The Study on Growth Performance of African Catfish (*Clarias gariepinus)* Reared in Earthen Pond Farming System

Nur Asmasyawati Binti Kamarudin

F15A0135

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DECLARATION

I hereby declare that the word embodied in this report is based on my original research except for citation and quotations which have been only acknowledgement.

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Signature

Student 's name :

Matric no. :

Date :

Approved by:

____

Supervisor's signature

Supervisor's name :

Cop :

Date :

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LIST OF TABLE

LIST OF ABBREVIATIONS

WG = eight gain

PWG = percentage weight gain

SGR = specific growth rate

FCR = feed conversion ratio

DO = dissolve oxygen

NO_2 = nitrites

NO_3= nitrates

NH_3= ammonia

CO_2= carbon dioxide

a.m. = ante meridiem

p.m = post meridiem

m = metre

cm = centimetre

LIST OF SYMBOLS

± = plus/minus sign

% = percent

°C = degree Celcius

TABLE OF CONTENT,

CONTENT		PAGE

The Study On Growth Performance of African Catfish (*Clarias gariepinus*) Reared in Earthen Pond Farming System

ABSTRACT

Aquaculture industry involves culture of many fish species of either fresh or brackish water origin such as tilapia and catfish. The African catfish (*Clarias gariepinus*) is one of most popular freshwater fish and have a high demand in Malaysia. This research study was carried out to monitoring the growth performance of African catfish (*C. gariepinus*) reared in earthen pond farming system. Thirty thousand (30 000) of African catfish (*C. gariepinus)* fingerlings were stocked in the earthen pond farming system with the size of 30.48 m × 12.19 m. The growth performance of African catfish (*C. gariepinus)* was evaluated for eight weeks. Water quality, percentage weight gain (PWG), specific growth rate (SGR) and feed conversion ratio (FCR) were determined. Initial body weight of African catfish (*C. gariepinus)* was 8.05 g ± 0.08 and final body weight of African catfish on week 8 was 19.74 g ± 0.27. The highest growth rate of African catfish (*C. gariepinus)* was showed on week 2 which was 0.45 g ± 0.06. The least value of feed conversion ratio was resulted in week 2 which was 0.14 ± 0.03 which was the best value for feed conversion ratio. All the water quality parameters were within the acceptable range for African catfish (*C. gariepinus*). In conclusion, earthen pond culture system was applicable for African catfish (*C. gariepinus*) farming.

Keywords: *Clarias gariepinus*, earthen pond, growth performance

Kajian Mengenai Perkembangan Pertumbuhan Ikan Keli Afrika (*Clarias gariepinus*) yang Dipelihara Dalam Sistem Penternakan Kolam Tanah

ABSTRAK

Industri akuakultur melibatkan banyak spesies ikan yang berasal dari air tawar atau payau seperti tilapia dan ikan keli. Keli Afrika (*Clarias gariepinus*) adalah salah satu ikan air tawar yang paling popular dan mempunyai permintaan yang tinggi di Malaysia. Kajian penyelidikan ini dijalankan untuk memantau prestasi pertumbuhan ikan keli Afrika (*C. gariepinus*) yang dibela di dalam sistem penternakan kolam tanah. Tiga puluh ribu (30 000) anak benih ikan keli Afrika (*C. gariepinus*) di bela di dalam sistem penternakan kolam tanah yang bersaiz 30.48 m × 12.19 m. Prestasi pertumbuhan ikan keli Afrika (*C. gariepinus*) telah dinilai selama lapan minggu. Kualiti air, peratusan berat badan (PWG), kadar pertumbuhan tertentu (SGR) dan nisbah penukaran makanan (FCR) telah ditentukan. Berat badan awal ikan keli Afrika *(C. gariepinus*) ialah 8.05 g ± 0.08 dan berat badan akhir ikan keli Afrika pada minggu ke-8 ialah 19.74 g ± 0.27. Kadar pertumbuhan tertinggi ikan keli Afrika (*C. gariepinus*) ditunjukkan pada minggu 2 iaitu 0.45 g ± 0.06. Nisbah penukaran suapan paling rendah yang dihasilkan pada minggu 2 iaitu 0.14 ± 0.03 yang merupakan nilai terbaik untuk nisbah penukaran makanan. Semua parameter kualiti air berada dalam nilai yang boleh diterima untuk ikan keli Afrika *(C. gariepinus*). Kesimpulannya, sistem penternakan kolam tanah boleh digunakan untuk penternakan ikan keli Afrika (*C. gariepinus*).

Kata kunci: *Clarias gariepinus*, kolam tanah, prestasi pertumbuhan,

CHAPTER 1

INTRODUCTION

1.1 Research background

Aquaculture of catfish have great important for economic and it is the most cultured fish in Malaysia. The growing of aquaculture industry is stunted by insufficient information about fish farming activity in Malaysia especially in culture system management and feedstuff which is costly. Due to the increasing population growth and health awareness, the demand for aquaculture as the food source also rising for years (Adewolu, Ogunsanmi and Yunusa, 2008). Therefore, the requirements for aquatic product also increase to fulfill the protein source of the body.

African catfish (*Clarias gariepinus*) is the popular species for aquaculture business in Southeast Asian countries (Putra, Rusliadi, Fauzi, Tang & Muchlisin, 2017; Muchlisin, Nadiya, Nadiah, 2010). This species has several advantages, for example, resistance to diseases and handling stress and high growth rate (Putra et al. 2017 ; El Naggar, John Rezk, 2006), thus accounting for its commercial importance worldwide (Muchlisin, 2015).

Other aquaculture attributes of *C. gariepinus* include high fecundity rate, ability to tolerate environmental extremes and high stocking densities, high plasticity in its feeding habits (Edward, Ladu & Elihu, 2010), as well as good market potential (Ali & Jauncey, 2005).

