LARVAL REARING, FEEDING AND SWIMMING BEHAVIOUR OF AFRICAN CATFISH, *Clarias gariepinus* LARVAE UNDER DIM LIGHT CONDITION

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THIS DISSERTATION IS SUBMITTED AS A PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE BACHELOR OF SCIENCE WITH HONOURS

AQUACULTURE PROGRAMME
SCHOOL OF SCIENCE AND TECHNOLOGY
UNIVERSITI MALAYSIA SABAH

MAY 2010

PUMS99:1

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JUDUL: LARVAL REARING, FEEDING AND SWIMMING BEHAVIOUR OF AFRICAN CATFISH, Clarias gariepinus LARVAE UNDER DIM LIGHT CONDITION

IJAZAH: BACHELOR SCIENCE IN AQUACULTURE

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DECLARATION

I declare that this dissertation is the result of my own independent work except where otherwise state.

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ACKNOWLEDGEMENTS

This dissertation has accumulated many debts of gratitude throughout its completion. Thus, 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 would not have been successful without their full commitment. Firstly, I would like to thanks to Assoc. Prof. Dr. Yukinori Mukai, my supervisor of my final year project, for his teaching and support to completing this dissertation. I would like also extend my sincere appreciation to Prof. Dr. Shigeharu Senoo, for giving me opportunity to join African catfish artificial seed production to get newly hatched larvae that used in this experiment and I would like to convey my heartiest appreciation to Mr. Lim Leong Seng, Tan Han Nai for their advice, suggestion and consultation. Finally, a thousand thanks to research assistant and staff in UMS hatchery and IPMB, my fellow friends and all my family members that been very supportive.

ABSTRACT

Larval rearing, swimming, feeding and biting behavior of African catfish, *Clarias gariepinus* were studied under five different light intensities (0, 0.1, 1, 10 and 100 lux). The study was conducted for 20 days, from 0 dAH until 20 dAH. In addition, the effects of light intensity on survival rate and growth rate were also evaluated. African catfish larvae had the highest survival under dim light condition and highest growth under dark condition. Beside, swimming activity and ingestion rate of brine shrimp (*Artemia naupli*) also highest under dim light condition. Beside, for biting behavior experiment, African catfish were found that had the lowest number of biting activity under the dim light condition. Therefore, from these results can be recommended that African catfish larvae can be cultured under dim light condition to obtain higher survival rate and lower cannibalism.

ABSTRAK

Pemeliharaan larva, tabiat berenang, tabiat makan dan tabiat menggigit Keli Afrika , Clarias gariepinus telah dikaji denagan lima keamatan cahaya yang berbeza (0, 0.1, 1, 10 dan 100 lux). Masa kajian ini adalah 20 hari, dari 0 dAH (hari pertama) hingga 20 dAH (hari ke-20). Selain itu, kesan daripada keamatan cahaya dievaluasi dengan peratusan hidup ikan dan pertumbuhan (berat badan dan jumlah panjang). Larva ikan Keli Afrika ditemui mempunyai peratusan hidup larva yang tertinggi di bawah kondisi cahaya redup dan pertumbuhan tertinggi di bawah keadaan gelap. Untuk eksperimen perilaku berenang dan perilaku makan, ikan larva Keli Afrika ditemui mempunyai aktiviti berenang tertinggi dan makan kuantiti yang paling banyak (Artemia nauplius) di bawah kondisi cahaya redup. Disamping itu, untuk eksperimen perilaku menggigit, , ikan larva Keli Afrika dijumpai mempunyai jumlah aktiviti menggigit terendah di bawah kondisi cahaya redup. Oleh kerana itu, dari keputusan ini boleh disarankan bahawa larva ikan larva Keli Afrika boleh diperliharakan di bawah kondisi cahaya redup untuk mengurangkan kanibalisme dan menigkatkan peratusan hidup.

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LIST OF ABREVIATIONS

%	Percentage
cm	Centimetre
d AH	Day after hatching
FAO	Food Agriculture Organization
HCG	Human Chorionic Gonadotropin
Individual/ mL	Individual per millilitre
Kg	Kilogramme
LHRHa	Luteinzing Releasing Hormone analog
mL	Millilitre
mm	Millimetre
Tails/L	Tails per litre
UMS	Universiti Malaysia Sabah

