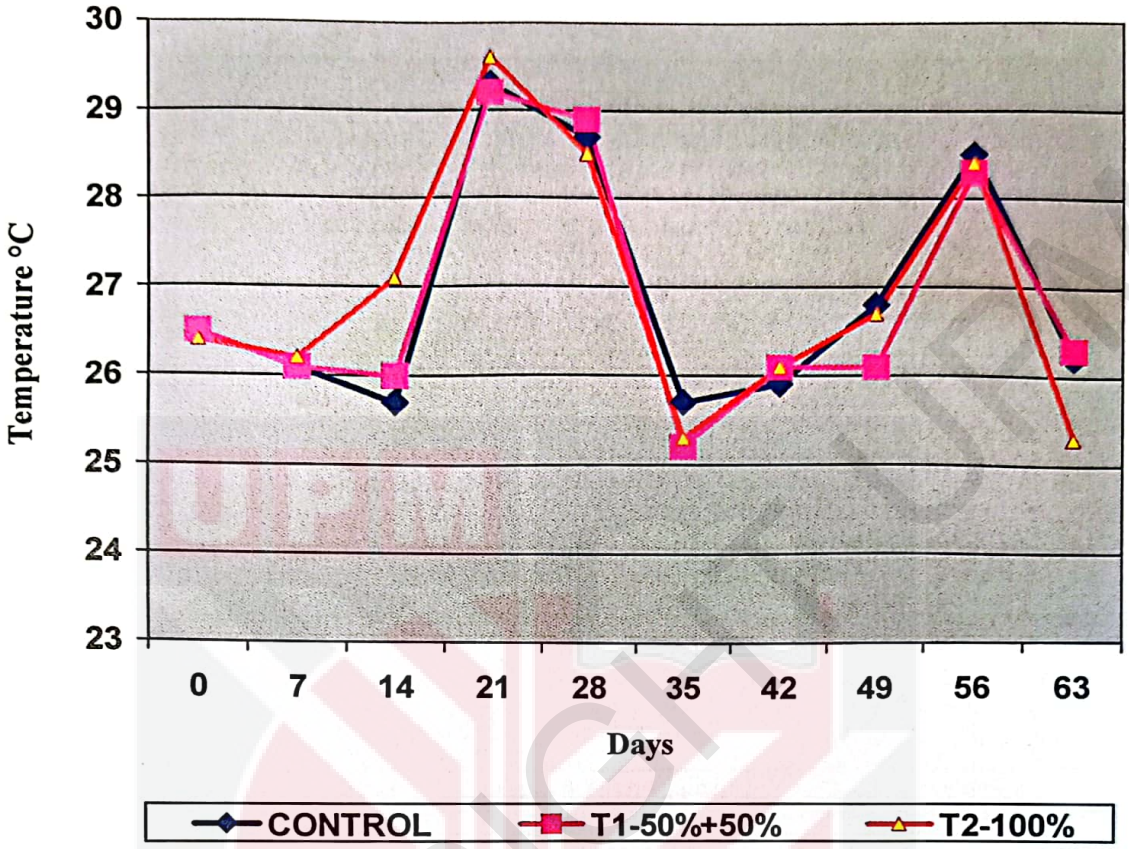

Figure 4.6: Mean temperature (°C) in 63 days of culture *Macrobrachium rosenbergii* larvae for the Control, Treatment 1 and Treatment 2.

