EFFECTS OF DIFFERENT WATER DEPTHS FOR AQUACULTURE PRODUCTION OF AFRICAN CATFISH, *Clarias gariepinus* JUVENILE

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THESIS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF BACHELOR OF SCIENCE

AQUACULTURE PROGRAMME
SCHOOL OF SCIENCE AND TECHNOLOGY
UNIVERSITI MALAYSIA SABAH

2010

DECLARATION

I hereby declared that this dissertation is the results of my own independent works, except where otherwise started.

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ACKNOWLEDGMENTS

First and foremost, I would like to express my sincere thank to my greatest supervisor, Prof. Dr. Shigeharu Senoo for the support and professional commitments. This research could never been accomplished without their guidance, hardship and motivation.

Besides that, I also want to dedicate my appreciation to Director of Borneo Marine Research Institute (BMRI), Prof. Dr. Saleem Mustafa who has made the facilities required for carrying out the research. Not to forget, Dr. Rossita Shapawi, Dr. Hideo Mochizuki, Ms. Audrey Daning Tuzan and all the lecturers of aquaculture science programme for their encouragement and assistance.

I also want to extend my appreciation to Norazmi Osman, Henry Lipan, Mohd. Addin Aazif, Mrs. Faihanna Ching Abdulah @ Ching Fui Fui, Esther Michelle Gunben, Nguang Siew Ing, Ch'ng Choon Looi, and Hiroko Matsubara and all the Research Assistants and Staffs in the Hatchery of Borneo Marine Research Institute for their contribution and advice.

Lastly, I would like to thank all my friends who have assisted me throughout the research, Lee Chee Kai, Kiu Hie Yung, Guntur Putera Malindo, Wong Mei Jing, Steffiana J. Jipanin, Sanlin Ludin, Ngu King Fui, Ooi Shing Yau and all my fellow coursemate. Lastly, my very specials appreciation goes to my beloved family for their endless love, care and support makes this possible.

ABSTRACT

Information on the effects of water depth to the aquatic animal is lacking especially on the African catfish, *Clarias gariepinus*. Therefore, the purpose of this study was to assess the influence of different water depth on the survival and growth rate of *C. gariepinus* juvenile. Fifteen day old juvenile were stocked at 9 tails /cm^2 in six aquarium designs with different water depth (5, 10, 15, 20, 25, and 30 cm). Total bottom area of aquarium is 2700 cm^2 and each aquarium has 300 tails of *C. gariepinus* juvenile. The highest survival rate and growth rate over 15 days was recorded at the 20 cm water depth. The results indicate that the 20 cm water depth is suitable for used in *C. gariepinus* juvenile rearing in order to obtain the high production at best survival and growth rates.

Keywords: Clarias gariepinus; water depth; juvenile rearing; survival; growth

ABSTRAK

Maklumat berkaitan dengan kesan kedalaman air yang berlainan terhadap kehidupan akuatik didapati tidak mencukupi terutamanya dalam spesis ikan keli Afrika, *Clarias gariepinus*. Oleh itu, tujuan kajian ini adalah untuk menilai pengaruhan kedalaman air terhadap kadar mandirian dan kadar pertumbuhan kepada *C.gariepinus* juvenil. Juvenil yang berumur lima belas hari telah disediakan dengan kepadatan stok 9 ekor /cm^2 dalam enam akuarium yang direka dengan kedalaman air yang berbeza (5, 10, 15, 20, 25, dan 30 cm). Keseluruhan keluasan tapak akuarium yang digunakan adalah 2700 cm^2 dan setiap akuarium mengandungi 300 ekor *C. gariepinus* juvenil. Kadar mandirian dan kadar pertumbuhan yang paling tinggi selepas 15 hari adalah *C.gariepinus* juvenil yang diternak dengan kedalaman air 20 cm. Ini menunjukkan bahawa kedalaman air 20 cm sesuai dipergunakan untuk menternak *C. gariepinus* juvenil dengan tujuan memerolehi pengeluaran yang maksimum dari segi kadar mandirian dan kadar pertumbuhan.