Apart from the government initiative in helping the rural area by aquaculture activity, it is also increase the intake of aquatic species that helps to develop the economy which is aquaculture production leads the market and the farmed fish tends to be cheaper also to increase economic access (Beveridge, Thilsted & Phillips (2013).

In Malaysia, the price for African catfish fingerling is RM 0.05 for each 5 cm body long. Its price depends on the size of the fingerling. The price for African catfish fingerlings in Malaysia are range from RM 0.04 to RM 0.13 each (Afiq, 2015). Then, the retail price for catfish after harvest are range from RM 5 to RM 8 per kg, meanwhile the wholesale price for catfish are range from RM 3 to RM 7 per kg following the market price (Lembaga Kemajuan Ikan Malaysia [LKIM], 2017).

Then, supply of feed must be able to fulfill the nutritional requirement of the cultured species and cost effective as well. The food with high quality not only will promote the growth performance of the species, but also help in improving the health of the cultured species. When health of the cultured species is well-managed, charge for disease treatment can be decrease. Skillful workers are needed to do pond preparation for stocking, stocks transfer, feeding, tank cleaning and harvesting. A farm manager is responsible to organize the workers and schedule overall farm management and operation (Lee & Wendy, 2010).

Fish farmers in Malaysia usually used plastic tanks because the tanks are easy to clean and install also the last several years. The tanks need simple procedures for take care of it in this modern country as plastic tanks are ideal if we live in a rented apartment or house and cannot make any major changes or construction (Agun, 2015). The used of tanks also lead to high of cost due to its high price. Therefore, other alternative are needed to minimise the cost and increase the production of catfish. Earthen pond may be useful because it has some advantages over the others aquaculture systems which potentially important for the farmers in increase the financial benefit.

This study was conducted to monitor the growth performance of African catfish *(C. gariepinus)* reared in earthen pond farming system. At the same time to help the fish farming in increase the production of fish with low mortality rate of the fish. The objective of the study was to determine the feed conversion ratio, specific growth rate and percentage weight gain of African catfish *(C. gariepinus)* using earthen pond farming system.

1.2 Problem statement

Aquaculture can create a big range of benefits including employment, food and income but governments must develop mechanisms for sustainable aquaculture on a large scale. The insufficient production of fresh water fish such as African catfish (*Clarias gariepinus*) due to lack of information about catfish farming system and culture system in Malaysia context. The improvement of growth performance is required in the study the culture system for aquaculture industries. Fish farmers in Malaysia need the initiative for rearing the fresh water fish with low capital needed and fast growth of fish. It also helps the fish farmers to optimize the growth as well as increase the profit from catfish farming business.

1.3 Objective

i. To monitor and determine the growth performance of African catfish (*Clarias gariepinus*) reared in earthen pond system.

1.4 Hypothesis

H_0 : Earthen pond system may not suitable for growth performance of African catfish (*Clarias gariepinus*)

H_a : Earthen pond system may suitable for growth performance of African catfish (*Clarias gariepinus*)

1.5 Significance of study

This research will focus on the way to improve growth performance of African catfish reared in earthen pond system by monitoring the growth rate every week for eight weeks. The success of this study could lead to produce the African catfish with high growth rate and increase the financial profit.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction of African catfish (*Clarias gariepinus*)

Aquaculture world is growing up along with the population growth which means that demand for aquaculture products also increase to fulfill the requirement of protein source for the body (Akeem, Ikhsan, Murni, Mohd & Armaya'u, 2018). Aquaculture industry involves culture of many fish species of either fresh or brackish water origin and among the important freshwater fish species is North African catfish which is also scientifically known as African catfish (*C.gariepinus*) (Akeem et al., 2018). The African catfish is the most commercially cultured fish in Nigeria because of its high survival rate. This species of catfish was introduced all over the world in the early 1980s although its raising started in central and western Africa in the early 1970's for being a potential species for aquaculture (Anoop, Sundar, Khan & Lal, 2009) .

The African Catfish, *C. gariepinus* is choice food fish species in Nigeria. It commands high demand from consumers and is mostly preferred by food fish aquaculturists. This is due to the ideal characteristics of this species which includes high growth rate at high stocking densities, a high food conversion, good meat quality and smoking characteristics as well as year round production (Eding & Kamstra, 2001). Its production is increasing as the total aquaculture production also increases and its culture is spread globally, with Nigeria officially reported as producing the highest annual amount of the fish (Akeem, Ikhsan, Murni et al. 2018).

African catfish, *C. gariepinus* are being cultured in worldwide due to their beneficial characteristics which fast growth, attain a large size and high market demand (Putra et al. 2017). This species can stand the wide range of environmental condition which in seasonal drying. They can withstand with this condition due to possessed of the special accessory breathing organ comprising of modified gill arches (Anoop et al., 2009).

There are around 100 species of African catfish, *C. gariepinus* are known in the world but only a several species mainly used in fish farming. These are the taxonomic hierarchy of African catfish, *C. gariepinus* from (Myers, Espinosa, Parr, Jones, Hammond & Dewey, 2018).

Table 2.1.1 Taxonomic hierarchy of African catfish (*Clarias gariepinus*)

Kingdom	**Animalia**
Phylum	Chordata
Class	Actinopterygii
Order	Siluriformes
Family	Clariidae
Genus	Clarias
Species	*Clarias gariepinus*

The African catfish, *C. gariepinus* species has a slight body, a flat bony head, and a broad, terminal mouth with four pairs of barbells. Its prominent barbells give it the image of cat-like whiskers. The fish is commonly cultured in earthen ponds culture system. However, it also can be cultured in other systems such as tanks and canvas. In the wild and riverine systems, the fish reproduces naturally but considerable struggle is required to make spawning under culture conditions (Myers, Espinosa, Parr et al. 2018). Rad et al. (2003) found that the African catfish is an excellent species for aquaculture as it is grows fast, omnivorous, and accepts relatively poor water quality.