Control : Sea Water
Treatment 1: 50% Sea Water + 50% Artificial Sea Water
Treatment 2: 100% Artificial Sea Water

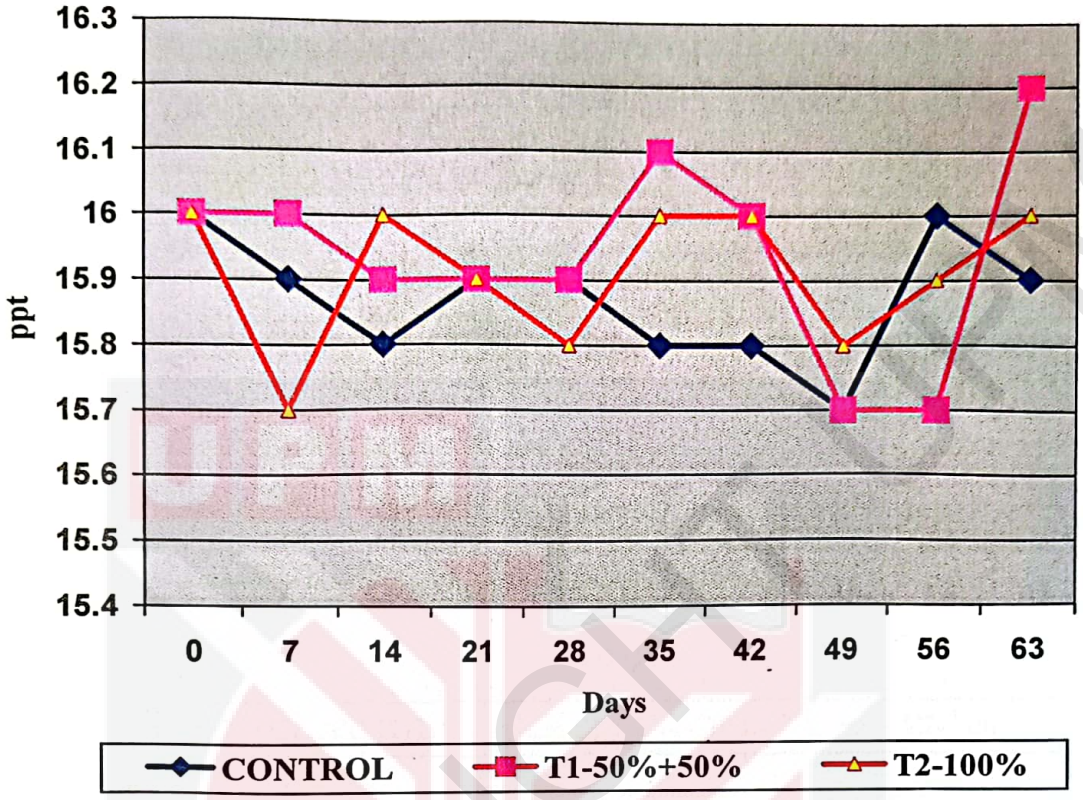

Figure 4.7: Mean salinity (ppt) in 63 days of culture *Macrobrachium rosenbergii* larvae for the Control, Treatment 1 and Treatment 2.

Control : Sea Water
Treatment 1: 50% Sea Water + 50% Artificial Sea Water
Treatment 2: 100% Artificial Sea Water

