UNIVERSITI PUTRA MALAYSIA

EARLY DEVELOPMENT OF Rutilus frisii kutum KAMENSKII LARVAE WITH EMPHASIS ON THE ONTOGENY OF DIGESTIVE TRACT

MAHDIEH JAFARI

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By

MAHDIEH JAFARI

Thesis submitted to the School of Graduates Studies, Universiti Putra Malaysia, in Fulfilment of the Requirements for the Degree of Doctor of Philosophy

December 2011

DEDICATION

I would like to dedicate this thesis with love to

The memory of my father "MOHAMMAD TAGHI JAFARI"

To keep his spirit alive

My dear mother Shokat Farah Avar

My adorable brother,

Mohammad

and

my darling sister,

Erfaneh

for their love, constant truth and assistance during my difficulties

Abstract of thesis presented to the Senate of Universiti Putra Malaysia in fulfilment of the requirement for the degree of Doctor of Philosophy

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December 2011

Chairman: Mohd. Salleh Kamarudin, PhD

Faculty: Agriculture

A series of experiments on the early development of Caspian kutum (*Rutilus frisii kutum*) larvae including the morphological and histological development of mouth and gut were conducted to determine the suitable feed type and size for the kutum larviculture and fry production on the basis of their morphological features. The embryonic and larval development of kutum were studied under hatchery conditions at 14-16º C using eggs were obtained through induced spawning of broodstock. Samples were taken every hour during the fertilization for two days and then six times per day till hatching (9 days). After hatching, daily observations were made until the fingerling stage. Nine main stages (zygote, cleavage, morula, blastula, gastrula, neurula, segmentation, pharyngula and hatching) and 30 sub-stages were observed during the embryonic development of kutum while three main stages and eighteen sub-stages were noted after the hatching until the juvenile stage. The mouth

and gut development were monitored using light microscopy after haematoxylin-eosin (H&E) staining. The larvae were first fed with egg yolk for 5 days and followed with *Artemia* nauplii and egg yolk until the end of 30-days. Ten to twenty larvae were daily sampled from hatching to 3 days after hatch (DAH) and thereafter at every 3 days until 30 days. The larval mouth opened at 3 DAH and the mouth size was 145 ± 15.01 µm at 90º opening. A strong linear relationship between mouth size and total length was established. The digestive system was made of an undifferentiated straight tube at hatch and the system became sectioned into buccopharynx, oesophagus and intestine as the larva grew. Goblet cells in oesophagus were observed at 5 DAH and increased in number between 7 to 15 DAH. The first goblet cells appeared in the intestine at 7 DAH and increased in number and became abundant with the differentiation of intestinal mucosa from 10 to 20 DAH. A swimbladder was connected to the oesophagus via a pneumatic duct which can be seen from 1 DAH. Liver and pancreas were observed at 2 DAH and their ontogenetic changes were observed during the larval growth.

The effects of diets on histological changes in digestive tract, growth, survival, body composition and digestive enzyme activities of kutum larvae were also studied. Larvae were fed for 30 days on three diets (egg yolk, *Artemia* nauplii, *Artemia* plus egg yolk) and starved in triplicates. No significant histological differences were observed in the intestine development of larvae at 5, 10 and 15 days among the feeding larvae. Starved larvae had smaller size and shape intestine. Larvae fed with *Artemia* plus egg yolk had significantly higher ($P<0.05$) final mean total length and body weight (28.6 ± 0.18 mm and 74 ± 3.64 mg, respectively) and the highest survival rate (70.9 ± 2.1%). The activities of digestive enzymes were detected at the

start of exogenous feeding. Protease activity increased with growth after 21 DAH. Specific pepsin content peaked between 5-7 DAH and then decreased in all treatments. No significant differences in total chymotrypsin activity were observed between larvae fed on *Artemia* and egg. The total lipase activity generally increased with the larval development. These findings suggested that Caspian kutum larvae should be able to ingest, digest and absorb food particles within 50- 100 µm Ø from 3 DAH onwards. The functional alimentary tract of kutum larvae was completed by the 30 DAH. A combination diet of *Artemia* and egg yolk was the best for the culture of kutum during early life stages. Further studies on the larval feed development should be conducted to improve the production and quality of kutum fry.

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia sebagai memenuhi keperluan untuk Ijazah Doktor Falsafah

PERKEMBANGAN AWAL LARVA *Rutilus frisii kutum* KAMENSKI, DENGAN PENEKANAN KEPADA ONTOGENI SALURAN PENGHADAMAN

Oleh

MAHDIEH JAFARI

Disember 2011

Pengerusi: Mohd. Salleh Kamarudin, PhD

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Satu siri eksperimen terhadap perkembangan awal larva ikan kutum Kaspian (*Rutilus frisii kutum*) termasuk perkembangan morfologi dan histologi mulut dan saluran pencernaan telah dilakukan untuk menentukan jenis dan saiz makanan yang sesuai bagi larvikultur dan pengeluaran fri ikan kutum berdasarkan ciri morfologi. Perkembangan embrio dan larva ikan kutum dalam persekitaran hatceri pada 14- 16º C dikaji menggunakan telur yang diperolehi secara pembiakan aruhan. Persampelan dilakukan setiap satu jam sewaktu peringkat persenyawaan selama dua hari diikuti sebanyak enam kali sehari sehingga peringkat penetasan (9 hari). Selepas penetasan, pemerhatian harian dilakukan sehingga ke peringkat jejari. Sembilan peringkat utama (zigot, belahan, morula, blastula, gastrula, neurula, segmentasi, pharyngula dan penetasan) dan 30 sub peringkat diperhatikan sewaktu perkembangan embrio ikan kutum manakala tiga peringkat utama dan 18 sub-peringkat didapati selepas penetasan sehingga peringkat juvenil. Perkembangan mulut dan saluran pencernaan dipantau menggunakan mikroskopi cahaya setelah diwarnakan menggunakan

hematoksilin-eosin (H&E). Larva diberi makan kuning telur selama 5 hari dan diikuti dengan naupli Artemia - kuning telur sehingga hari ke 30. Sepuluh hingga dua puluh larva dari peringkat penetasan hingga 3 hari selepas penetasan (DAH) telah disampel setiap hari dan seterusnya disampel pada setiap 3 hari sehingga 30 hari. Mulut larva membuka pada 3 DAH dengan saiz mulut 145 ± 15.01 μm pada pembukaan 90º. Terdapat hubungan linear yang kukuh antara saiz mulut dan panjang keseluruhan. Sistem pencernaan larva berbentuk tiub lurus semasa peringkat penetasan dan sistem itu menjadi bahagian bukofarink, esofagus dan usus apabila larva membesar. Sel goblet kelihatan dalam esofagus pada 5 DAH dan bertambah bilangannya di antara 7 hingga 15 DAH. Sel pertama muncul di dalam usus pada 7 DAH dan bilangan sel bertambah dan menjadi semakin banyak dengan pembezaan mukosa usus dari 10 hingga 20 DAH. Pundi renang bersambung ke esofagus melalui saluran pneumatik yang boleh dilihat dari 1 DAH. Hati dan pancreas kelihatan pada 2 DAH dan perubahan ontogenetik diperhatikan sepanjang pertumbuhan larva.

Kesan diet ke atas perubahan histologi saluran pencernaan, pertumbuhan, kemandirian, komposisi badan dan aktiviti enzim pencernaan larva ikan kutum telah juga dikaji. Larva diberi makan tiga diet (kuning telur, naupli Artemia, dan *Artemia* - kuning telur) dan dilaparkan selama 30 hari dalam triplikat. Tiada perbedaan histologi yang ketara dilihat dalam perkembangan usus larva yang diberi makanan pada hari 5, 10 dan 15. Larva yang dilaparkan mempunyai saiz dan bentuk usus yang lebih kecil. Larva yang diberi *Artemia* - kuning telur mempunyai panjang keseluruhan dan berat badan akhir (28,6 ± 0,18 mm dan 74 ± 3,64 mg, masing-masing) yang ketara lebih tinggi ($P<0.05$) serta kadar kemandirian yang tertinggi (70.9 ± 2.1%). Aktiviti enzim pencernaan dikesan pada permulaan pemakanan

eksogenus. Aktiviti protease meningkat dengan pertumbuhan terutamanya selepas 21 DAH. Kandungan spesifik pepsin memuncak pada 5-7 DAH dan kemudian menurun pada semua rawatan. Tiada perbezaan ketara dalam aktiviti keseluruhan kimotripsin diperhatikan antara larva yang diberi *Artemia* dan kuning telur. Aktiviti keseluruhan lipase secara amnya meningkat dengan perkembangan larva. Penemuan kajian ini menunjukkan bahawa larva ikan kutum Kaspian berupaya untuk memakan, mencerna serta menyerap partikel makanan dalam julat 50 - 100 μm Ø bermula dari 3 DAH. Saluran pencernaan larva ikan kutum yang berfungsi menjadi lengkap pada 30 DAH. Campuran *Artemia* dan kuning telur merupakan makanan terbaik untuk pengkulturan ikan kutum di peringkat awal hidupnya. Kajian lanjut mengenai pembangunan makanan larva perlu dilakukan untuk mempertingkatkan pengeluaran dan kualiti fri ikan kutum.

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I certify that a Thesis Examination Committee has met on 23rd December 2011 to conduct the final examination of Mahdieh Jafari on her thesis entitled "Early development of Caspian kutum (*Rutilus frisii kutum* kamenskii, 1901) larvae with an emphasis on the development of larval digestive tract" in accordance with Universities and University Colleges Act 1971 and Constitution of the Universiti Putra Malaysia [P.U. (A) 106] 15 March 1998. The Committee recommends that the student be awarded the Doctor of Philosophy.

