EFFECTS OF DIFFERENT LIGHT INTENSITIES ON SURVIVAL AND GROWTH OF ASIAN SEABASS, *Lates calcarifer* LARVAE

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IJAZAH: **MASTER OF SCIENCE (AQUACULTURE)**

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DECLARATION

I hereby declare that the material in this thesis is my own except for quotations, excepts, equations, summaries and references, which have been duty acknowledged.

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CERTIFICATION

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ABSTRACT

The effects of different light intensity on Asian seabass, *Lates calcarifer* larvae were studied in two stages: early (1 to 10 days after hatch, d AH) and late larval (14 to 42 d AH). The larvae were reared at 0, 500, 1,000 and 2,000 lx light intensities to investigate survival, cannibalism, growth, feeding, nutritional status and retina development. Results in early larval stage showed that survival was significant (P=0.02) in 1,000 lx (85.71±10.4 %) compared to 500 and 2,000 lx which are 65.23±18.32 % and 36.97±3.98 % respectively. Significant different (P=0.01) growth of larvae was recorded between 500 lx (6.30±0.4 mm) and 2,000 lx (3.56±0.36 mm) but insignificant different (P=0.07) with 1,000 lx (6.13±0.1 mm).
Absorption of yolk sac was showed significantly high (P=0.02) in 0 lx than other treatments 0.90±0.15 $\times 10^{-1}$ mm^2. Oil globule volume of Asian seabass in 0 and 500 lx was consistent from 0 until 24 h AH (3.27×10^{-1} mm^2 for both of the treatments).
In feeding incidence and feeding intake at 10 d AH, no significant different detected in all treatments.In morphometric ratio, the most significant changes were observed in body length ratio (BH:BL) where the larvae in 500 and 1,000 lx had moderate nutritional status. No significant different (P=0.22) in gut epithelium height (μm) in 1000 and 2000 lx (11.00±2.2 μm and 12.00±1.6 μm respectively). Morphology and retinal development in 2,000 lx and 500 lx indicated adaptive mechanisms. In the late larval stage, the highest survival was observed in 1,000 lx (90.00±10.0 %) but insignificant (P=0.23) in 500 lx (83.00±15.3 %). Cannibalism rate was significantly high (P=0.01) in 0 lx (60.0±1.0 %).Meanwhile, growth of the larvae in 1,000 and 2,000 lx (22.0±5.0 mm and 22.8±3.7 mm respectively) showed significantly high (P=0.03) than 0 and 500 lx (12.1±1.9 mm and 16.0±1.3 mm respectively).High significant in weight gain (P=0.02) was observed in 2000 lx (0.30±0.1 g) compared with other treatments (0 lx: 0.16±0.1 g; 500 lx: 0.15±0.0 g; 1,000 lx: 0.21±0.1 g).Thickness of photoreceptor layers (μm) showed significant different and indicated adaptive mechanisms. The present study proved that light intensity gave effects to the larvae and stages dependent (optimum light intensity in early and late larval stage were 1,000 lx and 500 to 2,000 lx respectively). The present study provided valuable insights into new techniques in larval culture and the implications of study highly valuable and relevant as light intensity can easily manipulated at a relatively low cost, decreased cannibalism and increased survival as well as profits in aquaculture industry.

