

# EFFECT OF LIVE FOOD ENRICHMENT ON SURVIVAL AND GROWTH OF MARINE LARVAL FISH WITH GONADS PROPERTIES STUDIES

#### **A Thesis**

Presented to the Graduate School
Faculty of Agriculture, Saba Basha, Alexandria University
In Partial Fulfillment of the
Requirements for the Degree

of

#### MASTER IN AGRICULTURAL SCIENCES

In (FISH PRODUCTION)

By

#### MONA MOHAMMED HESSIAN MOURAD

**July, 2009** 



# EFFECT OF LIVE FOOD ENRICHMENT ON SURVIVAL AND GROWTH OF MARINE LARVAL FISH WITH GONADS PROPERTIES STUDIES

#### Presented by

#### MONA MOHAMMED HESSIAN MOURAD

### For the Degree of MASTER IN AGRICULTURAL SCIENCES

## In Fish Production

Examiners' Committee:	<b>Approved</b>
Prof. Dr. Soliman. H. AbdEl-Rahman Prof. of Fish Nutrition	•••••
National Institute of Oceanography and Fish Alexandria	heries
Prof. Dr. Meseda. M. El-Garabawy Prof. of Fish Reproduction	••••••
National Institute of Oceanography and Fis	heries
Prof. Dr. Alaa. A. El-Dahhar Prof. of Fish Nutrition	••••••
Faculty of Agriculture (Saba-Basha) Alexandria University	
Prof. Dr. Samira. S. Assem Prof. of Fish Reproduction	•••••
National Institute of Oceanography and Fish	heries

### **ADVISOR'S COMMITTEE:**

Prof. Dr. Khalid A. El-Shazly Prof. of Animal Nutrition Faculty of Agriculture Alexandria University	••••••
Prof. Dr. Alaa A. El-Dahhar Prof. of Fish Nutrition Faculty of Agriculture (Saba-Basha)	••••••
Alexandria University Prof. Dr. Samira S. Assem Prof. of Fish Reproduction National Institute of	••••••
Oceanography and Fisheries Alexandria Prof. Dr. Mosad M. El-Telbaany Prof. of Fish breeding Faculty of Veterinary Medicine Alexandria University	•••••••••••••••••••••••••••••••••••••••

### لجنة الإشراف:

•••••	الأستاذ الدكتور / خالد عبد السلام الشاذلي
	أستاذ تغذية الحيوان
	كلية الزراعة-الشاطبي-جامعة الأسكندرية
••••••	الأستاذ الدكتور / علاء عبد الكريم الدحار (المشرف الرئيسي)
	أستاذ تغذية الأسماك
	كلية الزراعة-سابا باشا-جامعة الأسكندرية
••••••	الأستاذ الدكتور / سميرة شحاتة عاصم
	أستاذ تقريخ الأسماك المحار والمصايد (الأسكندرية)
	الأستاذ الدكتور / مسعد محمد التلباني
	أستاذ تربية الأسماك
	كلية الطب البيطرى - أدفينا - الأسكندرية



# تأثيرتحسين الغذاء الحى على حيوية ونمو يرقات الأسماك البحرية مع دراسة خواص المناسل

### مقدمة من منى محمد حسين مراد

للحصول على درجة الماجستير في العلوم الزراعية تخصص (إنتاج الأسماك)

<u>موافقون</u>	لجنه المنافشة والحكم على الرسالة:
•••••	الأستاذ الدكتور / سليمان حامد عبد الرحمن
	أستاذ تغذية الأسماك
	المعهد القومي لعلوم البحار والمصايد (الأسكندرية)
•••••	الأستاذ الدكتور / مسعدة الغرباوي
	أستاذ تفريخ الأسماك
	المعهد القومي لعلوم البحار والمصايد (الأسكندرية)
	الأستاذ الدكتور / علاء عبد الكريم الدحار
	أستاذ تغذية الأسماك
	كلية الزراعة- سابا باشا-جامعة الأسكندرية
•••••	الأستاذ الدكتور / سميرة شحاتة عاصم
	أستاذ تفريخ الأسماك
	المعهد القومي لعلوم البحار والمصايد (الأسكندرية)



## تأثيرتحسين الغذاء الحى على حيوية ونمو يرقات الأسماك البحرية مع دراسة خواص المناسل

رسالة علمية
مقدمة إلى الدراسات العليا
بكلية الزراعة - سابا باشا - جامعة الإسكندرية
استيفاء للدراسات المقررة للحصول على درجة
الماجستير في العلوم الزراعية

في إنتاج الأسماك

مقدمة من منى محمد حسين مراد

يوليو ٢٠٠٩

#### Acknowledgement

My sincere thanks to prof. Dr. Khalid A. El-Shazly professor of Animal Nutrition in Faculty of Agriculture, Alexandria University, for his help and guidance during this study.