2.2 Feeding behavior of African catfish (*Clarias gariepinus*)

Studies on the factors that determine feeding behavior of late juvenile and adult fish (>50 g –1.5 kg) that ensure optimum fish welfare have been undertaken by Hecht and Uys (1997) and van de Nieuwegiessen et al. (2009). These studies suggest that welfare in fish up to 100 g is significantly improved with increasing density, while welfare of larger fish is not negatively affected by higher density. The behavioral effect of higher density is that the fish assume a behavior pattern that is reminiscent of a "rolling bait ball" in which there is no sign of aggression, and this leads to improved feed consumption and improved food conversion ratios (FCRs) (Hecht & Uys, 1997).

The African Catfish is an opportunistic and omnivorous feeder ingesting a wide variety of food items such as algae, macrophytes, zooplankton, insects, fish prey, detritus, Amphibians and sand grains (Abera, 2007; Admasu et al., 2015; Dadebo, 2000). The diet composition may vary within season and spatial conditions of the environments (Houlihan et al., 2001). In the same way, the diet composition may also vary depends upon the fish size, maturity, and habitat differences (Kamal et al., 2010). It has the ability to efficiently utilize and/or switch between alternative food sources such as plants and detritus when prey animals become scarce (Winemiller & Kelso-Winemiller, 1996; Dadebo, 2000; Potts, Hecht and Andrew, 2008).

Normally catfish are bottom feeders, but their feeding habits are adaptable and they infrequently filter feed in groups at the surface of water. There are four standard feeding modes which are individual foraging, individual shovelling, surface feeding and formation feeding. Adoption of any one of the feeding modes depends on food availability (Bruton, 1979b). Catfish in ponds have been observed to snatch sinking pellets before they reach the substratum, then feed off the substratum and lastly surface to feed on the floating fines using the gill-rakers as a mechanism to filter out small particles (Hecht, Uys & Britz, 1998). Balance on health is obvious even 5 when a small quantity of fish is consumed (Claire, 2000). Fish can also provide up to 180 calories per capita per day (John, 2009).

2.3 Environmental Condition

2.3.1 Water quality

Water is the culture environment for fish and other aquatic organisms. It is the physical support in which they carry out their life functions such as feeding, swimming, breeding, digestion and excretion (Bronmark and Hansson, 2005).

Fish, unlike other animals, feed and defecate inside the same water where they live and the quality of the water inside which they live directly affects feed efficiency, rate of growth, survival and the state of health of the fish. When water quality depreciates, consumed feed is not properly converted into body flesh. Poor growth is recorded, fish survival is affected and ultimately massive fish kills may occur (Towers, 2014). In fish production, key water quality parameters which need to be continually monitored are temperature, dissolved oxygen and pH value. Water parameters play a major role in the overall business of profitable fish farming. Making profit from fish farming really goes beyond just giving food to the fishes. Water quality parameters such temperature, pH and dissolve oxygen (DO) level must be monitored and acceptable ranges must be maintained (Towers, 2014).

2.3.2 Temperature of water

Water temperature can affect the biological activity and metabolic rates of aquatic organisms (Wetzel, 2001). Unlike human that is warm blooded, fish are cold blooded. The metabolism which occurs in their bodies is greatly influenced by the water temperature. Since fish are cold blooded animal, therefore their rate of metabolism effect directly from the water. For the special care of catfish, the most suitable temperature is between the temperatures of 23°C and 32°C (McNally et al. 2004). Raised respiration rates at increased temperatures lead to raised oxygen consumption, which can be detrimental if rates remain increase for an extended period of time. Furthermore, temperatures above 35°C can begin to breakdown, or denatured, enzymes, reducing metabolic function. This is because of the fact that oxygen is not readily soluble in very warm water. High temperature in ponds will stress the fish and eventually lead to death (McNally et al. 2004).

When water temperature in the ponds consistently stays between 16ºC and 26ºC, feed intake reduces and fish growth rate also drags tremendously. A farmer will record high feed conversion ratio and the fish will also be stressed. Prolonged stress can open up the fish to opportunistic infections. When fish are consistently exposed to temperatures below 15ºC, fish growth will ultimately stop and death is just around the corner. Low temperature negatively affects rates at which wastes are converted in the water (Towers, 2014).

2.3.3 pH value of water

pH is the level of the hydrogen ion present in the water. Water may be acid, neutral or alkaline. Fish production will be greatly affected by extremely low or high pH. Extreme pH values can even kill the fish. According to Wetzel (2001), for the fish in the pond, acceptable pH value is between 6.5 to 8.5. When it is below 4, fish will die due to water acidity. Low pH in pond water is an indication of high CO_2 (carbon dioxide) in the water. The critical pH values vary depend to the fish species, other environmental conditions and the size of individual fish. As example, fish are more susceptible to extreme pH during their reproductive seasons, young fish and eggs are more sensitive than adults (Claude & Tucker, 2012).

Waters ranging in pH from 6.5 to 8.5 when sunrise are generally the most suitable for pond fish production. Most cultured fish will die in waters with pH below 4.5 and pH equal to or greater than 11. If pH not suitable for good fish production, the pH can be corrected. If the pH is below 6.5 at sunrise, use liming and alkaline fertilizers. If the pH is above 8.5 at sunrise, use acid fertilizers (Food and Agriculture Organization [FAO], 2006).

2.3.4 Dissolved oxygen (DO)

Then, the concentration of dissolved oxygen also included as the important things to care about in the way to increase the growth rate of catfish. Due to the increase of temperature,the solubility of oxygen and other gases will decrease (Environmental Protection Agency [EPA], 2012). This means that colder stream and lakes can grasp more dissolved oxygen than the warmer waters. If the water is too warm, it will not hold enough oxygen for aquatic organisms to survive.

