WATER QUALITY MONITORING OF GOLDEN AROWANA *(SCLEROPAGES FORMOSUS)* AT ORNAMENTAL AQUACULTURE FARM, BUKIT MERAH, PERAK

By

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LIST OF ABBREVIATIONS

APHA	American Public Health Association
BOD	Biochemical Oxygen Demand
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CO_2	Carbon dioxide
COD	Chemical Oxygen Demand
DID	Department of Irrigation and Drainage
DO	Dissolved Oxygen
DOE	Department of Environment
DOF	Department of Fisheries
DWNP	Department of Wildlife and National Parks
INWQS	Interim National Water Quality Standards
IUCN	International Union for Conservation of Nature and Natural Resources
LKIM	Fisheries Development Authority of Malaysia
MOA	Ministry of Agriculture
NAP3	Third National Agricultural Policy
NH_3-N	Ammoniacal Nitrogen
O_2	Oxygen
RASs	Recirculating Aquaculture Systems
SPSS	Statistical Package for the Social Sciences
SS	Suspended Solids
TAN	Total Ammonia
WQI	Water Quality Index

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PEMANTAUAN KUALITI AIR AROWANA EMAS (*SCLEROPAGES FORMOSUS*) DI KOLAM AKUAKULTUR IKAN HIASAN, BUKIT MERAH, PERAK

ABSTRAK

Pemantauan kualiti air untuk Arowana adalah untuk mengenal pasti keperluan kualiti air yang sesuai demi menggalakkan pembiakannya. Tujuannya adalah untuk memelihara spesis ikan warisan Malaysia ini dimana Bukit Merah adalah satu-satunya tempat Ikan Arowana Emas berjaya dibiakkan. Pensampelan dilakukan secara bersiri untuk 14 titik pensampelan bermula dari hulu iaitu di Empangan Bukit Merah dan berakhir di hilir di Sungai Kurau. Sebanyak lapan parameter yang terlibat iaitu suhu, konduktiviti, oksigen terlarut (DO), pH, ammoniacal nitrogen (NH_3-N), pepejal terampai (SS), permintaan oksigen kimia (COD) dan permintaan oksigen biologi (BOD_5). Keputusan yang diperolehi telah dibandingkan dengan garis panduan yang diberi oleh Jabatan Perikanan (DOF) dan Interim Kualiti Air Kebangsaan (INWQS) Kelas II. Keputusan menunjukkan bahawa purata kualiti air untuk semua titik pensampelan berada dalam lingkungan garis panduan yang diberikan kecuali parameter pepejal terampai. WQI untuk semua titik pensampelan di Bukit Merah telah diklasifikasikan sebagai Kelas II. Ini menunjukkan bahawa Arowana dapat membiak dengan baik apabila berada di dalam Kelas II. Ini dibuktikan dengan penghasilan Arowana sebanyak 346 ekor selama tempoh pemantauan. Selain itu, ini menunjukkan bahawa kualiti air di Bukit Merah tidak merosot dari hulu (sumber air) ke hilir (sisa air dibuang) dengan kehadiran aktiviti dari ladang akuakultur. Ujian korelasi Pearson telah dijalankan untuk mengenalpasti

hubung kait antara setiap parameter dengan penghasilan Arowana. Berdasarkan analisis, ia menunjukkan bahawa hanya pepejal terampai mempunyai korelasi yang kukuh dengan penghasilan Arowana.

WATER QUALITY MONITORING OF GOLDEN AROWANA *(SCLEROPAGES FORMOSUS)* AT ORNAMENTAL AQUACULTURE FARM, BUKIT MERAH, PERAK

ABSTRACT

Water quality monitoring for Arowana is to investigate the required water quality that is suitable for the fish and hence encourage its breeding. The purpose is solely to preserve this Malaysian heritage species since Bukit Merah is the only place where Golden Arowana was found to be successfully bred. A number of 14 sampling points were selected in series from upstream at Bukit Merah reservoir and end up downstream at Sungai Kurau. There are eight parameters involved which is temperature, conductivity, dissolved oxygen (DO), pH, ammoniacal nitrogen (NH_3-N), suspended solids (SS), chemical oxygen demand (COD) and biochemical oxygen demand (BOD_5). The monitored results were compared with the guidelines given by Department of Fisheries (DOF) and Interim National Water Quality Standard (INWQS) Class II. Result shows that the average for all sampling points were within the required guidelines except for SS. The WQI for all sampling points at Bukit Merah were classified as Class II. This signifies that WQI Class II is suitable for Arowana production where a total of 346 of Arowana fish had been produced during the monitoring period. Further, it indicates that water quality at Bukit Merah was not polluted and the water quality from upstream (water source) towards the downstream (water release) does not have a deteriorations effect due to the aquaculture activities. The Pearson correlation test was conducted to identify the relationships between each

parameter with the production occur. It shows that only SS have a strong correlation with the production of Arowana.