I would like to express my great gratitude to prof. Dr. Alaa El-Dahhar professor of Fish Nutrition, Faculty of Agriculture (Saba-Basha), Alexandria University for his useful advices, supervising the work, suggesting the problem and revising the manuscript.

I would like to express my deepest gratitude to prof. Dr. Samira S. Assem Prof. of Fish Reproduction, National Institute of Oceanography and fisheries, Alexandria for her professional experienced help that was given to me will always be memberable.

I am greatly indebted to Head of Animal and Fish Production Department and the all Department and the Marine Fish Laboratory members, Faculty of Agriculture (Saba-Basha), Alexandria University for their help during this work.

Special thanks are extended to all members of Aquaculture division, National Institute of Oceanography and fisheries, Alexandria for their great facilities throughout the work.

Finally, I would like to express my utmost gratitude to My Father, My Mother, My sisters and My brother for encouraging me during the work.

#### **CONTENTS**

		<u>Page</u> <u>No.</u>
CF	HAPTER 1: INTRODUCTION	1
	HAPTER 2: REVIEW OF LITERATURE	5
I.		5
	Nutritional requirement	6
	II.1. Artemia	7
	II.1.1. Fatty acids	9
	II.1.2. Vitamin C	18
	II.1.3. Silica.	22
Ш	. Mullet reproduction.	24
	HAPTER 3: MAREIALS AND METHODS	26
I.	Facilities and Fish	26
••	I.1. Experimental aquaria	26
	I.2. The fish larvae	26
	I.3. Larvae samples and processing	27
	I.4. Diet formulation and preparation	27
	I.5. Artemia hatching	28
	I.5.1. Harvesting	28
	I.5.2. Hatchability	28
ΤΤ	Biochemical analysis	30
11.	II.1. Dry weight and moisture content	30
	II.2. Total lipid contents	30
	II.3. Fatty acids contents.	30
ПП	Experimental design.	31
111	III.1. First experiment	31
	r - r	32
	III.2. Second experiment	32
	III.3.1. Reproduction criteria	32
		33
	III.3.2. Histological studies.	34
137	III.3.3. Electron microscope technique	35
	. Statistical analysis	36
I.		36
1.	First experiment	36
	· · · · · · · · · · · · · · · · · · ·	36
	1 2	36
	I.2. Growth performance and chemical composition of fish larvae  I.2.1. Growth	42
	I.2.2. Survival rate %	42
		44
	$\mathcal{E}$	
	I.2.4. Specific growth rate (SGR%/d)	44
	I.2.5. Condition factor	48
	I.2.6. Chemical composition of <i>Mugil cephalus</i> larvae	48
	I.2.6.1. Moisture contents.	48
	I.2.6.2. Total lipid contents.	48
ŢΤ	I.2.6.3. Fatty acids contents	50 57
П.	The second experiment	57 57
	II.1. Biochemical analysis of <i>Liza ramada</i> ovaries	57 57

