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TITUL: EFFECTS OF DIFFERENT SALINITY ON SURVIVAL AND GROWTH
OF JUVENILE MARBLE GOBY, *Oxyeleotris marmoratus*

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EFFECTS OF DIFFERENT SALINITY ON SURVIVAL AND GROWTH OF
JUVENILE MARBLE GOBY, *Oxyeleotris marmoratus*



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THIS DISSERTATION IS SUBMITTED IN PARTIAL FULFILLMENT OF THE
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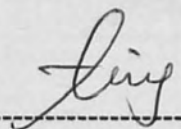
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I declare that this dissertation is the results of my own independent work, except where otherwise stated.

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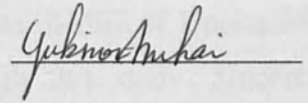


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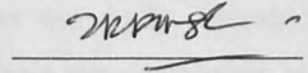
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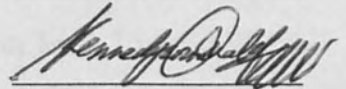
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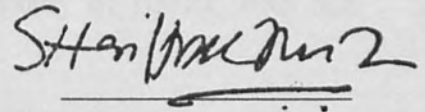
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ABSTRACT

Growth and survival of juvenile marble goby (*O. marmoratus*) were determined at salinities of 0, 10, 20 and 30 ppt. Two similar experiments were conducted. 25 juvenile *O. marmoratus*, 100 days after hatching (d AH) with mean initial body weight, BW of 0.269 ± 0.018 g and total length, TL of 29.98 ± 0.77 mm (experiment 1); 120 d AH with mean initial BW of 0.334 ± 0.036 g and TL of 32.17 ± 1.07 mm (experiment 2) were exposed these four salinities treatments with triplicates for 20 days in 7-litres plastic aquarium. Juvenile *O. marmoratus* were able to survive in 0 and 10 ppt treatments with 100% survival rate, where no mortality was found throughout the experiments period. Survival rate in 20 ppt was $94.0 \pm 1.7\%$ with no significant difference ($P > 0.05$) compared to those in 0 and 10 ppt. However, survival rate in 30 ppt ($77.3 \pm 5.2\%$) was significantly lower ($P < 0.05$) to the other treatments. Fish reared at 0 ppt had a specific growth rate of 2.56 ± 0.17 %/day in BW and 0.72 ± 0.07 %/day in TL, a rate significantly higher ($P < 0.05$) only to those fish reared at 30 ppt (1.13 ± 0.14 %/day in BW and 0.33 ± 0.03 %/day in TL). The study recommends that 0 ppt is the most suitable salinity to culture juvenile *O. marmoratus* for better survival and growth.



ABSTRAK

Pertumbuhan dan kemandirian juvenile marble goby (*O. marmoratus*) ditentukan pada saliniti 0, 10, 20 dan 30 ppt. Dua kajian yang sama dijalankan. 25 juvenil *O. marmoratus*, 100 hari lepas penetasan dengan min berat badan awal 0.269 ± 0.018 g dan min jumlah panjangnya 29.98 ± 0.77 mm (kajian 1); 120 hari lepas penetasan dengan min berat badan 0.334 ± 0.036 g dan min jumlah panjangnya 32.17 ± 1.07 mm (kajian 2) dikultur dalam empat saliniti tersebut dengan tiga replikat di dalam 7-liter akuarium selama 20 hari. Juvenil *O. marmoratus* didapati dapat hidup dalam 0 and 10 ppt dengan 100% kadar hidup di mana tidak ada kematian dijumpai sepanjang tempoh pengkulturan kajian. Kadar hidup juvenile *O. marmoratus* dalam 20 ppt adalah $94.0 \pm 1.7\%$ iaitu tidak ada perbezaan bererti ($P > 0.05$) berbanding dengan 0 dan 10 ppt. Manakala, kadar hidupnya dalam 30 ppt ($77.3 \pm 5.2\%$) adalah berbeza dengan ertinya ($P < 0.05$) terhadap saliniti lain. Juvenil *O. marmoratus* yang dikultur dalam 0 ppt mempunyai kadar pertumbuhan spesifik 2.56 ± 0.17 %/hari dalam berat badan dan 0.72 ± 0.07 %/hari dalam jumlah panjang, dengan kadarnya lebih tinggi secara bererti ($P < 0.05$) terhadap hanya kepada yang dikultur dalam 30 ppt (1.13 ± 0.14 %/hari, berat badan; dan 0.33 ± 0.03 %/hari, jumlah panjang). Dengan itu, kajian ini mencadangkan bahawa saliniti 0 ppt adalah saliniti yang paling sesuai dalam pengkulturan juvenil *O. marmoratus* untuk memperoleh kadar kemandirian dan pertumbuhan yang produktif.

