THE POSSIBILITIES OF LARVAL REARING FOR AFRICAN CATFISH, *Clarias gariepinus* IN LOW SALINITY

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THIS DISSERTATION IS SUBMITTED IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE BACHELOR OF SCIENCE WITH HONOURS IN AQUACULTURE

AQUACULTURE PROGRAMME
SCHOOL OF SCIENCE AND TECHNOLOGY
UNIVERSITI MALAYSIA SABAH

2006

PUMS99:1

UNIVERSITI MALAYSIA SABAH

BORANG PENGESAHAN STATUS TESIS@

UL: The Possibilities of Larval Rearing for African Catfish,
arias gariepinus in low salinity.

AH: Sarjana Muda Sains dengan Kepujian Akuakultur

A MARYSIA. LINDA JUMIT (HURUF BESAR) SESI PENGAJIAN: 2003/06

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DECLARATION

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

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ACKNOWLEDGEMENT

I would like to extend my heartiest appreciation to a great number of people who have contributed in my conquest of completing this dissertation. This dissertation would not have been successful without their full commitment. Firstly, I would like to thank Prof. Dr. Saleem Mustafa, director of Borneo Marine Research Institute for his kindly support in my research. I would also like to thank my supervisor, Prof. Dr. Shigeharu Senoo who has been a great help in constructive advices on my work, valuable suggestions, continuous encouragement throughout the completion of dissertation, and also for his expert guidance and for his patience, without which this work could not have been accomplished. I am also greatly in debt for Dr. Yukinori Mukai for his valuable advices and teaching. I would like to extend my thanks to Dr. Sitti Raehanah Muhamad Shaleh and Mr. Kennedy Aaron Aguol for spending their time to read through this dissertation and give valuable suggestions and feedbacks. I would like to thank to research assistant Ms. Audrey Daning Tuzan who had helped me and support me. My grateful thanks also go to the entire UMS hatchery's staff and research assistants. Last but not least, I would like to thank to my family, friends and course mates particularly to Imelda Jumit and Nortin Meabin for their love, care and guidance.

Marysia Linda Jumit

UMS, Kota Kinabalu

March 2006

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%	percentage
°C	degree centigrade
ANOVA	analysis of variance
cm	centimetre
g	gram
h	hour
l	litre
mg/l	miligram per litre
pH	potential of hydrogen
SD	standard deviation
SPSS	Statistical Package for Social Science
UMS	Universiti Malaysia Sabah
d AH	day after hatched
d AF	day after fertilized
ppt	part per thousand

CHAPTER 1

INTRODUCTION

1.1 Aquaculture

Aquaculture is the aquatic counterpart of agriculture and its origins extend back at least three thousand years (Beveridge, 1987). On a world basis, aquaculture has tremendous potential to supplement and/or replace wild captured species for human consumption and for export purposes. FAO defines aquaculture as the "farming of aquatic organisms, including mollusks, crustaceans, and aquatic plants". Farming implies human intervention in the rearing process to enhance production practices such as stocking, feeding, health maintenance, and predator protection. Farming also implies individual or corporate ownership of stock under cultivation.

Eighty percent of all fish produced by aquaculture come from Asia. The common carp and Chinese carp species are kept in small ponds, rice paddies, ditches or channels. They contribute significantly to local food. In Southeast Asia fish and mollusks provide over fifty percent of all consumed animal protein. China produces over sixty percent of world's farmed fish. The latest data available from FAO indicate that in 2002 global aquaculture production reached 51.4 million tons and Asia contributed 91.2 percent of the production quantity (FAO, 2004). This will continues to increase due to growing population, changing nutritional habits, increasing income, decline from capture sources and water pollution.

In Malaysia, aquaculture had begun more than 60 years ago with rather slow growth, expanding from 46 ha in 1957 to 1500 ha in 1967. Rapid expansion began in the late 1970s with an increase in pond hectares to 5100 ha by 1979. In 1995, fisheries statistics indicated that there was an overall increase about 23.9% (64,844 tons, RM 52 millions) in aquaculture production in Malaysia. The production of aquaculture in Malaysia continues to increase and attained 133,647 tons valued RM 654,089 million in 2001 (FAO, 2001). Malaysia has many sources of water bodies such as inland and coastal resource which gives more advantages in developing aquaculture industry. Estimated areas for freshwater and reservoirs is 206,000 ha, river and stream is 5743 km and coastline length is 920 km (Hanafi, 1991). Some of the important inland fish and marine species cultured in Malaysia are goby (*Oxyeleotris mamorada*), freshwater catfish (*Clarias sp.*), river catfish (*Pangasius sp.*), tilapia (*Oreochromis sp.)*, bighead carp (*Hypophthalmichtys nobilis*), common carp (*Cyorinus carpio*), seabass (*Lates calcarifer*), groupers (*Epinephelus sp.*), and snappers (*Lutjanus sp.*).