CHAPTER 1

INTRODUCTION

1.1 African catfish, *Clarias gariepinus*

The African catfish, *Clarias gariepinus* (Burchell 1822) is one of the most important species currently being farmed and it ranges from the Orange River in Cape of South Africa throughout Africa and into eastern Turkey (Hocutt, 1989). African catfish is a native species of tropical and subtropical fresh waters and been widely farmed in heated waters outside its natural range (Hecht and Appelbaum, 1988; Van Weerd, 1995). African catfish is able to grow up more than 170cm in the total length and 60 kg in body weight which is the largest freshwater clarrid fish (Robins, 1991). African catfish is an aggressive fish (Hecht & Appelbaum, 1988; Britz & Pienaar, 1992; Hecht & Pienaar, 1993; Kaiser et al., 1995a; Hossain, 1998). The presence of an accessory breathing organ enables this species to breath air when active or under very dry conditions (Teugels, 1986). Due to the fast growth, omnivore and it's desirable as food, African catfish is valuable for aquaculture worldwide (Khwuanjai Hengsawat, 1997). *C. gariepinus* is commonly known as "African catfish" and is locally known as "Keli Afrika" in Malaysia and "Hire-Namazu" in Japan (Frimodt, 1999).

1.2 Challenges in larviculture of African catfish

African catfish larvae is very different from the adult fish. Most of its main organs such as barbells, mouth, gut and gills are not developed yet. The weight of hatchlings is about 1.0-1.5mg and the total length is about 4mm.

The main problem in larval rearing of African catfish is cannibalism. Like other animals, fish often defend their food and territory (Grant, 1997). These activities are necessary to balance the need to eat and the need to avoid being eaten (Thorpe and Cho, 1995). However, such aggressive activities may causes in skin lesions and fin damage. The wounds increase their susceptibility to disease and weaken the fish making them more liable to cannibalism, or death as a consequence of their wounds (Kaiser, 1995).

From the previous study, the results showed that African catfish larvae swim actively under dark condition (Calista, 2009). Thus, the objectives of this studies was the further study which used five different light intensity than previous study than just on light and dark condition.

1.3 Effects of light on larval rearing of African catfish

Fish can be classified into species that rely predominantly on vision, and those that rely more on chemical, tactile or electrical senses (Schwassmann, 1971). African catfish have been reported to show photophobic behavior (Hogendoorn, 1980; Britz and Pienaar, 1992). Most fishes are visual feeders and need a minimal threshold light intensity to be able to develop and grow normally (Blaxter, 1986; Ounais-Guschemann, 1989; Boeuf & Le Bail, 1989). High light intensity may be stressful or even lethal if used to culture African catfish (Boeuf & Le Bail, 1989). Furthermore, fish behavior is influenced by light intensity, photoperiod and density (Page and Andrews, 1975; Britz & Pienaar, 1992; Thorpe & Cho, 1995; Kaiser, 1995; Appelbaum & McGeer, 1998; Hossain, 1998; Boeuf & Le Bail, 1999; Appelbaum & Kamler, 2000; Nwosu & Holzlöhner, 2000).

Britz & Pienaar (1992) reported that restriction of light may be used in its culture to enhance growth and reduce stress. This collaborate the view of Ogbe (2001) who reported that African catfish are bottom feeders that feed comfortably in the dark. These results seem to suggest that light plays a major role in regulating the activities of African catfish (Nwosu and Holzlöhner, 2000; Appelbaum and Mcgeer, 1998) and growth.

In this experiment, swimming & feeding behavior were observed under different light intensity and the growth and survival for larval rearing were also determined.

1.4 Objectives

The purpose of this study is to examine the swimming and feeding behavior for African catfish under different dim light intensity. The hypothesis for this experiment is under the low light condition, fish will swim actively than under high light condition.

Therefore, the objectives of this study were:

1. To determine survival and growth rate of African catfish larvae under dark and dim light condition.
2. To examine the swimming behavior of African catfish larvae under dim light condition.
3. To examine the feeding behavior of African catfish under dim light condition.
4. To examine the biting activity of African catfish under dim light condition.

CHAPTER 2

LITERATURE REVIEW

2.1 Fish behavior

Fish farming conditions, from extensive to highly intensive, may causes the same sort of behavioral problems are known from other animal production systems such as for pig and poultry. Behavioral problems such as reduction in feed intake, aggression, stereotypes and mortality are examples of stress caused by intensification of farming conditions. These behavioral problems can be solved or at least reduced if we understand their causes. Therefore, it is important to understand normal behavior of the fish under farming conditions. However, study of fish behavior under farming conditions is extremely difficult due to the high number of fish, making unambiguous observations almost impossible. Therefore studying fish behavior needs to be done under experimental condition.