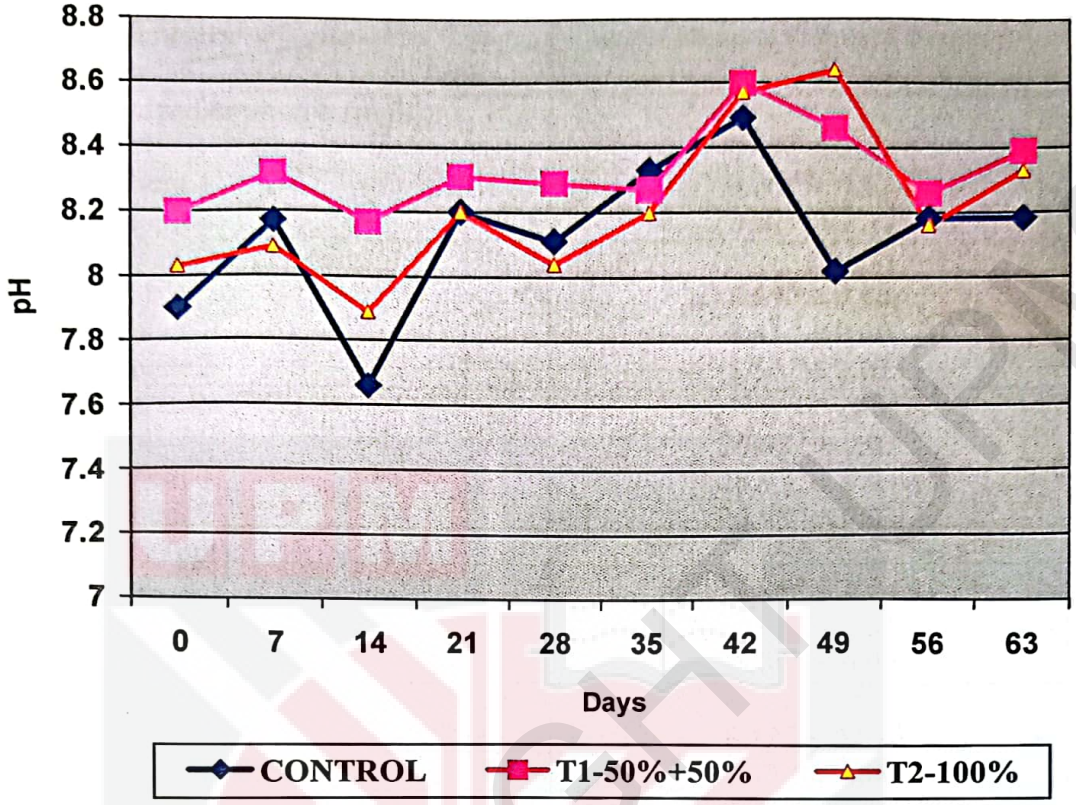

Figure 4.8: Mean pH in 63 days of culture *Macrobrachium rosenbergii* larvae for the Control, Treatment 1 and Treatment 2.

Control : Sea Water
Treatment 1: 50% Sea Water + 50% Artificial Sea Water
Treatment 2: 100% Artificial Sea Water

Table 4.6: Comparison the Mean of Water Quality Parameters

Parameters / Tank	Mean ± Standard Error
Un-ionized ammonia (mgl^{-1}):	
Control	$0.09^{b} \pm 0.12$
Treatment 1	$0.06^{a} \pm 0.12$
Treatment 2	$0.07^{ab} \pm 0.12$
Dissolved Oxygen (mgl^{-1}):	
Control	$8.69^{a} \pm 0.13$
Treatment 1	$8.41^{a} \pm 0.06$
Treatment 2	$8.54^{a} \pm 0.03$
Temperature (°C):	
Control	$26.92^{a} \pm 0.03$
Treatment 1	$26.97^{a} \pm 0.04$
Treatment 2	$26.98^{a} \pm 0.06$
Salinity (ppt):	
Control	$15.86^{a} \pm 0.04$
Treatment 1	$15.93^{a} \pm 0.01$
Treatment 2	$15.80^{a} \pm 0.09$
pH:	
Control	$8.12^{a} \pm 0.01$
Treatment 1	$8.32^{b} \pm 0.04$
Treatment 2	$8.22^{c} \pm 0.01$

Means within each parameter with the same superscripts are not significantly different at p=0.05 (DNMRT)

Control - Sea Water
T1- 50% Sea Water + 50% Artificial Sea Water
T2- 100% Artificial Sea Water

4.4.2 Effect between the concentration of dissolved oxygen (mgl^{-1}) inside the tank of sea water (Control), 50% of sea water and 50% of artificial sea water (T1), and 100% of artificial sea water (T2) throughout the 63 days of culture.