Kata kunci: Clarias gariepinus; kedalaman air; pemeliharaan juvenil; mandirian; pertumbuhan

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LIST OF SYMBOLS AND ABBREVIATIONS

cm	centimeter
cm^2	centimeter squared
d AH	day after hatch
DO	dissolved oxygen
g	gram
kg	kilogram
L	liter
m^2	meter cube
mg	milligram
mL	milliliter
mm	millimeter
N	total number of fish
NH_3-N	ammonia nitrogen
RM	Ringgit Malaysia
SD	standard deviation
^oC	degree celsius
%	percentage

CHAPTER 1

INTRODUCTION

1.1 Aquaculture

Aquaculture is an industrial process of raising aquatic organisms up to final commercial production within properly partitioned aquatic areas, controlling the environmental factors, and administering the life history of the organism positively and it has to be considered as an independent industry. Today, nearly one-third of the fish consumed by humans is the product of aquaculture, and the percentage will only increase as aquaculture expands and the world's conventional fish catch from oceans and lakes continues to decline because of overfishing (FAO, 2000).

Aquaculture accounted for 47 percent of the world's fish food supply in 2006. In the last 50 years world aquaculture has grown dramatically. From a production of less than 1 million tonnes in the early 1950s, production in 2006 have risen to 51.7 million tonnes, with a value of RM 299.44 billion. In 2006, 76 percent of global aquaculture production was freshwater finfish. Output amounted to 27.8 million tonnes, worth RM 112.1 billion (FAO, 2009).

1.2 African catfish, *Clarias gariepinus*

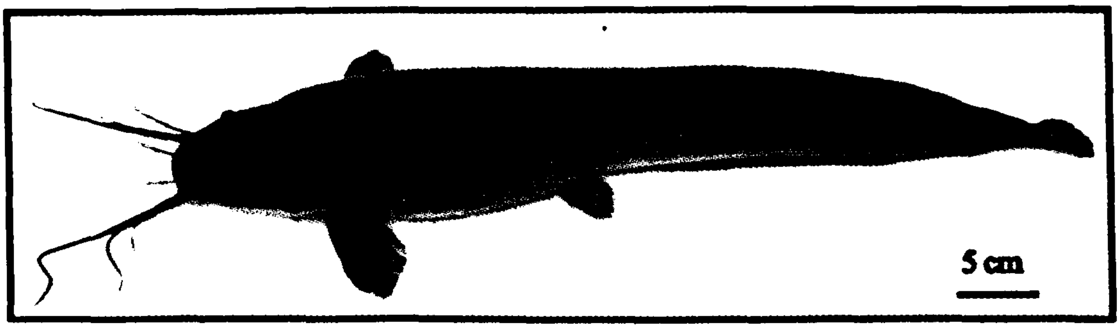

Photo 1.1 African catfish, *Clarias gariepinus* is an important species throughout the world.

African catfish, *C. gariepinus* (Photo 1.1) is one of the most important species that is farmed in tropical freshwater (Appelbaum & Kamler, 2000). This species was introduced to Malaysia in the 1980s' and since then had become one of the most popular freshwater fish (Baidya & Senoo, 2002).

C. gariepinus is an excellent candidate for aquaculture, due to its unique characteristics that showing high growth rate, strong to the disease, and resistant to handling and stress. It is omnivora and can withstand poor water quality (Hogendoorn & Vismans, 1983; Viveen *et al.*, 1985; Ritcher *et al.*, 1995; de Graff & Janssen, 1996; Appelbaum & Kamler, 2000).

C. gariepinus can tolerate to a wide range of temperatures, as well as to low oxygen and high salinity levels (Hecht *et al.*, 1996 and Otémé *et al.*, 1996). Moreover, they have high nutrition value and few bones. Because of their high fecundity and growth rate, they become an important commercial species worldwide (Hecht *et al.*, 1996).

1.2.1 Problem in *C. gariepinus* culture

High production cost is the limiting factor to the expansion of aquaculture industry in the world (Carlberg *et al.,* 2000). Development of growth enhancing strategies is one of the major priorities for aquaculture research, not only to increase fish yield but also to reduce the risk culture system failure. Appelbaum & Kamler (2000) and de Graff & Janssen (1996) reported the introduction of intensive rearing method of *C. gariepinus* in the Central African Republic and Ivory Coast encountered numerous technical and economical problems and one of the possible avenue is to ensure the economic viability of *C. gariepinus* through maximization of growth and survival rate while reducing the construction and operation cost of hatchery.