CHAPTER 1

INTRODUCTION

1.1 Introduction

The Asian Arowana (*Scleropages formosus*) is very popular among ornamental fish hobbyists. In Malaysia, it is the most expensive ornamental fish and a high value fish that have a high demand because of it's globally market. Basically there are three main varieties colour of this species which are Golden Arowana, Red Arowana and Green Arowana. Among these three varieties, the best quality is the Malaysian Golden Arowana which can only breed successfully at Bukit Merah Lake in the state of Perak, Malaysia. The Golden Arowana is also known as dragonfish or *Kelisa Emas*. The breeding seasons for Arowana normally occur from August to October every year. Since it can only breed at Bukit Merah, the government had gazzeted 186 hectares of land for the Arowana Breeding Zone (DOF, 2011). The water sources are from the Bukit Merah Lake.

Aquaculture output and water are dependent to each other. Therefore the status of the water quality reflected the aquaculture themselves. Golden Arowana breeds successfully in pond and the production are highly depending on the water quality. A continuous water supply is needed throughout the year and therefore it is crucial to know the appropriate water quality for this species. In its natural habitat, Arowana prefer slightly acidic water with clean and unpolluted natural surroundings. This is

especially at shallow rivers which had overhanging vegetation on the river bank (Suleiman, 2003). Plate 1.1 shows the Golden Arowana that was kept in aquarium at Bukit Merah for ornament purpose while Plate 1.2 shows the Golden Arowana at the aquaculture pond.

Plate 1.1 : Golden Arowana at Bukit Merah

Plate 1.2: Golden Arowana in aquaculture pond at Bukit Merah

Due to the great demand and Arowana popularity, this fish have been fiercely hunted in their native habitat for profits, which causes decline of the fish population in their natural habitat. This is especially for Malaysian Golden Arowanas and Red Arowanas, which have reached a stage of near extinction since 1980 (Dawes *et al.*, 1999). Due to the reason, this species was classified by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) as a highly endangered and been listed under Appendix 1 in 1975 (Greenwood *et al.*, 1996). CITES is an international agreement among the world governments which aims to ensure that international trade in specimens of wild animals and plants does not threaten their survivability. Levels of exploitation of some animal and plant species are high and brought some species close to extinction. Many wildlife species in trade are not endangered, but the existence of an agreement to ensure the sustainability of the trade is important in order to safeguard these resources for the future (CITES, 2011).

1.2 Problem Statements

In 1975, Arowana was classified by the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) as highly endangered and listed under Appendix 1. Appendix 1 includes species that was threatened with extinction and therefore trade in specimens of these species is permitted only in exceptional circumstances. Due to that, measures need to be taken in order to conserved this valuable species which can only breed successfully solely at Bukit Merah. Government had gazette only 186 hectare of land for Arowana aquaculture to protect the benefit of paddy agriculture there. Continued use of water from Bukit

Merah reservoir causes pressure to the consumer especially during water shortage occur since both paddy field farmer and Arowana farmer sharing the same water resource. Arowana need a continuous water source and good water quality for a better production.

1.3 Research Objectives

In order to achieve the purpose of this study, objectives are set as the guidelines. The objectives are stated as follow:

(a) To monitor the water quality in series from water source (Bukit Merah reservoir) followed by aquaculture ponds and finally downstream (Sungai Kurau).

(b) To compare the water quality obtained from the Golden Arowana farms with the guidelines given by Department of Fisheries (DOF) for Arowana water quality and with the standard from Department of Environment (DOE) Interim National Water Quality Standard (INWQS) for Class II.

(c) To evaluate the relationship between the water quality and productions of Golden Arowana.