II.2. Growth performance and chemical composition of fish larvae				<b>Page</b>
II.2.1. Growth II.2.2. Survival rate. II.2.3. Weight gain II.2.4. Specific growth rate (SGR%/d). II.2.5. Condition factor (K). II.2.6. Chemical composition of the larval body. II.2.6.1. Moisture contents. III.2.6.2. Total lipid contents. III.2.6.3. Fatty acids contents "before weaning" III.2.6.4. Fatty acids contents "after weaning" III.1. Reproductive Biology. III.1. Reproductive biology of Mugil cephalus. III.1. Maturity stages III.1. Maturity stages III.1.2. Monthly distribution of maturity stages III.1.3. Length at first sexual maturity. III.1.4. Gonadosomatic index III.1.6. Fecundity III.1.6.1. Analysis of absolute fecundity-length relationship III.1.6.2. Analysis of relative fecundity-weight relationship III.1.6.3. Analysis of relative fecundity-weight relationship III.1.2. Reproductive biology of Liza ramada III.2.1. Maturity stages III.1.1. Histological and ultrastructure characteristics in ovaries III.1.1. Histological and ultrastructure characteristics in ovaries III.1. Alength at first sexual maturity. III.2. Reproductive biology of Liza ramada III.1. Reproductive biology				<u>No.</u>
II.2.2. Survival rate	II.2. Grow	th perfo	ormance and chemical composition of fish larvae	60
II.2.3. Weight gain	II.2.1.	Growt	h	60
II.2.4. Specific growth rate (SGR%/d)	II.2.2.	Surviv	al rate	64
II.2.5. Condition factor (K)	II.2.3.	Weigh	t gain	64
II.2.6. Chemical composition of the larval body	II.2.4.	Specif	ic growth rate (SGR%/d)	69
II.2.6.1. Moisture contents				69
II.2.6.1. Moisture contents	II.2.6.	Chemi	cal composition of the larval body	69
III.2.6.3. Fatty acids contents "before weaning"				69
III. 2.6.4. Fatty acids contents "after weaning".  81  III. The Reproductive Biology.  89  III.1. Reproductive biology of Mugil cephalus.  89  III.1. Maturity stages.  89  III.1. Monthly distribution of maturity stages.  90  III.1. Length at first sexual maturity.  90  III.1. Gonadosomatic index.  93  III.1. Egg diameter and spawning.  93  III.1. Analysis of absolute fecundity-length relationship.  96  III.1. Analysis of relative fecundity-weight relationship.  96  III.1. Analysis of relative fecundity-weight relationship.  96  III.1. Histological and ultrastructure characteristics in ovaries.  101  III.2. Reproductive biology of Liza ramada.  111  III.2.1. Maturity stages.  111  III.2.2. Monthly distribution of maturity stages.  111  III.2.3. Length at first sexual maturity.  111  III.2.4. Gonadosomatic index.  114  III.2.5. Egg diameter and spawning.  115  III.2.6.1. Analysis of absolute fecundity-length relationship.  117  III.2.6.2. Analysis of absolute fecundity-length relationship.  117  III.2.6.3. Analysis of absolute fecundity-length relationship.  117  III.2.6.3. Analysis of absolute fecundity-length relationship.  117  III.2.6.3. Analysis of absolute fecundity-length relationship.  117	II.	2.6.2.	Total lipid contents	71
III. The Reproductive Biology	II.	2.6.3.	Fatty acids contents "before weaning"	71
III.1.Reproductive biology of Mugil cephalus.89III.1.1.Maturity stages89III.1.2.Monthly distribution of maturity stages90III.1.3.Length at first sexual maturity.90III.1.4.Gonadosomatic index93III.1.5.Egg diameter and spawning93III.1.6.Fecundity93III.1.6.1.Analysis of absolute fecundity-length relationship96III.1.6.2.Analysis of relative fecundity-weight relationship96III.1.6.3.Analysis of relative fecundity-weight relationship96III.1.7.Histological and ultrastructure characteristics in ovaries101III.2.Reproductive biology of Liza ramada.111III.2.1.Maturity stages111III.2.2.Monthly distribution of maturity stages.111III.2.3.Length at first sexual maturity.111III.2.4.Gonadosomatic index114III.2.5.Egg diameter and spawning114III.2.6.1.Analysis of absolute fecundity-length relationship117III.2.6.2.Analysis of relative fecundity-length relationship117III.2.6.3.Analysis of absolute fecundity-weight relationship117III.2.6.3.Analysis of absolute fecundity-weight relationship117	II.	2.6.4.	Fatty acids contents "after weaning"	81
III.1.1 Maturity stages	III. The Repro	oductive	Biology	89
III.1.1 Maturity stages	III.1.	Repro	ductive biology of Mugil cephalus	89