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This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the degree of Doctor of Philosophy. The members of the Supervisory Committee were as follows:

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DECLARATION

I declare that the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

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MAHDIEH JAFARI

Date: 23 December 2011

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µm	Micro meter
A	Anal
Af	Anal fin
ai	anterior intestine
b	blastomers
b	buccopharynx
bb	basibrancial
Bb	Brush border
Bc	Buccal cavity
bl	blastula
BV	blood vessel
C	Cranium
cb	ceratobranchial
Ce	cuboidal epithelium
cm	centimeter
Cr	cephalic region
CRD	completely randomized design
DAF	Days after fertilization
DAH	Days after hatching
Df	Dorsal fin
E	embryo
e	eye
g	gram
G	gut tube
G	glycogen
Gb	Gas bladder
Gc	Goblet cell
GL	Gut length
Gr	germ ring
H	head
h	heart

H & E	Hematoxylin & Eosin
hb	hypobranchial
He	hepatocytes
I	intestine
Il	islet of Langerhance
IS	intracellular
IV	intestinal valve
kg	Kilogram
km	kilometer
km^2	Square kilometer
km^3	Cubic kilometer
L	liver
Li	lipid
LJ	Lower jaw
Ll	Lateral line,
lp	lamina propria
LV	lipid vacuoles
m	myomere
m	maxilla
M	mouth
Ma	Mandible
mc	meckel's cartilage
mc	mucus cell
MF	myomere fiber
mm	millimeter
MU. C	mucus cell
Mv	Microvilli
N	notochord
n	Nostril
oc	otic capsul
ºC	Degree centigrade
Oe	oesophagus
op	optic vesicle

Op	Operculum
Ov	optic vesicle
P	preblast
P	pancreas
pd	pneumatic duct
PD	pancreatic duct
pe	posterior oesophagus
Pef	Pelvic fin
Pf	Pectoral fin
pg	pigmentation
pi	posterior intestine
Pm	Pre maxilla
R	Rectum
RGI	Relative gut index
S	Somite
Sm	submucosa
s	sinusoids
SB	swimblader
SV	supranuclear
T	Tail
tb	taste bud
TL	Total length,
UJ	Upper jaw
Y	Yolk

CHAPTER 1

INTRODUCTION

1.1 Background of the Study

The Caspian Sea is the unique lake on the Earth with a surface area of 371,000 km^2, a volume of 78,200 km^3 and covers a coast line of 1200 km long, and the width varies between 204 and 566 km (Froehlich *et al.*, 1999). It is a delimit basin (without outflows) and is bordered by southern Russia, western Kazakhstan and Turkmenistan, northern Iran and eastern Azerbaijan. The maximum depth of the Caspian Sea is about 1025 meters (Zaidi and Mustafaev, 2003). Its salinity is about 12.7 ppt, approximately a third of the salinity of most seawater (CEP, 2004).

The Caspian Sea has a high economic value in terms of the natural resources. About 130 fish species live in the Caspian Sea. Some of which are commercially important, including the five unique sturgeon species, namely the beluga sturgeon (*Huso huso*), the Persian sturgeon (*Acipenser persicus*), the Russian sturgeon (*Acipenser gueldenstaedtii*), the Ship sturgeon (*Acipenser nudiventris*) and the Stellate sturgeon (*Acipenser stellatus*). In addition bony fishes present are Caspian kutum (*Rutilus frisii kutum*), mullets (*Mugil auratus* and *M. saliens*), breams (*Abramis brama*), carps (*Cyprinus carpio*), salmons (*Salmo trutta caspius*), Pike-perch (*Lucioperca lucioperca*), Roach (*Rutilus rutilus*), and kilka fish (*Clupeonella delicatula, C. engrauliformis, C. grimmi*). After the sturgeon fish, the Caspian kutum is the second commercially important fish in the Caspian Sea (Coad, 1979).

This species is a migratory fish, similar to most of Caspian Sea fishes and it migrates to fresh water river for spawning (Derzhavin, 1934; Azari, 1979). The Caspian kutum is an anadromous fish with three populations (one autumn form and two spring forms). The spring forms enter the rivers in March to April and autumn form enters the rivers in November to December (Razavi, 1997; Abdoli, 1999). However, the spring population of kutum stock faced a decline since early 1950s resulting in a significant drop in the catch (CEP, 2002).

Factors contributing to the decline in kutum population and catch (1950-1980) include illegal fishing during spawning season, over-exploitation of kutum resources, hydro- electricity engineering buildings (dams) as well as redistribution of water for agriculture fields' irrigation that caused changes the normal hydrological cycle. The releases of agricultural pesticides, domestic sewage and industrial pollutions into the rivers also have led to the deterioration of the water quality of natural habitats while sand removal from river bottom for building construction destroyed the spawning substrates. All these factors plus the illegal fishing and use of nets with smaller than the permitted mesh size have threatened the Caspian kutum stocks.

The Iran Fisheries Organization (IFO) has decided to restore the depleted spring forms stocks kutum in the Caspian Sea. Caspian kutum artificial breeding for releasing fingerlings had actually been attempted in 1939 for three rivers in Iran. The number was small and accurate data was not recorded. Faridpak in (1961) conducted an experimental on restocking of fingerlings in several rivers in the south Caspian Sea basin. Emadi (1979) reported that 28-44 million fingerlings were released in year 1979. Following the drastic decline in kutum stocks in 1980-81 when kutum catches

reached less than 500 tons in a year, the Guilan Fisheries Research Center has been tasked to develop a practical artificial breeding program for the spring form kutum.

The stock conservation program for kutum was started in 1979 when the fingerlings of the spring population of this species were released to rivers that has successfully increased to kutum stocks (Azari, 1991). Since then artificial breeding and the release of kutum fingerlings have been included in annual activities of the Iranian Fisheries Organization until today. Fingerlings are released to improve natural spawning in few areas and raising the water level which had contributed to increase stocks (IFRO, 2010) .

1.2 Statement of Problems

At the present, three government hatcheries (Shahid Ansari in Guilan Province, Shahid Rajaee in Mazandaran Province and Sijoval in Golestan Province in the south of Caspian Sea) are responsible to propagate and release spring forms of kutum fingerlings (Abdolhay, 1997). As mentioned earlier Caspian kutum is the most popular fish with the highest economic value consumed by the Iranian people. Kutum population in the Caspian Sea is now dominated by the stocks produced from artificial breeding programs. Although restocking enhancement plays a significant role in revitalization the kutum population and fishery in the Caspian Sea, recent studies showed that the decrease in the average weight of released Caspian kutum from 1.56g in 1992 to 0.7g in 1998 has resulted in lowering survival coefficient and decreasing the annual kutum catch (Afraei *et al.*, 2010; IFRO, 2000, 2010).

In the present artificial breeding practices, no selection program is involved in choosing Caspian kutum male and female broodstocks which subsequently will cause the loss the gene bank of this species. Loss of variation in genetic stocks and the gradual depletion of the gene bank are parameters of great concern in the long run. The decrease in growth rate, mean length and fecundity and the increase in the number of abnormal larvae will become evident to the next 25 to 40 years (Pourkazemi, 2000).

Rearing of fish larvae is the most critical stage in the aquaculture in which the balance between rapid fish growth and optimum use of food should be considered. In kutum larval culture, feeding management is very important because suitable or correct feeding will increase the survival and growth of fish (Haghighi, 2006; Fallahi *et al.*, 2009; Gholami, 2010). Survival rate of fingerlings in the first years of life depends on their weight and quality at the time of release into the sea (Steiger and Schulz, 1989).

In Iran, two hundred million fingerlings of Caspian Kutum, with an average of one gram weight of fingerlings are released to open ecosystem annually, although, high percentages of larvae die before reaching the fingerling stage. Some of them needs a longer time to reach to this stage and some are remain underdeveloped (Fallahi *et al.*, 2009). Heavy mortality in fish larvae occurs in early life stage because lack of suitable foods which subsequently leads fish larvae to a point no return (PNR) even under good conditions (Fallahi *et al.*, 2009). Furthermore, feeding of fish larvae is strongly relevant to food size in relation to mouth size and gut structure of larvae

(Keast and Webb, 1966; Person *et al.*, 1993; Kohinoor *et al.*, 1995; Ghada Ahmed, 2000).

Studies on Caspian kutum larvae feeding (Effatpanah, 1992; Haghighi, 2006; Afraei *et al.*, 2009; Fallahi *et al.*, 2009) gave some useful information. However, a major gap remains on kutum larval nutritional requirements and digestive tract physiology. These lack of knowledge have caused high mortality and low quality larvae, which commonly observed in kutum hatchery in Iran as reported by Kazeroni (1996) and Fallahi *et al.* (2009).

1.3 Significance of Study

Knowledge of larviculture conditions is required for a successful rearing through the critical periods of fish larvae in early life stages such as fertilization, hatching, and nursery. Suitable behavioral development and the ability to rear preferred larval food sources consistently in large quantities are required for the growth and success of the commercial fish aquaculture industry.

Significant progression of normal embryogenesis allows an early screening of hatchery production runs, which can help establish the value of broodstock fish, and assist decision making on the distribution of resources such as rearing environment to different sets of embryo. Embryology can help to improve comparative studies with other species. To date, there is no published data about the early development of *R. frisii kutum* in hatchery conditions, histology and morphology of mouth and gut

development, relationship between the mouth size and gut, and suitable size of food during larval stages digestive enzyme.

As feeding of fish larvae is strongly affected by food particle size, mouth size and gut structure, study on mouth and gut system is necessary for Caspian kutum rearing in intensive culture. Understanding of nutritional physiology of fish larvae, the knowledge on the development of the alimentary tract and its function during ontogenetic development is vital and recommended for nursery and pond culture (Segner *et al.*, 1993). Information on the beginning time of the full function digestive tract also shows the best time for larvae releasing to the sea.