1.4 Scope of Research

Samples of water were taken in series from upstream at Bukit Merah reservoir, followed by Terusan Besar, intake structure, Arowana farm which consists of eight ponds, outlet vault, drainage canal and lastly downstream at Sungai Kurau with total of 14 sampling points. The periods of monitoring are from 27th February 2011 to 2nd October 2011 consists of 15 different observation dates. The time of sampling started at 8.00 am on each sampling day. Parameters chosen in this study were based on the requirements from the DOF for Arowana water quality and the paramater involved in the evaluation of water quality index (WQI). There were eight parameter monitored in this study. The parameter involved in the evaluation of WQI are dissolved oxygen (DO), biochemical oxygen demand (BOD_5), pH, chemical oxygen demand (COD), ammoniacal nitrogen (NH_3-N) and suspended solids (SS) while the other two parameters are temperature (TEMP) and conductivity (COND). WQI were measured and classified based on the Interim National Water Quality Standard, Malaysia (INWQS). The results were being compared with the guidelines given by Department of Fishery (DOF) on Arowana's water quality and DOE INWQS Class II standard. The productions of Arowana were then being observed and evaluate to find the relationship with the water quality obtained.

1.5 Significance of Research

Arowana fish at Bukit Merah will then be export to the international market where CITES Permit is needed to be issued for the purpose of export, import and re-export of endangered species. CITES Permit is only issued by the DOF. In order to have the

CITES permit, they need to comply with the standard for biosecurity measures for ornamental fish farm. Among the standards are:

I. Water was properly screened/treated before used for cultured.

II. Discharge water was properly screened/treated before discharge.

III. Discharge water treatment record (DOF, 2012a)

In order to comply with those standards, knowledge about the water quality status at the farm is necessary. Research on water quality of the water source (Bukit Merah reservoir) is crucial for aquaculture production in order to give a brief knowledge to the Arowana's farmers about the current status of water quality at their farm so that suitable treatment can be done in order to increase the production of Arowana.

1.6 Thesis Layout

This thesis is mainly organized into five major chapters consist of introduction, literature review, methodology, result and discussion of the result and finally the conclusions and recommendation.

Chapter 1 gave a brief introduction about the Golden Arowana, the research objective, scope of research, the problem statement and the significance of the research.

Chapter 2 provides the literature review of the background, idea, and facts related with the past and existing knowledge about Golden Arowana and its water quality.

Chapter 3 describes the research approach which focused on the study area, method of sampling and the laboratory work.

Chapter 4 discuss about the findings and result obtained from the research.

Chapter 5 presents the conclusions of the thesis and recommendations for further study.

CHAPTER 2

LITERATURE REVIEW

2.1 Introduction

This chapter highlights the freshwater ornamental fish aquaculture in Malaysia. The background of Asian Arowana is discussed and focuses specifically on the Malaysian Golden Arowana at Bukit Merah. Further, the details on the habitat and the diet of Malaysian Golden Arowana, their maturity and the breeding biology are elaborated. The required water quality for the ornamental freshwater is discussed as well and finally the water quality of Malaysian Golden Arowana will be compared with other ornamental fish.

2.2 Freshwater Aquaculture

Freshwater fish represent the largest numbers of pets typically found in home aquaria (Miller and Mitchell, 2009). Generally, this aquaculture starts up as a hobby by the fish enthusiasts and then nowadays this fish-keeping had become commercially worldwide market generating millions of dollars annually (Pelicice and Agostinho, 2005). According to Halachmi (2006), most of the fish are raised in culture ponds or tanks. An estimated 4000 to 5000 freshwater fish species have been kept in aquaria, with several hundred species being most popular (Sales and Janssens, 2003). About 90% of the ornamental fish trade is in freshwater species which are farm-bred

(Wood, 2001). It shows a huge potential for freshwater farm-breeding especially in Malaysia.

Freshwater aquaculture families including characins, cyprinids, catfish, killifish, rainbow fishes, gouramies, livebearers and cichlids. The freshwater aquaculture can be divided into two groups where the first group is regarded as ornamental fish and the second group act as a food. Majority of these species require much larger systems as might be represented in a public aquarium display. However, some of these species were raised and kept by the hobbyist (Miller and Mitchell, 2009). The major local fish species harvested at the Bukit Merah area other than Arowana fish are catfish (*Clarisa macrocephus*), the snake-head (*Channa striata*) and the gouramies (*Trichogaster pectoralis and T.trichopterus*) (Ali, 1993). Arowana could not thrive in a natural condition due to the competition with other predator species such as catfish and snake-head. Thus, the survival of natural breed Arowana is diminishing with a rapid phase (MOA, 2012).