Most of the pond and tank aquaculture have average water depth of 1 – 2 m (Yoo & Boyd, 1994). The water depth used in *C. gariepinus* juvenile rearing is different in each farm due to lack information. Depth is usually determined for reasons the related to habitat preference of the primary cultured species and construction costs (McLarney, 1984).

According to Teugels (1986), *C. gariepinus* is a bottom feeder which occasionally feeds at the surface. They are obligate air breathers, which mean they do spend some time on the surface. It also is a relatively poor swimmer that spends most of the time on the bottom of lakes and rivers (Pienaar, 1968). Usually, the water level used by the farmer in Malaysia to culture *C. gariepinus* is quite high. As the result, *C. gariepinus* need to spent more energy to swim to the water surface to do air breathing and to feed. But, if the water depth used to culture *C. gariepinus* is lower, *C. gariepinus* juvenile can save them energy which otherwise would be used for survival and growth (Hecht & Uys, 1997). By lower down the water depth, the construction costs can be saved by reducing the height of tank.

Low water depth mean least freshwater is used to culture *C. gariepinus*. As we know, seventy two percent of Earth surface is covered with water, but ninety seven percent of the water is seawater and three percent of freshwater. Freshwater is not distributed evenly in the world, some countries like Brazil, Russia, Canada, Indonesia, China and Columbia have the bulk of fresh water, while others like the African countries have less freshwater (Peter *et al.*, 2006). So, freshwater is very valuable and expensive in some countries. Through this, the operation cost of hatchery can be reduced.

1.3 Objectives of the Study

In order to improve the survival and growth rate of *C. gariepinus* juvenile while reducing the construction and operation cost of hatchery, it is necessary to determine the optimum water depth in *C. gariepinus* juvenile rearing. For this study, following objectives have been outlined:

To improve the *C. gariepinus* juvenile rearing techniques by:

a. Determining the influence of low water depth on survival and growth rates of *C. gariepinus* juvenile.

b. Determining the optimum water depth of *C. gariepinus* juvenile rearing.

CHAPTER 2

LITERATURE REVIEW

2.1 African catfish, *Clarias gariepinus*

African catfish is scientifically known as *Clarias gariepinus*. It is also known as "keli Afrika" in Malaysia, "hire-namazu" in Japan (Frimodt, 1995) and sharptooth catfish in African. It is the largest freshwater clariid fish, which grows to more than 170 cm in total length and 60 kg in body weight (Robins *et al.*, 1991). *C. gariepinus* is an important species throughout the world because it has several advantages such as good taste, high growth rate, strong resistance to diseases and low oxygen, and easy to culture (Pilly, 1990; Appelbaum & Kamler, 2000; Mansour *et al.*, 2002).

2.1.1 Taxonomy

Even though more than 100 different species of the Genus *Clarias* have been described in Africa, a recent systematic revision based on morphological, anatomical and biographical studies has been carried out by Teugels (1982), who recognized 32 valid species. However, confusion of this species name occurred when in African countries, it has been described as *C. lazera* in Northern and Central parts; *C. senegalensis* in the Eastern parts; *C. mossambicus* in the Western parts; and *C. gariepinus* in the Southern parts. Nevertheless, many scientists and culturists are dealing with a single species in the entire region as *C. gariepinus*. *C. gariepinus* is belonged to the Chordata, Class of Actinopterygii, Order of Siluriformes, Family of Clariidae (Santoso, 1994), and Genus of Clarias.

2.1.2 Distribution

C. gariepinus is widely distributed in tropical region throughout Africa (Viveen *et al.*, 1985) and has long been consider as one of the most suitability species to be cultured (El Bolock & Koura, 1960; De Kimpe & Micha, 1974). According to Suyanto (2001), *C.gariepinus* culture is being carried out widely in Netherlands, Vietnam, Philippines, Thailand, Indonesia, Laos, Myanmar and Malaysia as well (Black & Pickering, 1998). It inhabits the tropical swamps, lakes, food plains and rivers, some of which are subject to seasonal drying and they can survive due to the presence of their accessory air breathing organs (Bruton, 1979; Viveen *et al.*, 1985; de Graff & Janssen, 1996).