Effect comparison of dissolved oxygen (mgl^{-1}) inside the tank of Control, Treatment 1, and Treatment 2 throughout the 63 days of culture are shown in Figure 4.5. The mean concentration of dissolved oxygen (mgl^{-1}) in the Control tank is 8.69 ± 0.13 mgl^{-1}. Whereas the value of concentration dissolved oxygen (mgl^{-1}) for the Treatment 1 is 8.41 ± 0.06 mgl^{-1} whereby the mean dissolved oxygen concentration is 8.54 ± 0.03 mgl^{-1} for the Treatment 2.

The daily water quality measurement of the larval rearing tanks showed that level of dissolved oxygen ranged from 7.0 to 9.2 mgl^{-1}. There is no significant differences ($p \geq 0.05$) inside the tank of Control, Treatment 1 and Treatment 2 throughout the 63 days of culture are shown in Table 4.6.

4.4.3 Effect between the concentration of Temperature (°C) inside the tank of sea water (Control), 50% of sea water and 50% of artificial sea water (T1), and 100% of artificial sea water (T2) throughout the 63 days of culture.

Effect comparison of concentration temperature (°C) inside the tank of Control, Treatment 1, and Treatment 2 throughout the 63 days of culture are shown in Figure 4.6. The mean of temperature in the Control tank is 26.92 ± 0.03 (°C). Whereas the value of temperature for the Treatment 1 is 26.97 ± 0.04 °C whereby the mean temperature of Treatment 2 is 26.98 ± 0.06 °C.

The temperature in the tank of Control, Treatment 1 and Treatment 2 throughout the 63 days of culture has been found to be almost the same as the day the data was

recorded. This is probably caused by the environment whereby the tank location situated is the same. On the second and third week, the temperature for the nine tanks decreased because of the frequent rainy condition, which also causes the rate of the larvae survival to decline. There is no significant different ($p \geq 0.05$) inside the tank of Control, Treatment1 and Treatment 2 throughout the 63 days of culture are shown in Table 4.6.

4.4.4 Effect between the concentration of salinity (ppt) inside the tank of sea water (Control), 50% of sea water and 50% of artificial sea water (T1), and 100% of artificial sea water (T2) throughout the 63 days of culture.

Effect comparison concentration of salinity (ppt) inside the tank of Control, Treatment 1, and Treatment 2 throughout the 63 days of culture are shown in Figure 4.7. The mean concentration of salinity (ppt) is 15.86 ± 0.04 ppt in the Control tank. Whereas the value of concentration of salinity (ppt) for the Treatment 1 is 15.93 ± 0.01 ppt whereby the mean concentration of salinity (ppt) is 15.79 ± 0.08 ppt for the Treatment 2.

There is no significant differences ($p \geq 0.05$) inside the tank of Control, Treatment 1, and Treatment 2 throughout the 63 days of culture are shown in Table 4.6. Salinity between the nine tanks is almost the same.

4.4.5 Effect between the concentration of pH inside the tank of sea water (Control), 50% of sea water and 50% of artificial sea water (T1), and 100% of artificial sea water (T2) throughout the 63 days of culture.

Effect comparison concentration of pH inside the tank of Control, Treatment 1, and Treatment 2 throughout the 63 days of culture are shown in Figure 4.8. The mean concentration of pH in Control tank is 8.12 ± 0.01. Whereas the value of

concentration of pH for the Treatment 1 is 8.32 ± 0.04 however the mean concentration of pH for Treatment 2 is 8.22 ± 0.01. There is a significant differences ($p \leq 0.05$) inside the tank of Control, Treatment 1, and Treatment 2 throughout the 63 days of culture are shown in Table 4.6.

CHAPTER 5

DISCUSSION

This research can be visualized as a system that encourages the change of water daily. To carry out such intensive system is almost impossible therefore it is done according to one's ability and limited facilities.

