# THE OPTIMUM LIGHT CONDITION TO IMPROVE SURVIVAL AND GROWTH RATES OF SUTCHI CATFISH (*Pangasianodon hypophthalmus*) LARVAE

BY

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A thesis submitted in fulfilment of the requirement for the degree of Master of Science (Biosciences)

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# ABSTRACT

Sutchi catfish *Pangasianodon hypophthalmus* (Sauvage, 1878) is one of the most important freshwater fish species cultured in Southeast Asia. Artificial seed production of sutchi catfish in the hatchery is very important to supply enough seeds to the farmers in the aquaculture industry. However, the survival rates of its larvae were low when reared in the hatchery. Providing optimum rearing condition for sutchi catfish larvae in the hatchery should increase the seeds production. Light conditions were reported to influence the survival and growth of fish. Hence, this study was conducted to determine the optimum light conditions in term of light wavelength and light intensity for the rearing of sutchi catfish larvae. Three experiments were conducted, which were larval rearing, larval behaviour, and larval feeding behaviour experiment. For all three experiments conducted, five light wavelengths (white, blue, green, yellow and red lights) and four light intensities ($1.40\times10^{-4}$, $1.40\times10^{-3}$, $1.40\times10^{-2}$, and $1.40\times10^{-1}$ µmol/m²/s) was used. The results for larval rearing experiment showed that the survival rates, growth rates, and production index were higher in red light and have the tendency to become higher in low light intensity ($1.40\times10^{-4}$ and $1.40\times10^{-3}$ µmoles/m²/s). Next, in larval behaviour experiment, the larvae showed lower aggressive behaviour in red light and low light intensity ($1.40\times10^{-4}$ and $1.40\times10^{-3}$ µmoles/m²/s). Lastly, feeding behaviour experiment showed that the larvae ingest a higher number of *Artemia* sp. nauplii under white, yellow, and red light wavelengths. Although there was no significant effect of light intensity towards the feeding behaviour, the number of *Artemia* sp. nauplii ingested tend to be higher in lower light intensity. Longer light wavelength such as red light with low light intensity resembles the light condition in the natural habitat of sutchi catfish. In conclusion, the red light wavelength under low light intensity ($1.40\times10^{-4}$ and $1.40\times10^{-3}$ µmoles/m²/s) is recommended for the rearing of the sutchi catfish larvae.

## خلاصة البحث

إن السمك السلور الساتشي الذي يسمى بـ *Pangasianodon hypophthalmus* (Sauvage, 1878) هو أحد من أهم أنواع أسماك المياه العذبة في جنوب شرق آسيا. إن إنتاج البذور الاصطناعية من سمك السلور الساتشي هم جدًا لتوفير البذور الكافية للمزارعين في صناعة الاستزراع المائي. ومع ذلك، كانت معدلات البقاء على قيد الحياة يرقات منخفضة عندما تربى في المفرخ. إن توفير أفضل ظروف تربية يرقات قرموط السلور الساتشي في المفرخ يجب أن يزيد من إنتاج البذور. تم الإبلاغ عن ظروف الإضاءة يتأثرعلى بقاء ونمو الأسماك. وبالتالي، أجريت هذه الدراسة لتحديد ظروف الإضاءة المثلى من حيث طول الموجة الخفيفة وكثافة الضوء لتربية يرقات سمك السلور الساتشي. وقد أجريت ثلاث تجارب، والتي كانت تربية اليرقات، والسلوك اليرقات، وتجربة سلوك التغذية اليرقات. لجميع التجارب الثلاثة التي أجريت، خمسة أطوال موجية ضوئية (أضواء بيضاء ، زرقاء ، خضراء ، صفراء وحمراء) وأربعة شدة ضوئية (1.40 × 10-4 ، 1.40 × 10-3 ، 1.40 × 10-2 ، و 1.40 × 10-1 تم استخدام µmol / م² / ثانية). أظهرت نتائج تجربة تربية اليرقات أن معدلات البقاء ومعدلات النمو ومؤشر الإنتاج كانت أعلى في الضوء الأحمر ولديها ميل لتصبح أعلى في شدة الإضاءة المنخفضة (1.40 × 10-4 و 1.40 × 10-3 µmoles / م² / ثانية). بعد ذلك ، في تجربة سلوك اليرقات ، أظهرت اليرقات سلوكًا أقل عدوانية في الضوء الأحمر وكثافة منخفضة للضوء (1.40 × 10-4 و 1.40 × 10-3 µmoles / م² / ثانية). أخيرًا ، أظهرت تجربة سلوك التغذية أن اليرقات تستوعب عددًا أكبر من Artemia sp. nauplii تحت موجات الضوء الأبيض والأصفر والأحمر. على الرغم من عدم وجود تأثير كبير لشدة الضوء تجاه سلوك التغذية ، إلا أن عدد Artemia sp. Naupli تميل إلى أن تكون أعلى في انخفاض كثافة الضوء. يشبه طول موجة الضوء الأطول مثل الضوء الأحمر مع شدة الإضاءة المنخفضة حالة الضوء في الموائل الطبيعية لسمك السلور الساتشي. والملاحظة في الختام ، يوصى باستخدام طول موجة الضوء الأحمر تحت شدة الإضاءة المنخفضة (1.40 × 10-4 و 1.40 × 10-3 µmoles / م² / ثانية) لتربية يرقات سمك السلور الساتشي.