1.4 Objectives of Study

The objectives of this study were:

i. To describe embryonic development in early life stage of Caspian kutum.

ii. To examine development of mouth and gut morphology and histology in Caspian kutum larvae.

iii. To determine the effects of diets on histological features of digestive system, growth, survival and body composition.

iv. To determine ontogenetic changes of some digestive enzymes of Caspian kutum larvae.

REFERENCES

Abbasi, K., Valipour, A., Talebi Haghighi, D., Sarpanah, A., and Nezami, S. (1999). *Atlas of Fishes in Iran* (*Inland waters of Guilan*). Bandar Anzali: Gilan Fisheries Research Center.

Abdolhay, H. A. *Artificial reproduction of fish for stock enhancement in south of the Caspian Sea*. Paper presented In Seventh Conference of Shilat, responsible fisheries. Iranian Fisheries (in Farsi), Tehran, Iran. 17–18 February 1997.

Abdolhay, H. A., Daud, S. K., Rezvani Ghilkolahi, S., Pourkazemi, M., Siraj, S. S., and Abdul Satar, M. K. (2010). Fingerling production and stock enhancement of Mahisefid (*Rutilus frisii kutum*) lessons for others in the south of Caspian Sea. *Review of Fish Biology Fisheries* 13: 177-185.

Abdoli, A. (1999). The Inland Water Fishes of Iran. Tehran, Iran: Natural and Wild Life Museum of Iran Publishers (In Farsi).

Abdolmaleki, S. (2006). Trends in stocks fluctuation of *Rutiluse frisii kutum* in the Caspian Sea. *Iranian Scientific Fisheries Journal* 15: 103–114.

Abdolmaleki, S., and Ghaninezhad, D. (2007). Stock assessment of the Caspian Sea kutum (*Rutilus frisii kutum*) in Iranian coastal waters of the Caspian Sea. *Iranian Scientific Fisheries Journal* 16(1): 103-114 (In Farsi).

Abdurakhmanov, Y. A. (1962). Fish of freshwater bodies of Azerbaijan (pp.89-96). SSSR: Azerbaijan.

Abi-Ayad A., and Kestemont P. (1994). Comparison of the nutritional status of goldfish (*Carassius auratus*) larvae fed with live, mixed or dry diet. *Aquaculture* 128(1-2): 163- 176.

Abraham, F. B., Anton, J. I., and Bartley, D. M. (2004). Marine and coastal stocking: global status and information needs. Marine Ranching FAO Fisheries Technical Paper. Rome: FAO.

Afraei, M. A., Mansor, M., Abdolmalaki, S., Keymaram, F., Isa, M., and Janbaz, A. A. (2010). Age and growth of kutum (*Rutilus frisii kutum*, Kamenskii, 1901) in southern Caspian Sea. *International Aquatic Research* 2: 25-33.

Afraei, M. A., Mashhor, M., Abdolmaleki, S., and EL-Sayed, A. F. M. (2009). Food and feeding habits of the Caspian kutum, *Rutilus frisii kutum* (Cyprinidae) in Iranian waters of the Caspian Sea. *Cybiu* 33(3): 193-198.

Afraei, M. A., Mashhora, M., Khooa, K. H., Abdolmalakic, S., Fazlib, H., and Janbazb, A. A. (2008). Some Biological Characteristics of the Caspian Kutum, *Rutilus frisii kutum* (Cyprinidae) of the Southern Caspian Sea. Paper presented at the International Conference on Environmental Research and

Technology. Penang, pp. 494-497. Malaysia. Penang: Universiti Sains Malaysia.

Ahlstrom, E. H. (1968). Review "Development of fishes of the Chesapeake Bay region, an atlas of egg, larval, and juvenile stages" part1. *Copeia* 1: 648-651.

Al-Hussaini, A. H. (1949). On the Functional Morphology of the Alimentary Tract of Some Fish in Relation to Differences in their Feeding Habits: Anatomy and Histology. *Journal Microscopical Science* 90(2): 109-139.

Alarcón, F. J., Martinez, T. F., Diaz, M., and Moyano, F. J. (2001). Characterization of digestive carbohydrase in the gilthead sea bream (*Sparus aurata*). *Hydrobiologia* 445: 199-204.

Alvarez-González, C. A., Cervantes-Trujano, M., Tovar-Ramírez, D., Conklin, D. E., Nolasco, H., Gsibert, E., and Piedrahita, R. (2006). Development of digestive enzymes in California halibut *Paralichthys californicus* larvae. *Fish Physiology Biochemistry* 31: 83-93.

Amornsakun, T. (1999). Some aspects in early life stages of larval red-tail catfish, *Mystus wyckioides Songklanakarin*. *Journal of Science Technology* 21(4): 401-406.

Amornsakun, T., and Hassan, A. (1996). Aspect in early life stage of larval red snapper, *Lutjanus argentimaculatus* (Forskal). *Journal of Science Technology* 18: 9-15.

Amornsakun, T., Sriwatana, W., and Chamnanwech, U. (2002). Some aspects in early life stage of sand goby, *Oxyeleotris marmoratus*. Songklanakarin. *Journal of Science Technology* 24(4): 611-619.

AOAC. (1995). AOAC.Official Methods of Analysis.16th ed. Washington, DC.: AOAC International.

Appelbaum, S. (1995). Interactions between feed and feeding behaviour in larval fish. Proceedings of Aquatech '95. (Harrison, K.E. & Waddy, S.L. eds). *Bull. Aquaculture Association of Canada* 2, 20–24.

Arul, V. (1991). Effects of delayed feeding on growth and survival of *Channa striatus* (Bloch) larvae. *Aquatic Fisheries Management* 22: 423-434.

Azari, G. (1979). Taiin hamavari mahi sefid, *Rutilus frisii kutum* (in Farsi with English abstract) *Journal of Faculty of Veterinary Medicine, University of Tehran* (35): 66–78.

Azari, G. (1990). *The nutritional value of Artemia in feeding Acipenseridae*. Paper presented at the The Collection of Papers on Proper Exploitation of Caspian Fish Reserves. Iran- Tehran (pp 509-523). National Conferences in Iran Shilat. May 20-22, 1990.

Azari, G. (1991). Rearing of mahi sefid larvae, *Rutilus frisii kutum* for fish stocking in the southern part of the Caspian Sea. Paper presented at the International Symposium of Larviculture. Gent Belgium: August 27-30, 1991.

Azari, G. Razavi, B., and Hosseinpoor, N. (1990). A study on artificial propagation and culturing of white fish *Rutilus frisii kutum* (Kamenskii) in Iran. *Journal of Veterinary Faculty, University of Tehran* 45(1): 454-467.

Azari Takami, G. (1990). *The nutritional value of Artemia in feeding Acipenseridae*. Paper presented at the The Collection of Papers on Proper Exploitation of Caspian Fish Reserves, National Conferences in Iran Shilat. May 20-22, 1990.

Bagarinao, T. (1986). Yolk resorption, onest of feeding and survival potential of larvae of three tropical marine fish species reared in the hatchery. *Marine Biology* 91(4): 449-459.

Baglole, C. J., Murray, H. M., Goff, G. P., and Wright, G. M. (1997). Ontogeny of the digestive tract during larval development of yellowtail flounder: a light microscopic and mucous histochemical study. *Fish Biology* 51(1): 120-134.

Balon, E. (1975). Terminology of intervals in fish development. *Journal Fisheries Research Board Canada* 32: 1663-1670.

Banerji, S. R. (1974). Hypophysation and life history of *Channa punctatus* (Bloch). *Journal of the Inland Fisheries Society of India* 16: 62-73.

Barrington, E. J. W. (1975). The alimentary canal and digestion. In Brown E. M. (Ed.), *The Physiology of Fishes* (pp. 109-161). New York: Academic Press.

Bartley, M. D., and Rana, K. (1998). Iran Promotes Aquaculture Development. FAO Aquaculture Newsletter (Vol. 19).

Behzadi, S. (1991). Normal development of *Rutilus frisii kutum.* Master of Science Thesis. Islamic Azad University.

Berg, L. S. (1948). Freshwater fishes of USSR and adjacent countries. USSR: Trudy Institute Aced. Nack USSR. Guide to the Fauna of the USSR No. 27. Vol. 1, 504 pp. Jerusalem: Israel Program for Scientific Translations Ltd.

Bernfeld, P. (1955). Amylase, alpha and beta. *Methods Enzymology*. In: Colowick SP, Kaplan NO (Eds.), Methods in Enzymology, vol. 1 (pp.149-158). New York:Academic Press.

Berry, P. Y., and Low, M. P, (1970). Comparative Studies on Some Aspects of the Morphology and Histology of *Ctenopharyngodon idellus*, *Aristichthys nobilis*, and Their Hybrid (*Cyprinidae*). *Copeia* 4: 708-726.

Bisbal, G. A., and Bengtson, D. A. (1955). Development of the digestive tract in larval summer flounder. *Journal of Fish Biology* 47(2): 277-291.

Bisbal, G. A., and Bengtson, D. A. (1995). Effect of delayed feeding on survival and growth of summer flounder (*parolichthys dentatus*) larvae. *Marine Ecology Progress Series* 121(301-306).

Bitterlich, G. (1985a). Digestive enzyme pattern of two stomachless filter feeders, silver carp. *Hypophthalmichthys molitrix* Val., and bighead carp, *Aristichthys nobilis* Rich. *Journal of Fish Biology* 27(2): 103-112.

Bitterlich, G. (1985b). The nutrition of stomachless phytoplanktivorous fish in comparison with tilapia. *Hydrobiologia* 121(2): 173-179.

Blaxter, J. H. S. (1988). Pattern and variety in development. In Fish Physiology. In Hoar W. S. & Randall D. J. (Eds.), *The Physiology of Developing Fish* (Vol. XIA, pp. 1-58). New York: Academic Press.