The relevance of monitoring the level of dissolved oxygen in ponds is very important. For the African catfish, a farmer should try as much as possible to maintain dissolved oxygen levels at between 4mg/liter to saturation levels in the pond. Gas bubble disease can happen to the fish when DO levels are consistently too high and the water is super-saturated to well above 300 per cent. When DO level is consistently between 1.5mg/liter to 5mg/liter, fish will be alive, but feed intake will reduce (Towers, 2014). Fish breathe in oxygen for general body metabolism. DO is needed to help breakdown any potentially harmful metabolic waste into less harmful forms, e.g ammonia (NH_3) broken down into nitrites (NO_2) and then into nitrates (NO_3) (Oyin, 2013).

Dissolved oxygen (DO) is a serious environmental indicator in aquaculture. Insufficient DO is the main cause of fish kills, and fish farmers know that low-oxygen conditions are their worst enemy. Low DO saturation can be caused by a host of factors such as high water temperatures, atmospheric conditions, stratification and pond turnover and harmful alga bloom (Elliot, 2018)

2.4 Earthen pond culture system for African Catfish

Fish ponds should be constructed in areas with a slope of not more than 1 per cent and near a steady water source. This helps to use gravity in inflow and draining of the ponds. Higher inclinations increase the cost of construction and predisposes the ponds to collapse of barriers. Draining the pond is a routine management practice intended to help in preventing overflowing, harvesting, eradicating predators, de-silting, and improving the bottom conditions of the pond. The drainage should be from where the pond is deepest (Daily Nation, 2015).

Earthen pond are reservoir, artificial dams, or lake that built for different species of fishes in order to maintain some features of the natural aquatic environment. Earthen ponds are created mechanically, or manually, in a carefully selected site which high water holding ability. Shovels and diggers are used in the manual construction of earthen pond. However, in modern times, the use of excavators is increasing in human population to dig ponds. An excavator can dig a pond that ten men will normally dig in five days within just ten hours. For commercial pond construction, use of excavator is more charge effective than manual construction. It also can attain good depths in hours and saves time (Eniola, 2016).

Fish culture production in Nigeria includes lake stocking and production in ponds, cages and tanks (Ita, 1995). Pond culture is the most prevalent. Virtually all aspects of pond culture of African Catfish (*C. gariepinus*) in Nigeria has been developed and documented to ensure profitable production of the species. The appreciable quantity of water and large expanse of land required for pond culture has however limited the expansion of African Catfish culture in Nigeria (Ita, 1995). The suitable land for earthen pond must take into awareness availability of water, or at least confirm wetlands out of season and in season. Other aspects that must be considered are soil permeability, soil texture and soil type. A site placed in an area that mostly has sandy soil charges more when it comes to the construction because ponds built in such areas will need sandbagging to avoid the ruin of pond (Eniola, 2016).

2.5 Feed conversion ratio (FCR) of African catfish

This term was used in aquaculture industry to determine the level of performance acquired from an additive or a feed**.** FCR allows for an estimation of the feed that will be needed in the growing cycle of fish. Knowing quantity feed will be needed then lets a farmer to determine the profitability. It takes less feed to produce one kilogram of fish when a feed has low FCR. A low FCR is a good indication of a great quality feed (December,2011). FCR was calculated according to Okpako, 2010 :

$$\text{Feed conversion ratio (FCR)} = \frac{\text{Total feed intake (g)}}{\text{Total wet weight gain (g)}}$$

2.6 Specific growth rate (SGR) of African catfish

This term was used in aquaculture industry to estimate the production of fish after a certain period by using the following formulae (Okpako, 2010):

$$\text{SGR} = \mathit{Final\ body\ weight\ of\ fish} - \mathit{Initial\ body\ weight\ of\ fish}\ /$$

$$\mathit{No\ of\ days\ reared}$$

2.7 Percentage weight gain (PWG) of African catfish

This term was used in aquaculture industry to determine the percentage weight gain by the cultured fish. Percentage weight gain of African catfish *(C.gariepinus)* within the period of the experiment was calculated according to Cheikyula & Ofojekwu (2003) and Adewolu et al. (2008) :

$$\text{PWG (\%)} = 100 \times \frac{\mathit{Final\ mean\ body\ weight}\ (g) - \mathit{initial\ mean\ body\ weight}\ (g)}{\mathit{Initial\ mean\ body\ weight}\ (g)}$$

CHAPTER 3

MATERIALS AND METHODS

3.1 Materials

3.1.1 Equipments

All the equipments that had been used in this study are electronic balance, fishing net, plastic beaker, pail and multi-parameter (YSI Pro Multi-parameter, Australia).

3.1.2 Raw materials

Raw materials that had been used in this study are African catfish (*C. gariepinus*) fingerlings, commercial feed and organic fertilizer (cow dung).

3.2 Methods

3.2.1 Location and study design

The experiment was carried out at Agro Techno Park in University Malaysia Kelantan Jeli Campus, Kelantan. The experiment was conducted for eight weeks by monitoring the weight gain to get the result on the growth performance of African catfish *(C. gariepinus*) reared in earthen pond system. The experiment was carried out using earthen pond farming system. The size of the pond is 30.48 m × 12.19 m. The size of a catfish pond is measured by its water surface area when the pond is full of water. The depth of the pond was 1.5 m.