III.1.2. Monthly distribution of maturity stages 90  III.1.3. Length at first sexual maturity 990  III.1.4. Gonadosomatic index 933  III.1.5. Egg diameter and spawning 933  III.1.6. Fecundity 993  III.1.6.1. Analysis of absolute fecundity-length relationship 964  III.1.6.2. Analysis of relative fecundity-length relationship 965  III.1.6.3. Analysis of absolute fecundity-weight relationship 966  III.1.6.4. Analysis of relative fecundity-weight relationship 966  III.1.7. Histological and ultrastructure characteristics in ovaries 101  III.2. Reproductive biology of Liza ramada 111  III.2.1. Maturity stages 111  III.2.2. Monthly distribution of maturity stages 111  III.2.3. Length at first sexual maturity 111  III.2.4. Gonadosomatic index 114  III.2.5. Egg diameter and spawning 114  III.2.6. Fecundity 117  III.2.6.1. Analysis of absolute fecundity-length relationship 117  III.2.6.2. Analysis of relative fecundity-length relationship 117  III.2.6.3. Analysis of absolute fecundity-weight relationship 117  III.2.6.3. Analysis of absolute fecundity-weight relationship 117  III.2.6.3. Analysis of absolute fecundity-weight relationship 117	III.1.1			89
III.1.3. Length at first sexual maturity.90III.1.4. Gonadosomatic index93III.1.5. Egg diameter and spawning93III.1.6. Fecundity.93III.1.6.1. Analysis of absolute fecundity-length relationship96III.1.6.2. Analysis of relative fecundity-length relationship96III.1.6.3. Analysis of absolute fecundity-weight relationship96III.1.6.4. Analysis of relative fecundity-weight relationship96III.1.7. Histological and ultrastructure characteristics in ovaries101III.2. Reproductive biology of Liza ramada111III.2.1. Maturity stages111III.2.2. Monthly distribution of maturity stages111III.2.3. Length at first sexual maturity.111III.2.4. Gonadosomatic index114III.2.5. Egg diameter and spawning114III.2.6. Fecundity117III.2.6.1. Analysis of absolute fecundity-length relationship117III.2.6.2. Analysis of relative fecundity-length relationship117III.2.6.3. Analysis of absolute fecundity-weight relationship117				90
III.1.5. Egg diameter and spawning 93  III.1.6. Fecundity 93  III.1.6.1. Analysis of absolute fecundity-length relationship 96  III.1.6.2. Analysis of relative fecundity-length relationship 96  III.1.6.3. Analysis of absolute fecundity-weight relationship 96  III.1.6.4. Analysis of relative fecundity-weight relationship 96  III.1.7. Histological and ultrastructure characteristics in ovaries 101  III.2. Reproductive biology of Liza ramada 111  III.2.1. Maturity stages 111  III.2.2. Monthly distribution of maturity stages 111  III.2.3. Length at first sexual maturity 111  III.2.4. Gonadosomatic index 114  III.2.5. Egg diameter and spawning 114  III.2.6. Fecundity 117  III.2.6.1. Analysis of absolute fecundity-length relationship 117  III.2.6.2. Analysis of relative fecundity-length relationship 117  III.2.6.3. Analysis of absolute fecundity-weight relationship 117  III.2.6.3. Analysis of absolute fecundity-weight relationship 117				90
III.1.6. Fecundity	III.1.4	. Gonad	osomatic index	93
III.1.6. Fecundity93III.1.6.1. Analysis of absolute fecundity-length relationship96III.1.6.2. Analysis of relative fecundity-length relationship96III.1.6.3. Analysis of absolute fecundity-weight relationship96III.1.6.4. Analysis of relative fecundity-weight relationship96III.1.7. Histological and ultrastructure characteristics in ovaries101III.2. Reproductive biology of Liza ramada111III.2.1. Maturity stages111III.2.2. Monthly distribution of maturity stages111III.2.3. Length at first sexual maturity111III.2.4. Gonadosomatic index114III.2.5. Egg diameter and spawning114III.2.6. Fecundity117III.2.6.1. Analysis of absolute fecundity-length relationship117III.2.6.2. Analysis of relative fecundity-length relationship117III.2.6.3. Analysis of absolute fecundity-weight relationship117	III.1.5	. Egg di	ameter and spawning	93
III.1.6.2. Analysis of relative fecundity-length relationship 96 III.1.6.3. Analysis of absolute fecundity-weight relationship 96 III.1.6.4. Analysis of relative fecundity-weight relationship 96 III.1.7. Histological and ultrastructure characteristics in ovaries 101 III.2. Reproductive biology of <i>Liza ramada</i> 111 III.2.1. Maturity stages 111 III.2.2. Monthly distribution of maturity stages 111 III.2.3. Length at first sexual maturity 111 III.2.4. Gonadosomatic index 114 III.2.5. Egg diameter and spawning 114 III.2.6. Fecundity 117 III.2.6.1. Analysis of absolute fecundity-length relationship 117 III.2.6.2. Analysis of relative fecundity-length relationship 117 III.2.6.3. Analysis of absolute fecundity-weight relationship 117			· •	93