LIST OF CONTENTS

	Page
DECLARATION	ii
AUTHENTICATION	iii
ACKNOWLEDGEMENT	iv
ABSTRACT	v
ABSTRAK	vi
LIST OF CONTENTS	vii
LIST OF TABLES	ix
LIST OF FIGURES	xi
LIST OF ABBREVIATIONS	xii
CHAPTER 1 INTRODUCTION	1
1.1 Aquaculture in Malaysia	1
1.2 Marble Goby, <i>Oxyeleotris marmoratus</i>	4
1.3 Significance of the study	5
1.4 Objectives of the study	6
CHAPTER 2 LITERATURE REVIEW	7
2.1 Taxonomy and morphology	7
2.2 Natural habitat and culture condition	8
2.3 Salinity effect	10
2.3.1 Effects on hatching rate and larval development	11
2.3.2 Effects on survival and growth	12
CHAPTER 3 MATERIALS AND METHODS	15
3.1 Experimental fish	15
3.2 Experimental system	17
3.3 Growth and survival	20
3.4 Statistical analysis	21
CHAPTER 4 RESULT	23
4.1 Survival rate at salinities of 0, 10, 20 and 30 ppt	23
4.2 Growth rate at salinities of 0, 10, 20 and 30 ppt	25



4.2.1	Growth rate in body weight, BW	25
4.2.2	Growth rate in Total Length, TL	27
CHAPTER 5 DISCUSSION		28
CHAPTER 6 CONCLUSION		32
REFERENCES		33
APPENDIX – 1		39

LIST OF TABLES

Table No.	Page
3.1 Daily feeding schedule and feed types that were given throughout the experiments	19
4.1 Mean survival rate of juvenile <i>O. marmoratus</i> after 20 days of rearing in different salinities	24
4.2 Mean of BW and TL gain, SGR in BW and TL of juvenile <i>O. marmoratus</i> after 20-day period in different salinities	25

APPENDIX – 1

Table No.	Page
1.1 Measurement of juvenile <i>O. marmoratus</i> used in experiment I and II	39
1.2 Survival rate of juvenile <i>O. marmoratus</i> in different salinities for 20 days (combination of experiment I and II)	40
1.3 Body weight, BW measurement of juvenile <i>O. marmoratus</i> in each salinity treatment at 10 days interval	41
1.4 Body weight, BW gain and specific growth rate, SGR in BW of juvenile <i>O. marmoratus</i> after 20-day rearing period in different salinities respectively	42
1.5 Total length, TL measurement of juvenile <i>O. marmoratus</i> in each salinity treatment at 10 days interval	43
1.6 Total length, TL gain and specific growth rate, SGR in TL of juvenile <i>O. marmoratus</i> after 20-day rearing period in different salinities respectively	44



1.7	Analysis of oneway ANOVA and Post Hoc Test for survival rate 0, 10, 20 and 30 ppt	45
1.8	Analysis of oneway ANOVA and Post Hoc Test for Body weight, BW gain in 0, 10, 20 and 30 ppt	46
1.9	Analysis of oneway ANOVA and Post Hoc Test for specific growth rate, SGR of body weight,BW in 0, 10, 20 and 30 ppt	47
1.10	Analysis of oneway ANOVA and Post Hoc Test for total length, TL gain in 0, 10, 20 and 30 ppt	48
1.11	Analysis of oneway ANOVA and Post Hoc Test for specific growth rate, SGR of total length, TL in 0, 10, 20 and 30 ppt	49