2.1.3 Morphology

The body of *C. gariepinus* is round and elongated. Strong pectoral fins with spines that are serrated on the outer pectoral ray (Teugels, 1986). The head is flattened, highly ossified, the skull bones (above and on the sides) forming a casque and the body is covered with smooth and scaleless skin, which is darkly pigmented in the dorsal and lateral parts of the body (Viveen *et al.*, 1985).

The mouth of *C. gariepinus* is quite large and subterminal (Skelton, 1993; Teugels, 1986) with four pairs of barbels that can be distinguished as nasal, maxillary, outer mandibular and inner mandibular which serves as tentacles. The maxillary barbels of *C. gariepinus* are extended far behind the posterior extremity of pectoral fin base and nasal barbells reaching to the gill opening (Mohsin & Ambak, 1983). Furthermore, Viveen *et al.* (1985) has mentioned that the main function of the barbels are for prey detection by touch and smell the predator during night time and in highly turbid or muddy waters.

2.14 Behaviour

C. gariepinus is relatively poor swimmers that spend most of the time on the bottom of lakes and rivers (Pienaar, 1968). According to Teugels (1986), they are bottom feeder which occasionally feeds at the surface. They also obligate air breathers, which mean they do spend some time on the surface. *C. gariepinus* also able to move across land to another water source during damp conditions (Skelton, 1993). They simply extend their strong pectoral fins and spines and begin crawling through shallow pathways. *C.gariepinus* displays nocturnal behavior (Santoso, 1994), which active at night and prefer to stay in cooler and darker place.

2.15 Artificial Reproduction

According to de Graff & Janssen (1996), *C. gariepinus* does not spawn in captivity spontaneously even though they are left to natural spawning. This is due to the environmental factors as rise in water level and inundation of shallow areas does not occur at the fish farms. So, artificial propagation under more controlled condition, hormone treatment, stripping of the eggs, and collection of the sperm followed by fertilization of the eggs has been developed in the early seventies (de Graff & Janssen, 1994). This method has been known as time effective, increasing fertilization rate and hatching rates and able to support higher survival and growth rate (de Graaf & Jansse, 1994).

Artificial seed production usually started with broodfish selection (de Graaf & Janssen, 1994). A mature female with a well distended body and soft swollen abdomen will be selected (Brown & Gratzek, 1980). The most common technique to induce final maturation and ovulation in *C. gariepinus* is to inject the female with hormones pituitary gland material (de Graff & Janssen, 1996). The speed of final maturation and ovulation is dependent upon water temperature (de Graff & Janssen, 1996). Then, the mature eggs can be collected by gently pressing the abdomen towards the genital papilla and male *C. gariepinus* is killed to take out testes and cut into small pieces to obtain the milt (Suyanto, 2001). Finally, artificial fertilization is done by mixed the eggs and sperms.

2.2 Larval Rearing

Larval rearing is an important step following the artificial seed production in artificial condition (Veera, 2002). Larvae of *C. gariepinus* are distinguished when the yolk sac will be absorbed within 3 days after hatching (Viveen *et al.*, 1985). The time of first feeding, food availability and their ability to consume food are decisive factors for establishing successful exogenous feeding, and crucial for larval survival and growth (Sanderson & Kupferberg, 1999). Larvae rearing should be carried on for one to two weeks; however, it is depending on growth rate and hatchery management.

2.3 Cannibalism

Cannibalism is the act of killing and consuming the whole or major part of an individual belonging to the same species (Baras & Jobling, 2002). Cannibalism can occur between unrelated animals and between siblings, and can be exerted by parents on their offspring or vice versa (Baras & Jobling, 2002). It is a frequent phenomenon in fish especially in culture environments where fish are unable to escape predation via habitat segregation or mitigation.

A number of factors potentially influence the extent and rate of cannibalism in fish. These factors generally fall into two major categories, for example, size-related and behavioral factors. Within the size-related category, the principal cause of cannibalism is size variation within a cohort caused by genotypic differences, which dictate differences in egg size and the individual growth rates (DeAngelis *et al.*

1979). Factors which have been found to affect the behavior of larvae and thus cause cannibalism are food availability, population density, refuge, water clarity, light intensity, feeding frequency and frequency at which alternative prey is presented (DeAngelis *et al.*, 1979, Fox, 1975, Hecht & Appelbaum, 1988 and Katavic *et al.*, 1989).