2.1.1 Feeding behavior of African catfish

In many fish species, vision has a dominant role in the search for food and the preliminary assessment of the edibility of food items. Visual deprivation in such fish causes either a decrease in the intensity or results of feeding, or makes feeding entirely impossible (Girsa, 1981; Manteifel, 1965; Kestemont and Baras, 2001). The non-visual organs of senses play a far greater role in the search and detection of prey in bottom and near-bottom fish, as well as in fish leading a crepuscular or nocturnal mode of life or inhabiting large depths, underground water bodies, caves, etc. (Pavlov and Kasumyan, 1998). The final phase of the feeding behavior in all fish irrespective of the mode of life and specific features of feeding is based on the function of the oral gustatory system and, in part, of mechanoreceptor. The sensory control promoted by the functioning of these two contact sense organs permits performing an ultimate assessment of the grasped prey and making a decision whether to swallow or reject it (Kasumyan, 1997; Kasumyan and Doving, 2003).

In African catfish larvae, the functional digestive system is complete in 5 days after the starting of exogenous feeding (Verreth, 1994). After 48 to 72 hours hatching, when they are swimming freely and when two third of their yolk sac was absorbed, they will accept external feed (Hecht and Appelbaum, 1987). African catfish has nocturnal feeding habits and also omnivorous (Bruton, 1979; Hogendoorn, 1981; Viveen, 1985).

2.2 Cannibalism in African catfish larvae

Light provokes an indirect effect on African catfish larval aggression by increasing swimming activity which in turn promotes multiple encounters between individuals and enhances aggressive behavior (Appelbaum and McGeer, 1998). Like other animals, fish often defend their food and territory (Grant, 1997). These activities find their origin in the need to balance the need to eat and the need to avoid being eaten (Thorpe and Cho, 1995). These fish aggression activities usually results in skin lesions and in fin damage. This in turn increases their susceptibility to disease and weakens the fish, making them more liable to cannibalism or death as a consequence of their wounds (Kaiser, 1995). This aggressive activities may therefore results in stocks loses, and in turn to depressed food conversion efficiency and growth due to the higher energy requirement (Hecht and Uys, 1997).

2.3 Effects of light on survival and growth of African catfish larvae

Light play an important role in regulating fish growth and behavior (Britz and Pienaar, 1992; Thorpe and Cho, 1995; Appelbaum and McGeer, 1998; Hossain, 1998; Boeuf and Le Bail, 1999). Light acts as a powerful directive factor synchronizing cycles of metabolism and activity in fish and other organisms (Hossain, 1999). Beside, stress, aggression and cannibalism were reduced and growths were enhanced (Britz and Pienaar, 1992) when African catfish were reared in continuous dark or dim light condition. Under the light condition, African catfish were stressed and show a behavior like searching for cover and have lower growth rate, whereas in dark condition, they appeared normally active (Britz and Pienaar, 1992). This led to suggestion that restriction of light may be used in culture for enhancement of growth and stress reduction (Britz and Pienaar, 1992).

2.4 Sensory organs of African catfish

The information from a variety of different sensory system is used by animals to accomplish behavioral objectives (New, 2001). In fishes, sensory organs are used for their adaptability in the environment to survive. It may function in detecting prey or predator, vibration and sound (Royce, 1984). By fully using the sensory organs, fishes have the ability to search the food that can prevent them from starvation, protect from danger, and to form schooling in swimming (Royce, 1984). In fishes, their visual stimulus is highly dependent on the environmental light regime (Von Der Emde, 2004).

When fish hatched, some species already have several kinds of sensory organs while some other species are not equipped with any (Von Der Emde, 2004). After hatched, the sensory organs develop rapidly in fish larvae. African catfish has five sensory organs; there are eyes, free neuromasts, olfactory organ, taste buds and inner ear. Each sensory have their own ability or specialized function. For example, eye is a visual stimulation which is a sense broadly used in most activity done by animals and mammals. In fishes, the uses of eye dependent on the environmental light intensity. The main function of eye is to estimate the distance of prey or predators.

Whereas, for free neuromast is mechano sensory organs in larval fish (Mukai, 1995) which is used to respond to mechanical stimulation such as vibration, water current and touch. Lateral line also included in mechanoreceptor organs. Lastly, for the taste buds and olfactory organs is a chemoreceptor which is used to respond on chemical stimulation such as smell and taste. The chemical sense is important for the aquatic invertebrate especially for those living in the dark place and also for the some night-active species.