The fingerlings of African catfish, *C. gariepinus* with the size of 5cm body long were used in the study. The catfish fingerling were purchased from the local farm in Kelantan. Around 30000 fingerlings of *C. gariepinus* were put in the earthern pond to monitor their growth performance for eight weeks. The catfish fingerlings were feed three times a day which are on 8 am, 12 noon and 6 pm with commercial feed. The feed consume by the fish is 5% from its body weight. According to FAO (2006), newly hatched fry are fed several times daily at 6–10 percent of fish weight. Fingerlings are fed between 2 and 5 percent of their body weight per day, divided into two or more feedings, while broodfish are fed 1 to 2 percent of their weight per day.

At first, cleaning process of the earthen pond were held with the help of Agrotechno Park worker. Before the nursery pond is filled with water the banks of the watercourses were cleaned and monitored on weak points for repair and leakage. Grasses were cut and excess residue from the bottom off pond were removed. The pond bottom then was allowed to dry for a few days as to kill potential fry predators such as amphibian larvae, water insects and catfish fingerlings from previous rearing, and also to raise the mineralization or oxidation of nutrients in the bottom of pond.

The pond bottom allowed to dry to enhance mineralization (oxidation) of nutrients for a few days and then limed to stocking new batch of fry. Liming has several beneficial effects, such as disinfecting (quicklime) the substratum by raising the pH of the water. The pH allowed to stabilize between 7–9 before fingerlings are stocked into the pond. Water source used in fish ponds from natural sources such rivers or rain. The water free of silt, predators, poison, unwanted fish and also have high level of dissolved oxygen. Ponds located in areas prone to flooding as this may be the reason of heavy losses from washed or escaped fish.

3.2.2 Sampling of African catfish (*Clarias gariepinus*)

Once a week, the sample were collected at three different spot in earthen pond to get the average body weight of catfish. The catfish in earthen pond was randomly sampled by weekly by removing a sample of catfish with a fishing net. The purpose was to determine catfish growth performance in weight. On sampling day, catfish from pond were weighed in grams using a l-kg electronic balance. The average body weight of the fishes was recorded. After data collection, feed conversion ratio (FCR), specific growth rate (SGR), weight gain (WG) and percentage weight gain (PWG) are calculate by using the formula.

3.2.3 Water quality monitoring in earthen pond culture system

During the study, water-quality parameters were monitored twice a week in the earthen pond. Water temperature, dissolved oxygen (DO) and pH were measured at a depth of 30 cm at the following times: 08:00 and 16:00 hours by using multi-parameter (YSI Pro Multi-parameter, Australia). Monitoring water quality activity such pH value, water temperature and dissolve oxygen level were held on Sunday and Wednesday each week.

3.2.4 Data collection and analysis

Data on African catfish, *C. gariepinus* fish growth performance were recorded once a week for eight weeks. The weight of randomly selected group of catfish was determined with an electronic balance of model. The experimental pond was inspected two times to remove dead fish, if any. African catfish, *C. gariepinus* weight gain (WG), percentage weight gain (PWG), feed conversion ratio (FCR), specific growth rate (SGR) were determined as follows. The initial and final mean weights of catfish were computed as follows:

i. According to Cheikyula & Ofojekwu (2003) and Adewolu et al. (2008), weight gain (WG) OF African catfish (*C. gariepinus*) was calculated as:

Final weight of fish - Initial weight of fish

ii. According to Cheikyula & Ofojekwu (2003) and Adewolu et al. (2008), percentage weight gain (PWG) of African catfish (*C. gariepinus*) was calculated as

PWG (%) = 100 × (Final mean body weight (g)-initial mean body weight (g))/(Initial mean body weight (g))

iii. According to Okpako (2010), specific growth rate (SGR) of African catfish (*C. gariepinus*) was calculated as:

SGR = Final body weight of fish - Initial body weight of fish / No of days reared

iv. According to Okpako (2010), feed conversion ratio (FCR) of African catfish (*C. gariepinus*). This was calculated from the relationship of feed intake and wet weight gain

$$FCR = \frac{\text{Total feed intake (g)}}{\text{Total wet weight gain (g)}}$$

CHAPTER 4

RESULTS AND DISCUSSION

4.1 Weight Gain (WG) and percentage weight gain (PWG)

African catfish, *Clarias gariepinus* mean weight gain (WG) data for eight weeks reared in earthen pond culture system were presented in Table 4.1.1. Weight gain of African catfish, *C. gariepinus* was not influenced by any treatment during the study. The highest weight gain by the African catfish, *C. gariepinus* was performed during week two which was 3.17 g ± 0.59 while the lowest weight gain performed by African catfish, *C. gariepinus* was during week 1 which was 0.73 g ± 0.58, slow growth performance occur after week two. African catfish, *C. gariepinus* shown the non uniform increasing weight gain for every week until the last week.

There was slow gain of weight by African catfish, *C. gariepinus* during week 6 until week 8 which were 1.11 g ± 0.93, 0.97 g ± 0.80 and 0.84 g ± 0.51, slightly different of growth rate improvement occur during 3 weeks. Even though the African catfish, *C. gariepinus* showed slow gain of weight after week two, but the weight gain still occur until last week of study conducted that proved the earthen pond culture system was suitable to be used by the fish farmers for growing up African catfish, *C. gariepinus*

Table 4.1.1 Weight gain (WG) of African catfish (*C. gariepinus*) in earthen pond culture system

Week	Weight gain/fish (g/fish) (Mean ± SD)
1	0.73 ± 0.58
2	3.17 ± 0.59
3	1.25 ± 0.95
4	1.82 ± 0.73
5	1.80 ± 1.14
6	1.11 ± 0.93
7	0.97 ± 0.80
8	0.84 ±0.51

Table 4.1.2 Total weight gain (WG) of African catfish (*C. gariepinus*) in earthen pond culture system

Week	Weight gain (g/fish) (Mean ± SD)
1 to 8	11.70 g ± 0.19

Table 4.1.2 showed the result for total weight gain of African catfish, *C. gariepinus* in earthen pond culture system start from week one until the end of the study conducted which was week eight. The total weight gain of fish was 11.70 g ± 0.19 which was a large

amount of gaining weight. The African catfish, *C. gariepinus* showed the rapid growth due to the condition of earthen pond which more likely their natural habitat. Their growth performance affected environmental condition which was comfortable for catfish and a large stocking area that help this species to have excellent growth performance. According to Putra et al. (2017) and El Naggar, John, Rezk et al. (2006), this species has several advantages, for example, resistance to diseases and handling stress and high growth rate that help this species to survive.