Sabah has many advantages over the other states to develop the aquaculture industry due to its geographical factors. Sabah experiences a typical equatorial climate, with constant temperature of between 27 to 34 °C, considerable amount of rain (1,800 to

4,000 mm per year) and high humidity. It has a "heavily intended" coastline of about 1440 km and is surrounded on three sides by seas: South China Sea in west, Sulu Sea in north and Celebes Sea in east (Singh, 2003). There are more than 2,000 rivers and streams can be found in almost every district.

Clarias gariepinus is one of the catfish species cultivated in Malaysia. It is known as "African catfish", and also locally known as "Keli Afrika" in Malaysia. This freshwater fish was introduced to Malaysia in 1980s. The species was brought in illegeally from Thailand by fish farmers and has spread throughout Malaysia. Since then it is popular among the consumer because of its better flesh and faster growth. In year 2000, the catfish production (*Clarias* spp., *Pangasius* spp. and *Mystus* spp.) was 12 115 metric tons which contributed to 23.9% of the total freshwater aquaculture production. In Sabah, the production of *Clarias spp.* in 2000 for aquaculture was 219 metric tons (Department of Fisheries, Malaysia, 2000).

C. gariepinus is a native fish of Nile and Niger River and is widely distributed throughout Africa. This largest *clariid* freshwater fish can grow to more that 170 cm total length and 60 kg in body weight. It has been introduced for fish culture purposes throughout the world including Southeast Asia and South America. FAO fishery statistics indicated that global aquaculture production for *C. gariepinus* in 2004 was more than 10,000 tons (FAO, 2004). *C. gariepinus* has been considered to be synonyms with *C. mossambicus* and *C. senegalensis*. It has several advantages such as high growth rate, strong resistance to diseases and wider variety of omnivorous feeding habits compared with *C. batrachus* and *C. macrocephalus.*

In Africa, this species inhabit tropical swamps, lakes, rivers and flood plain. *C. gariepinus* has the ability to survive for long periods out of water by breathing air directly. This is because of its unique accessory respiratory organ that occupies the upper part of each branchial cavity. These suprabranchial arborescent organs arise from the gill arches and enable the fish to utilize atmosphere oxygen by providing a highly vascularized and extensive gill epithelium-covered surface area for absorption. They are also able to survive in drying pool by these suprabranchial organs as long as they have access to atmospheric air. This fish has been reported to survive in fresh water as well as in brackish water at salinities of up to 29 ppt (Pillay, 1990).

1.2 The Significance of the Study

Freshwater fish can be categorized into two groups, stenohaline and euryhaline species. The stenohaline species are limited to freshwater only whereas the euryhaline species can adapt to a relatively wide range of salinities. Androgamus eurayhaline species such as Atlantic salmon *Salmo salar* and Pacific salmon *Oncorhynchus spp.*, commence life in freshwater, migrate to the sea as juveniles but return to freshwater for breeding. The Asian bass, *Lates calcatifer*, is a highly euryhaline species that requires saline water for spawning but lives in brackish water estuaries and freshwaters. Mossambicus tilapia, *Oreochromis mossambicus* considered as a remarkable euryhaline freshwater fish because it can grow faster in brackish water and seawater than in freshwater and is able to adapt salinities as high as 120 ppt (Stickney, 2000).

Several information salinity tolerances on stenohaline freshwater species such as *Cyprinus carpio*, grass carp, *Ctenopharyngodon idella*, silver carp, *Hypopthalmichyts molitrix*, which have upper salinity tolerance limits of approximately 15, 14, and 10 ppt respectively (Stickney, 2000). Another species of catfish, channel catfish, *Ictalurus punctatus* is known able to tolerate in salinity of 14 ppt. Whilst it is assumed that stenohaline freshwater are unable to tolerate salinities much higher in full strength sea water, experimental data on higher lethal salinity tolerance limits and effective ranges of salinity for growth are lacking for most species.