ABSTRAK

KESAN KEAMATAN CAHAYA YANG BERBEZA KE ATAS KELANGSUNGAN HIDUP DAN PERTUMBUHAN LARVA SIAKAP, Lates calcarifer

Kesan keamatan cahaya yang berbeza ke atas larva siakap Lates calcarifer di jalankan dalam dua peringkat: peringkat awal (1 hingga 10 hari) dan peringkat akhir larva (14 hingga 42 hari). Larva di kultur dalam 0, 500, 1,000 dan 2,000 lx untuk mengetahui kelangsungan hidup, kadar kanibalisma, pertumbuhan, pemakanan, status nutrisi dan pertumbuhan retina. Keputusan dalam peringkat awal larva menunjukkan kelangsungan hidup larva tinggi secara signifikan (P=0.02) dalam 1,000 lx (85.71±10.4 %). Kadar pembesaran larva tinggi secara signifikan (P=0.01) dalam 500 lx (6.30±0.4 mm) tetapi tidak ada perbezaan yang signifikan (P=0.07) dilihat dalam 1,000 lx (6.13±0.1 mm). Penyerapan kantung telur cepat secara signifikan dalam 2,000 lx tapi tidak ada perbezaan yang berbeza (P=0.08) dalam insiden pemakanan dan pengambilan pemakanan. Berdasarkan dengan ratio morfometrik,perubahan yang paling ketara dilihat dalam ratio panjang badan (BH:HL) dimana larva dalam 500 dan 1,000 lx mempunyai badan yang sederhana manakala larva dalam 2,000 lx mempunyai badan yang agak panjang. Tidak ada perbezaan yang signifikan (P=0.23) di lihat dalam ketinggian epithelium usus (µm) dalam 1,000 (11.00±2.20 µm) dan 2,000 lx (12.00±1.65 µm). Morfologi dan pertumbuhan retina dalam 2,000 lx dan 500 lx menunjukan mekanisma adaptasi. Pada peringkat akhir larva, kelangsungan hidup yang tertinggi di lihat dalam 1,000 lx (90.00±10.0 %) tetapi tidak ada perbezaan yang signifikan (P=0.23) dalam 500 lx (83.00%) dan 2,000 lx (56.60%). Kadar kanibalisma tinggi secara signifikan (P=0.01) dalam 0 lx (60.0±1.0%) tetapi tidak signifikan (P=0.13) dalam 2,000 lx (40.00±1.0%).Manakala, pertumbuhan larva dalam 1,000 (22.0±4.99 mm) dan 2,000 lx (22.8±3.71 mm) menunjukan tinggi secara signifikan (P=0.03) berbanding 0 (12.1±1.91 mm) dan 500 lx (16.0±1.33 mm). Penambahan berat badan yang tinggi secara signifikan (P=0.02) dilihat dalam 2000 lx (0.30±0.1 g) berbanding rawatan lain (0 lx: 0.16±0.1 g; 500 lx: 0.15±0.0 g; 1,000 lx: 0.21±0.1 g). Ketebalan lapisan fotoresiptor (µm) menunjukan perbezaan signifikan. Kajian ini membuktikan bahawa keamatan cahaya memberikan kesan ke atas larva. Kajian ini memberikan pandangan yang berguna dalam teknik pengkulturan yang baru dan implikasinya sangat berguna dan releven kerana kematan cahaya mudah dimanipulasi, menggunakan kos rendah, mengurangkan kanibalisma dan meningkatkan kelangsungan hidup serta meningkatkan pendapatan dalam industri akuakultur.

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Kg	-	Kilogram
G	-	Gram
MT	-	Metric tonnes
m^2	-	Meter square
Mm	-	Millimeter
mm^2	-	Millimeter square
μm	-	Micrometer
Cm	-	Centimeter
M	-	Meter
L	-	Liter
mg/L	-	Milligram per liter
sp.	-	Species
Nd	-	No data
H	-	Hours
COJ	-	Cod oil juice
RM	-	Ringgit Malaysia
Lx	-	Lux
d AH	-	Days after hatch
h AH	-	Hours after hatch
FAO	-	Food and Agriculture Organization
Ppt	-	Part per thousand
AA	-	Amino acid
OGV	-	Oil globule volume
OGD	-	Oil globule diameter
OG	-	Oil globule
M	-	Melanophore
EV	-	Eye vesicle
ED	-	Eye diameter
E	-	Eye
IE	-	Inner ear

YS	-	Yolk sac
YSV	-	Yolk sac volume
YD	-	Yolk sac diameter
YH	-	Yolk sac height
DNA	-	Deoxyribonucleic acid
RNA	-	Ribonucleic acid
BD	-	Body depth
BL	-	Body length
HL	-	Head length
Mo	-	Mouth
In	-	Intestine
B	-	Body
Ta	-	Tail
ANR	-	Average number of rotifer
FI	-	Feeding incidence
et al.,	-	and others, and the rest
MH	-	Musculature height
GH	-	Gut height
RT	-	Retinal layers
PR	-	Photoreceptor layers
IU	-	International unit
Ni	-	Initial number of fish
Nf	-	Final number of fish
P	-	Number of larvae removed
Mr	-	Number of dead fish

LIST OF SYMBOLS

%	-	Percentage
°C	-	Degree celcius

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CHAPTER 1

INTRODUCTION

1.1 Aquaculture Industry in Malaysia

Aquaculture sector had been industrialized in west Malaysia since 1920's meanwhile in east Malaysia had initiated in the early 1990's (Hamdan *et al.*, 2012). Aquaculture in west or peninsular Malaysia started with the freshwater and brackish water aquaculture subsequently in late 1930's including grass carp (*Ctenopharyngodon idella*), bighead carp (*Hypophthalmichthys nobilis*) and silver carp (*Hypophthalmichthys molitrix*) cultured in ex-mining pools (Ang, 1990). Aquaculture in Malaysia continuously developed where marine shrimp such as tiger shrimp (*Penaeus monodon*), banana shrimp (*P. merguiensis*) and the Indian white shrimp (*P. indicus*) that cultured in trapping ponds were introduced in mid-1930's and subsequent culture of blood cockels (*Anadara granosa*). In 2013, the total amount of aquaculture production was 308,000 tonnes (RM2.6 billion) (Hashim, 2015). The aquaculture industry in Malaysia was continuously developing and contributed significantly in economy, food security and employment opportunities (Hamdan *et al.*, 2012).