Boehlert, G. W., and Kusakari, M. (1986). Energetics during embryonic development in kurosoi, *Sebastes schlegefi* Hilgendorf. *Journal of Experimental Marine Biology Ecology* 101: 239-256.

Bolasina, S., Pérez, A., and Yamashita. (2006). Digestive enzyme activity during ontogenetic development and effect of starvation in Japanese flounder, *Paralichthys olivaceus*. *Aquaculture* 252(2-4): 503-515.

Borlongan, I. G. (1990). Studies on the digestive lipases of milkfish, *Chanos chanos*. *Aquaculture* 89(3-4): 315-325.

Boulhic, M., and Gabaudan, j. (1992). Histological study on the organogenesis of the digestive system and swim bladder of the Dover sole, *Solea solea* (Linnaeus, 1758). *Aquaculture* 102(4): 373-396.

Bucke, D. (1971). The anatomy and histology of the alimentary tract of the carnivorous fish the pike *Esox lucius* L. *Fish Biology* 3: 421–431.

Buddington, R. K. (1985). Digestive secretions of lake sturgeon, *Acipenser fulvescens*, during early development. *Fish Biology* 26: 715-723.

Buddington, R. K., and Doroshov, S. I. (1986). Digestive enzyme complement of white sturgeon (*Acipenser transmontanus*). *Comparative Biochemistry and Physiology* 83A: 561-567.

Cahu, C. L., and Infante, J. L. Z. (2001). Subtitution of live food by formulated diets in marine fish larvae. *Aquaculture* 200(1-2): 161-180.

Cahu, C. L., and Zambonino Infante, J. L. (1997). Is the digestive capacity of marine fish larvae sufficient for compound diet feeding? *Aquaculture International* 5: 151-160.

Cara, J. B., Moyano, F. J., Cárdenas, S., Fernández-Díaz, C., Yúfera, M., and Magomedov G. (2003). Assessment of digestive enzyme activities during larval development of white bream. *Fish Biology* 63: 48-58.

Carneiroi, P., MikosI, J. D., SchorerI, M., FilhoI, P., and Bendhackii, F. (2003). Live and formulated diet evaluation through initial growth and survival of jundiá larvae, Rhamdia quelen. *Journal Sciences Agriculture* (*Piracicaba, Braz.*) 60(4): 615-619.

CEP. (2002). Caspian Sea transboundary diagnostic analysis, Caspian Environmental Program, from http://www.caspianenvironment.org/caspian.htm. Accessed 2006 November 28.

CEP. (2004). Caspian Sea - General background from http://www.caspianenvironment.org/caspian.htm. Accessed 2008 October 12.

CEP. (2007). Caspian Sea, general background from http://www.caspianenvironment.org/caspian.htm. Accessed 2008 October 12.

Chai, Y., Xie, C., and Wei, Q. W. (2011). Yolk-sac absorption and point of no return in Chinese sturgeon *Acipenser sinensis* larvae. *Journal of Applied Ichthyology* 27: 687–689.

Chakrabarti, R., Rathore, R. M., and Kumar, S. (2006). Study of digestive enzyme activities and partial characterization of digestive proteases in a freshwater teleost, *Labeo rohita*, during early ontogeny. *Aquaculture Nutrition* 12(1): 35-43.

Chantanachookhin, C., Seikai T, and M., T. (1991). Comparative study of the ontogeny of the lymphoid organs in three species of marine fish. *Aquaculture* 99: 143-150.

Cheah, S. H., Sharr, H. A., Ang. KJ., and Kabir. A. (1985). An Evaluation of the Use of Egg Yolk, *Artemia* nauplii, Microworms and Moina as Diets in Larval Rearing of Helostoma temmincki Cuvier and Valenciennes. *Pertanika* 8(1): 43-51.

Chen, B. N., Qin, J. G., Kumar, M. S., Hutchinson, W. G., and Clarke, S. M. (2006). Ontogenetic development of the digestive system in yellowtail kingfish *Seriola lalandi* larvae. *Aquaculture* 256: 489-501.

Chong, A. S. C., Hashim, R., Chow-Yang, L., and Ali, A. B. (2002). Partial characterization and activities of proteases from the digestive tract of discus fish (*Symphysodon aequifasciata*). *Aquaculture* 203: 321-333.

Chow, M., Chen, F., and SIM, B. K. (1969). Induced spawning of the three major chinese carps in Malacca, Malaysia. Malay. *Agriculture* 47(2): 211-238.

Coad, B. W. (1979). A provisional, annotated check-list of the freshwater fishes of Iran. *Journal of the Bombay Natural History Society* 76(1); 86-105.

Cousin, J. C. B., and Baudin-Laurencin, F. (1985). Morphogenese de l'appareil digestif de la vessie gazeuse du turbot, *Scophthalmus maximus* L. *Aquaculture* 47: 305 – 319.

Cousin, J. C. B., Baudin-Laurencin, F., and Gabaudan, J. (1987). Ontogeny of enzyme activities in fed and fasting turbot, *Scophthalmus maximus* L. *Fish Biology* 30: 15-33.

Crespo, N., and Esteve-Garcia, E. (2001). Dietary fatty acid profile modifies abdominal fat deposition in broiler chickens. *Pollution Science Journal* 80: 71-78.

Cunha, I., and Planas, M. (1999a). Optimal prey size for early turbot larvae (*Scophthalmus maximus L.*) based on mouth and ingested prey size. *Aquaculture* 175(8): 103-110.

Cunha, I., and Planas, M. (1999b). Optimal prey size for early turbot larvae, *Scophthalmus maximus* L. based on mouth and ingested prey size. *Aquaculture* 175: 103-110.

Cunha I., and Planas, M. (1999). Optimal prey size for early turbot larvae (*Scophthalmus maximus L.*) based on mouth and ingested prey size. *Aquaculture* 175(8): 103-110.

Dabrowski, K. (1982). Proteolytic enzyme activity decline in starving fish alevins and larvae. *Environmental Biology Fish Journal* 7(1): 73-76.

Dabrowski, K. (1983). Digestion of protein and amino acid absorption in stomachless fish, common carp (*Cyprinus carpio* L.) *Comparative Biochemistry and Physiology Part A: Physiology* 74(2): 409-415.

Dabrowski, K. (1984). The feeding of fish larvae: present « state of the art » and perspectives. *Reproduction Nutrition Development* 24: 807-833.

Dabrowski, K., and culver, D. (1991). The physiology of larval fish, digestive tract and formulation of starter diets. *Aquaculture Magazine* 17: 49-61.

Dabrowskia, K., and Bardegaa, R. (1984). Mouth size and predicted food size preferences of larvae of three cyprinid fish species. *Aquaculture* 40(1): 41-46.

Deplano, M., Connes, R., Diaz, J. P., and Barnabé, G. (1991a). Variation in the absorption of macromolecular proteins in larvae of the sea bass (Dicentrarchus *labrax*) during transition to exotrophic phase. *Marine Biology* 110: 29-36.

Deplano, M., Diaz, J. P., Connes, R., Kentouri-Divanach, M., and Cavalier, F. (1991b). Appearance of lipid-absorption capacities in larvae of the sea bass

Dicentrarchus labrax during transition to the exotrophic phase. *Marine Biology* 108: 361-371.

Derzhavin, A. N. (1934). Fresh water fishes of the southern coast of the Caspian Sea. In (7: 91-126). Russia: Trudy azerbaijankogo Otdela Zakavkazskogo Filial Academia Nauk SSSR, Sector Zoology.

Dettlaff, T. A., Ginsburg A. S., and Schmalhausen O. I. (1993). Development of prelarvae. In: Sturgeon Fishes, Developmental Biology and Aquaculture. Berlin: Springer-Verlag.

Dhert, P., Lavens, P., and Sorgeloos, P. (1992a). Stress evaluation: a tool for quality control of hatchery-produced shrimp and fish fry. *Aquaculture Europe Journal* 17(2): 6-10.

Dhert, P., Lavens, P., and Sorgeloos, P. (1992b). A simple test for quality evaluation of cultured fry of marine fish. *Med. Fac. Landbouww, University Gent* 57(4b): 2135-2142.

Diaz, J. P., Mani-Ponset, L., and Blasco, C. (2002). Cytological detection of the main phases of lipid metabolism durin early post-embryonic development in three teleost species: *Dicentrarchus labrax, Sparus aurata* and *Stizostedion lucioperca*. *Journal of Aquatic Living Resource* 15: 169-178.

Doi, M., and Singhagraiwan, T. (1993). Biology and culture of the red snapper, *Lutjanus argentimaculatus.*Thailand: The research project of fisheries resource development in the Kingdom of Thailand, Department of Fisheries. 29-51.

Domeneghini, C., Pannelli Straini, R., and Veggetti, A. (1998). Gut glycoconjugates in *Sparus aurata* L. (Pisces, Teleostei). A comparative histochemical study in larval and adult ages. *Histopathology Journal* 13: 359-372.

Dorafshan, S., and Heyrati, F. (2006). Spawning induction in Kutum (*Rutilus frisii kutum*) Kamenskii, 1901, using carp pituitary extract or GnRH analogue combined with metoclopramide. *Aquaculture Research* 37(8): 751-755.

Dou, S., Masuda, R., Tanaka, M., and Tsukamoto, K. (2002). Feeding resumption, morphological changes and mortality during starvation in Japanese flounder larvae. *Fish Biology* 60: 1363-1380.

Ebrahimi, M. (2001). Economic assessment of fingerling releasing in south of the Caspian Sea. (in Farsi) (pp. 40). Iranian Fisheries Organization publisher.

Eda, H., Fujiwara, T., and Takita, T. (1994). Embryonic, larval and juvenile development in laboratory-reared dragonets, *Repomucenus beniteguri*. *Japan Journal Ichthyology* 40: 465-473.

