EFFECT OF DIFFERENT SALINITY ON GROWTH AND SURVIVAL OF AFRICAN CATFISH, *Clarias gariepinus* JUVENILE

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THIS DISSERTATION IS SUBMITTED IN FULFILLMENT OF THE REQUIREMENT TO GRADUATE AS A BACHELOR OF SCIENCE WITH HONOURS

AQUACULTURE

FACULTY OF SCIENCE AND NATURAL RESOURCES

UNIVERSITI MALAYSIA SABAH

2014

PUMS 99:1

UNIVERSITI MALAYSIA SABAH

BORANG PENGESAHAN STATUS TESIS

JUDUL: EFFECT OF DIFFERENT SALINITY ON GROWTH AND SURVIVAL OF AFRICAN CATFISH, Clarias gariepinus JUVENILE

IJAZAH: BACHELOR OF SCIENCE WITH HONOURS (AQUACULTURE)

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ACKNOWLEDGEMENT

Praise God as I finally complete my dissertation writing. First of all, I would like to extend my deepest gratitude and thanks to my supervisor, Prof. Dr. Gunzo Kawamura for his kind, patience and valuable teachings; for his readiness to guide and offer help throughout the experiment as well as completing this dissertation. This thesis would not have been produced without his guidance and help. I am also indebted to Prof. Dr. Shigeharu Senoo for his valuable consultation and suggestions throughout completing the final year project experiment. Thank you very much.

I would like to thank all the staffs and research assistants of Marine Fish Hatchery for their assistance and in technical and theoretical terms that lead to successful completion of this thesis. Not to forget the staff of Borneo Marine Research Institute for kindly lending a hand when needed.

In addition, a thank you to my friends and course mates for the valuable suggestions, help and moral support. Lastly, I would like to extend heartfelt thanks to my father (Gudid bin Padasian) and my mother (Flavia binti Gombirod) for their endless support and encouragement to complete my degree study.

ABSTRAK

Sabah mempunyai pantai yang terpanjang di Malaysia iaitu 1600 km, ini menandakan bahawa Sabah sangat kaya dengan air laut. Pengkulturan ikan ini di air laut akan membolehkan penggunaan sepenuhnya air masin. Objektif kajian ini ialah menentukan tahap kemasinan yang optimum pada pertumbuhan dan kebolehan untuk hidup untuk Keli afrika juvenil. Keli afrika juvenil yang digunakan masing-masing mempunyai jumlah berat dan jumlah panjang sebanyak 0.37 g dan 34.20 mm dan ikan ini dikultur dalam 0, 2, 4, 6 dan 8 ppt. Setiap tangki diisi dengan 350 ekor ikan dan tidak ada replikasi. Penternakan telah dijalankan selama 6 minggu dalam sistem peredaran akuakultur dan ikan diberi makan 3 kali sehari. Keputusan menunjukkan bahawa 4 ppt mempamerkan pertumbuhan yang paling tinggi dari segi berat badan (21.24 g), tambahan berat dan kadar pertumbuhan spesifik. Pertumbuhan sebanyak 5743 % direkodkan dalam 4 ppt. Walau bagaimanapun, tidak ada perbezaan bererti antara 0 dan 2 ppt. Sementara itu, 6 dan 8 ppt menunjukkan kesan yang memudaratkan pada pertumbuhan tetapi ikan dalam 8 ppt mempunyai perbezaan bererti antara semua rawatan. Untuk kemandirian ikan, 0 ppt mempunyai kadar relatif yang tinggi tetapi tidak ada perbezaan signifikan dengan 2 dan 4 ppt. Kemandirian ikan menurun pada 6 dan 8 ppt dimana dalam 8 ppt, kemandirian ikan ialah 65 % iaitu mempunyai signifikan yang lebih rendah berbanding rawatan yang lain. Kondisi faktor ikan mempunyai signifikan yang tinggi dalam 8 ppt daripada 0, 2, 4 dan 6 ppt. Kesimpulannya, Keli afrika juvenil boleh dipelihara di 0, 2 dan 4 ppt tanpa sebarang kesan buruk pada pertumbuhan dan kemandirian ikan.