# APPROVAL PAGE

I certify that I have supervised and read this study and that in my opinion, it conforms to acceptable standards of scholarly presentation and is fully adequate, in scope and quality, as a thesis for the degree of Master of Science (Biosciences)

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*This thesis is dedicated to:*

*My late father,Ismail bin Sohor.*
*My late mother, Zauyah binti Bakar.*
*Everyone.*
*Life.*

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# LIST OF ABBREVIATIONS

| | |
|---|---|
| CCD | Charge-coupled device |
| FAO | Food and Agriculture Organization |
| HCG | Human Chrorionic Gonadotropin |
| LED | Light emitting diodes |
| PI | Production index |
| $SGR_{BW}$ | Specific growth rates for Body weight |
| $SGR_{TL}$ | Specific growth rates for total length |
| SR | Survival Rates |
| UV | Ultraviolet |

# LIST OF SYMBOLS

| | |
|---|---|
| % | Percent |
| °C | Degree Celsius |
| µmoles/m²/s | Micromoles per square metre per second |
| Cm | Centimetre |
| G | Gram |
| Kg | Kilogram |
| L | Litre |
| M | Metre |
| Ml | Millilitre |
| Nm | Nanometre |
| Ng | Nanogram |
| Ppt | Parts per thousand |
| SD | Standard deviation |
| SE | Standard error |

# CHAPTER ONE

# INTRODUCTION

## 1.1 RESEARCH BACKGROUND

Fish is a source of animal protein for human consumption (Richards et al., 2001; Richards et al., 2003; Yaowu et al., 2009; Beveridge et al., 2013; Ibrahim et al., 2014). As human population increases year by year, the demand for fish increases. Fisheries and aquaculture are the two sectors which contribute to provide fish for human.

Fisheries as the main sector cannot provide enough fish supply for human (Food and Agriculture Organization (FAO), 2018). In fisheries, the fish is captured in the wild, either in sea or freshwater basins including rivers and lakes. The high demand for fish leads to overfishing, thus the fish resource is decreasing (Beveridge et al., 2013). This uncontrolled fishing will result in the extinction of some valuable fish species. Therefore, it is important to culture fish in order to satisfy the demand.

Aquaculture is a method to increase the production of fish (Adewumi & Olaleye, 2011) and according to FAO (2018), aquaculture provides 48% of the total world fish production in 2016. This amount is increasing year by year to satisfy the demand of the fish. China is the highest producer of fish from aquaculture which is consistently providing more than half of the fish than the rest of the world.

In Malaysia, the aquaculture industry is important for fish production. Both marine and freshwater fishes are cultured on farm. Fish species that being cultured in

Malaysia includes grouper, sea bass, red tilapia, African catfish, sutchi catfish and climbing perch (Ibrahim et al., 2014; Yusoff et al., 2016).