2.2.1 Arowana

Asian arowana (*Scleropages formosus*) was listed by CITES as a highly endangered fish species (Yue et al., 2004). This fish is an ancient fish species from the Osteoglossidae family which is one of the most primitive teleostean forms (Greenwood et al., 1996). The natural distribution of the Asian Arowana covers large areas of Southeast Asia, which include Malaysia, Indonesia, Cambodia, Laos, the Philippines, Vietnam and Thailand (Dawes et al., 1999). According to Scott and

Fuller (1976) which cited by Yue et al., (2004) the typical habitat of Arowana is swamps, flooded forests, lakes, rivers and reservoirs.

2.2.2 Catfish

The catfish is the most economically important species harvested from the rice-fish farming system of Malaysia (Ali, 1993). Catfish represent one of the largest groups of freshwater fishes, with more than 2000 species. Since this species perform many different roles which is as ornamentals, as food fish in aquaculture, as research animals, and for sport fishing, this species had become one of the important group in freshwater fishes group. Most catfish are found in freshwater, although there are two families that contain saltwater species. Catfish are primarily benthic or bottom-dwellers (Miller and Mitchell, 2009). The fish usually does not reproduce in culture ponds, so the farmer has control over pond populations. However, a large number of fry are easily produced and obtained since they are easily to spawn. Channel catfish are hardy, live over a wide range of temperatures and adapt well to all commonly used culture systems (Tucker and Robinson, 1990).

2.2.3 Snake head

The snake head fish is widely distributed in the freshwater areas of Southeast Asia, and usually consumed as a common food, especially in Thailand. It is a high-value freshwater air breathing fish occupying a predatory niche at the top of the food chain. The snake-head fish are not only caught from natural freshwaters, but are also

produced in culture ponds (Hara et al., 1998) where it is cultured on a limited scale in Thailand and Indonesia (Chinabut et al., 2006).

2.2.4 Gouramies

Gouramies fishes are only found in southern and western Africa and eastern and southeastern Asia. According to Alfred (1962) which cited by Cole et al., (1999), it is the most common species of fish in rice-field areas and is sometimes collected for food in certain parts of Asia and Africa. Generally this species avoid predation from birds and fish by inhabits the thickly vegetated areas of rivers, canals, lakes and swamps. According to Sand et al., (1971) which cited by Cole et al., (1999), the growth of gouramies, as of other fish, depends greatly on temperature, size and population of the tank including the amount and quality of food where those factors should be kept as equal as possible.

2.3 Ornamental Fishes in Malaysia

The ornamental fish business is the fastest-growing in Malaysia's agriculture sector (MOA, 2011). Malaysia is the third largest producer of ornamental fish after Singapore and Indonesia with a 7% share of the global market in 2000 (MOA, 2012). The ornamental fish industry is characterized by aggregation of various fish species from many source countries where usually involving developing countries in the tropics. The fish were then brought into high value-added wholesale markets such as Singapore and Hong Kong with on-sale to developed countries (Whittington and

Chong, 2007). There are many smaller wholesale supply centers such as Germany that imports live ornamental fish from Malaysia, (Moravec et al., 1999).

Ornamental fish is a high value product, ranking in an average of US$1.8 million per tonne. The price ratio of ornamental fish to those bred for consumption is about 100:1 (MOA, 2012). The ornamental world market for the industry has shown some recovery after the economic crisis of 1997 and can be expected to reach its previous growth levels of 10 to 15% annually. Over a 10 year period (1990-2000), the ornamental industry had experienced an average of 24% growth in exports. According to Ministry of Agriculture (MOA, 2012), in 2001, this export-oriented sub-sector had increase and manages to achieve growth rate of more than 35% a year.

Table 2.1: Production and value of ornamental fishes in Malaysia

Year	Production	Value
2003*	428,298,151	RM 97.64 million
2004*	455,723,540	RM 106.03 million
2006**	644,099,783	RM181.74 million
2007**	558,178,294	RM647.05 million
2008***	590,139,150	RM748.50 million
2009***	507,216,127	RM770.12 million

Sources: *DOF 2004, **DOF2007, ***DOF2009

Table 2.1 shows the production and value of ornamental fish in Malaysia from year 2003 to 2009. The total production of ornamental fish had increased by 18.43 % from 428,298,151 in year 2003 to 507,216,127 in year 2009. In terms of value, the increase was 688 % from RM 97.64 million in 2003 to RM 770.12 million 2009. This tremendous increase in value was due to the re-adjustment of the price for the ornamental fish in 2007 especially for Arowana species throughout the country (DOF, 2007). For example, the state of Johor was the largest producer of ornamental

fish including aquatic plants contributing 325,465,398 of ornamental fish valued at RM651.68 million (DOF, 2009). In the next section, the focus will be on Arowana aquaculture at Bukit Merah.