ABSTRACT

Sabah has the longest coastline in Malaysia which is about 1600 km. This indicates that Sabah is rich in saline water. The culture of this fish in saline water brings full utilization of the saline water. The objective of this study is to determine the optimum salinity on growth and survival for rearing African catfish, *Clarias gariepinus* juvenile. The juvenile catfish used was 0.37 g and 34.20 mm in body weight and total length respectively and the fish was subjected to 0, 2, 4, 6 and 8 ppt. 350 African catfish juvenile were stocked in a tank with no replicates. Rearing was carried out for 6 weeks in recirculating aquaculture system and fed 3 times daily. The results showed that 4 ppt exhibit the highest growth in terms of body weight (21.24 g), weight gain and specific growth rate. 5743 % of growth was recorded in 4 ppt. However, there was no significant difference between 0 and 2 ppt. Meanwhile, 6 and 8 ppt showed detrimental effects on the growth but fish in 8 ppt was significantly lower in terms of growth in the rest of the treatment. For the survival of fish, 0 ppt was relatively higher but no significant difference with 2 and 4 ppt. Survival of fish decreases in 6 and 8 ppt whereby in 8 ppt survival was 65 % which was significantly lower than the whole treatment. Condition factor of fish was significantly higher in 8 ppt than 0, 2, 4 and 6 ppt with the value of 0.76. In conclusion, African catfish juvenile can be reared in 0, 2 and 4 ppt without any adverse effect on the growth and survival of fish.

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LIST OF ABBREVIATIONS

SGR = Specific growth rate

ppt = parts per thousand

mm = millimeter

g = gram

CHAPTER 1

INTRODUCTION

1.1 Aquaculture in Malaysia

The aquaculture industry in Malaysia has begun in 1920's. Since then, it has been quickly developed and is now one of the industries that contribute to Malaysia's economy by increasing local production for food security and increasing export revenues. Recently, this industry has become important and it is included in the government's most recent policy programme in 1998-2010. In 2010, the government targeted that aquaculture yield is to reach 200 %.

There is multiple culture type that is practiced in Malaysia. Among them are brackish culture, marine aquaculture and also freshwater aquaculture. Brackish water culture is still the predominant practice. This is due to the long coastline of Malaysia which is 4 780 km (FAO, 2005). In 2010, it contributes 73.26% of the total aquaculture production. Meanwhile, for freshwater aquaculture, it contributed 155,398.63 tonnes which was 26.74 % and 27.17 % of the total production and value of the overall aquaculture sub-sector respectively. Compared to the year before which is 2009, the value is increasing (Department of Fisheries, 2010).

As the culture practice consists of brackish culture, marine aquaculture and freshwater, so there are a variety of species cultured in accordance with their habitat. For brackish water as well as marine water, the major production is that of bivalvemolluscs such as the blood cockles followed by shrimps, notably the whiteleg shrimp, *Litopenaeus vannamei* and marine fish like the barramundi, *Lates calcarifer*. On the other hand, freshwater culture includes the Nile tilapia, *Oreochromis niloticus*, catfish species namely the hybrid between *Clarias batrachus* and the African catfish and carps.

The aquaculture production is still very small compared to capture fisheries. The production only contributes less than 0.2 % to gross domestic product. Nevertheless, the yield of this industry is of high value even for the domestic market as well as for the export market, and if the fish yield is analysed according to the culture technique like freshwater, freshwater catfish itself has the highest production among all other freshwater species.

1.2 African catfish, *Clarias gariepinus* (Burchell, 1822)

African catfish (Figure 1.1) is originally a native of the African continent except Meghreb, Upper and Lower Guinea, and the Cape provinces of South Africa (Picker & Griffiths, 2011).