Intensive system was created in Tahiti during the 1970 (AQUACOP, 1977). It produces larvae of prawn by using recycled water. The operational and equipment cost is fairly high due to the usage of a few water pump and a high technology filter. This system requires great management and an experienced operator. Chemical substances are being used continually and in a huge amount. The production of juvenile prawns are equally as high (110 larvae per litre) with the maintenance cost between 2.2-2.5 cents/per larvae and the duration of production is about 30-35 days. This system is built nearby to the sea because it requires a lot of sea water. It is very appropriate for commercial managment (Yaakob and Liong, 1996).

As an overall, the ratio of 100% sea water as a Control tank, 50% of sea water and 50% of artificial sea water as a Treatment 1 (T1) and 100% artificial sea water as Treatment 2 (T2) gives survival rates, metamorphosis period to the post larvae stage, and the index of the larvae stage, which are different throughout the whole period of the research conducted. The value obtained from this research shows a good improvement from Treatment 1-50%+50% and Treatment 2-100%.

Table 4.1 shows the productivity of prawn larvae from the Treatment 1 is capable of competing with a few results that were conducted fully using sea water as a rearing medium. The pL production from Treatment 1 is actually able to overcome a few results that has been obtained from experiment done using sea water as the breeding medium. Result from experiment shows that there are significant differences ($p \leq 0.05$) from 'survival rate' between the Control tank and the T1-50%+50% and T2-100% (Table 4.2). This proves that the Treatment 1 not only results in a high pL productivity but also minimizes the usage of sea water. Through the experiment, the larvae from the Control tank displays the highest 'survival rate' with the production of pL at 1.34% compare the Treatment 2 at 0.43%.

Table 5.1: The list of research on larvae *Macrobrachium rosenbergii* using sea water.

Post larvae / litre	Survival rate (100%)	Time to complete metamorphosis process	Sources
19	-	-	Ling, (1969)
7	-	47	Fujimura and Okamoto (1970)
12.0	43.5	40	Hagood and Willis (1976)
54	75.5	34	Manzi *et al* (1977)
12.5	55.45	42.5	Adisukresno *et al* (1982)
18.9	-	25-51	Lee (1982)
10.3 ± 2.5	40.5 ± 9.9	30-47	Ang and Cheah (1986)

The survival rate decreases when the percentage of salt water increase. The difference of mortality is caused by the differences amount of chemicals, trace elements and benificial bacteria present in salt water and sea water (Hawkins,1981). Kinne (1976), said the loss of important element from sea water during evaporation process while the salt preparation is conducted, causing the survival rate of the larvae to be quite low.

This result is roughly way better than the result that was once conducted by past researches. (Ling, 1969; Fujimura and Okamoto, 1970) and (Lee, 1982) (Table 5.1). There is significant difference ($p \leq 0.05$) between the Control tank and the tank of Treatment 2, based on the period for the larvae to metamorphosis into the post larvae (Table 4.2).

When the percentage of sea water increases, it will slower down the period of the larvae to metamorphose into post larvae. This, supports the statement of Ang (1986), whereby it states the period of larvae conversion slows down if the percentage of salt water increases to 60%. This result, therefore, is supported by the research of Yambot and Vera Cruz (1986) whereby it is found that the usage of salt water will increase the total of days for the larvae to metamorphose into post larvae. The result produced from this test shows the Control tank take the faster time than the Treatment 1 and Treatment 2 to complete 100% metamorphosis into post larvae. (Table 4.3).

Based on the food intake, the higher stage of the larvae increases, the rate of its food intake would also increase. Through the observation done, it is shown that the larvae are not exactly active in catching the food given. Ling (1969) reported that the prawn larvae eats continuously so long as it is suitable based on its size. Sick and Beaty

(1974) also showed that the larvae of *Macrobrachium rosenbergii* at the stage of VII-VIII cannot consume nauplie *Artemia* food at the size of 0.7mm. This statement is accurate with the results produced from this research.