Researches and studies on salinity tolerance and effect of salinity on growth and survival rate for freshwater species is necessary because it would be economically advantageous in the use of freshwater in seed production, especially in arid region or when freshwater is limiting. Some studies indicated that there is a possibility to culture *C. gariepinus* in the brackish water environment.

1.3 The Objectives of the Study

The aims of this study are to determine the possibilities of larval rearing in low salinity on and to observe the effect of low salinity on growth and survival rate of *C. gariepinus* larvae with the objective of developing an improved hatchery management of this species.

CHAPTER 2

LITERATURE REVIEW

2.1 Taxonomy

Clarias gariepinus is commonly known as African catfish that belonged to the Phylum of Chordata, Class of Pisces, Sub class of Teleost, Order of Ossariophyci, Sub order of Siluroidae and Family of Claridae. *C. gariepinus* is also from the largest genus, *Clarias* with 32 species in Africa and another 10 or so species occur in Southern Asia (de Graff and Jansen, 1996).

2.2 Distribution

C. *gariepinus* is found distributed in nearly all over Africa and in Asia Minor such as Jordan, Israel, Lebanon, Syria and South Turkey. This tropical freshwater fish has been the species of interest to culture in Netherlands, United Kingdom, Italy, Germany, South East Asia and South America (Bruton, 1979).

C. gariepinus inhabit tropical swamps, lakes, streams, river and floodplains. *Clarias spp.* has the ability to aestivate by burying themselves in the mud and can tolerate oxygen-depleted water.

2.3 Biology

C. gariepinus displayed an eel shape, an elongated cylindrical body, dorsal and anal fins very long and spineless. The head is flattened, highly ossified, the skull bone forming casque and the body covered with a smooth, scaleless skin. They have four pair of unbranched barbells, one nasal, and one maxillar on the vomer and two mandibulars on the jaws. Tooth plates are placed on the jaws as well as on the vomer. The barbels are used to detect preys (Viveen *et al.*, 1985).

One of the characteristic that differentiate *C. gariepinus* from other fishes is the presence of a unique accessory respiratory organ that occupies the upper part of each branchial cavity. These suprabrancial arborescent organs arise from the gill and enable the fish to utilize atmospheric oxygen by providing highly vascularized and extensive gill epithelium-covered surfaces are for absorption. Observation of *C. gariepinus* in the mud of porridge like consistency revealed that they take air in through the mouth and release bubble from the opercular openings (Berra, 2001). The fish turn lighter in color when exposed to light and show a mosaic-like pattern of light and dark exposure during stress.

2.4 Natural reproduction

C. gariepinus becomes mature under natural condition at size 32 cm and spawns in the flooded river. Rising water levels at this time of year provide the stimulus for spawning activity. The spawning seasons varies between July and September and in West Africa in April and May. Spawning usually takes place at night in the shallow inundated areas of the rivers lakes and streams. (Blakely, 1989)

Courtship is preceded by highly aggressive encounters between males. Courtship and mating takes place in shallow waters between isolated pairs of males and females. A batch of milt and eggs is released followed by a vigorous swish of the female's tail to distribute the eggs over a wide area. There is no parental care for ensuring the survival of the catfish offspring except by the careful choice of a suitable site. Development of eggs and larvae is rapid and the larvae are capable of swimming within 48-72 hours after fertilization at 23-28 °C (Bruton, 1979).

2.5 Artificial Reproductions

Artificial propagation techniques under more controlled conditions, including stripping of eggs, collection of sperm, followed by egg fertilization, have been developed which were proved to be reliable for the mass production. It has several advantages including better rates of fertilization and hatching, protection against predators and unfavorable environmental conditions and better conditions for growth and survival.

2.6 Larval rearing of *Clarias gariepinus*

Generally a complete finfish larviculture consisted of three important phases of techniques which are brood fish management, larval rearing and food preparation (Liao *et al.*, 2001). The first phases is brood fish management which involve techniques of collecting and culturing high quality brood fish, inducing maturation and spawning, manipulating sex, preserving sperm and collecting and incubating eggs. The second phase is larval rearing where techniques that have been developed concern on the larva rearing system, nutrient requirement, cannibalism prevention and pond management. The success of commercial scale of seed production will be determined by the nutritional content and size of food given to the larvae and fry. The third phases is food preparation which involves the use of highly unsaturated fatty acids (HUFAs) - supplemented feeds, the application of suitable live food for different larval stages, and the adoption of live food enrichment protocols. In order to produce mass quantity of healthy seed, it is crucially important to improve larval rearing techniques, understand the morphology of larvae, larvae behavior and reaction of larvae to culture conditions.