Sibling cannibalism has been observed earlier among fry of *C. gariepinus* in hatcheries (Janssen, 1985) and has been studied in detail by Hecht *et al.* (1988). Within aquarium experiments two types of cannibalism can be distinguished, type one which is the tail first cannibalism, where predator and prey size are almost equal, occurring in a weight range of 0.006 g – 0.9 g and type two which is the head first cannibalism, where predator size exceeds prey size, occurring in a weight range of 0.9 g – 4.6 g. Once the weight of the fish exceeds 4.6 g, cannibalism ceased to exist in these aquarium experiments due to the fact that the mouth width of the largest fish in the sibling population is smaller than the head width of the smallest fish (Janssen, 1985).

In ponds, two groups of fingerlings can be distinguished 40 days after stocking. One is the small group (0–3%) with an average weight of 8–12 g and a large group (± 97%) of fingerlings weighing 0.5 –3.0 g. This phenomenon explains why after a long rearing period the number of fry harvested is low and their average weight is high (Hecht *et al.*, 1987).

2.4 Effects of Water Depth on *C. gariepinus*

Due to lack information, a study on the water depth of *C. gariepinus* is necessary to determine the optimum production. Relationship of water depth and *C. gariepinus* rearing is important subject to achieve the reliable method in mass production. In Taiwan, Liao *et al.* (2001) reported most of the indoor system for larval rearing use concrete tank, which have 100 – 200 cm and a volume of less than 100 m^3 but outdoor system is usually bigger, with the areas larger than 100 m^2 and water depth of 100 – 150 cm, and has a lower operating cost. The comparisons two different system with the different water depth are made in table 2.1.

Table 2.1 Comparison of two different systems in term of water depth for larval rearing in Taiwan.

Characteristics	Indoor	Outdoor
Pond and tank water depth	100 – 200 cm	100 – 150 cm
Water volume	< 100 tonnes	> 100 tonnes
Larval survival rate	High	Unstable
Feed supply and water control	Poor	Easy
Larval growth	Slow	Fast
Larvae quality	Poor	Good
Production cost	High	Low
Filamentous alga growth	Impossible	Possible

Another suggestion of water depth was mention by Viveen *et al.* (1985) for the construction and preparation of the nursery ponds of *C. gariepinus* is 50 to 60 cm. Nevertheless, Lawson (1995) recommended the water depth of rearing *C. gariepinus*, a minimum was 90 cm and a maximum was 150 cm. In others species, Lawson (1995) also recommended that the water depth in trout ponds average about 100 cm at the inflow and slope to 150 – 200 cm at the outflow. The water depth of shrimp ponds are rarely deeper than about 60 – 90 cm and pond used for crawfish production are fairly shallow averaging 50 – 60 cm.

2.4.1 Construction and Operation Cost in Aquaculture

High production cost is the limiting factor to the expansion of aquaculture industry in the world (Carlberg *et al.*, 2000). Development of growth enhancing strategies is one of the major priorities for aquaculture research, not only to increase fish yield but also to reduce the risk culture system failure. Appelbaum & Kamler (2000) and de Graff & Janssen (1996) reported the introduction of intensive rearing method of *C. gariepinus* in the Central African Republic and Ivory Coast encountered numerous technical and economical problems and one of the possible avenue is to ensure the economic viability of *C. gariepinus* through maximization of growth and survival rate while reducing the construction and operation cost of hatchery.

Depth is usually determined for reasons related to construction costs and habitat preference of the primary cultured species (McLarney, 1984). Despite its theoretical importance, depth as a factor in pond ecosystem management has been given little attention only (Grobbelaar, 1989). So, the significant effect of water depth is important in aquaculture to construction the ponds and tanks. The construction of ponds and tanks is expensive, ranging from RM 4,000 to more than RM 20,000 per acre in 1991 and depending on the site and the design in term of water depth. So, water depth is important in effectively using water and able to develop a profitable aquaculture operation in an aquaculture system (Yoo & Boyd, 1994).

2.4.2 Thermal Stratification in Water

Thermal stratification is related to incoming heat, water depth, and degree of water column mixing. Thermal stratification occurs due to the amount of light decreases rapidly with the increasing of water depth. The layer of warm surface water is called the epilimnion and the bottom layer of cooler water is known as the hypolimnion (Yoo & Boyd, 1994).

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