Moller (1978) also stated that the prawn larvae will reject food that is not suitable with its size. On the contrary, over feeding would result to cannibalism (Gopalakrishnan, 1976). The food factor should also be taken into account. The food digestion rates for any larvae species do not only depend on the age of the larvae, but it also depends on the size, shape, texture, food taste and its water quality especially the temperature (Alam, 1992). The growth rate of larvae for all the tanks are the different. On the contrary, there is an apparent difference between the Control tank and Treatment 2 (Table 4.2). The growth rate is also quite slow probably because the releasing stocking larvae rate which gets higher will decelerate the growth rate of the prawn. A high stocking densities will always give bad result of lower growth rate. Stock should be to 30-40 larvae per litre (New and Singholka, 1985).

CHAPTER 6

CONCLUSION

The results from this research show that the substitution of sea water with salt water, at the combination of a certain percentage, will eventually cause a difference on the survival rate and on the growth of *Macrobrachium rosenbergii.* The combination of 50% of salt water produces the best result. This success signifies that part of the usage and transportation cost for the sea water can actually be saved. The apparent difference at the usage of 100% salt water compared to the control tank shows that the treatment are not suitable to be adapted.

There is significant difference based on the survival and growth between the Control tank and the 50% treated tank. This goes to prove that the PL can be culture in the next stage even though at the early stage the larvae is culture in a different salt water combination.

Due to this, a further research which involves a long period of time should be conducted in order to be able to see the next survival and growth rate of the larvae stage. Apart from that, a research on the suitability of the food size towards the larvae should be carried on to increase the level of food consumption which then leads to the increase of the survival and growth rate of this prawn's larvae.

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Mean Survival Rate of *Macrobrachium rosenbergii* (Larvae Per Liter) in Sea Water Tank

TANK 1

Week	Survival rate			Mean	Percentage (%)			Mean
	Replication				Replication			
	1	2	3		1	2	3	
0	2000	2000	2000	2000	100	100	100	100
7	1116	1120	1128	1121.33	55.8	56	56.4	56.07
14	716	690	720	708.67	35.8	34.5	36	35.43
21	308	340	317	321.67	15.4	17	15.85	16.08
28	77	65	72	166	3.85	3.25	3.6	3.57
35	50	51	54	50	2.5	2.55	2.7	2.58
42	21	18	23	18	1.05	0.9	1.15	1.03
49	17	13	20	13	0.85	0.65	1	2.5
56	15	11	9	9	0.75	0.55	0.45	0.58
63	10	9	10	9	0.5	0.45	0.5	0.48

TANK 2

Week	Survival rate			Mean	Percentage (%)			Mean
	Replication				Replication			
	1	2	3		1	2	3	
0	2000	2000	2000	2000	100	100	100	100
7	1100	1103	1101	1101	55	55.15	55.05	55.07
14	610	609	612	610	30.5	30.45	30.6	30.52
21	210	211	207	209	10.5	10.55	10.35	10.47
28	61	59	57	59	3.05	2.95	2.85	2.95
35	49	50	46	48	2.45	2.5	2.3	2.42
42	22	19	25	22	1.1	0.95	1.25	1.1
49	25	22	23	23	1.25	1.1	1.15	11.67
56	20	21	18	20	1	1.05	0.9	0.98
63	15	13	16	15	0.75	0.65	0.8	0.73

TANK 4

Week	Survival rate			Mean	Percentage (%)			Mean
	Replication				Replication			
	1	2	3		1	2	3	
0	2000	2000	2000	2000	100	100	100	100
7	900	923	940	921	45	46.15	47	46.05
14	589	623	610	607.33	29.45	31.15	30.5	30.37
21	405	380	390	391.67	20.25	19	19.5	19.58
28	48	58	63	56	2.4	2.9	3.15	2.82
35	23	25	28	25	1.15	1.25	1.4	1.27
42	7	8	10	8.3	0.35	0.4	0.5	0.42
49	5	3	5	4.3	0.25	0.15	0.25	0.22
56	4	5	5	4.7	0.2	0.25	0.25	0.23
63	3	2	3	2.7	0.15	0.1	0.15	0.13