The result for percentage of weight gain (PWG) for African catfish, *C. gariepinus* during the study conducted was showed in Table 4.1.3. The highest percentage weight gain obtained by African catfish, *C. gariepinus* along eight weeks of study resulted in week two which was 36.27 % ± 7.49. In contrast, the lowest percentage weight gain of African catfish, *C. gariepinus* was showed in week eight which was 4.49 % ± 2.77. The overall result for percentage weight gain among African catfish, *C. gariepinus* was showed non uniform increase of weight gain for eight weeks of study

Table 4.1.3 Percentage weight gain of African catfish (*C. gariepinus*) in earthen pond culture system

Week	Percentage weight gain (%/fish) (Mean ± SD)
1	9.10 ± 7.17
2	36.27 ± 7.49
3	10.80 ± 8.32
4	13.91 ± 5.87
5	12.11 ± 7.89
6	6.76 ± 5.73
7	5.47 ± 4.57
8	4.49 ± 2.77

Commercially raised any type of catfish are exposed to various stressors, particularly extremes in water temperature. However, African catfish, *C. gariepinus* also known as one of the excellent species for aquaculture as it is grows fast, omnivorous, and accepts relatively poor water quality (Rad et al, 2003). Earthen pond more likely natural habitat for African catfish, *C. gariepinus* which more nature than other culture systems such as cages and tanks.

4.3 Specific Growth Rate (SGR)

The result of specific growth rate for African catfish that reared in earthen pond in this present stud was presented in Table 4.3.1. The African catfish had showed there are increasing of the growth rate for each week starting from week one of the study until week eight of the study conducted. The highest growth rate of African catfish, *C. gariepinus* was showed on week two which was 0.45 g ± 0.06 while the lowest growth rate of African catfish, *C. gariepinus* was showed on week one which was 0.10 g ± 0.08. There was uneven increasing of specific growth rate showed by the African catfish, *C. gariepinus* from week one to week eight that had been reared in earthen pond culture system.

Table 4.3.1 Specific Growth Rate of African catfish (*C. gariepinus*) in earthen pond culture system

Week	Specific growth rate (g/day)
1	0.10 ± 0.08

2	0.45 ± 0.06
3	0.18 ± 0.14
4	0.23 ± 0.06
5	0.26 ± 0.16
6	0.16 ± 0.13
7	0.14 ± 0.11
8	0.12 ± 0.07

This aquaculture species provely suitable to be reared in earthen pond system better than other culture system such as cages and tanks. Earthen pond culture system provides sufficient area for growth and can avoid cannibalism problem that always occur in other culture system. This observation corroborates the work of Royle (2001) who studied cannibalism among *Clarias gariepinus*, *Tilapia*, *Heterobranchus longifilis* fry and fingerlings have been identified as one of the major problems by small – scale hatchery operators for fish farming.

The growth rate of African catfish, *C. gariepinus* continue increasing non uniformly for each week due to their special characteristics which can survive in extreme environmental condition such as extremely high or low of water temperature. According to Saad et al (2009), this species of fish which was African catfish, *C. gariepinus* had capture attention of aquaculturists because of its biological characteristics that include resistance to diseases, faster growth rate and possibility of high stocking density.

4.4 Feed Conversion Ratio (FCR)

Table 4.4.1 showed the result of feed conversion ratio of African catfish (C. gariepinus) that had been reared in earthen pond culture system for eight weeks during the present study. The highest value of feed conversion ratio was resulted in week six which was 2.29 ± 3.17. in contrast, the least value of feed conversion ratio was resulted in week two which was 0.14 ± 0.03. According to Technical Buletin (2011), feed conversion ratio is simply the amount of feed it takes to grow a kilogram of fish and a low feed conversion ratio, is a good indication of a high quality feed. As the amount of protein in the diet increases, the food conversion ratio gets smaller. These result greatly related to the specific growth rate that have been showed in Table 4.3.1 which in week two, the growth rate was the highest and low feed conversion ratio value are achieved in that week. For the weeks, feed conversion ratio values are acceptable.

Table 4.4.1 Feed Conversion Ratios (FCR) of African catfish (*C. gariepinus*) reared in earthen pond culture system

Week	Feed conversion ratio (Mean ± SE)
1	0.91 ± 0.77
2	0.14 ± 0.03
3	1.49 ± 2.01
4	0.41 ± 0.18
5	0.44 ± 0.27
6	2.39 ± 3.17
7	1.41 ± 0.98
8	1.79 ± 1.66

Fish raised in an optimum environment obviously convert feed more efficiently than those raised under less than ideal conditions. Also zooplanktons and phytoplanton are available as additional sources of feed in earthen pond (Benadine, 2017).

The African Catfish is an opportunistic and omnivorous feeder ingesting a wide variety of food items such as algae, macrophytes, zooplankton, insects, fish prey, detritus, Amphibians and sand grains (Abera, 2007; Admasu et al., 2015; Dadebo, 2000). According to Houlihan et al (2001), the diet composition may vary within season and spatial conditions of the environments. In the same way, the diet composition may also vary depends upon the fish size, maturity, and habitat differences (Kamal et al., 2010).