III.1.6.2. Analysis of relative fecundity-length relationship 96 III.1.6.3. Analysis of absolute fecundity-weight relationship 96 III.1.6.4. Analysis of relative fecundity-weight relationship 96 III.1.7. Histological and ultrastructure characteristics in ovaries 101 III.2. Reproductive biology of <i>Liza ramada</i> 111 III.2.1. Maturity stages 111 III.2.2. Monthly distribution of maturity stages 111 III.2.3. Length at first sexual maturity 111 III.2.4. Gonadosomatic index 114 III.2.5. Egg diameter and spawning 114 III.2.6. Fecundity 117 III.2.6.1. Analysis of absolute fecundity-length relationship 117 III.2.6.2. Analysis of relative fecundity-length relationship 117 III.2.6.3. Analysis of absolute fecundity-weight relationship 117	III	.1.6.1.	Analysis of absolute fecundity-length relationship	96
III.1.6.3. Analysis of absolute fecundity-weight relationship 96 III.1.6.4. Analysis of relative fecundity-weight relationship 96 III.1.7. Histological and ultrastructure characteristics in ovaries 101 III.2. Reproductive biology of <i>Liza ramada</i> 111 III.2.1. Maturity stages 111 III.2.2. Monthly distribution of maturity stages 111 III.2.3. Length at first sexual maturity 111 III.2.4. Gonadosomatic index 114 III.2.5. Egg diameter and spawning 114 III.2.6. Fecundity 117 III.2.6.1. Analysis of absolute fecundity-length relationship 117 III.2.6.2. Analysis of relative fecundity-length relationship 117 III.2.6.3. Analysis of absolute fecundity-weight relationship 117	III	.1.6.2.	· · · · · · · · · · · · · · · · · · ·	96
III.1.6.4. Analysis of relative fecundity-weight relationship	III	.1.6.3.	· · · · · · · · · · · · · · · · · · ·	96
III.1.7. Histological and ultrastructure characteristics in ovaries	III	.1.6.4.	· · · · · · · · · · · · · · · · · · ·	96
III.2.Reproductive biology of Liza ramada.111III.2.1. Maturity stages111III.2.2. Monthly distribution of maturity stages.111III.2.3. Length at first sexual maturity111III.2.4. Gonadosomatic index114III.2.5. Egg diameter and spawning114III.2.6. Fecundity117III.2.6.1. Analysis of absolute fecundity-length relationship117III.2.6.2. Analysis of relative fecundity-length relationship117III.2.6.3. Analysis of absolute fecundity-weight relationship117	III.1.7	. Histol	· · · · · · · · · · · · · · · · · · ·	
III.2.1. Maturity stages111III.2.2. Monthly distribution of maturity stages111III.2.3. Length at first sexual maturity111III.2.4. Gonadosomatic index114III.2.5. Egg diameter and spawning114III.2.6. Fecundity117III.2.6.1. Analysis of absolute fecundity-length relationship117III.2.6.2. Analysis of relative fecundity-length relationship117III.2.6.3. Analysis of absolute fecundity-weight relationship117			<del>-</del>	111
III.2.2. Monthly distribution of maturity stages	III.2.1	-		111
III.2.3. Length at first sexual maturity			• •	111
III.2.4. Gonadosomatic index114III.2.5. Egg diameter and spawning114III.2.6. Fecundity117III.2.6.1. Analysis of absolute fecundity-length relationship117III.2.6.2. Analysis of relative fecundity-length relationship117III.2.6.3. Analysis of absolute fecundity-weight relationship117			· ·	111
III.2.5. Egg diameter and spawning114III.2.6. Fecundity117III.2.6.1. Analysis of absolute fecundity-length relationship117III.2.6.2. Analysis of relative fecundity-length relationship117III.2.6.3. Analysis of absolute fecundity-weight relationship117		_	· · · · · · · · · · · · · · · · · · ·	114
III.2.6. Fecundity117III.2.6.1. Analysis of absolute fecundity-length relationship117III.2.6.2. Analysis of relative fecundity-length relationship117III.2.6.3. Analysis of absolute fecundity-weight relationship117				114
III.2.6.1. Analysis of absolute fecundity-length relationship117III.2.6.2. Analysis of relative fecundity-length relationship117III.2.6.3. Analysis of absolute fecundity-weight relationship117			1 0	
III.2.6.2. Analysis of relative fecundity-length relationship			•	
III.2.6.3. Analysis of absolute fecundity-weight relationship 117			· · · · · · · · · · · · · · · · · · ·	
			•	
III 2 6 4 Analysis of relative fecundity-weight relationship		.2.6.4.	Analysis of relative fecundity-weight relationship	117
III.2.7. Histological characteristics in ovary				
CHAPTER 5: DISCUSSION			· ·	
CHAPTER 6: SUMMARY				
CHAPTER 7: REFERENCES				
CHAPTER 8: ARABIC SUMMAREY				117
LIST OF TABLES				
LIST OF FEGURES				