2.4 Asian Arowana

The Asian Arowana or it scientific name *Scleropages formosus* are commonly known as the dragonfish. The Asian arowana belongs to the order *Osteoglossiformes*, one of the ancestral teleost clades with extant representatives restricted to freshwater habitats (Yue et al., 2006a). It belongs to an ancient family of fishes, the Osteoglossidae, which literally means bony-tongue. The fish is called that because the structure of the bone-shaped tongue, hard and rough work as gripping teeth according to the nutritional behavior as predatory fish (Yue et al., 2006b).Table 2.2 shows the taxonomy of Arowana.

Table 2.2: Arowana Taxonomy (DOF, 2005)

Class	Pisces
Order	Clupeiformes
Sub order	Osteoglossidei
Family	Osteoglossidae
Genus	Scleropages
Species	Scleropages formosus

Naturally, there are three basic different color varieties for Asian Arowana, namely Golden Cross Back (Figure 2.1) from West Malaysia, Super Red (Figure 2.2) from Indonesia's West Kalimantan and the Green variety (Figure 2.3), which can be found in rivers of Malaysia, Indonesia, Myanmar and Thailand (Goh and Chua, 2000).

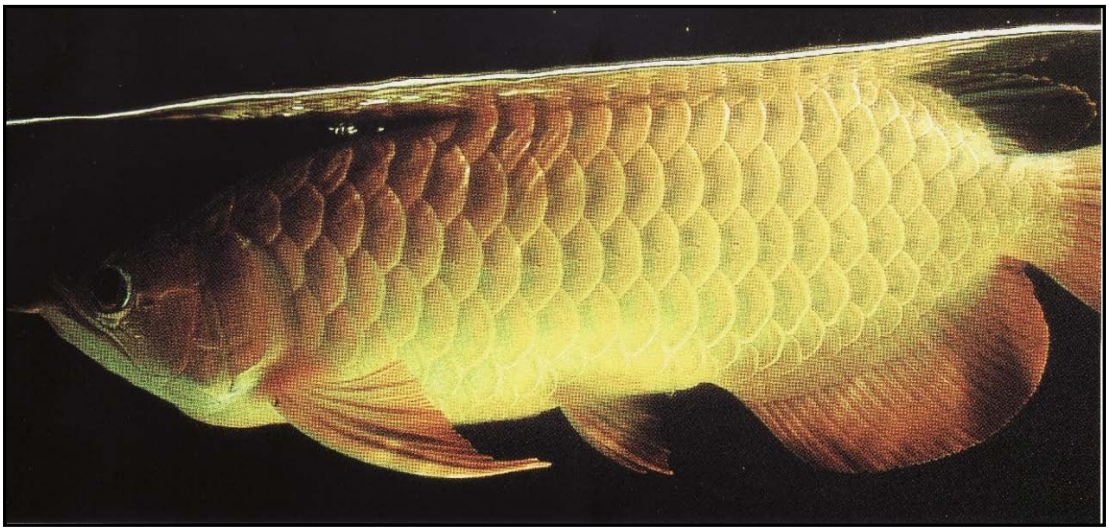

Figure 2.1 : Golden Cross Back Arowana (Goh and Chua, 2000)

Figure 2.2 : Super Red (Goh and Chua, 2000)

Figure 2.3: Green Arowana (Goh and Chua, 2000)

Arowana is one of the most expensive ornamental fish species in the world and of most valuable species in the Asian ornamental trade (Natalia et al., 2004). Initially, this species is relatively abundance in the wild. It is widely distributed in Southeast Asia which includes Cambodia, Indonesia, Laos, Malaysia, Myanmar, Vietnam, Thailand, and the Philippines (Kottelat et al., 1993). However, due to the high demand, the value of this species had increased abruptly. The high cost of each fish, even juveniles, causes this species to be exported in small numbers or to average aquarists (Ng and Tan, 1997). For instance, an invidual adult of red or golden Asian Arowana might cost over US$20,000 at the ornamental fish market (Yue et al., 2004). The breeding and farming of Arowana is being carried out in several countries such as Indonesia, Singapore and Malaysia (Kottelat and Whitten, 1996; Fernando et al., 1997). This fish can adapt well in captivity and are usually kept in a solitary tank (Ng and Tan, 1997). It is a relatively long-lived fishes with average age of 30 to 90 years old (Sareh, 2009).