Eda, H., Murashige, R., Oozaki, Y., Hagiwara, A., Eastham, B., and Bass, P. (1991). Factors affecting intensive larval rearing of striped mullet, *Mugil cephalus*. *Aquaculture* 91: 281-294.

Effatpanah, C. I. (1992). Study on feeding of kutum fish (*Rutilus frisii kutum*) in pondculture without artificial food. Master of Science Thesis. Islamic Azad University.

El-Sayed, A. F. M., Moyano, F. J., and Martinez, I. (2000). Assessment of the effect of plant inhibitors on digestive protease of Nile tilapia using in vitro assays. *Aquaculture International* 8: 403-415.

Elbal, M. T., García Hernández, M. P., Ozano, M. T., and Agulleiro, B. (2004). Development of the digestive tract of gilthead sea bream (*Sparus aurata*, L.). Light and electron microscopic studies. *Aquaculture* 324: 215-238.

Emadi, H. (1977). *Rutilus frisii kutum*: its past and present status in the northern waters of Iran. Guilan, Bandar Anzali: Guilan Fisheries Research Center Press (in Persian).

Emadi, H. (1979). The state of the fishing and reproduction of the Kutum, *Rutilus frisii kutum*, in The Caspian Sea of Iran. *Journal of Ichthyology* 19: 151-154.

Emmanuel, M. C., and James, M. (1989). The effects of feeding rotifers reachions *Plicatilis typicus*, on the yield and growth of tilapia *Oreochomis spilurus* fry. *Aquaculture* 77: 353-361.

Eusebio, P. S., Coloso, R. M., and Mamauag, E. P. (2004). Apparent digestibility of selected ingredients in diets for juvenile grouper, *Epinephelus coiodes* (Hamilton) *Journal of Aquatic Research* 35: 1261-1269.

Fallahi, M., Azari, G., Vossoughi, G. H., Mashinchian, A., and Mehdipour, N. (2011). Effects of Daphnia magna fed with B group vitamins-enriched Chlorella sp. and *Scenedesmus obliquus* on the growth rate of *Rutilus frisii kutu*m fry. *International Journal Environment Research* 5(3): 763-768.

Fallahi, M., Fatemi, S. M. R., Vosoghy, G., Matinfar, M., and Sharifian, M. (2009). Increasing in growth of *Rutilus frisii kutum* larvae with using slurry (fermented organic manure) in Yosefpoor propagation and rearing center (Iran). *Journal of Fisheries and Aquatic Science* 4(1): 22-31.

Faria, C., Gil, F., and Almada, V. C. (2006). Ontogenetic development of *Parablennius pilicornis* (Pisces: Blenniidae) in controlled conditions. *Scientia Marina* 70(4): 667-671.

Faridpak, F. (1961). A list of fishes of the Caspian Sea and the northern shore of Iran. Guilan, Bandar Anzali: Guilan Fisheries Research Center (In Farsi).

Faridpak, F. (1968). Fertility of the Mahisefid *Rutilus frisii kutum* (Kamenskii) (In Farsi). *Problems of Ichthyology* 8(61-68).

Fermin, A. C., and Bolivar, M. E. C. (1991). Larval rearing of the Philippine freshwater catfish, *Clarias macrocephalus* (Gunther), fed live zooplankton and artificial diet: a preliminary study. *The Israeli Journal of Aquaculture-Bamidgeh* 43(3): 87-94.

Ferraris, R. P., Tan, J. D., and De La Cru M.C. (1987). Development of the digestive tract of milkfish, *Chanos chanos* (Forsskal): Histology and histochemistry. *Aquaculture* 61(3- 4): 241-257.

Ferron, A., and Leggett, W. C. (1994). An appraisal of condition measures for marine fish larvae. *Journal of Advance Marine Biology* 30: 217-303.

Fowler, L. G. (1972). Growth and mortality of fingerling Chinook salmon as affected by egg size. *Progressive Fish Culturist* 34(66-69).

Freehold, N. J. (1972). Worthington Enzyme Manual: enzymes, enzyme reagent, related biochemicals. New Jersey: Worthington Biochemical Corporation Press.

Froehlich, K., Rozanski, K., Povinec, P., Oregioni, B., and Gastaud, J. (1999). Isotope studies in the Caspian Sea. *Science of the Total Environment* 237(238): 419-427.

Fukuhara, O. (1986). Morphological and functional development of Japanese flounder in early life stage. *Bulletin of Japan Society Sciences Fish* 52(1): 81-91.

Galgani, F., and Nagayama, F. (1987). Digestive proteases in five species of Lithodidae (Crustacea, Decapoda). *Comparative Biochemistry and Physiology* 87*B*: 103-107.

Gall, G. A. E. (1974). Influence of size of eggs and age of female on hatchability and growth of rainbow trout. *California Fish Game* 60(26-35).

Gawlicka, A., Parent, B., Horn, M., Ross, N., Opstad, I., and Torrisen, O. J. (2000). Activity of digestive enzymes in yolk-sac larvae of Atlantic halibut (*Hippoglossus hippoglossus*): indication of readiness for first feeding. *Aquaculture* 184: 303-314.

Ghada Ahmed, E. (2000). Mouth and gut development of Malaysian River Catfish *Mystus Nemurus* larvae. Master of Science Thesis. Universiti Putra Malaysia.

Ghaninejad, D., and Abdulmaleki, S. (2007). Annual stocks assessment of bony fish in the Caspian Sea. TEHRAN: Iran Fisheries Research Institute Publishers (IFRO).

Gholami, M. (2010). Effects of n-3 HUFA enriched daphnia magna on growth, survival, stress resistance and fatty acid composition of white fish fry (*Rutilus frisii kutum*). *Journal of Fish Aquatic Science* 5: 49-55.

Giri, S. S., Sahoo, S. K., Sahu, B. B., Sahu, A. K., Mohanty, S. N., and Mukhopadhyay, P. K. (2002). Larval survival and growth in *Wallago attu* (Bloch and Schneider): effects of light, photoperiod and feeding regimes. *Aquaculture* 213: 151-161.

Gisbert, E., Giménez, G., Fernández, I., Kotzamanis, Y., and Estévez, A. (2009). Development of digestive enzymes in common dentex, *Dentex dentex* during early ontogeny. *Aquaculture* 287: 381–387.

Gisbert, E., Piedrahita, R. H., and Conklin, D. B. (2004). Ontogenic development of the digestive system in California halibut (*Paralichthys californicus*) with notes on feeding practices. *Aquaculture* 232: 455-470.

Glass, H. J., Macdonald, N. L., Moran, R. M., and Stark, J. R. (1989). Digestion of protein in different marine species. *Comparative Biochemistry and Physiology* 94B: 607-611.

Glebe, B. D., Appy, T. D., and Saunders, R. L. (1979). Variation in Atlantic salmon (Salmo salar) reproduction traits and their implications in breeding programs. *Journal of Marine Science* 23: 1-11.

Govoni, J. J., Boehlert, G. W., and Watanabe, Y. (1986). The physiology of digestion in fish larvae. *Journal of Environment Biology Fishes* 16: 59-77.

Gwak, W. S., Seikai, T., and Tanaka, M. (1999). Evaluation of starvation status of laboratory-reared Japanese flounder, *Paralichthys olivaceus*, larvae and juveniles based on morphological and histological characteristics. *Journal of Fish Sciences* 65: 339-346.

Haghighi, T. D. (2006). Embryonic development and nutritional requirments of kutum fry, *Rutilus frisii kutum.* PhD Thesis, Universiti Putra Malaysia.

Hamlin, H. J., Hunt von Herbing, I., and Klin, L. G. (2000). Histological and morphological evaluations of the digestive tract and associated organs of haddock throughout post-hatching ontogeny. *Fish Biology* 57: 716–732.

Hans, J. F. (1989). First feeding of marine fish larvae: Are free amino acids the source of energy? *Aquaculture* 80(1-2): 111-120.

Harms, J., Anger, K., Klaus, S., and Seeger, B. (1991). Nutritional effects on ingestion rate, digestive enzyme activity, growth and biochemical composition of *Hyas araneus* L. (Decapoda: Majidae) larvae. *Journal of Experiences Marine Biology Ecology* 145: 233-265.

Hasan, M. R., and Macintosh, D. J. (1992). Optimum particle size in relation to body size of common carp, *Cyprinus carpio* L., fry. *Aquaculture Fish Management* 23: 315-325.

Hepher, B. (1988). Nutrition of pond fishes: Cambridge University Press. England.

Hoehne-Reitan, K., Kjørsvik, E., and Gjellesvik, D. R. (2001). Development of bile salt-dependent lipase in larval turbot. *Fish Biology* 58: 737-745.

Hofer, R., and Nasir Uddin, N. (1984). Digestive processes during the development of the rouch (*Rutilus rutilus* L). *Fish Biology* 26: 683-689.

Holcik, J. (1995). New data on the ecology of kutum fish, *Rutilus frisii kutum* from the caspian Sea. *Ecology of fresh water fish* 4(175-179).

Holm, J. C. (1986). Review on experiments on the use of zooplankton as food in salmonid smolt production. *Aquaculture Engineering* 5: 33-47.

Hopkins, K. D. (1992). Reporting fish growth: a review of the basics. *Journal of the World Aquaculture Society* 23: 173-179.

Horn, M. H., Gawlicka, A. K., German, D. P., Logothetis, E. A., Cavanagh, J. W., and Boyle, K. S. (2006). Structure and function of the stomachless digestive system in three related species of new World silverside fishes (Atherinopsidae) representing herbivory, omnivory, and carnivory. *Marine Biology* 149(1237-1245).

Hughes, G. M., Munshi, J. S. D., and Ojha, J. (1986). Post embryonic development water and air breathing organs of *Anabas testudineus* (Bloch). *Fish Biology* 29: 443-450.