LIST OF FIGURES

Figure No.		Page
1.1	Malaysia aquaculture production from several freshwater fish in 2003	3
1.2	Marble goby, <i>Oxyeleotris marmoratus</i>	6
3.1	Juvenile <i>O. marmoratus</i> (100 d AH)	16
3.2	Growth measurement	16
	A Measurement of BW by using analytical balance (AND, Japan)	
	B Measurement of TL by using caliber	
3.3	Transmore that used to anesthetize the fish	17
3.4	Refractometer (ATAGO, Japan)	18
3.5	Water quality (DO, pH and temperature) monitoring	19
	A DO/pH meter (CYBERSCAN, Singapore)	
	B Thermometer (ZEAL, England)	
3.6	Flow chart for the summary of experiment set up	22
4.1	Mean survival rate of juvenile <i>O. marmoratus</i> in different salinities over a 20-day period	24
4.2	Mean BW gain of juvenile <i>O. marmoratus</i> after 20-day rearing period in 0, 10, 20 and 30 ppt	26
4.3	Mean SGR for BW and TL of juvenile <i>O. marmoratus</i> after 20-day rearing period in 0, 10, 20 and 30 ppt	26
4.4	Mean TL gain of juvenile <i>O. marmoratus</i> after 20-day rearing period in 0, 10, 20 and 30 ppt	27



LIST OF ABBREVIATIONS

°C	degree centigrade
%	percentage
BMRI	Borneo Marine Research Institute
BW	body weight
cm	centimeter
d AF	days after fertilization
d AH	days after hatching
DO	dissolved oxygen
g	gram
GDP	Gross Domestic Product
km	kilometer
km ²	kilometer square
l	liter
mg	milligram
ml	milliliter
mm	millimeter
mt	metric ton
ppt	part per thousand
S.D	standard deviation
SGR	specific growth rate
SPSS	Statistical Package for Social Science
TL	total length
UMS	Universiti Malaysia Sabah



CHAPTER 1

INTRODUCTION

1.1 Aquaculture in Malaysia

Malaysia has many potential and advantages in developing the aquaculture sector. Malaysia has a total land area of about 329,758 km² and 4,400 km of shoreline (Ang, 1990). It's rich and diverse shoreline and inland areas have not yet been utilized fully in expansion for aquaculture development. Department of Fisheries (2005) highlighted the vast potential of inland areas and coastal areas in Malaysia and estimated that the production from the aquaculture industry could be increased by as much as four folds from its present level (196,874 metric tons) by the year 2010.

Malaysia is a tropical country and has high and consistent temperature averaged around 30 °C allowing fish to spawn year round. The coldest period are usually between December and January with the temperature ranging between 22-32 °C and the hottest period are April and May when temperatures ranges between 24-35 °C (Ang, 1990). Malaysia also has many mountains region, with heavy rainfall all around the year, which gives rise to many rivers; and about four-fifths of Malaysia is covered by forests and



swamps areas are habitats for many species of fish. There are about 6,410 km² of mangrove areas along the coasts, which provide breeding and nursery grounds for fish, besides ensuring the supply of shelter and food to other marine organisms and protecting the coastline from erosion (Yusoff *et al.*, 1997).

Aquaculture used to be a secondary activity developed mainly on a small scale basis in family-sized holdings and commercial application only began in the mid-1980s. The National Agriculture Policy (1992-2010) was formulated by Malaysian Government in 1984 and had given due recognition to the development of aquaculture as an important source of fish protein for the domestic and export markets (Mohd. Mazlan, 1997). Consequently, the aquaculture would have to be developed on commercial basis with effective aquaculture system being introduced to increase productivity. Various programs had been established through research support, hatcheries and fry production centres, extension and training, promotional campaigns, quality and disease control and tax incentives, to encourage the full-scale commercialization of the aquaculture industry.