### LIST OF TABLES

Table No.	<u>Title</u>	Page No.
1	The composition and chemical analysis of the experimental diet used during the study to feed larvae ( <i>M. cephalus</i> and <i>L. ramada</i> ).	27
2	Fatty acid composition (% of the total fatty acids) for lipid include in flathead mullet gonad ( <i>Mugil cephalus</i> ) at ripe stage	37
3	Average of weekly body weight (g) of flathead mullet larvae ( <i>Mugil cephalus</i> ) fed for eight weeks at five groups of treated <i>Artemia</i> with emulsified fish oil (2 and 4 g/million <i>Artemia</i> ) for 6 or 12 hour during the first experiment.	39
4	Average of survival rate (%) of flathead mullet larvae ( <i>Mugil cephalus</i> ) fed at five groups of treated <i>Artemia</i> for eight weeks with emulsified fish oil (2 and 4 g/million <i>Artemia</i> ) for 6 or 12 hour during the first experiment, before and after weaning.	43
5	Average of weight gain (mg) and specific growth rate (SGR%/day) of flathead mullet larvae ( <i>Mugil cephalus</i> ) fed at five groups of treated <i>Artemia</i> for eight weeks with emulsified fish oil (2 and 4 g/million <i>Artemia</i> ) for 6 or 12 hour during the first experiment, before weaning.	45
6	Average of final body weight (mg), weight gain (mg), total length (cm), condition factor (K) and specific growth rate (SGR%/day) of flathead mullet larvae ( <i>Mugil cephalus</i> ) fed at five groups of treated <i>Artemia</i> for eight weeks with emulsified fish oil (2 and 4 g/million <i>Artemia</i> ) for 6 or 12 hour during the first experiment, after weaning.	46
7	Average of moisture (%) and lipid (% of the dray weight) of flathead mullet larvae ( <i>Mugil cephalus</i> ) fed at five groups of treated <i>Artemia</i> for eight weeks with emulsified fish oil (2 and 4 g/million <i>Artemia</i> ) for 6 or 12 hour at the end of the first experiment.	49
8	Average of fatty acids % of the total fatty acids of flathead mullet larvae ( <i>Mugil cephalus</i> ) fed for eight weeks at five groups of treated <i>Artemia</i> with emulsified fish oil (2 and 4 g/million <i>Artemia</i> ) for 6 or 12 hour during the first experiment.	51
9	Average of saturated fatty acids % of the total fatty acids of flathead mullet larvae ( <i>Mugil cephalus</i> ) fed for eight weeks at five groups of treated <i>Artemia</i> with emulsified fish oil (2 and 4 g/million <i>Artemia</i> ) for 6 or 12 hour during the first experiment.	52
10	Average of monounsaturated fatty acids % of the total fatty acids of flathead mullet larvae ( <i>Mugil cephalus</i> ) fed for eight weeks at five groups of treated <i>Artemia</i> with emulsified fish oil (2 and 4 g/million <i>Artemia</i> ) for 6 or 12 hour during the first experiment.	53
11	Average of highly unsaturated fatty acids % of the total fatty acids of flathead mullet larvae ( <i>Mugil cephalus</i> ) fed for eight weeks at five groups of treated <i>Artemia</i> with emulsified fish oil (2 and 4 g/million <i>Artemia</i> ) for 6 or 12 hour during the first experiment.	54
12	Fatty acid composition (% of the total fatty acids) for lipid include in thinlip mullet ( <i>Liza ramada</i> ) ovary at ripe stage.	58

Table No.	<u>Title</u>	Page No.
13	Average of body weight (g) each 5 days of thinlip mullet larvae ( <i>Liza ramada</i> , Risso 1826) fed for fifty days at six groups of treated <i>Artemia</i> with emulsified fish oil (1 or 2 g./ million <i>Artemia</i> ), silica (0.15 ml Fortsil®/million <i>Artemia</i> ), and vitamin C (0.45 g ascorbic acid/million <i>Artemia</i> ) during the second experiment.	61
14	Average of survival rate (%) of thinlip mullet larvae ( <i>Liza ramada</i> , Risso 1826) fed for fifty days at six groups of treated <i>Artemia</i> with emulsified fish oil (1 or 2 g/ million <i>Artemia</i> ), silica (0.15 ml Fortsil®/million <i>Artemia</i> ), and vitamin C (0.45 g ascorbic acid/million <i>Artemia</i> ) during the second experiment before and after weaning.	65
15	Average of weight gain (WG) (mg) and specific growth rate (SGR%/d) of thinlip mullet larvae ( <i>Liza ramada</i> , Risso) fed for fifty days at six groups of treated <i>Artemia</i> with emulsified fish oil (1 or 2 g./ million <i>Artemia</i> ), silica (0.15 ml Fortsil®/million <i>Artemia</i> ), and vitamin C (0.45 g ascorbic acid/million <i>Artemia</i> ) during the second experiment before weaning.	66
16	Average of final body weight (FBW) (mg), weight gain (WG) (mg), total length (cm), condition factor (K) and specific growth rate (SGR%/d) of thinlip mullet larvae ( <i>Liza ramada</i> , Risso) fed for fifty days at six groups at treated <i>Artemia</i> with oil (1 or 2 g./ million <i>Artemia</i> ), silica (0.15 ml Fortsil®/million <i>Artemia</i> ), and vitamin C (0.45 g ascorbic acid/million <i>Artemia</i> ) during the second experiment after weaning.	67
17	Average of moisture (%) of thinlip mullet larvae ( <i>Liza ramada</i> , Risso 1826) fed at six groups at treated <i>Artemia</i> for fifty days with oil (1 or 2 g/ million <i>Artemia</i> ), silica (0.15 ml Fortsil <sup>®</sup> /million <i>Artemia</i> ), and vitamin C (0.45 g VC/million <i>Artemia</i> ) during the second experiment before and after weaning.	70
18	Average of the thinlip mullet larval body lipid content %DW of the second experiment according to the six treatments, (enriched <i>Artemia</i> with 1 or 2 g emulsified fish oil each without additives or with 0.15 ml Fortsil <sup>®</sup> as source of silica or 0.45 g ascorbic acid as (vitamin C)/million <i>Artemia</i> ) before and after weaning.	72
19	Average of fatty acids % of the total fatty acids of thinlip mullet larvae, <i>Liza ramada</i> , fed for fifty days at six groups of treated <i>Artemia</i> with emulsified fish oil (1 or 2 g/million <i>Artemia</i> ), silica (0.15 ml Fortsil®/million <i>Artemia</i> ), and vitamin C (0.45 g ascorbic acid/million <i>Artemia</i> ) during the second experiment, before weaning.	73
20	Average of saturated fatty acids % of the total fatty acids of thinlip mullet larvae, <i>Liza ramada</i> , fed for fifty days at six groups of treated <i>Artemia</i> with emulsified fish oil (1 or 2 g/million <i>Artemia</i> ), silica (0.15 ml Fortsil®/million <i>Artemia</i> ), and vitamin C (0.45 g ascorbic acid/million <i>Artemia</i> ) during the second experiment, before weaning.	74-75