CHAPTER 3

MATERIALS AND METHODS

3.1 Source of larvae

African catfish larvae were obtained from the UMS Hatchery by artificial spawning. For the artificial spawning, one matured female and two male were selected. The matured female fish was injected with ovaprin hormone with the dosage of 0.5ml/kg. After 8 hours, the eggs were checked by cannulation and striped out by hand when the eggs were matured. For male fish, the abdomen was cut to locate the testis. Needle was used to make small holes to drive out the milt from testes and collect them by siphon using vacuum. The abdomen of the male fish was stitched and the fish was released into the quarantine tank. The milt was mixed with the eggs and washed by using the water with sand to eliminate the stickiness of the eggs. The fertilized eggs were incubated in the incubation tank. After 24 hours, larvae were hatched out and the newly hatched larval were transferred to the larvae rearing tank.

3.2 Larval rearing for swimming and feeding behavior experiment

The newly hatched larvae of the African catfish were separated and reared in two aquariums which one aquarium is for swimming experiment and another is for feeding behavior. The water quality in the aquariums was maintained by doing the bottom cleaning and water exchange. The larvae were fed twice a day until satiation with brine shrimp (*Artemia naupli*).

3.3 Experimental Procedure

3.3.1 Larval rearing experiment

The larval rearing experiments were carried out by using the 0 day after hatching (dAH) larvae under the different light intensities of 0, 0.1, 1, 10, and 100 lux. The Power- Glo high intensity lamp was used as the source of the light in the experiment and the light was filtered by using Hoya light filter according to the desired light intensities. The reason of using the Power- Glo high intensity lamp was to supply the lights that have the short wave length which similar to the natural sunlight compare to normal florescent lamp. Besides, the Hoya light filters were used to filter the light that supply from the Power- Glo high intensity lamp to the light intensity that needed for the experiment. The reason that Hoya light filter was used because this light filter will reduce the light wave length equally. The larval rearing experiments were conducted in the dark room that covers with black covers to avoid the disturbance of light from outside.

Fifteen 7L aquaria were used under 5 light intensity which are 0, 0.1, 1, 10, and 100 lux. There were three aquaria for each light intensity. Each of the aquariums was filled with five liter water with the stocking density 10 tails per liter. That means there 50 tails of larvae in each aquarium. The experiments were conducted with three replicates. The duration for this experiment was 20 days which from 0 day after hatching till 20 days after hatching. The light intensity in the dark room was measured by using the lux meter.

For the routine work, bottom cleaning and change the water for 10% for each tank were done daily. During water exchange, the dead larvae were removed and counted. At 2 dAH, the larvae were fed with brine shrimp (*Artemia naupli*) twice daily with the amount 2500 individuals per aquarium.

At the end of the experiment, the larvae were anesthetized with TRICAIN-S (MS-222). The numbers of survival larvae for each aquarium were recorded. The body weight and the body length of each larva were also measured. To measure the length, ruler was used and to measure the weight, the larvae were dried using tissue first to remove the water. Then, the larvae were put into the Petri dish and were weighed using analytical balance. After measurement, the larvae were preserved in 10% Formalin solution.