In 2003, fisheries sector in Malaysia had contributed about 1.37% to the Gross Domestic Product (GDP) and provided direct employment to 89,433 fishermen and 21,114 fish culturist in the year 2003 (Department of Fisheries, 2005). Besides production from inshore and deep sea fishing, the development of aquaculture has the real potential to increase fish production.



Total production from the aquaculture stood at 196,874 metric tons (mt) valued at RM 1,172.30 million, which was an increase of 2.63% of the over the 2002 output of 191,843 mt and contributed to about 13.27% of the overall fish production in Malaysia. Freshwater aquaculture contributed 26.0% of the total aquaculture production in 2003, increasing by 7.60% from 46,403 mt in 2002 to 49,946.61 mt in 2003 (Department of Fisheries, 2005). From the Figure 1.1, it shows aquaculture production on several targeted freshwater species in Malaysia in 2003. The major productions are Red tilapia, African catfish, River catfish (Patin); which respectively contributed 40.2%, 25.4% and 8.6% of the total freshwater aquaculture production. Among these species, the production of Marble goby was the lowest, which contributed only 683.47 mt or 1.4% from the total freshwater aquaculture production. However, there was an increase in the production of Marble goby if compared to its production in 1997 which was 39 mt (Department of Fisheries, 1999).

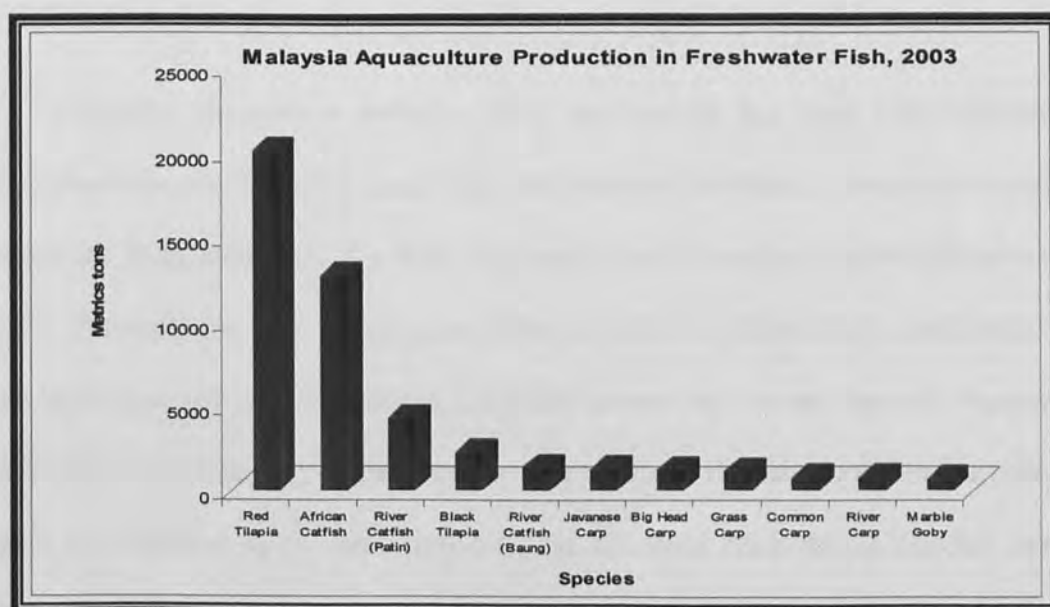
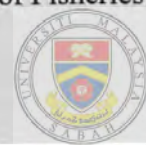


Figure 1.1 Malaysia aquaculture production from several freshwater fish in 2003

Source: Department of Fisheries (2005)



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1.2 Marble Goby, *Oxyeleotris marmoratus*