4.5 Environmental Condition

Water quality inspection is one of the most important factors besides good feeding or feed in fish production. It values were not static, varies with season, water source, the time of the day, weather conditions, temperature, soil type, stocking density, culture systems and feeding rates. For a successful aquaculture project, the management and dynamics of water quality in the culture media should be taken into concern. Managing and monitoring water quality is crucial for successfully generating a crop of fish. Temperature, dissolved oxygen, pH and other factors also affect the environmental quality of the production ponds. Failure to keep good water quality will give best result in weak performance and at worst result in the loss of an entire crop of fish.

All the water quality parameters were within the acceptable range for African catfish (*C. gariepinus*) were stated in Table 4.5.1. The water temperature ranged from 27.2 to 30.1°C, which the data shown the water temperature for earthen pond that used for growing up 30 000 catfish juveniles. This statement shown from the previous study, water temperature between 27.2°C and 30.1°C were very stable temperature for catfish farming and optimum range of temperature was about 23°C to 32°C (McNally et al. 2004). McNally et al, 2004 also stated that, temperatures above 35°C can begin to denatured or breakdown the enzymes and reducing metabolic function of the fish.

Dissolve oxygen (DO) levels range from 4.64 to 6.50 mg/L in earthen pond shown in Table 4.5.1. African catfish, *C. gariepinus* has lung like structures that enable them to breathe air. This made it possible to survive very low oxygen levels in the pond such 2 mg/L. A fish farmer should try and focus as much as possible to maintain the dissolved oxygen levels at between 4mg/liter to saturation levels in the pond which is 8 mg/L for African catfish, *C. gariepinus* farming. As the dissolved oxygen level were below the optimum level (Towers, 2014)

Then, Table 4.5.1 show that the pH values of earthen pond are range from 7.02 to 8.1. These values are monitored twice a week for eight weeks. The optimum pH values for catfish farming are range from 6.5 to 8.5 (Wetzel, 2001) which mean that the data collected from the study are acceptable and the way to maintain the pH values should be applied by the farmers. Fish production can be greatly affected by excessively low or high pH. Extreme pH values can even kill the fish. Most cultured fish will die in waters with pH below 4.5 and pH equal to or greater than 11 (Food and Agriculture Organization [FAO], 2006).

Table 4.5.1 Average water quality parameters measured in earthen pond culture system of African catfish (*C. gariepinus*)

Water parameter	**Experiment data recorded**
Temperature (°C)	27.2-30.1°C
pH	7.02-8.16
Dissolve oxygen (mg/L)	4.64-6.50 mg/L

CHAPTER 5

CONCLUSION

5.1 Conclusion

Based on the finding of present study conducted, earthen pond culture system is recommended for fish farmers in Malaysia. The information obtained from this study revealed that the growth performance of African catfish *C. gariepinus* in earthen pond system was a successful. This type of culture system was recommended for fish farmers for enhanced growth of African catfish, *C. gariepinus*. The total weight gain of fish was 11.70 g ± 0.19 after eight weeks of study conducted.

The highest growth rate of African catfish, *C. gariepinus* was showed on week two which was 0.45 g ± 0.06 while the lowest growth rate of African catfish, *C. gariepinus* was showed on week one which was 0.10 g ± 0.08. Considering the results of this study, rearing of African catfish, *C. gariepinus* fry in earthen pond culture system well-thought-out as the most ideal method for seed production if the target is to attain fast growth. There were improvement in growth performance of African catfish, *C. gariepinus* in this present study.

Based on the present study, the advantages of earthen pond culture system that useful to be practice by the fish farmers are the earthen pond is not expensive to construct due to it only need suitable area and soil. Then, it can contain a large number of fish in a pond due to bigger size of culture system differ with cages or tanks which much smaller than earthen pond. The stocking density of fishes are big and give a better profit for fish farmers. Apart from that, The fishes are bred in an environment similar to their natural habitat which were muddy and sanny at bottom of the pond. A moist and muddy environment is the most suitable for fresh water fish.

Earthen pond culture system gives the African catfish, *C. gariepinus* the environment similar with freshwater environments, including quiet waters like lakes, ponds, and pools. They are also very prominent in flowing rivers, rapids, and around dams. Earthen pond culture system, this type of fish pond is also called as natural pond because it can only be built in a place where there is a flowing underground water and enough clay soil. Lastly, the growth rate African catfish, *C. gariepinus* in the earthen pond culture system was fast. They continued to gain weight even though there are fast and slow gain of weight during 8 weeks of present study conducted.

5.2 Recommendation

Appropriate production systems are essential for successful aquaculture especially for African catfish, *C. gariepinus*. Fish farmer in Malaysia are recommended to run fish farming business to fulfill the demand for fresh water fish such as African catfish, *C. gariepinus* by rearing them in earthen pond culture system. Earthen pond culture system have been proved as one of the culture system that need low capital for a newbie business starter and help the fishes to have better growth performance.

Besides, for ensuring the success of choosing earthen pond as fish culture system , proper management of pond and water quality are needed. Proper management of pond include the management before, on going and after the placement of fish fingerling into the pond to avoid high mortality of fish that cause by physical and biological problems. The earthen pond must have function water flow machine to make sure that there are inflow and outflow of water from the pond. That was important to avoid overflowing of water from the pond, allow the complete draining of the pond and easier for harvesting activity.

Based on the present study, the advantages of earthen pond culture system that useful to be practice by the fish farmers are the earthen pond is not expensive to construct due to it only need suitable area and soil. Then, it can contain a large number of fish in a pond due to bigger size of culture system differ with cages or tanks which much smaller than earthen pond. The stocking density of fishes are big and give a better profit for fish farmers. Apart from that, the fishes are bred in an environment similar to their natural habitat which were muddy and sanny at bottom of the pond. A moist and muddy environment is the most suitable for fresh water fish (Food and Agriculture Organization [FAO], 2006).