A2-Mean Survival Rate of *Macrobrachium rosenbergii* (Larvae Per Liter) in 50% Sea Water + 50% Artificial Sea Water Tanks

TANK 5

Week	Survival rate			Mean	Percentage (%)			Mean
	Replication				Replication			
	1	2	3		1	2	3	
0	2000	2000	2000	2000	100	100	100	100
7	853	862	870	861.67	42.65	43.1	43.5	43.08
14	500	520	480	500	25	26	24	25
21	320	260	270	283.33	16	13	13.5	14.17
28	58	63	70	63.67	2.9	3.15	3.5	3.18
35	32	38	29	33	1.6	1.9	1.45	1.65
42	10	9	12	10.33	0.5	0.45	0.6	0.52
49	5	7	8	6.67	0.25	0.35	0.4	0.33
56	4	4	5	4.33	0.2	0.2	0.25	0.22
63	4	4	5	4.33	0.2	0.2	0.25	0.22

TANK 7

Week	Survival rate			Mean	Percentage (%)			Mean
	Replication				Replication			
	1	2	3		1	2	3	
0	2000	2000	2000	2000	100	100	100	100
7	920	890	850	886.67	46	44.5	42.5	44.33
14	402	515	534	483.67	20.1	25.75	26.7	24.18
21	225	320	250	265	11.25	16	12.5	13.25
28	70	63	59	64	3.5	3.15	2.95	3.2
35	42	39	40	40.33	2.1	1.95	2	2.02
42	5	6	5	5.33	0.25	0.3	0.25	0.8
49	7	6	7	6.67	0.35	0.3	0.35	0.33
56	5	4	6	5	0.25	0.2	0.3	0.25
63	4	3	4	3.67	0.2	0.15	0.2	0.18

TANK 9

Week	Survival rate			Mean	Percentage (%)			Mean
	Replication				Replication			
	1	2	3		1	2	3	
0	2000	2000	2000	2000	100	100	100	100
7	930	923	890	914.33	46.5	46.15	44.5	45.72
14	415	420	460	432	20.75	21	23	21.58
21	209	201	203	204	10.45	10.05	10.15	10.22
28	200	197	149	182	10	9.85	7.45	9.1
35	58	63	41	162	2.9	3.15	2.05	2.7
42	23	20	18	20.33	1.15	1	0.9	1.02
49	15	14	13	14	0.75	0.7	0.65	0.7
56	15	17	13	15	0.75	0.85	0.65	0.75
63	12	12	11	11.67	0.6	0.6	0.55	0.58

A3-Mean survival rate of *Macrobrachium rosenbergii* (Larvae Per Liter) in Artificial Sea Water Tanks

TANK 3

Week	Survival rate			Mean	Percentage (%)			Mean
	Replication				Replication			
	1	2	3		1	2	3	
0	2000	2000	2000	2000	100	100	100	100
7	820	830	780	810	41	41.5	39	40.5
14	415	330	440	395	20.75	16.5	22	19.75
21	102	115	130	116	5.1	5.75	6.5	5.78
28	40	35	47	40.67	2	1.75	2.35	2.03
35	22	24	19	21.67	1.1	1.2	0.95	1.08
42	7	5	6	6	0.35	0.25	0.3	0.3
49	2	1	2	1.67	0.1	0.05	0.1	0.08
56	2	2	1	1.67	0.1	0.1	0.05	0.08
63	1	1	1	1	0.05	0.05	0.05	0.15

TANK 6

Week	Survival rate			Mean	Percentage (%)			Mean
	Replication				Replication			
	1	2	3		1	2	3	
0	2000	2000	2000	2000	100	100	100	100
7	620	670	720	670	31	33.5	36	33.5
14	300	290	320	303.33	15.00	14.5	16	15.17
21	120	117	110	115.67	6	5.85	5.5	5.78
28	48	46	40	44.67	2.4	2.3	2	2.23
35	10	13	26	16.33	0.5	0.65	1.3	0.82
42	4	4	3	3.67	0.2	0.2	0.15	0.18
49	5	4	5	4.67	0.25	0.2	0.25	0.23
56	3	3	2	2.67	0.15	0.15	0.1	0.13
63	3	3	3	3	0.15	0.15	0.15	0.15