Table	<u>Title</u>	Page No.
<u>No.</u> 21	Average of monounsaturated fatty acids % of the total fatty acids of thinlip mullet larvae, <i>Liza ramada</i> , fed for fifty days at six groups of treated <i>Artemia</i> with emulsified fish oil (1 or 2 g/million <i>Artemia</i> ), silica (0.15 ml Fortsil <sup>®</sup> /million <i>Artemia</i> ), and vitamin C (0.45 g ascorbic acid/million <i>Artemia</i> ) during the second experiment, before weaning.	76
22	Average of highly unsaturated fatty acids % of the total fatty acids of thinlip mullet larvae, <i>Liza ramada</i> , fed for fifty days at six groups of treated <i>Artemia</i> with emulsified fish oil (1 or 2 g/million <i>Artemia</i> ), silica (0.15 ml Fortsil®/million <i>Artemia</i> ), and vitamin C (0.45 g ascorbic acid/million <i>Artemia</i> ) during the second experiment, before weaning.	77
23	Average of fatty acids % of the total fatty acids of thinlip mullet larvae, <i>Liza ramada</i> , fed for fifty days at six groups of treated <i>Artemia</i> with emulsified fish oil (1 or 2 g/million <i>Artemia</i> ), silica (0.15 ml Fortsil®/million <i>Artemia</i> ), and vitamin C (0.45 g ascorbic acid/million <i>Artemia</i> ) during the second experiment, after weaning.	82
24	Average of saturated fatty acids % of the total fatty acids of thinlip mullet larvae, <i>Liza ramada</i> , fed for fifty days at six groups of treated <i>Artemia</i> with emulsified fish oil (1 or 2 g/million <i>Artemia</i> ), silica (0.15 ml Fortsil®/million <i>Artemia</i> ), and vitamin C (0.45 g ascorbic acid/million <i>Artemia</i> ) during the second experiment, after weaning.	83-84
25	Average of monounsaturated fatty acids % of the total fatty acids of thinlip mullet larvae, <i>Liza ramada</i> , fed for fifty days at six groups of treated <i>Artemia</i> with emulsified fish oil (1 or 2 g/million <i>Artemia</i> ), silica (0.15 ml Fortsil®/million <i>Artemia</i> ), and vitamin C (0.45 g ascorbic acid/million <i>Artemia</i> ) during the second experiment, after weaning.	85
26	Average of highly unsaturated fatty acids % of the total fatty acids of thinlip mullet larvae, <i>Liza ramada</i> , fed for fifty days at six groups of treated <i>Artemia</i> with emulsified fish oil (1 or 2 g/million <i>Artemia</i> ), silica (0.15 ml Fortsil®/million <i>Artemia</i> ), and vitamin C (0.45 g ascorbic acid/million <i>Artemia</i> ) during the second experiment, after weaning.	86
27	Monthly distribution of maturity stages in flathead mullet female <i>Mugil cephalus</i> throughout the period from January to December (2007).	91
28	The percentage distribution of the immature and mature flathead mullet female in <i>Mugil cephalus</i> throughout the period from January to December (2007).	92
29	Gonadosomatic indices (GSI) values of sexually mature flathead mullet female <i>Mugil cephalus</i> at different stags of maturation.	94
30	The maximum, minimum and average values of absolute fecundity in flathead mullet <i>Mugil cephalus</i> related to each total length throughout the period from January to December (2007).	97
31	The maximum, minimum and average values of relative fecundity in flathead mullet <i>Mugil cephalus</i> related to each total length throughout the period from January to December (2007).	98