Sutchi catfish (*Pangasianodon hypophthalmus*) is an important fish species cultured in cages and ponds in Malaysia. Sutchi catfish is a freshwater fish belonging to the family of Pangasiidae. It is originated from the Mekong River basin in Vietnam, extending to Chao Phraya River in Thailand (Rohul Amin et al., 2005; Na-Nakorn & Moeikum, 2009; De Silva & Phuong, 2011). Sutchi catfish is also a very important fish in Southeast Asia. Sutchi catfish has high demand in market because it grows rapidly, able to tolerate low dissolved oxygen, and have good taste with white meat (Halls & Johns, 2013; Lefevre et al., 2011).

Sutchi catfish seeds are successfully produced in the hatchery to supply to the fish farmers. The larvae of sutchi catfish are reared in hatchery. Then, the seed fishes are distributed to the farms. For rearing of sutchi catfish larvae, environmental factors such as temperature, light condition, dissolved oxygen, salinity and pH of the water are important. These environmental factors affect the survival and the growth rates of the larvae (Boeuf & Payan, 2001; Mustapha et al., 2012; Nguyen et al., 2014; Panicz et al., 2015).

The problem in sutchi catfish seeds production is low survival rates during the larval stage. The low survival rates are caused by the strong cannibalism, especially in the early stage of the larvae from two days old until seven days old (Baras et al., 2010; Mukai, 2010). The cannibalism and the high mortality rates are serious problems for sutchi catfish larval rearing (Subagja et al., 1999).

Mukai (2010; 2011) and Mukai et al. (2013a) revealed that the cannibalism behaviour and the mortality rates of sutchi catfish larvae can be reduced when the larvae are reared under dim or dark condition. Mukai et al. (2013a) also showed that the behaviour of sutchi catfish larvae is affected by light. Tan et al. (2017) also suggested that the sutchi catfish larvae have tendency to have higher survival and growth rates under longer light wavelengths (yellow and red) and lower light intensity ($1.40\times10^{-3}$ $\mu mol/m^2/s$) than other light wavelengths (white, blue and green) and light intensities (1.40, $1.40\times10^{-1}$ and $1.40\times10^{-2}$ $\mu mol/m^2/s$) . The results of Tan et al. (2017), Mukai (2010; 2011) and Mukai et al. (2013a) studies showed that light condition is a crucial environmental factor that is proved to affect the cannibalism behaviour and the mortality rates of sutchi catfish larvae.

However, the optimum light condition for rearing sutchi catfish larvae still have not yet determined. Under different light wavelengths and intensities, the cannibalistic and the feeding behaviours of the larvae are also still not fully understood. Thus, the present study was performed differently from Tan et al. (2017), by lowering the light intensity used for the experiment to determine the optimum light condition for the larvae. The cannibalistic and the feeding behaviours of the larvae were also compared in each light wavelengths and intensities.

The sutchi catfish seeds production can be improved by providing optimum light condition when rearing sutchi catfish larvae. Therefore, the optimum light conditions in terms of light wavelength and intensity will be further determined in this study.

## 1.2 PROBLEM STATEMENTS

Production of sutchi catfish seeds in hatchery is low because of the low survival rate during larval rearing. High cannibalism and mortality rate during the early stage of larvae decrease the production (Subagja et al., 1999; Baras et al., 2010; Mukai, 2010).

Sutchi catfish production relies only on artificial seed production especially in Malaysia because it is not a local fish species.

Previous studies showed that survival and growth rates of sutchi catfish larvae are affected by the light conditions. Tan et al. (2017) suggested that longer light wavelengths (red and yellow) and low light intensity ($1.40 \times 10^{-3}$ μmol/m$^2$/s) tend to increase the survival and the growth rates of sutchi catfish larvae. In Tan et al. (2017) study, they compared five light wavelengths which were white, blue, green, yellow and red lights, together with four light intensities which were 1.40, $1.40 \times 10^{-1}$, $1.40 \times 10^{-2}$ and $1.40 \times 10^{-3}$ μmol/m$^2$/s. Another study by Mukai (2010) using only white light showed that the cannibalism behaviour and the mortality rate of sutchi catfish larvae can be reduced when the larvae are reared under dim or dark condition.

Thus, it is important to determine the optimum light wavelength and intensity for the rearing of sutchi catfish larvae. In the present study, lower light intensity than study by Tan et al. (2017) was added to get the optimum light condition for survival and growth rates of the larvae. The addition of the light intensity of $1.40 \times 10^{-4}$ μmol/m$^2$/s because the sutchi catfish also shows the abilities to have a low mortality rate in much darker condition based on Mukai (2010).  The larval cannibalistic and the feeding behaviours under each light conditions were examined to get the optimum light wavelength and intensity for sutchi catfish larvae.