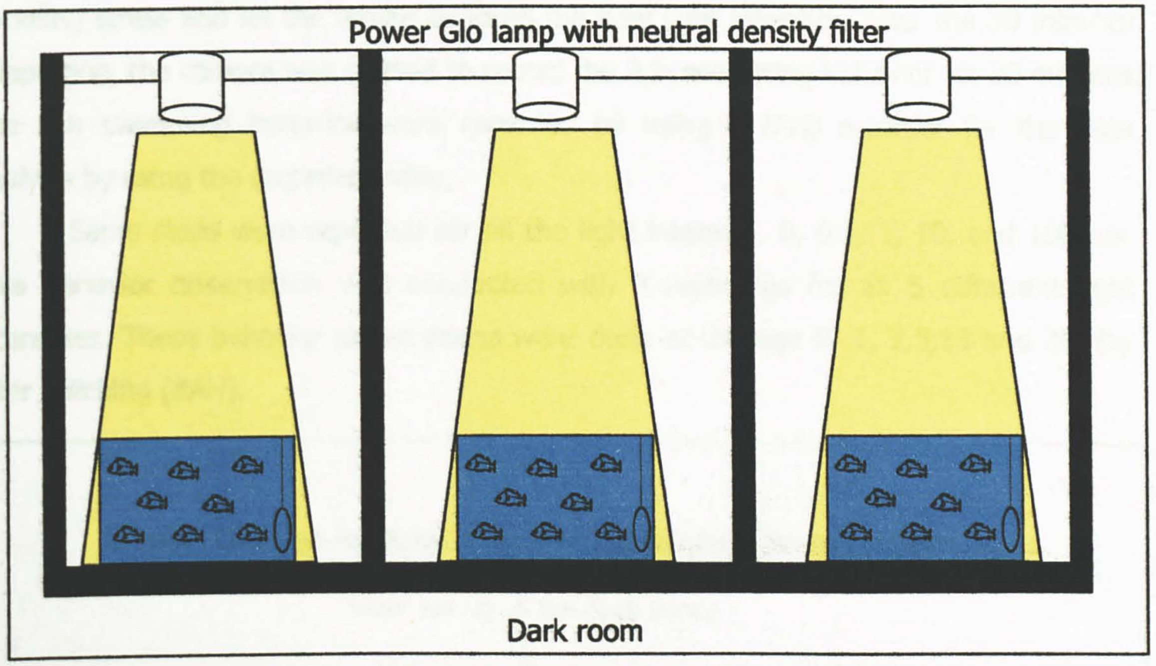

Figure 3.1 Experimental designs for swimming and feeding behavior experiment.

3.3.2 Swimming behavior experiment

The swimming behavior experiments were carried out by using the 0, 1, 2,5,13 and 20 dAH larvae under the different light intensities of 0, 0.1, 1, 10, and 100 lux. The swimming behavior experiments were conducted in the dark room that was used in the larval rearing experiment to avoid the disturbance of light from outside. The camera and Power- Glo high intensity lamp were set up in the dark room so that the result can be analyzed from the recorded video. The camera that was used in this experiment was the camera with the infrared light that was 900nm. Infra red light camera was used to allowed the observation of the fish behavior under completely dark or under dim light condition. Beside, the infrared light with the wavelength 900nm was used so that fish larvae cannot detect the infrared light. The light intensity in the dark room was measured by using the lux meter before every experiment started.

First, a glass basin was prepared and filled with 1000ml of fresh water. After that, 10 tails of larvae were caught and transferred to the glass basin. Then, the glass basin which contains larvae was transferred to the dark room for the experiment.Then, the glass basin was put under the camera and record. Before the experiment start, the larvae were leave for adaptation in the new environment for 30 minutes to reduce the handling stress and let the larvae adapted the new light intensity. After the 30 minutes adaptation, the camera was started to record the fish swimming behavior for 30 minutes. The fish swimming behavior were recorded by using a DVD recorder for the data analysis by using the recorded video.

Same steps were repeated for all the light intensity, 0, 0.1, 1, 10, and 100 lux. This behavior observation was conducted with 3 replicates for all 5 different light intensities. These behavior observations were done at the age 0, 1, 2,5,13 and 20 day after hatching (dAH).

Power- Glo high intensity lamp with Hoya light filter and camera were set up in the dark room

↓

10 tails of larvae were transferred to the glass basin that filled with 1000ml of freshwater

↓

Glass basin was transferred in to the dark room

↓

The fish larvae were leave adaptation for 30 minutes

↓

Video recording was done for 30 minutes

↓

Same procedures were repeated for 0, 0.1, 1, 10 and 100 lux

↓

3 replicates were done

Figure 3.2 Procedures for swimming behavior experiment under different light intensities.

3.3.3 Feeding behavior experiment

The feeding behavior experiments were conducted under the same condition as swimming behavior experiment. First, 300 individuals of brine shrimp (*Artemia naupli*) were fed into the glass basin. Since feeding experiment was conducted, so, the larvae that used for the feeding experiment had to be starved for at least 6 hours before the experiment. The fish larvae were leaved to eat the brine shrimp (*Artemia naupli*) for 30 minutes and the eating behavior was recorded by using the camera.

After 30 minutes eating time, the larvae in the glass basin were anesthetized using TRICAIN-S (MS-222). The larvae in the glass basin were observed under microscope where the number of eaten brine shrimp (*Artemia naupli*) inside their stomach will be calculated and recorded. The same procedures are repeated using the different light intensities.

Under the same condition as swimming behavior

↓

300 individuals of brine shrimp (*Artemia naupli*) were feed into the glass basin

↓

Fish larval were leave to eat the brine shrimp (*Artemia naupli*) for 30 minutes

↓

Fish larvae were anesthetized using TRICAIN-S (MS-222)

↓

Numbers of eaten brine shrimp (*Artemia naupli*) inside stomach were calculated and record under microscope

Figure 3.3 Procedures for feeding behavior experiment under different light intensities.

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