TANK 8

Week	Survival rate			Mean	Percentage (%)			Mean
	Replication				Replication			
	1	2	3		1	2	3	
0	2000	2000	2000	2000	100	100	100	100
7	720	830	815	788.33	36	41.5	40.75	39.42
14	321	340	350	337	16.05	17	17.5	16.85
21	98	109	96	101	4.9	5.45	4.8	5.05
28	63	69	56	62.7	3.15	3.45	2.8	3.13
35	15	20	19	18	0.75	1	0.95	0.9
42	3	2	5	3.33	0.15	0.1	0.25	0.17
49	6	5	6	5.67	0.3	0.25	0.3	0.28
56	5	5	4	4.67	0.25	0.25	0.2	0.23
63	2	2	2	2.00	0.1	0.1	0.1	0.1

APPENDIX B

Mean water of un-ionized ammonia, dissolved oxygen, temperature, salinity, and pH in culture tanks of *Macrobrachium rosenbergii* during the study period.

Tank	Mean ± Standard Error
Un-ionized ammonia (mgl^{-1}):	
Control	0.09 ± 0.01
Treatment 1	0.06 ± 0.01
Treatment 2	0.07 ± 0.01
Dissolved Oxygen (mgl^{-1}):	
Control	8.70 ± 0.13
Treatment 1	8.41 ± 0.06
Treatment 2	8.54 ± 0.03
Temperature (°C):	
Control	26.92 ± 0.03
Treatment 1	26.97 ± 0.04
Treatment 2	26.98 ± 0.06
Salinity (ppt):	
Control	15.86 ± 0.04
Treatment 1	15.93 ± 0.01
Treatment 2	15.80 ± 0.09
pH:	
Control	8.12 ± 0.01
Treatment 1	8.32 ± 0.04
Treatment 2	8.22 ± 0.01

APPENDIX C

ANOVA table for analysis water quality parameter

UN-IONIZED AMMONIA

Source of Variation	Df	SS	MS	F
Row	2	.002	.001	4.146
Columns	1	.001	.001	5.192
Treatment	1	.001	.001	3.100
Error	6	.001	0.000	
Total	8	.003		

DISSOLVED OXYGEN

Source of Variation	Df	SS	MS	F
Row	2	.126	.063	3.117
Columns	1	.038	.038	1.899
Treatment	1	.088	.088	4.335
Error	6	.121	.020	
Total	8	.247		

TEMPERATURE

Source of Variation	Df	SS	MS	F
Row	2	.006	.003	.544
Columns	1	.005	.005	.947
Treatment	1	.001	.001	.140
Error	6	.034	.006	
Total	8	.040		

pH

Source of Variation	Df	SS	MS	F
Row	2	.061	.031	15.653
Columns	1	.013	.013	6.844
Treatment	1	.048	.048	24.463
Error	6	.012	.002	
Total	8	.073		

ppt

Source of Variation	Df	SS	MS	F
Row	2	.026	.013	1.420
Columns	1	.006	.006	.688
Treatment	1	.020	.020	2.151
Error	6	.055	.009	
Total	8	.081		

PUBLICATION OF THE PROJECT UNDERTAKING

This is to certify that I have no objection to publish the project title "**GROWTH PERFORMANCE AND SURVIVAL OF GIANT FRESHWATER PRAWN LARVAE *Macrobrachium rosenbergii* (de Man) GROWN IN NATURAL AND ARTIFICIAL SEA WATER**" 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 the form approved by the Faculty.

AIDA BINTI ZAKARIA

Date: 3 MEI 2007