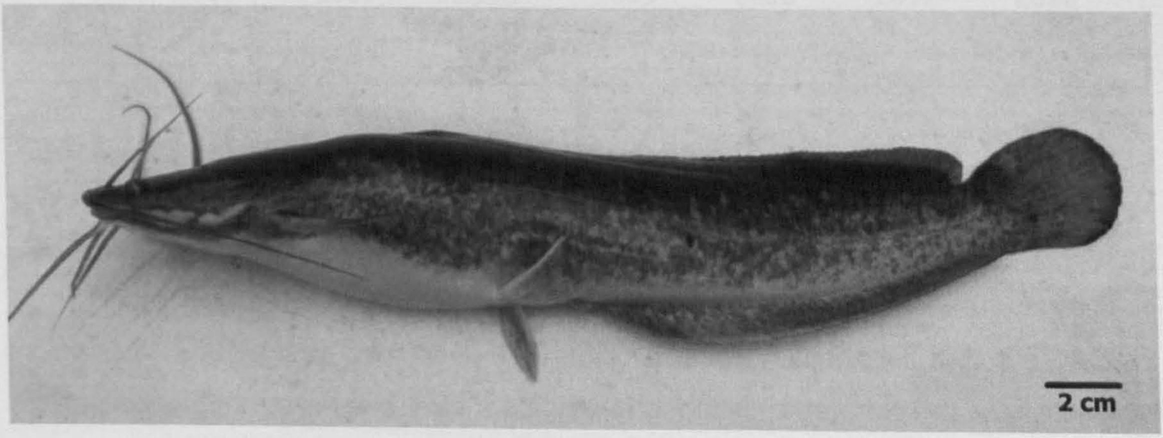

Figure 1.1 Lateral view of the broodstock of African catfish

This fish is widely cultured since its introduction in the 1980's, this include Malaysia itself. It is locally known as Keli Afrika, and this fish is mostly cultured in peninsular part of Malaysia than Sabah and Sarawak (Department of Fisheries, 2011). This fish exhibits many qualities which makes it a very suitable species for aquaculture production such as fast growth, high fecundity and resistant to diseases. In addition, this fish can withstand handling stress and has high palatability which makes it delicious to certain people (Gbulubo & Erondu, 1998; Machariaet *al.*, 2005). Figure 1.2 shows the production of freshwater catfish in Malaysia.