Table No.	<u>Title</u>	Page No.
32	The maximum, minimum and average values of absolute fecundity in flathead mullet <i>Mugil cephalus</i> related to each gutted weight throughout the period from January to December (2007).	99
33	The maximum, minimum and average values of relative fecundity in flathead mullet <i>Mugil cephalus</i> related to each gutted weight throughout the period from January to December (2007).	100
34	Monthly distribution of maturity stages in thinlip mullet female <i>Liza</i> ramada through the period from May (2007) to April (2008).	112
35	The percentage distribution of the immature and mature female in thinlip mullet <i>Liza ramada</i> throughout the period from May (2007) to April (2008).	113
36	Gonadosomatic indices (GSI) values of sexually mature thinlip mullet female <i>Liza ramada</i> at different stags of maturation.	115
37	The maximum, minimum and average values of absolute fecundity in thinlip mullet <i>Liza ramada</i> related to each total length throughout the period from May (2007) to April (2008).	118
38	The maximum, minimum and average values of relative fecundit thinlip mullet <i>Liza ramada</i> related to each total length throughout period from May (2007) to April (2008).	119
39	The maximum, minimum and average values of absolute fecundity in thinlip mullet <i>Liza ramada</i> related to each gutted weight throughout the period from May (2007) to April (2008).	120
40	The maximum, minimum and average values of relative fecundity in thinlip mullet <i>Liza ramada</i> related to each gutted weight throughout the period from May (2007) to April (2008).	121

#### LIST OF FIGURES

Fig. No.	<u>Title</u>	Page No.
1	Concentration of fatty acids content in ovary of flathead mullet female ( <i>Mugil cephalus</i> ) at ripe stage.	38
2	The relationship between pooled means of body weight (g) of flathead mullet larvae ( <i>Mugil cephalus</i> ) and time (weeks) fed <i>Artemia</i> treated with 0, 2 and 4 g emulsified fish oil.	40
3	The relationship between pooled means of body weight (g) of flathead mullet larvae ( <i>Mugil cephalus</i> ) and time (weeks) fed <i>Artemia</i> treated with emulsified fish oil for 6 or 12 hour.	40
4	Average of weekly body weight (g) of flathead mullet larvae ( <i>Mugil cephalus</i> ) fed at five groups of treated <i>Artemia</i> for eight weeks with emulsified fish oil (2 and 4 g/million <i>Artemia</i> ) for 6 or 12 hour during the first experiment.	41
5	Average of survival rate (%) of flathead mullet larvae ( <i>Mugil cephalus</i> ) fed at five groups of treated <i>Artemia</i> for eight weeks with emulsified fish oil (2 and 4 g/million <i>Artemia</i> ) for 6 or 12 hour during the first experiment, before and after weaning.	43
6	Average of weight gain (mg) and specific growth rate (SGR%/day) of flathead mullet larvae ( <i>Mugil cephalus</i> ) fed at five groups of treated <i>Artemia</i> for eight weeks with emulsified fish oil (2 and 4 g/million <i>Artemia</i> ) for 6 or 12 hour during the first experiment, before weaning.	45
7	Average of weight gain (mg), final body weight (mg), total length (cm), condition factor (K) and specific growth rate (SGR%/day) of flathead mullet larvae ( <i>Mugil cephalus</i> ) fed at five groups of treated <i>Artemia</i> for eight weeks with emulsified fish oil (2 and 4 g/million <i>Artemia</i> ) for 6 or 12 hour during the first experiment, after weaning.	47
8	Average of moisture (%) and lipid (% of the dray weight) of flathead mullet larvae ( <i>Mugil cephalus</i> ) fed at five groups of treated <i>Artemia</i> for eight weeks with emulsified fish oil (2 and 4 g/million <i>Artemia</i> ) for 6 or 12 hour at the end of the first experiment.	49
9	Average pooled means of saturated and unsaturated fatty acids (% of the total fatty acids) of flathead mullet larvae ( <i>Mugil cephalus</i> ) fed <i>Artemia</i> treated with 0, 2 and 4 g emulsified fish oil.	55
10	Average pooled means of monounsaturated, omega-6 and omega-3 fatty acids (% of the total fatty acids) of flathead mullet larvae ( <i>Mugil cephalus</i> ) fed <i>Artemia</i> treated with 0, 2 and 4 g emulsified fish oil.	55
11	Average pooled means of saturated and unsaturated fatty acids (% of the total fatty acids) of flathead mullet larvae ( <i>Mugil cephalus</i> ) fed <i>Artemia</i> treated with emulsified fish oil for six and twelve hour.	55