Since 1960s, the demand for Asian Arowana in the ornamental fish industry had increased significantly which causes this species to be hunted fiercely due to its popularity (Yue et al., 2004). This is mainly for Malaysian Golden Arowana and Red Arowana, which have reached a stage of near extinction since 1980 (Greenwood et al., 1996). In the past, Arowana was only regarded as a cheap food fish in market and only occasionally seen in the aquarium trade. However, its sudden popularity had become an Asian phenomenon. In the late 1970s, Chinese superstitious believe that by keeping this fish will bring the owner good luck and prosperity. This was due to the deep gold and the bright red colors of some Arowanas, which Chinese and Japanese regard it relation to good luck and prosperity. This sudden phenomenon,

were the reason for hobbyist especially businessmen were paying higher price to own this Arowana in order to have a good luck charm (Ng and Tan, 1997; Goh and Chua, 2000).

Asian Arowana was vulnerable to overexploitation which causes the populations of this species keep decreasing in their natural habitat. Illegal harvesting and trading of highly valued strains from wild populations are still major problems threatening the conservation efforts for this species (Ng and Tan, 1997). Other than that, several reproductive characteristics such as low fecundity, oral brooding habit and open-water spawner habit were the reasons for their extinctions (Kottelat and Whitten, 1996; Fernando et al., 1997). Basically, Arowana is individualistic and territorial. Thus, they are scattered over a wide area, making their collection difficult.

Due to the extinctions of this species, it is listed by the CITES in Appendix I as a highly endangered species where a special permit is required for farms dealing with its culture (Yue et al., 2006a). Arowana were also placed on the Red List of the 2006 International Union for Conservation of Nature and Natural Resources (IUCN) (Hilton-Taylor, 2000; Hu et al., 2009).

The IUCN Red List of Threatened Species is the most comprehensive resource detailing the global conservation status of plants and animals (Rodrigues et al., 2006). It is among the most widely used tools available to conservationists worldwide for focusing attention on species of conservation concern (Gärdenfors et al., 2001). Only the F2 generation from the commercially captive-bred individuals can legally be exported (Rahman et al., 2008). According to CITES under the

Animal Production Systems & CITES Source Codes, the source code F represent the animals born in captivity (CITES, 2013). In Arowana, there are F0, F1, F2 and F3 which indicates the stage of pure breed generation. Table 2.3 simplifies the definition for each generation.

Table 2.3: Details on Arowana generation (CITES, 2013)

Generation	Details
F0	Wild habitat from river or lake Not for traded market, only for breeding purpose
F1	Variations from F0 Traded within the producer country
F2	Variation from F1 Traded world wide
F3	Variation from F2 Traded worldwide

On the other hand, CITES is an agreement between countries, called signatories. The aim is to regulate the international trade in wildlife and wildlife products. The convention basically came from the idea of representatives from countries who were concerned about threats to wild stocks arising from international trade in specimen and their products during a series meeting that held during the 1960s and early 1970s. On February 1973, the agreement had been launched with 81 countries involved. The effective official starting date of the convention was on 1 July 1975. CITES operates mainly through three Appendices, each reflecting a different level of perceived threat and defining specific controls with regard to trade (Dawes, 1999). Table 2.4 describe for each appendices.

Table 2.4: List of Appendices and the Definition (CITES, 2011)

Appendix	Definition
Appendix I	Includes species threatened with extinction. Trade in specimens of these species is permitted only in exceptional circumstances
Appendix II	Includes species not necessarily threatened with extinction, but in which trade must be controlled in order to avoid utilization incompatible with their survival.
Appendix III	Contains species that are protected in at least one country, which has asked other CITES Parties for assistance in controlling the trade. Changes to Appendix III follow a distinct procedure from changes to Appendices I and II, as each Party's is entitled to make unilateral amendments to it.