Hummel, B. C. W. (1959). A modified spectrophotometric determination of chymotrypsin, trypsin and thrombin. *Canadian Journal Biochemistry Physiology* 37: 1393-1399.

Hunt von Herbing, I., Boutilier, R. G., Miyake, T., and Hall, B. K. (1996). Effects of temperature on morphological landmarks critical to growth and survival in larval Atlantic cod (*Gadus morhua*). *Marine Biology* 124(593-606).

Hunter, J. R. (1981). Feeding ecology and predation of marine fish larvae. In Lasker R. (Ed.), *Marine fish larvae. Morphology, Ecology, and Relation to Fisheries* (pp. 33-72). Washington: Sea Grant Publisher.

Hyatt, K. D. (1979). Feeding strategy. In Hoav W. S., Randall D. J. & Brett J. R. (Eds.), *Fish physiology* (Vol. III). London: Academic Press.

IFO. (2008). *Annual Statistics of Iran Fishery Organization*. from http://www.shilat.com.news.htm. Accessed 2008 November 12.

IFRO. (1997). Annual Report, 1995-1996 of Caspian Sea. Iranian Fisheries Research Organization: Tehran.

IFRO. (2000). Annual Report, 1998-2000 of Caspian Sea. Iranian Fisheries Research Organization: Tehran.

IFRO. (2007). Annual Report, 2003-2007 of Caspian Sea. Iranian Fisheries Research Organization: Tehran.

IFRO. (2010). Annual Report, 2004-2009 of Caspian Sea. Iranian Fisheries Research Organization: Tehran.

Imgbian, T. D., Lamai, S. L., and Shola S.G. (2010). Growth and Survival Rate of Heterobranchus longifilis Larvae Fed Live Zooplankton and Formulated Diet. *Patnsuk Journal* 6(1): 66-76.

Jany, K. D. (1976). Studies on the digestive enzymes of the stomachless bonefish *Carassius auratus gibelo* (Bloch) Endopeptidases. *Comparative Biochemistry Physiology* 53B: 31-38.

Johnston, D. J., Ritar, A. J., and Thomas, C. W. (2004). Digestive enzyme profile reveal digestive capacity and potential energy sources in fed and starved spiny lobster (*Jasus edwardsii*) phyllosoma larvae. *Comparative Biochemistry Physiology* 138B: 137-144.

Jones, A., and Houde, E. D. (1981). Mass rearing of fish fry for aquaculture. In Bilio M., Rosenthal H. & Sinderman G. J. (Eds.), *realism in aquaculture: achievements, constraints, perspectives* (pp. 351-374). Belgium: European Aquaculture Society Publishers.

Jun-sheng, L., Jian-lin, L., and Ting-ting, W. (2006). Ontogeny of protease, amylase and lipase in the alimentary tract of hybrid Juvenile tilapia (*Oreochromis niloticus* × *Oreochromis aureus*). *Fish Physiology Biochemestry* 32: 295–303.

Kalmer, E. (2002). Ontogeny of yolk-feeding fish: an ecological perspective. *Reviews in Fish Biology and Fisheries* 12: 79-103.

Kamarudin, M. S., Bakar, H. A., and saad, C. R. (1996). *Effect of live food, artificial and mixed diet on the survival, growth and digestive enzyme activities of clarias gariepinus (Bruchell) larvae.* In: MacKinlay D, Shearer K (Eds.) pp 19-24. Gut shop '96: Feeding Ecology and Nutrition in fish Symposium Proceeding. American Fisheries Society. San Francisco.

Kamarudin, M. S., Jones, D. A., and Vay, L. L. (1993). The Potential for Replacement of Live Feeds in Larval Culture. *Journal World Aquaculture Society* 24: 190- 210.

Kamarudin, M. S., Otoi, S., and Saad, C. R. (2011). Changes in growth, survival and digestive enzyme activities of Asian Redtail catfish, *Mystus nemurus*, larvae fed on differnt diets. *African Journal of Biotechnology* 10(21): 4484-4493.

Kamier, E. (1992). Early Life History of fish : An Energetic Approach. In Blaxter J. H. S. (Ed). Springer Publisher. New York.

Kane, J. (1984). The feeding habits of co-occurring cod and haddock larvae from Georges Bank. *Marine Ecology Progress Series* 16: 9-20.

Kapoor, B. G., Smith, H., and Verighina, I. A. (1975). The alimentary canal and digestion in teleosts. *Journal of Advance Marine Biology* 13: 109-239.

Kazeroni, M. M. (1996). Preliminary study on semi- artificial propagation of kutum fish in the Southern Rivers of Caspian sea. Iranian fisheries Co. Under-secretary of propagation and rearing of aquatic. Training publication (Vol. 8): Iran Shilat Organization Press. Tehran.

Keast , A., and Webb, D. (1966). Mouth and body form relative to feeding ecology in the fish fauna of small lake, Lake Opinicom, Ontario. *Journal of the Fisheries Research Board of Canada* 23: 1845-1874.

Khara, H., Keyvan, A., Nezami, S., Mehdinejad, K., and Moahmmadjani, T. (2002). Diet of *Rutilus frisii kutum* x *Ctenopharyngodon idella* hybrid. In Farsi. *Iranian Journal of Fisheries Sciences* 11(2): 31-42.

Kim, B., Divakaran, S., Brown, C. L., and strowski, C. A. (2001). Comparative digestive enzyme ontogeny in two marine larval fishes: Pacific threadfin (*Polydactylus sexfilis*) and bluefin trevally (*Caranx melampygus*). *Fish Physiology and Biochemistry* 24: 225-241.

Kimmel, C. B., Ballard, W. W., Ulman, B., and Schilling, T. F. (1995). Stages of embryonic development of the Zebra fish. *Developmental Dynamic* 25: 203-310.

Kimmel., C. B., and Warge, R. M., (1995). Tissue specific linage of the Zebra fish embryo in the gastrula. *Science of the Total Environment* 231: 365- 368.

Kjørsvik, E., Van der Meeren, T., Kryvi, H., Arnfinnson, J., and Kvenseth, P. G. (1991). Early development of the digestive tract of cod larvae, *Gadus morhua* L., during start-feeding and starvation. *Fish Biology* 38: 1-15.

Kohinoor, A. H., Hagus, M. Z., and Osman, M. H., (1995). Food size preferences of climbing perch, *Anabas testudineus* Bloch and the African catfish, *Claris gariepinus* Burchell larvae. *Bangladesh journal of zoology* 23(2): 159-166.

Kolkovski, S. (2001). Digestive enzymes in fish larvae and juveniles: Implications and applications to ormulated diets. *Aquaculture* 200: 181-201.

Kolkovski, S., Koven, W., and Tandler, A. (1997b). The mode of action of Artemia in enhancing utilization of microdiet by gildthead seabream *Sparus aurata* larvae. *Aquaculture* 155: 193-205.

Koshio, S., Sakakuru, Y., Iida, Y., Tsukamoto, K., Kida, T., and Dabrowski, K. (1997). The effect of vitamin C intake on schooling behaviour of amphidromous fish, ayu Plecoglossus altivelis. *Fisheries Science 63: 619-624.*

Kuliev, Z. M. (1984). Variation of morphometric indices in Caspian vobla, *Rutilus rutilus caspicus*. *Journal of Ichthyology* 24(6): 139-148.

Kumar, S., and Chakrabarti, R. (1998). Ontogenic development of amylase activity in three species of Indian major carps, *Catla catla*, *Labeo rohita* and *Cirrhinus mrigala* in relation to natural diet. *Asian Fisheries Science* 10: 259-263.

Kurokawa, T., Shiraishi, M., and Suzuki, T. (1998). Qualification of exogenous protease derived from zooplankton in the intestine of Japanese sardine *Sardinops melanoticus* larvae. *Aquaculture* 161: 491-499.

Lauff, M., and Hofer, R. (1984). Proteolytic enzymes in fish development and the importance of dietary enzymes. *Aquaculture* 37: 335-346.

Lazo, J. G., Holt, A., and Arnold, C. (2000). Ontogeny of pancreatic enzymes in larval red drum *Sciaenops ocellatus*. *Aquaculture Nutrition* 6: 183-192.

Lemieux, H., Blier, P., and Dut. J. D. (1999). Do digestive enzymes set a physiological limit on growth rate and food conversion efficiency in the Atlantic cod (*Gadus morhua*). *Fish Biology* 20: 293-303.

Leu, M. Y., and Chou, Y. H. (1996). Induced spawning and larval rearing of captive yellowfin porgy, *Acanthopagrus latus* (Houttuyn). *Aquaculture* 143: 155-166.

Lillie, R. (1965). Histopathologic Technic and Practical Histochemistry, 3rd edition. New York: McGraw-Hill Book Co.

Lindsay, G. J. H. (1984). Distribution and function of digestive tract chitinolytic enzymes in fish. *Fish Biology* 24: 529-536.

Ljunggren, L. (2002). Growth response of pike perch larvae in relation to body 2. Size and Zooplankton abundance. *Fish biology* 60(2): 405-414.

Logothetis, E. A., Horn, M. H., and Dickson, K. A. (2001). Gut morphology and function in *Atherinops affinis* (Teleostei: Atherinopsidae), a stomachless omnivore feeding on macroalgae. *Fish Biology* 59: 1298-1312.

Lovell, T. (1989). Digestion and metabolism, In nutrition and feeding of fish: In Ronald, H. Chhorn, L., Eds). New York: Van Nostrand Reinhold Publishers.

Luizi, F. S., Gara, B., Shields, R. J., and Bromage. N.R. (1999). Further description of the development of the digestive organ in Atlantic halibut (*Hippoglossus hippoglossus*) larvae, with notes on differential absorption of copepod and Artemia prey. *Aquaculture* 176: 101-116.