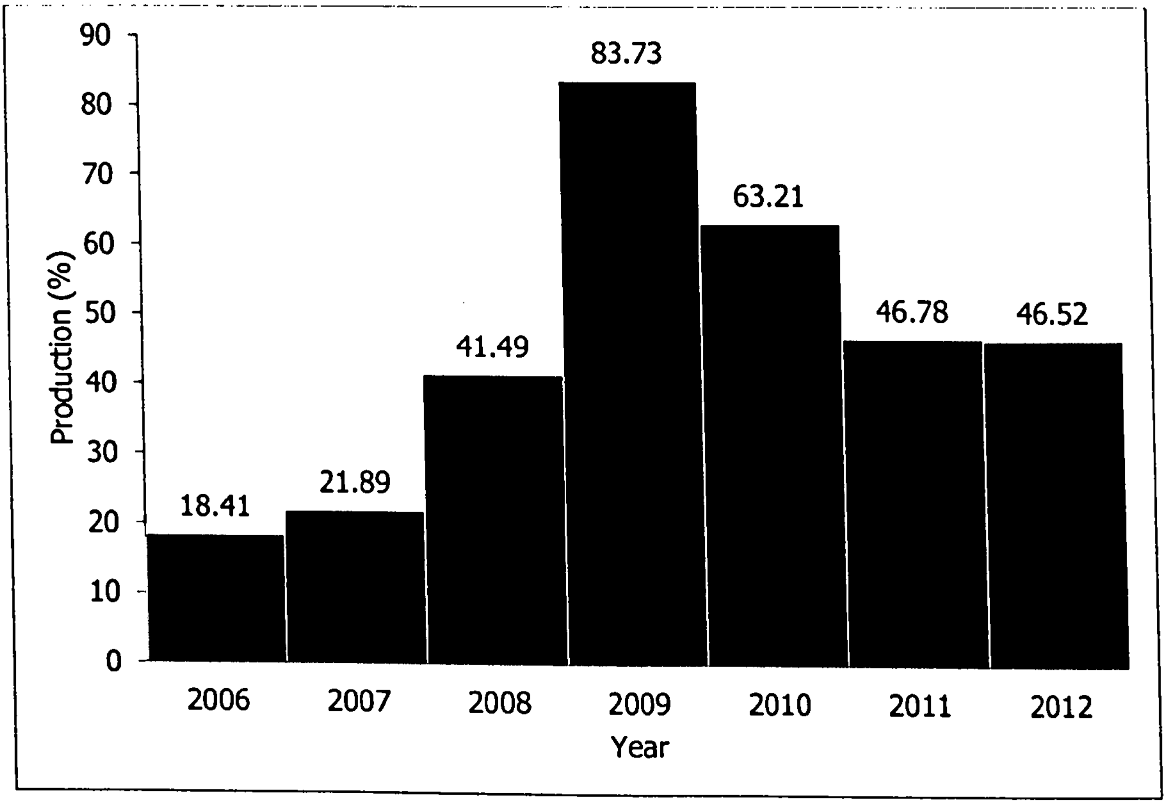

Figure 1.2 Production of freshwater catfish in 2006 to 2012 in Malaysia

Source: Department of Fisheries, 2013

From Figure 1.2, it can be seen that the production of freshwater catfish is inconsistent and always fluctuates. Therefore, it is very important that the yield is maintained and increased and from the figure also it implies that this fish is of economic importance as it is produced in large quantities and is cultured primarily in freshwater pond in Southeast Asia.

African catfish is classified as a freshwater stenohaline species (Britz & Hecht, 1989). A stenohaline organism is an organism that can tolerate only a narrow range of salt concentrations of the water in which it lives (Schmidt-Nielsen, 1975). In other words, this fish can be cultured in low-saline water. In fact, African catfish can tolerate salinity up to 10 ppt (Safriel & Bruton, 1984).

1.3 Salinity

Salinity is a measure of the content of salts in soil or water. In an aquatic environment, salinity is known to affect the physiological and survival of aquatic organisms (Wang *etal.*, 1997; Partridge *et al.*, 2002; Sampaio & Bianchini, 2002; Carlos*et al.*, 2004; Fielder *etal.*, 2005; Tsuzuki *et al.*, 2007; Bodinier *et al.*, 2010 & Gbulubo *et al.*, 2011). Aside from that, some studies also has been conducted on the food intake, food conversion, metabolic adaptations and body composition against different salinity (Arunachalam & Reddy, 1979; Luz *et al.*, 2008). Hence, euryhaline fish as well as stenohaline fish can be affected by salinity.

The previous study states that African catfish can tolerate up to 10 ppt (Safriel & Bruton, 1984). However, the tolerance differs according to the life stages of the fish. According to Gbulubo & Erondu (1998), the optimal salinity for the hatching of the eggs ranged from 0 to 5 ppt. Above 5 ppt, the hatching rate was significantly low. As salinity increases up to 8 ppt, the eggs would not hatch at all. However, juvenile African catfish has 94 % survival in 9.5 ppt. As for the adult African catfish, it can tolerate up to 10 and 15 ppt (Chervinski, 1984). The survival of African catfish in low saline water is due to its ability to control both the volume of water and the concentration of electrolytes in the internal body fluid (Gbulubo *et al.*, 2011). The process of maintaining the movement of water and electrolytes is known as osmoregulation.