2.5 Malaysian Golden Arowana at Bukit Merah, Perak

The government had gazette 186 hactares of land to be reserved as Arowana Aquaculture Zone at Bukit Merah. According to DOF (2011), Arowana is one of the aquaculture commodities that had been given a priority in the Third National Agricultural Policy (NAP3). It is a high value industry with a wide range of market. In 2008 the values of Arowana fish worth RM 95.7 million where Perak contributed about RM 24.6 million of the totals. These values increase by 52.6% on 2009 with RM 146 million where Perak contributed about RM 48.3 million (DOF, 2011).

There are two varieties of Malaysian Golden Arowana in Malaysia which are further classified based on the basic color scales, which are the Gold- Based and the Blue - Based Arowana. These native breeds can only be found at Bukit Merah Lake, Perak. Gold-Based color is known to achieve full color at a younger age than other varieties.

The Blue Base Golden is known to be the original strain from Bukit Merah Lake and Kerian River and its tributaries. The quality of Malaysian Golden Arowana is classified by observing the metallic based color and the level of golden scale. It must have the following criterion which is lay down by the Department of Fisheries Malaysia (DOF) in Table 2.5.

Table 2.5: Criteria and Characteristic for Malaysian Golden Arowana (DOF, 2012b)

Criteria	Characterisctic
Scale	Have highlighted gold ring located at the end of the scales
Number of golden scale rows	6
Number of lateral line scales	24 to 25
Tail shape	Wide, rounded
Operculum (gill cover)	Closed, golden
Tentacles	Pair, located at the tip of the lower jaw
Fine scales (scales pearls, chu)	2 lines, shiny gold-colored below the dorsal fin
Reinforcement tail	Golden
Lips	Not red

In Malaysia, Arowana breeding activities are carried out commercially for the purpose of export to the international market and one of the agencies involved is the Department of Fisheries. The main export countries are Japan, Hong Kong, China, Taiwan, Canada, Vietnam and Singapore (DOF, 2011). Arowana were also marketed at local request where the local market does not require any regulation. In the local market, the Malaysian Golden Arowana measuring 15-20 cm are sold at RM1, 500 – RM2, 000 per fish (MOA, 2011).

At the international market, trading of second generation Arowana requires a CITES permit from the DOF. Only F2 generation fish from the "Commercial Captive-Breeding Operation" as defined by CITES are allowed to be traded. Companies or individuals that run the production of Arowana fry for foreign markets are required

to register as the "Commercial Captive-Breeding Operations" with the cooperation of the Department of Wildlife and National Parks (DWNP). The main condition to be complied to is that the fish must be able to breed in captivity at least up to the second generation or F2 (MOA,2011).

Based on an analysis by Fisheries Development Authority of Malaysia (LKIM), this project involves a large investment wherein the cost to start Arowana breeding on land measuring 0.25 hectares is estimated at RM139,392 with minimum equipment of air blower and water pump. Returns or revenue would be gained only in the fourth or fifth year although this depends on the quality of the breed, nutrition and management of farm (MOA, 2012).

The market value of the Arowana fish is also influenced by the preferences of fish enthusiasts. However, currently the demand and prices remain high, especially in the international market. In general, there are not many who are capable of venturing into fish seed production now due to a high start-up and operation capital as well as the time needed to breed the fish, which is usually five years. Nonetheless, based on the current market, this activity is feasible and draws profitable returns (DOF, 2005).

2.5.1 The Habitat and Diet of Arowana

The typical habitat of Arowana is swamps and flooded forests, lakes, rivers and reservoirs (Suleiman, 2003). In Asia, these species breed in aquaculture ponds and therefore mud ponds are the most cost effective and suitable for breeding place. An outdoor mud pond is subjected to many factors such as climatic changes, soil

conditions, amount of sunlight, density of rainfall, and availability of water plants. For instance, too little of rainfall will make the water pH increase and too much of rainfall will lower the water pH values. Other than that, the amounts of sunlight were also played an important factor for the Arowana captivity. According to Goh and Chua (2000), the Asian Arowana was first bred in captivity in the Sembawang Field Experimental Station Singapore in 1981 (Goh and Chua, 2000). However, in the recent years, several other captive broodstocks had been established in Singapore, Malaysia and Indonesia (Dawes et al., 1999). According to Scott and Fuller (1976) which cited by Yue et al., (2004), the diet of Asian Arowana is wide-ranging, including insects, arachnids, non woody roots and tubers where a fully grown individual may weigh over 7 kg and its length could exceed a meter.