Ma, H., Cahu, C., Zambonino, J., Yu, H., Duan, Q., Le Gall, M.-M., and Mai, K. (2005). Activities of selected digestive enzymes during larval development of large yellow croaker (*Pseudosciaena crocea*). *Aquaculture* 254: 239-248.

Ma, H., Sivaloganathan, B., Reddy, P. K., and Lam, T. J. (2001). Ontogeny of α-amylase gene expression in seabass (*Lates calcarifer*). *Marine Biotechnology Journal*. 3: 463-469.

Makrakis, M. C., Nakatini, K., Bialetzki, A., Sanchez, P. V., Banmgartner, G., and Gomes, L. C. (2005). Ontogenic shift in digestive tract morphology and diet of fish larvae of the Itapúa reservoir Brazil. *Journal of Environmental Biology of fishes* 72:99-107.

Margulies, D. (1993). Assessment of the nutritional condition of larval and early juvenile tuna and Spanish mackerel (Pisces, *Scombridae*) in the Panama Bight. *Marine Biology* 115: 317-330.

Marimuthu, K., and Haniffa, M. A. (2007). Embryonic and Larval Development of the Striped Snakehead *Channa striatus*. *Taiwania Journal* 52: 84-92.

Martin, F. D., and Wright, D. A. (1987). *Nutritional state analysis and its use in predicting striped bass recruitment: laboratory cahbration*. (pp 109-114) Paper presented at the American Fisheries Society Symposium 2. Maryland.

Martinez, I., Moyano, F. J., Fernandez-Diaz, C., and Yufera, M. (1999). Digestive enzyme activity during larval development of the Senegal sole (*Solea senegalensis*). *Fish Physiology and Biochemistry* 21: 317-323.

Masuda, R., and Tsukamoto, K. (1998). Stock enhancement in Japan: review and perspective. *Bulletin of Marine Science* 62: 337-358.

May, R. C. (1974). *Larval mortality in marine fishes and the critical period concept*. (In: Blaxter, J.H.S. (Ed.). pp 3-19. The early life history of fish. New York: Springer Publishers.

McFadzen, I. R., Lowe, D. M., and Coombs, S. H. (1994). Histological changes in starved turbot larvae (Schophtalmus maximus) quantified by digital image analysis. *Fish Biology* 44: 255-262.

Mito, S. (1960). Keys to the pelagic fish eggs and hatched larva: found in the adjacent waters of Japan. *Science Bulletin Faculty Agriculture, Kyushu University* 18(1): 71-94.

Morrison, C. M., Miyake, T., and Wright, J. R. (2001). Histological study of the development of the embryo and early larva of *Oreochromis niloticus* (Pisces:Ciclidae). *Morphology* 247: 172–195.

Moser, H. G. (1996). The early stages of fishes in the California Current region (Vol. 33- 1-1503pp): Lawrence: Allen Press, Inc.

Moyano, F. J., Díaz, M., Alarcón, F. J., and Sarasquete, C. (1996). Characterization of digestive enzyme activity during larval development of gilthead seabream (*Sparus aurata*). *Fish Physiology Biochemestry* 15: 121-130.

Moyle, P. B., and Cech, J. (1982). *Fishes: an Introduction to Ichthyology* (3rd ed.): Prentice Hall Publishers. New Jersey.

Munilla-Morana, R., Stark, J. R., and Barbour, A. (1990). The role of exogenous enzymes in digestion in cultured turbot larvae (*Scophthalmus maximus* L.) *Aquaculture* 88(3-4): 337-370.

Myszkowski, L., and Wolnicki, J. (1998). Aquaculture and quality the use of stress tests to evaluate physiological condition of fish. *Recapitulation. Kom. Ryb.* 6: 3-5.

Nash, C. E., Kuo, C. M., and McConnel, S. C. (1974). Operational procedures for rearing larvae of the grey mullet, *Mugil cephalus Linnaeus*. *Aquaculture* 3: 15-24.

Neira, F. J., Keane, J. P., Lyle, J. M., and Tracey, S. R. (2008). Development of eggs and larvae of *Emmelichthys nitidus* (Percoidei: Emmelichthyidae) in south-eastern Australia, including a temperature-dependent egg incubation model. *Estuarine, Coastal and Shelf Science* 79: 35-44.

Netch, N. F., and Witt, A. (1962). Contributions to the life history of the longnose gar (*Lepisosteus osseus*) in Missouri. *Transactions of the American Fisheries Society* 91: 251-262.

Noaillac-Depeyre, J., and Hollande, H. (1981). Evidence for Somatostatin, Gastrin and Pancreatic Polypeptide-like Substances in the Mucosa Cells of the Gut in Fishes with and without Stomach. *Cell Tissue Research* 216: 193-203.

Oozeki, Y., and Bailey, K. M. (1995). Ontogenetic development of digestive enzyme activities in larval walleye pollock, *Theragra chalcogramma*. *Marine Biology* 122: 177-186.

Oppenheimer, J. M. (1947). Organization of the teleost blastoderm. *Quart. Review Biology* 22: 105- 118.

Ostaszewska, T., Kossakowski, M., and Wolinicki, J. (2006). Morphological changes of digestive structures in starved tench *Tinca tinca* (L.) juveniles. *Aquaculture International* 14: 113-126.

Ouraji, H., Khalili, K., Ebrahimi, G., and Jafarpour, A. (2010). Determination of the optimum transfer time of kutum *(Rutilus frisii kutum*) larvae from live food to artificial dry feed. *Aquaculture International* 19(4): 683-691.

Parivar, K., Behzadi, S., and Razavi, B. (1993). The chronological development of embryo in Rutilus frisii kutum (Kamenskii). *Journal of Iranian Fisheries* 1: 3-24.

Park, J. Y., and Kim, I. S. (2001). Histology and mucin histochemistry of the gastrointestinal tract of the mud loach, in relation to respiration. *Fish Biology* 58: 861-872.

Parra, G., and Yúfera, M. (2001). Comparative energetics during early development of two marine fish species, *Solea senegalensis* (Kaup) and *Sparus aurata*. *Journal of Experiment Biology* 204: 2175-2183.

Pearson, W. D., Thomas, G. A., and Clark, A. L. (1979). Early piscivory and timing of the critical period in post larval longnose gar at mile 571 of the Ohio River. *Transactions of the Kentucky Academy of Science* 40: 122-128.

Pedersen, B. H. (1993). Growth and mortality in young larval herring (*Clupea harengus*); effects of repetitive changes in food availability. *Marine Biology* 117: 117-186.

Pena, R., Dumas, S., Villalejo-Fuerte, M., and Ortiz-Galindo, J. L. (2002). Ontogenetic development of the digestive tract in reared spotted sand bass *Paralabrax maculatofasciatus* larvae. *Aquaculture* 62(8): 1-12.

Pérez-Casanova, J. C., Murray, H. M., Gallant, J. W., Ross, N. W., Douglas, S. E., and Johnson, S. C. (2006). Development of the digestive capacity in larvae of haddock (*Melanogrammus aeglefinus*) and Atlantic cod (*Gadus morhua*) *Aquaculture* 251: 337-410.

Person, L. J., Alexandre, J. C., Thébaud, L., and Mugnier, C. (1993). Marine fish larvae feeding: formulated diets or live preys. *Journal World Aquaculture Society* 24: 211-224.

Person, L. J., Samain, J. F., and Daniel, J. Y. (1989). Evolution de l'activité de la trypsine et de l'amylase au cours du developpement chez la larve de bar (*Dicentrarchus labrax*). Effet de l'age et du sevrage. *Oceanis* 15: 465-480.

Peter, C. W. (1996). Ecological explantation through functional morphology: The feeding biology of sunfishes. *Journal of Ecology* 77(5): 1336-1343.

Petkam, R., and Moodie, G. E. (2001). Food particle size, feeding frequency, and the use of prepared food to culture larval walking catfish (*Clarias macrocephalus*). *Aquaculture* 194: 349-362.

Piri, M., Nezami, S., and Ordog, V. (1999). Effects of Diazinon, Malathion, Machete and Saturn on mortality of fingerling of *Rutilus frisii kutum*.In Farsi. *Iranian Journal of Fisheries Sciences* 7(4): 9-18.

Pitman, R. W. (1979). Effects of female age and size on growth and mortality in rainbow trout. *Progressive Fish Culturist* 41: 202-204.

Polo, A., Yúfera, M., and Pascual, E. (1991). Effect of temperature on egg and larval development of Sparus aurata. *Aquaculture* 92: 367-375.

Potaros, M., and Sitasit, P. (1967). Induced spawning of Pangasus sutehz (Fowler) (pp. 14pp): Department of Fisheries. Bangkok, Thailand.

Pourkazemi, M. (2000). Management and enhancement of sustainable resource (No 18, pp. 17-30). Tehran: Aquaculture Department, shilat Iran Publishers (in Persian).

Rafiqur Rahman, M., Aminur Rahman, M., Noor Khan, M., and Hussain, M. (2004). Observation on the Embryonic and Larval Development of Silurid Catfish, Gulsha (*Mystus cavasius Ham.*). *Pakistan Journal of Biological Sciences* 7(6): 1070-1075.

Rahman, M. M., Miah, M. I., Taher, M. A., and Hasan, M. M. (2009). Embryonic and larval development of guchibaim , *Mastacembelus pancalus* (Hamilton). *Journal of Bangladesh Agriculture University* 7(1): 193-204.

Ramezani Fard, E., Kamarudin, M. S., Harmin, S. A., Saad, C. R., Abd Satar, M. K., and Daud, S. K. (2010). Ontogenic development of the mouth and digestive tract in larval Malaysian mahseer, *Tor tambroides Bleeker*. *Journal of Applied Ichthyology* 27(3): 920–927.