Marble goby, *Oxyeleotris marmoratus* (Figure 1.2) is the largest freshwater Eleotridae which can grow more than 2 kg in body weight (BW) and 50 cm in total length (TL). This species is mainly distributed in the Southeast Asia Region such as Thailand, Cambodia, Vietnam, Singapore, Indonesia, the Philippines, and Fiji (Cheah *et al.*, 1994; Senoo *et al.*, 1994a). This species is also known as “Sand Goby” in English, “Ikan Ketutu” or “Ikan Hantu” in Malay and “Soon Hock” in the Chinese Fujian and Guangdong dialect, and it is also called as “Bamboo Fish” (Senoo *et al.*, 1994a). *O. marmoratus* is the most expensive freshwater table fish in Malaysia (Senoo *et al.*, 1997). The retail price of this species is RM 20-50 kg⁻¹ as compared to other freshwater species such as Tilapia, African catfish, Common carp, Grass carp, and Big head carp which prices are RM 2-12 kg⁻¹ (Department of Fisheries, 2005).

Presently, the natural resource of *O. marmoratus* has been over-exploited in Peninsular Malaysia. Therefore, some fish middlemen in the Kuala Lumpur are importing this species from Indonesia, Thailand, Cambodia, and Malaysian Borneo (Senoo *et al.*, 1994a). Consequently, there is increasing interest in the cultivation of *O. marmoratus* due to its high price and market demand. Over the last several decades, people's increasing dependence on cultured *O. marmoratus*, as opposed to wild fish, as a source of dietary protein has resulted in an increasing level of scientific effort being directed toward propagation techniques (Donaldson *et al.*, 1983). However, there are several problems in culture of *O. marmoratus* such as slow growth during juvenile stage, peculiar feeding



behavior, lack of formulated feeds and high mortality rate (Ang, 1980; Cheah *et al.*, 1994; Lin *et al.*, 2000).

1.3 Significance of the study

Complete aquacultural systems has already been established on several species such as carps, cat fishes, salmons, trouts, sea bream, and Tilapias; thus, a lot of information is available in the cultural history of these species (Senoo *et al.*, 1994a). However, the same authors are in the opinion that the aquacultural system of the *O. marmoratus* still requires much study despite various efforts and experiences since 1970's. Many studies had been conducted on the seed production technique, egg development and early larval stage of *O. marmoratus* (Senoo *et al.*, 1992; Senoo *et al.*, 1993a; Senoo *et al.*, 1993b; Senoo *et al.*, 1994a; Senoo *et al.*, 1994b; Senoo *et al.*, 1994c; Senoo *et al.*, 1997). However there is still lack of studies on the further life stage of *O. marmoratus*, especially in the juvenile stage since low survival and poor growth are still remaining major constraints in this stage.

More information is needed for the purpose of cultivation. Environmental conditions, such as salinity, temperature, pH, dissolved oxygen (DO), and others are vital, principally for the growth and survival, of *O. marmoratus* in different life stages. This information could assist in selecting the most suitable sites for cultivation, as well as providing information on hatchery operation on the optimum conditions for rearing this species. There is possibility that their survival and growth performance will be affected

by different water salinity. However, the salinity tolerance of this fish is not clear defined because all available data appear to be from freshwater (Roberts, 1989). Therefore, it is crucial to know the performance of juvenile *O. marmoratus*, especially their survival and growth in different salinity.

1.4 Objectives of the study

This study was intended to elucidate the challenges of low survival and growth in the juvenile *O. marmoratus* that might be influenced by different salinity. The main objectives of this study are as follow:

1. To determine the optimum salinity for higher growth and survival rate of juvenile *O. marmoratus*.
2. To improve culture technique of juvenile *O. marmoratus* by culturing them in suitable water salinity that will promote better survival and growth.