Moreover, other way to improve the growth performance of African catfish, *C. gariepinus* by doing the testing on feed and feeding trial conducted. Fish farmer can enhance the growth performance of African catfish by improving the nutrition level of fish feed because because good feeding source also give high impact on the growth performance of fish.

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APPENDIX A

Table 1 Raw data of average body weight of African catfish (*C. gariepinus*) reared in earthen pond culture system

	I	W1	W2	W3	W4	W5	W6	W7	W8
LEFT	7.956	8.182	11.745	13.641	14.716	17.775	17.914	18.284	19.454
MIDDLE	8.083	9.451	12.917	13.074	14.934	16.451	17.653	19.536	19.791
RIGHT	8.104	8.714	11.205	12.891	15.419	16.248	18.231	18.901	19.988
AVERAGE	8.047667	8.782333	11.95567	13.202	15.023	16.82467	17.93267	18.907	19.74433
STD	0.080077	0.637254	0.875226	0.391041	0.359851	0.829248	0.289452	0.626022	0.270041

Table 2 Raw data of weight gain (WG) of African catfish (*C. gariepinus*) reared in earthen pond culture system

	W1	W2	W3	W4	W5	W6	W7	W8
Sample 1	0.226	3.563	1.896	1.075	3.059	0.139	0.37	1.17
Sample 2	1.368	3.466	0.157	1.86	1.517	1.202	1.883	0.255
Sample 3	0.61	2.491	1.686	2.528	0.829	1.983	0.67	1.087
AVERAGE	0.734667	3.173333	1.246333	1.821	1.801667	1.108	0.974333	0.837333
STD	0.581117	0.592905	0.949216	0.727285	1.141929	0.925587	0.801097	0.50602

Table 3 Raw data of percentage weight gain (PWG) of African catfish (C. gariepinus) reared in earthen pond culture system

	W1	W2	W3	W4	W5	W6	W7	W8
Sample 1	2.840623	43.54681	16.14304	7.880654	20.7869	0.781997	2.065424	6.399037
Sample 2	16.92441	36.67337	1.215453	14.22671	10.15803	7.306547	10.66674	1.305283
Sample 3	7.527147	28.58618	15.04685	19.61058	5.376484	12.20458	3.675059	5.751018
%AVE	9.097393	36.26879	10.80178	13.90598	12.10714	6.764374	5.469075	4.485113
STD	7.171995	7.488515	8.320078	5.871537	7.887933	5.730559	4.572695	2.772809

Table 4 Raw data of specific growth rate (SGR) of African catfish (*C. gariepinus*) reared in earthen pond culture system

	W1	W2	W3	W4	W5	W6	W7	W8
Sample 1	0.032	0.509	0.271	0.154	0.437	0.02	0.053	0.167
Sample 2	0.195	0.495	0.022	0.266	0.217	0.172	0.269	0.036
Sample 3	0.087	0.356	0.241	0.26	0.118	0.283	0.096	0.155
AVERAGE	0.104667	0.453333	0.178	0.226667	0.257333	0.158333	0.139333	0.119333
STD	0.082924	0.084583	0.13593	0.063003	0.16328	0.132032	0.114334	0.072418

Table 5 Raw data of feed conversion ratio (FCR) on African catfish (*C. gariepinus*) reared in earthen pond culture system

	W1	W2	W3	W4	W5	W6	W7	W8
Sample 1	1.779	0.123	0.315	0.614	0.196	6.05	2.424	0.808
Sample 2	0.294	0.127	3.809	0.355	0.396	0.699	0.476	3.706
Sample 3	0.659	0.176	0.355	0.261	0.725	0.424	1.338	0.869
AVERAGE	0.910667	0.142	1.493	0.41	0.439	2.391	1.412667	1.794333
STD	0.773827	0.029513	2.005815	0.182814	0.267109	3.171769	0.976144	1.655833

APPENDIX B

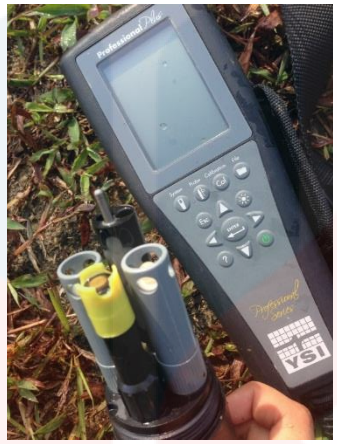

Figure 1 : Water multi-parameter used to measure water quality

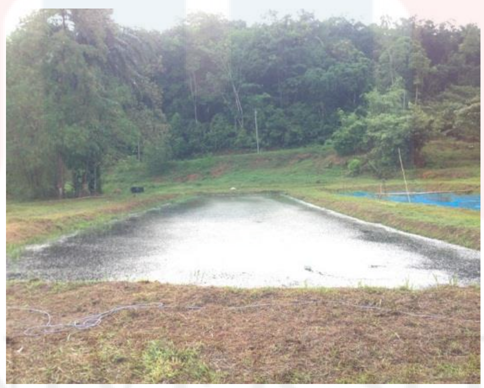

Figure 2 : Earthen pond farming system

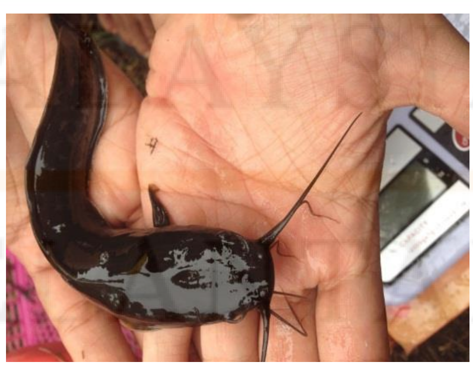

Figure 3 : African catfish (*C. gariepinus*) fingerling