2.5.2 Arowana Maturity

Arowana attain the first maturity when it reaches 4 to 5 years old with weight of 1 to 2 kg. The two sexes of Asian Arowana are quite difficult to distinguish visually because there are no obvious phenotypic signs of sexual dimorphism, especially in young adults (Scott and Fuller, 1976; Dawes et al., 1999). However, these become apparent after maturity is reached. Table 2.6 describes the characteristics for different sexual of Arowana. The matured males brood will have a brighter colour compare to the females brood. Other than that, the determination of Arowana male and female is based on the body shape and the size of the mouth cavity. Male fish have a slimmer and shallower body depth and a bigger mouth then the females. The larger mouth and deeper lower jaw in males are for eggs incubating purposes. The size of the males

head is relatively bigger and it is normally seems to be more aggressive especially in competing for food (Suleiman, 2003).

Table 2.6: Characteristics for male and female Arowana (Suleiman, 2003)

Characteristics	Male	Female
Colour	Brighter	Darker
Body shape	Slimmer and shallower body depth	Wider body depth
Mouth cavity	Larger mouth and deeper lower jaw	Smaller mouth and lower jaw
Head	Bigger head	Smaller head
Behaviour	More aggressive Leading in competing for food	Less aggressive

2.5.3 Arowana Breeding Biology

The reproductive biology of Asian Arowana is unusual for a fish whereby the individuals mature quite late. Usually 30 to 100 eggs were produced and they tend to show an advanced degree of parental care (Yue et al., 2004). According to Suleiman (2003), Arowana breeds once a year in its natural habitat, which is usually on August to October. During courtship, the male and female will swim closer to each other with their bodies are touching for about two weeks. Eventually the female releases a cluster of orange-red eggs where the male will scoop them into its mouth to fertilize the eggs by incubated it for 50 to 60 days (Suleiman, 2003). The fertilized eggs can be found around August with sizes between 6 and 7 cm. It can be seen quietly under the water surface, between the grasses or roots nearby the riverbank (DOF, 2005).

2.5.3.1 Harvesting the Arowana

The natural incubation process for Arowana was normally in a period of 50 to 60 days (Goh and Chua, 2000). Harvesting was conducted to shorten the incubation period of fertilized eggs in the male mouth. It was done by manually removed the

fertilized eggs from the male's mouth on the 30th day after spawning. Extra care should be taken in order to avoid injury and struggling with the male brood. During the harvesting, a fine net to catch the male brood with a wet cotton towel to cover the fish must be prepared (Plate 2.1). The eggs were taken out from the male brood by pulling slowly the lower jaw backward and by slightly shaking the fish body until the half developed eggs were released. A plastic bag was used to collect the larvae (Plate 2.2) where usually about 20 to 35 eggs can be collected from a single brood at one time (Suleiman, 2003). Plate 2.3 shows the harvest fertilized eggs that were obtained from the Easterm Arowana farm.

Plate 2.1: A fine net to catch the male brood with a wet cotton towel to cover the fish

Plate 2.2: A plastic bag was used for collecting the eggs

Plate 2.3: The harvest fertilised eggs

2.5.3.2 In Vitro Incubator

Incubation process by the male brood in natural habitat has a lower percentage of living for the fry. Therefore, the best practice to make sure the high percentage of living for the fry is by in vitro incubation. The fry will be incubated in a glass aquarium tank as in Plate 2.4. Aeration will be given sufficiently with temperature between 27 to 28°C. The water depth is about 20 cm (DOF, 2005). According to Suleiman (2003), 90 to 100% of survival rate can be achieved by applying the in vitro hatching technique (Suleiman, 2003).

Plate 2.4: In Vitro Incubation

Plate 2.5: 8th week Arowana fry

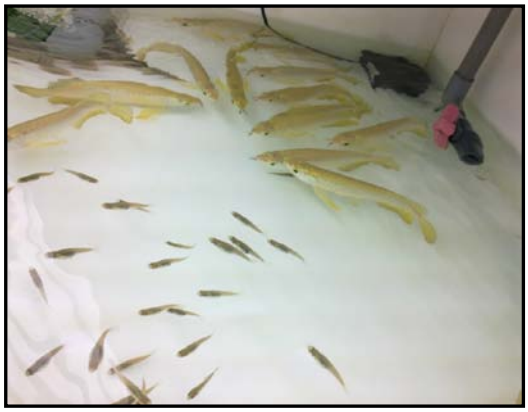

Plate 2.6: Three month old Arowana