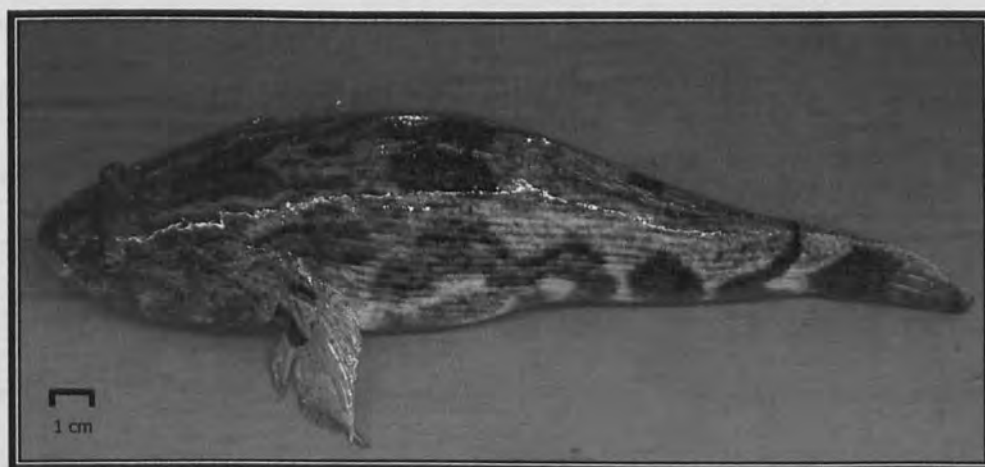


Figure 1.2 Marble goby, *Oxyeleotris marmoratus*

CHAPTER 2

LITERATURE REVIEW

2.1. Taxonomy and morphology

Marble goby belongs to the kingdom of *Animalia*, with phylum as *Chordata* and superclass as *Pisces*; the order is *Perciformes* and suborder is *Gobioidea*; with the family name as *Eleotridae*, genus name as *Oxyeleotris* and species name as *Oxyeleotris marmorata* (Komarudin, 2000). According to Bleeker (1874), the Eleotridae or sleepers comprise some genera and 150 species of mostly tropical, marine, brackish, and freshwater fishes. Two genera and four species occur in the fresh waters of western Borneo. *Oxyeleotris* is unusual among eleotrid genera in being almost entirely restricted to fresh water species of the genus occur in Southeast Asia and others in the Austrian region. Three species known from Western Borneo are *O. urophthalmus*, *O. urophthalmoides* and *O. marmoratus*.

Kottelat *et al.* (1993) had stated that Eleotrididae is a small family similar to Gobiidae; however, it can be differentiated from other Gobiidae by their separate pelvic fin and the six branchiotegeal rays. Most of the members of this family can be found in sea,

brackish waters and estuaries; while *O. marmoratus* is found in freshwater. *O. marmoratus* has colour in alcohol dark brown above, pale brown below; body with a series of large, dark blotches; fins with black bands or dusky (Bleeker, 1877). The morphological changes on the eggs and larvae of *O. marmoratus* were observed by Senoo *et al.* (1994c) who stated that the juvenile stage of *O. marmoratus* was after 40 days after fertilization (d AF) where the yellow-ocher pigmentation appeared on body.

Senoo *et al.* (1994a) reported the correlations between the morphological and behavioral changes in *O. marmoratus* larvae. Observation on the behavioral changes of the egg and larvae of *O. marmoratus* from 2-40 d AF had been reported by (Senoo *et al.* 1994c). Gobies usually change their habitat from pelagic to benthic as they change from the larval to the juvenile stages. Senoo *et al.* (1994c) stated that newly hatched larvae 2-3 d AF lay on the tank bottom and gradually exhibited the “swim up, sink down” behavior. On 4-5 d AF, they are positively phototactic and show active S-posture and horizontal swimming. They are negatively phototactic after 25 d AF and schooling at the bottom. The larvae show active swimming on the bottom on 30-35 d AF until they are not active after 40 d AF which considered as juvenile stage thereafter.

2.2. Natural habitat and culture condition

Koumans (1953) had reported that the *O. marmoratus* also occurred in river as well as estuaries. Kottelat *et al.* (1993) also reported that *O. marmoratus* was found in rivers,



swamps, reservoirs and canals along the Mekong and Chao Phraya Basins, Malay Peninsula, Indochina, Philippines and Indonesia.