1.2 Problems of Seed Production in Aquaculture Industry

In general, global production of aquaculture has been continuously increased over the past 50 years (Anon, 2003). However, there still are problems and inconsistent in maximize aquaculture production due to as low and unstable survival and growth of larvae especially in early stage (Sugama *et al.*, 2004; Williams *et al.*, 2004; Mukai *et al.*, 2008; Puvanendran *et al.*, 2008). In early larval stage, the larvae are very fragile and frequently subjected to critical condition (Hatziathanasiou*, et al.* 2002). In order to maximize survival and growth of larvae, attention on various factors should be taken seriously such as light intensity, salinity, temperature, dissolved oxygen and pH level (Sugama *et al.*, 2004; Oboh and Nneji, 2013). Optimum condition for environmental parameters should be taken under consideration to maximize survival and growth of larvae. (Sugama *et al.*, 2004; Oboh and Nneji, 2013). Meanwhile, in the present study light intensity is choosen as the studied parameter to observe its effects on larval survival and growth performance.

1.3 Light Condition in Larval Rearing System

Light intensity can be described as the quantity of illumination on the water surface (Stuart and Drawbridge, 2011). There are many studies reported that light intensity gives an influence on survival, growth, feeding, cannibalism, nutritional status and retina development of fish larvae (Sigholt *et al.*, 1995; Han *et al.*, 2005; Villamizar *et al.*, 2009; Oboh and Nneji, 2013). In general, fish have range of light intensity threshold to develop normally (Puvanendran and Brown, 2008; Almazán-Rueda *et al.*, 2004). Some fish larvae prefer on high light intensity for example like gilthead seabream (*Sparus aurata*) and leopard coral grouper (*Plectropomus leopardus*) (Tandler and Mason, 1983) where higher survival and growth was observed in 600–1,300 lx and 1,000-3,000 lx respectively (Yoseda *et al.*, 2008).

However, inappropriate light condition harmful to fish larvae. According to Tuckey and Smith (2001), in light condition may cause larvae to expend more energy than is being gained or known as energy expenditure and leads to disruption of nutritional status of larvae. Moreover, high light intensity leads to aggressive behavior of fish and promote cannibalism rate of fish. Cannibalism is assumable as serious problem in fish culture because will lead to high mortality and loss of profits especially in aquaculture industry (Katavic *et al.,* 1988). Therefore, optimum of light intensity in aquatic environment should be determined to ensure high growth and survival of larvae. Hence, the effect of light intensity should be investigated individually for each desirable aquaculture species.

Light intensity also influenced on endogenous feeding of larvae. Korkut *et al.* (2006) showed absorption rate of oil globule of sharpsnout seabream (*Diplodus puntazzois*) significantly higher in light condition (450 lx) which is final volume of oil globule was 0.00074 ± 0.00 than in dark condition condition (0 lx) which is final volume of oil globule was 0.00082 ± 0.00. Light intensity also influenced on feeding performances of larvae (Villamizar *et al.,* 2009) by ability influenced on localization, catch, and ingested prey of larvae (Boeuf and Le Bail, 1999). Hence, light plays an important role in ensuring successful foraging activity and eventually lead to better survival and growth in the subsequent stage but the effects are species-dependent.

Light intensity is very important for visual feeder which relies on vision and use retina as the main sensory organ for feeding purpose (Boeuf and Le Bail, 1999). Exposing fish retina on continuous and high light intensity was harmful. Atlantic cod (*Gadus morhua*), Atlantic salmon (*Salmo salar*) and European sea bass (*Dicentrarchus labrax*) reared in 51–380 W/m^2 light intensity in continuous light for 30 days have retinal photodamage (Migaud *et al.*, 2007). These results have important welfare implications with regards to the use of artificial light in culture and should be considered when designing lighting protocols in the aquaculture industry.

In the natural environment, the main source of light comes from sunlight. The intensity of sunlight is extremely unstable and change over tremendous range. There are various factors that effect on the intensity of sunlight such as weather or climate in specific locations. In Malaysia, most of the time has rainy and sunny season, sometimes it can be cloudy condition. Intensity of very hard to control especially in outdoor culture. Hence, the specific impact of light intensity should be investigated specifically in detail for each individual desirable species. Manipulation of artificial light should be proposed as an advancement of culture technique in the aquaculture industry. Clearly, a study on the effects of light intensity is important to carry out in order to provide the optimum condition or environmental preference for individual species of larvae. Therefore, in the present study is attempting to carry out research of light on Asian seabass especially in larval stage.

1.4 Introduction of Target Species, Asian seabass (*Lates calcarifer*)

Asian seabass (*L. calcarifer*) has been chosen as a target species in the present study because of several advantages such as have relatively high resistance to disease, can tolerate in extreme environment, excellent organoleptic quality, have high demand in local and international market, and have high price (Mino, *et al.*,