1.4 Osmoregulation

Osmoregulation is the process in which internal water and electrolyte concentration of the internal environment is maintained. Osmoregulation in freshwater fish and marine fish differs with each other. For freshwater fish, it is naturally hyperosmotic to its surrounding solution. Freshwater teleosts must extract NaCl from the environment to maintain ionic balance (Krogh, 1937). So, the fish have to spend more energy for osmoregulation to maintain the electrolyte balance in its body between its surrounding solutions (Evans, 2008). Thus, it is known that osmoregulation is an energy demanding process, whereby it takes 20 % to more than 50 % of the total energy expenditure and this energy is applied even in species with lower metabolic rates such as the catfish; *Ictalurus punctatus* and *Ictalurus nebulosus* (Boeuf & Payan, 2001).

If the osmotic pressure of the surrounding solution is the same with its of body osmotic pressure, the fish is said to be in an isotonic and isosmotic environment. Thus, it can be expected that the energetic cost of osmoregulation is minimize. This means that, the energy needed for osmoregulation process can be used to other processes in the body such as growth. Hence, more energy will be used for growth (Brett, 1979; Jobling, 1994).

Although there is no problem with the culture of African catfish in freshwater, by assuming that the energy needed for osmoregulation is minimized and consequently more energy for growth would be gained if the fish is cultured in brackish water, perhaps culturing this fish low saline water will lead to rapid growth of the fish. Nonetheless, the impact of culturing juvenile African catfish in brackish water is not known. At certain salinity, the growth as well as the survival of juvenile African catfish will be enhanced.

1.5 Objective

This study aims to determine the effect of salinity on the growth and survival of juvenile African catfish, *Clarias gariepinus*.

CHAPTER 2

LITERATURE REVIEW

2.1 Taxonomy

Catfish species that caught the interest for fish farming belong to the subgenus *Clarias*. Previous study found that there are 5 species within subgenus; *Clarias*. Those species were;

- *Clarias anguilarus*
- *Clarias senegalensis*
- *Clarias lazera*
- *Clarias mossambicus*
- *Clarias gariepinus*

However, after the subgenus *Clarias* revised back in 1982, Teugels (1982) found that only two species considering the number of gill rakers of the fish. The species was *C. gariepinus* and *C. anguillaris* (de Graaf & Janssen, 1996).

2.2 Habitat of African catfish, *Clarias gariepinus*

This fish is can tolerate many different habitats. It can even be found in the upper reaches of estuaries. But, this fish is considered to be a freshwater species. It favours floodplains, slow flowing rivers, lakes and dams (Skelton, 2001).

2.3 Biology

2.3.1 Diet and mode of feeding

African catfish considered as omnivorous due to it scavenging and predatory behaviour (Bruton, 1979a). According to Willoughby & Tweddle (1978), larger individuals show a specific dietary shift towards fish. This fish can be efficient in terms of predation, sometimes it hunts in groups on small fish against submerged aquatic vegetation before swallowing them (Merron, 1993). Other studies also showed that this fish exhibit solitary feeding, social hunting and coordinated pack-hunting foraging behaviours.

2.3.2 Growth

African catfish shows a rapid growth rate both in length and weight. However, this strongly influenced on ambient conditions and habitat (Britz & Pienaar, 1992) and findings showed that the growth is positively density dependent (Hecht & Appelbaum, 1987). African catfish are known to have a life span of 8 years or more (Bruton & Allanson, 1980).

2.4 Impact of salinity on growth

Freshwater and marine fish can be cultured in brackish water. This is feasible because fish are capable of osmoregulation. Freshwater teleost have a significantly lower plasma salt content but they are still distinctively hyperosmotic to their environment with sodium and chloride ions abundant in the plasma. This creates osmotic and ionic gradients between the freshwater fish and it surrounding solution making it overhydrated and salt depleted (Boisen*et al.*, 2003). As a consequence, freshwater teleost produce large volume of dilute urine (Evans, 2008).