O. marmoratus was cultured in ponds and ex-mining pools either in monoculture or in polyculture with tilapias. Cage culture of this species in lakes and rivers had also been successfully done (Cheah *et al.*, 1994). Cage culture of *O. marmoratus* in floating bamboo or wooden cages had been carried out in Thailand since the early 1970s (Suwansart, 1979). Recently, there was a study done on the cove polyculture of *O. marmoratus* with silver carp, bighead carp, common carp and grass carp in Tri An Reservoir of Vietnam. This study revealed the result of improving productivity and economic performance both in *O. marmoratus* and carps. It had proven that this cove polyculture system has a prominent prospect ecologically, technologically and economic performance (Vu *et al.*, 2003).

Senoo *et al.* (1994c) elaborated the larval rearing method for *O. marmoratus* that require tank cleaning and 30 - 50% water exchange daily from 7 d AF. The water must be well aerated and treated with 20 W fluorescent light above the tank daily from 0800 – 1800 h with 100 – 800 lux on the water surface until 30 d AF. This is because the larvae were negatively phototactic after 30 d AF. The water temperature, dissolved oxygen (DO) and pH during the larval rearing ranged from 27.0 – 29.5 oC, 2.1 - 7.8 mg/l, and 7.5 – 7.9, respectively.



The *O. marmoratus* larvae commenced feeding on phytoplankton at 3 d AF when the eyes were pigmented and the yolk sac had been absorbed to almost the same size as the air bladder (Senoo *et al.*, 1994a). Tavarutmaneeagul *et al.* (1988) fed chicken egg slurry and rotifers (*Brachionus sp.*) to the larvae from 7-20 days after hatching (d AH). Thereafter, the larvae were transferred to outdoor tank and feed daily with live organisms, such as *Moina* spp., *Brachionus* spp., *Chironomid* (Blood worm) larvae and trash fish from 30-60 d AH.

Amornsakum *et al.* (2003) had also reported on the feeding regime of larvae and juveniles of *O. marmoratus*. The author suggested that larvae at 3-18 d AH consumed only rotifer. 21 - 27 d AH larvae with average total length of 0.44 - 0.65 cm consumed rotifer and *Artemia nauplii*. Whereas, 30 - 45 d AH larvae with average total length 0.69 - 2.15 cm consumed only *Moina*. From 60 d AH, only the *Chironomus* larvae were given and most of the juveniles became used to feeding on it within a few days. At the later stage, the juveniles are fed on minced fish, shellfish and shrimp or artificial pellet.

2.3. Salinity effect

Effects of salinity on survival, growth and reproduction of aquatic animals had been discussed by Watanabe (2000). The author stated that effective salinity ranges for reproduction and growth of aquatic organism may be narrow or broad depending on species and vary with life stage. It also may be modified by other environmental factors, particularly temperature.



2.3.1. Effects on hatching rate and larval development

The salinity was reported affect the hatching rate of *O. marmoratus*. Mok (2004) reported that the hatching rate for the eggs of *O. marmoratus* that were incubated in 10 ppt was the best among the 4 treatments (0, 10, 20 and 30 ppt). It also showed that least mortalities occurred both in eggs and larvae in 10 ppt salinity test. Besides, the result also indicated that 10 ppt of salinity can also shorten the hatching period of the eggs where the hatching peak occurred on the fourth day after spawning. With this, there was higher possibility to produce well-hatched larvae due to its hatching period.

Huang *et al.* (2000) elaborated that salinity had a significant effect on the hatching rate for black porgy (*Acanthopagrus schlegeli*) eggs. The hatching rate was recorded as 85% at 37 and 34ppt and 60% at 31ppt, but no eggs were hatched at 28ppt. During the yolk sac larval stages, the effects of salinity on body length and oil globul volume were significant while body length decreased significantly with increasing salinity. Fashina-Bombata and Busari (2003) had reported that there was improvement in the hatching rates of *Heterobranchus longifilis* eggs when incubated in salinity range of 1.5-3.1 ppt.

Madrones-Ladja, (2002) had reported that the best salinity levels for embryonic development and larval survival of *Placuna placenta* at metamorphosis ranged from 22-34 ppt and larval growth from 16-34 ppt. The tolerance of *P. placenta* to lower and higher salinities progressively increased as larvae developed from embryo to the plantigrade



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