The yolk sac of larvae *C. gariepinus* will be absorbed within 3 d AH and it can start feeding before the yolk sac totally absorbed. Normally, they will start to search for food and the size ranges 5 up to 30 mm in total length and its body weight ranges 1.2 up to 100 mg (Viveen *et al.*, 1985). *C. gariepinus* larvae are also defines as during yolk sac larvae completing the external function. Therefore, rearing the larvae should be carried on for one to two weeks depending on the growth rate and the hatchery management.

2.6.1 Feeding

Proper feeding of larvae is necessary to produce high quality seed. It is an important factor to achieve high growth and survival rates. The sequential food in early stages is different in different species. The freshwater fish are generally given *Brachionus sp*, *Artemia salina* or *Moina spp.* as their initial diet in the early larval stage. At the later stage the larvae or juveniles are fed minced fish, shellfish and shrimp or on artificial pellet. This showed that obviously different species of fish require different feeding techniques (Amornsakun *et al.*, 2003).

The small mouth size of *O. marmoratus* larvae of about 0.1 mm limits the types of food. They were fed with live rotifers and chicken-slurry to the larvae after the yolk sacs was absorbed (Tavarutmaneegul and Lin, 1988). Thirty days after hatching (30 d AH), the larvae were transferred to outdoor tank and feed daily with live organisms (*Moina* spp., *Brachionus* spp., *Chironomid* larvae) and trash fish.

The larvae of *C. gariepinus* can be fed with *Artemia salina* subsequently for seven days and are fully weaned to this diet fourteen to twenty one days after the exogenous feeding. They are transferred from the aquaria to 10001 mg fry rearing tanks when the larvae attain a weight of about 100 mg which about two weeks after starting feeding (Hoar, 1995).

2.6.2 Water depth and Stocking density

There are many techniques of larval rearing *C. gariepinus* of in water depth of pond and concrete tanks. Bardach *et al.*, (1994) recommended that ponds up to 1 m deep used for larval rearing of this species but best results are obtained in water 10 to 18 cm deep. de Graaf and Janssen (1996) designed 100 to 150 meters square with 80 cm water depth of earthen nursing pond to culture this species. Zamzairi (2003) suggested that 15 cm for water depth used for larval rearing because it is easy to observe the *C. gariepinus* larvae, save water utility and low cost of tank construction. Optimal stocking density for larval rearing of this species was 100 tails per meter squares harvesting about 35 to 40 juveniles per meter squares after five weeks (de Graaf, 1996)

2.6.3 Fish behavior

Understanding of larval behavior of larvae to feeds and environmental condition is important to improve larval rearing techniques. Most behavior traits have a genetic basis and subject to selection like other biological characters. Liao *et al.* (2001) reported that knowledge of changes in fish behavior with development or in response to varying environmental condition may suggest culture techniques that lead to increase growth and survival.

Cannibalism is a frequently phenomenon in fish and will occur (Smith and Reay, 1991). *C. gariepinus* has cannibalistic behavior which caused by overcrowding in the tank

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Cannibalism is a frequently phenomenon in fish and will occur (Smith and Reay, 1991). *C. gariepinus* has cannibalistic behavior which caused by overcrowding in the tank or pond due to high stocking density or water depth (de Graaf, 1996). In the study effect of stocking density on the dynamics of cannibalism in sibling larvae of *Perca fluviatilis* under controlled conditions provided evidence that the decrease of cannibalism among perch under increasing stocking density resulted from a combination of factors such as lower proportion of cannibals, lower per capita impact, delayed emergence of cannibalism. The survival rate was significantly higher at the highest stocking density in sibling larvae of *Perca fluviatilis* (Baras *et al.*, 2003).

2.6.4 Water quality

Water quality is defined as the web of the chemical, biological and physical factors which constitute the water environment and influence the production of fish. Temperature, dissolved oxygen, pH and salinity are critically important water quality parameter in aquaculture. This is because the growth and survival rate of fish is greatly dependent on a variety interacting environmental factors. According to Senoo *et al.* (1994), for successful larval culture, rearing condition must be very good with water changing at 30 - 50% daily from 7 d AF. The water must be well aerated and treated with 20 W fluorescent light daily up to 30 d AF. This is because after 30 d AF, the larvae became phototactic negatively.

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