## 1.3 SIGNIFICANCE OF THE STUDY

The optimum light condition in terms of light wavelength and intensity for the rearing of sutchi catfish larvae were determined from the present study. The optimum light wavelength and intensity were recommended to be used in the hatchery for the rearing of the larvae. This will improve the production of sutchi catfish seeds.

## 1.4 RESEARCH HYPOTHESIS

i. Sutchi catfish larval survival and growth rates will be increased under optimum light wavelength and intensity.

ii. Sutchi catfish larval aggressive behaviour will decrease under optimum light wavelength and intensity.

iii. Sutchi catfish larval feeding rate will increase under the optimum light wavelength and intensity.

## 1.5 RESEARCH OBJECTIVES

i. To determine the survival rate, the growth rate and the production index of sutchi catfish larvae under different light wavelengths and intensities.

ii. To compare the aggressive behaviour of sutchi catfish larvae under different light wavelengths and intensities.

iii. To compare the feeding behaviour of sutchi catfish larvae under different light wavelengths and intensities.

# CHAPTER TWO

# LITERATURE REVIEW

## 2.1 SUTCHI CATFISH

### 2.1.1 Taxonomy of Sutchi Catfish

*Pangasianodon hypophtahlmus* Sauvage, 1878 or the common name is sutchi catfish belongs to the kingdom Animalia and phylum Chordata. It is classified in the class of ray-finned fishes or known as the class of Actinopterygii below the order of Siluriformes. Chheng et al. (2004) added that sutchi catfish belongs to family Pangasiidae (shark catfish) and genus *Pangasianodon*. The taxonomic classification of sutchi catfish can be simplified as in Table 2.1.

Table 2.1 Taxonomic Classification of Sutchi Catfish, *P. hypophthalmus*

| **Scientific classification** | |
|---|---|
| Kingdom | Animalia |
| Phylum | Chordata |
| Class | Actinopterygii |
| Order | Siluriformes |
| Family | Pangasiidae |
| Genus | *Pangasianodon* |
| Species | *Pangasianodon hypophthalmus* |
| Author | Sauvage, 1878 |

Apart from sutchi catfish, *Pangasianodon hypophthalmus* has many other common names. The examples of the common names are pangasius catfish, iridescent shark catfish, tiger shark, striped catfish, Siamese shark and Asian shark catfish (Roberts & Vidthayanon, 1991; Slembrouck et al., 2009; Ha et al., 2009; FAO, 2010).

### 2.1.2 Geographical Distribution and Habitat of Sutchi Catfish

Naturally, sutchi catfish can be found along the Chao Praya river and the Mekong river basins in Cambodia, the Lao People's Democratic Republic (Lao PDR), Vietnam and Thailand (Roberts & Vidthayanon, 1991; Rainboth, 1996; Vidthayanon et al., 1997; So et al., 2006).

According to Chheng et al. (2004), sutchi catfish habitat is in the benthopelagic area in the Mekong river basins which the water in that area is cloudy. Sutchi catfish prefers water temperature between 26 and 29 °C, and pH between 6.5 and 7.5 (Riehl & Baensch, 1996; Halls & John, 2013). This species is air-breathing fish which can tolerate low dissolved oxygen (DO) in the water until 0.5 – 0.1 mg/litre (Cacot, 1999; Van Zalinge et al., 2002; FAO, 2010; Lefevre et al., 2011). In terms of feeding biology, this species is known as omnivore species which can feed on fruits, algae, fish larvae and other small organisms (Lim et al., 1999; FAO, 2010; Halls & John, 2013; Chheng et al., 2004).

Sutchi catfish migrates when the water level changed. When the water level increases during flood season, they move to upstream for spawning and when the water level decreases, they are back to the downstream to find deeper areas (Hill & Hill, 1994; FAO, 2010). The eggs have the ability to adhere to exposed roots of trees or submerged plants (Poulsen et al., 2004; Van Zalinge et al., 2002; FAO, 2010). After the eggs hatch