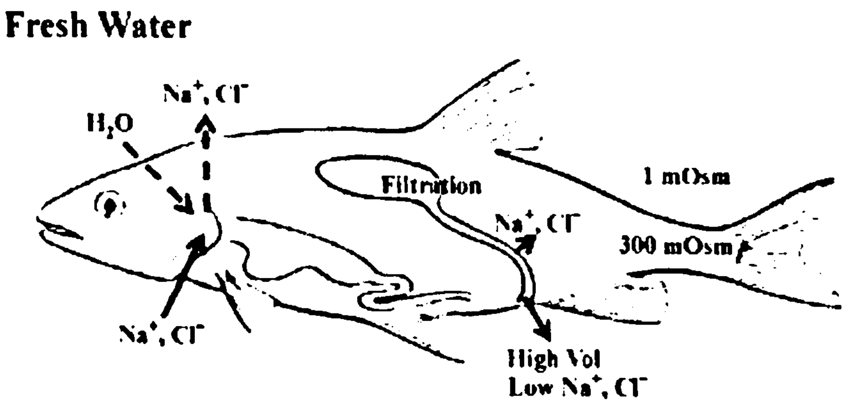

Figure 2.1 Osmoregulation in freshwater fish

Source: Randall *et al.*, 1997

As osmoregulation has a high energetic cost, if African catfish is cultured in a condition whereby its ionic and osmotic concentration in the body is the same as its surrounding solution, less energy will be used for osmoregulation process and probably the energy is supplied to the other life processes such as growth. Studies have been carried out on freshwater fish tested against different salinity. Deyi & Kejing (1993) found rapid growth of carp, *Cyprinus carpio* fingerlings in 3 ppt, and it is said to be due to less energy expenditure for osmotic regulation. Another study shows that goldfish, *Carassius auratus* exhibits good growth and no signs of stress up to 6 ppt salinity (Luz *et al.*, 2008).

2.5 Impact of salinity on survival

Averse environment can affect the survival of aquatic organism. Similarly, a change in salinity will produce the same result. However, the effect depends on the severity and the amount of exposure of the aquatic organism towards the change in salinity. Some species of fish can still thrive even when there is a change in salinity. For example the marine species; cobia, *Rachycentron canadum* can survive up to 5 ppt (Resley *et al.*, 2006).

Therefore, the study suggested that cobia can be cultured in brackish water. In freshwater fish such as the goldfish, the fish can survive in saline waters up to 6 ppt salinity without any signs of stress. At the same time, the use of salinity to reduce the incidence of diseases and mortality will prevent the fish from getting disease thus ensure its survival however the salinity level must not produce significant physiological alterations in the fish itself (Luz*et al.*, 2008).

CHAPTER 3

MATERIALS AND METHOD

3.1 Experimental fish

The juvenile African catfish was obtained from the Universiti Malaysia Sabah Fish Hatchery (Figure 3.1).

Figure 3.1: Lateral view of the African catfish juvenile

The total length of the fish was 34.20 mm with a standard deviation of 4.14 mm mm meanwhile the weight of fish is 0.37 g with 0.10 g of standard deviation among all the fish (Table 3.1). The initial measurement of the total length and body weight of fish was measured using a digital caliper and electronic balance respectively. The stocking density was approximately 5 juvenile fish per liter. Totally, there was 350 fish per tank.

Table 3.1 The initial total length (mm) and body weight (g) of 20 African catfish juveniles

Total length (mm)	Body weight (g)
28.00	0.31
34.34	0.40
36.17	0.46
31.02	0.70
32.90	0.18
31.34	0.33
36.69	0.44
33.39	0.35
33.39	0.31
35.80	0.36
36.89	0.42
42.89	0.33
21.90	0.32
34.72	0.28
37.3	0.43
36.54	0.31
35.41	0.35
37.37	0.42
32.98	0.27
32.07	0.31
36.35	0.44
34.20±4.14 (Mean±SD)	0.37±0.10 (Mean±SD)

3.2 Preparation of test solution

There were 5 salinity used in this experiment: 0, 2, 4, 6 and 8 ppt. The control treatment was 0 ppt to compare the result on the growth and survival of fish between the rest of the treatments.

The salinity of the water was produced by using seawater. Hence, seawater was mixed with freshwater by using this formula:

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