Rathore, R. M., and Chakrabarti, R. (2009). Ontogenic changes in the digestive enzyme pattern and characterization of proteases in Indian major carp *Cirrhinus mrigala*. *Aquaculture Nutrition* 5: 1-13.

Razavi, B. (1995). Kutum fish (*Rutilus frisii kutum*) life. Anzali: Guilan Fisheries Research Center Publishers.

Razavi, B. (1997). Breeding and rearing of the Black Sea roach in the Islamic Republic of Iran. The 1st Congress of Ichthyologists of Russia. Moscow: Book of Abstracts. VNIRO Press. Moscow.

Razavi, B. (1999). Past, present and future of bony fishes, sustainable development (pp. 60). Iranian Fishery Research Organization Publishers.

Ribeiro, L., Zambonino-Infante, J. L., Cahu, C., and Dinis, M. T. (1999). Development of digestive enzymes in larvae of *Solea senegalensis*, Kaup 1858. *Aquaculture* 179: 464-473.

Rombout, J. H., and Taverne-Thiele, J. J. (1982). An immunocytochemical and electron-microscopical study of endocrine cells in the gut and pancreas of a stomachless teleost fish, *Barbus conchonius* (*Cyprinidae*). *Cell Tissue Research* 227(3): 577-593.

Sakakura, Y., Koshio, S., Iida, Y., Tsukamoto, K., Kida, T., and Blom, J. H. (1998). Dietary vitamin C improves the quality of yellowtail (*Seriola quinqueradiata*) seedlings. *Aquaculture* 161: 427-436.

Salehi, H. (2002). Economic assessment of fingerling releasing *Rutilus frisii kutum* in Iran. *Journal of Marine Science of Iran* 1: 35-45 (in Farsi).

Santamaría Rojas, C. A., Marín de Mateo, M., Traveset, R., Sala, R., Grau, A., Pastor, E., Sarasquete, M. C., and Crespo, S. (2004). Organogenesis in larval common *Dentex dentex* L., (Sparidae): histological and histochemical aspects. *Aquaculture* 237: 207-228.

Sarasquete, M., González Canales, M. L., Arellano, J. M., Muñoz-Cueto, J. A., Riberio, L., and Dinis, M. T. (1995). Histochemical aspects of the yolk sac and digestive tract of larvae of Senegal sole, *Solea senegalensis* (Kaup, 1858). *Histopathology* 11: 881-888.

Sarasquete, M., Polo, A., and Gonzáles de Canales, M. L. (1993). A histochemical and inmunological study of digestive enzymes and hormones during the larval development of the sea bream (*Sparus aurata* L.). *Histochemistry* 25: 430-437.

Sarnowski, P. (2004). The effect of metals on swimbladder inflation of common carp(*Cyprinus carpio* L.) larvae. *Electronic journal of polish Agriculture University* 7(1): 1-12.

Segner, H., Röch, R., Verreth, J., and Witt, U. (1993). Larval nutritional physiology: studies with *Clarias gariepinus*, *Coregonus lavaraetus* and *Scophthalmus maximus*. *Journal of the World Aquaculture Society* 24: 121-134.

Segner, H., Storch, M., Reinecke, W., Kloas, L., and Hanke, W. (1994). The development of functional digestive and metabolic organs in turbot, *Scophthalmus maximus*. *Marine Biology* 119: 471-486.

Sfakianakis D. G., Koumoundouros G., Anezaki L., Divanach P., and M., K. (2003). Development of a saddleback-like syndrome in reared white sea bream (*Diplodus sargus*). *Aquaculture* 217: 673-676.

Sharma, J. G., and Chakrabarti, R. (1997). Ontogenic changes of amylase and proteolytic enzyme activity of Indian major carp, *Catla catla* (Ham.) in relation to natural diet. *The Indian Journal of Animal Sciences* 67: 932-934.

Sharyati, A. (1993). Fishes of the Caspian Sea region (in Farsi). pp 77-79. Iranian Fisheries Company Publishers. Tehran.

Shirota, A. (1970). Studies on the mouth size of fish larvae. *Bulletin of the Japanese Society of Scientific Fisheries* 36(4): 353-368.

Siefert, R. E. (1969). Characteristic for separation of White and black Crappie Larvae transactions. *American Fisheries Society* 98: 326-328.

Silva, S. S. D., and Anderson, T. A. (1995). Fish nutrition in Aquaculture. 2-6 Boundory Row- London, SE1, 8HN: Chapman and Hall. London.

Simon, T. P., and Tyberghein, E. J. (1991). Contributions to the early life history of the spotted gar, *Lepisosteus oculatus* Winchell, from Hatchet Creek, Alabama. *Kentucky Academy of Science* 52: 124-131.

Simon, T. P., and Wallus, R. (1989). Contributions to the early life histories of gar (Actinopterygii: *Lepisosteidae*) in the Ohio and Tennessee River basins with emphasis on larval development. *Kentucky Academy of Science* 50: 59-74.

Smith, L. S. (1980). Aquaculture development and coordination programme. Fish feed technology.Chapter 1. In *Digestion in Teleost Fishes*. Seattle, Washington: Lectures presented at the FAO/UNDP Training Course in Fish Feed Technology, held at the College of Fisheries. University of Washington. USA.

Sorgeloos, P., and Van Stappen, G. (2001). International study on Artemia LXIII. Field study of the *Artemia urmiana* (Günther, 1890) population in Lake Urmiah, Iran. *Hydrobiologia* 466: 133-143.

Springate, J. R. C., and Bromage, N. R. (1985). Effects of egg size on early growth and survival in rainbow trout (Salmo gairdneri Richardson). *Aquaculture* 47(163- 172).

Steiger, M., and Schulz, M. (1989). Variability of aerosol size distributions above the North Sea and its implication to dry deposition estimates. *Journal of Aerosol Science* 20: 1229- 1232.

Sunde, J., Eiane, S. A., Rustad, A., Jensen, H. B., Opstvedt, J., Nygård, E., Venturini, G., and Rungruangsak- Torrissen, K. (2004). Effect of fish feed processing conditions on digestive protease activities, free amino acid pools, feed conversion efficiency and growth in Atlantic salmon (*Salmo salar* L.). *Aquaculture Nutrition* 10: 261-277.

Svardson, G. (1949). Natural selection and egg number in fish. *Journal of Institute of Fresh water Research* 29: 115-122.

Sveinsdóttir, S., Thorarensen, H., and Gudmundsdóttir, A. (2006). Involvement of trypsin and chymotrypsin activities in Atlantic cod (*Gadus morhua*) embryogenesis *Aquaculture* (260): 307-314.

Synder, D. E. (1983). Fish eggs and larvae, in Nielson, L.A., And Johnson,D.L.eds., Fisheries techniques. *American Fisheries Society* 165-197 pp.

Tajuddin, A., Pathmasothy, Z., Haron, S., and Lim, T. J. (1977). Pembiaka aruhan Lee Koh dan Lampam. No.49 (Vol. 49, pp. 15). MARDI. Malaysia.

Takashi, I. (2004). Stages of normal development in the medaka Oryzias latipes. *Journal of Mechanisms of Development* 121: 605-618.

Takemura, A. (1996). Imunohistochemical localization of lysozyme in the prelarvae of tilapia, *Oreochromis mossambicus*. *Fish Shellfish Immunology* 6: 75–77.

Tanaka, M. (1973). Studies on the structure and function of the digestive system of teleost larvae. Kyoto University, Japan.

Tarnchalanukit, W., Chuapoehuk, W., Suraniranat, P., and Na Nakorn, U. (1982). Pla Duk Dan CultureThailand: Faculty of Fisheries, Kasetsart University (in Thai).

Thakur, N. K., Pal, R. N., and Khan, H. A. (1974). Embryonic and larval development of *Heteropneustes fossilis* (Bloch). *Journal of the Inland Fisheries Society of India* 6: 33-44.

Thalathiah, H. S., Hamilah, H., and Ahmad, A. A. (1983). *A study on the breeding aspects of Pangasus sutchi (Fowler) in Melaka*. Paper presented at the International Conference on the Development and Management of the Tropical Living Aquatic Resources. August 2 - 5. Universiti Pertanian Malaysia. Selangor.

Theilacker, G. H. (1978). Effect of starvation on the histological and morphological characteristics of jack mackerel, *Trachurus symmetricus* larvae. *Fisheries Bulletin* 76: 403-414.

Thorpe, J. E., Miles, M. S., and Keay, D. S. (1984). Developmental rate, fecundity and egg size in Atlantic salmon (Salmo salar L). *Aquaculture* 43: 289-305.

Tolouei, M. H., and Sobhani, M. (1998). Reproduction of *Rutilus frisii kutum* with hormone injection in Sefidrood River. Paper presented at the Eight Conference of Shilat, Tehran. 17-18 Feb 1998.

Trotter, A. J., Pankhurst, P. M., and Hart, P. R. (2001). Swimbladder malformation in hatchery-reared striped trumpeter *Latris lineata* (Latridae). *Aquaculture* 198: 41–54.

Umur, O., Cirik, E., and Cirik, S. (2010). Histological development of digestive tract in discus, *Symphysodon spp*. larvae. *Aquaculture International* 18: 589–601.

Valipour, A., and Khanipour, A. A. (2008). KUTUM, Jewel of the Caspian Sea. Tehran: IFRO and CEP publishers.

Victor, B. C. (Ed.). (1991). *Settlement strategies and biogeography of reef fishes*. San Diego, CA. : Acad. Press.

Vosooghi, G., and Mostagir, B. (2003). Fresh Water Fish. Tehran: Tehran University Press.

Voss, R., Dickmaan M., and Schmidt, J. O. (2009). Feeding ecology of Sprat (*Sprattus sprattus* L.) and sardine (*Sardina pilchardus*) larvae in the German Bight, North Sea. *Oceanologia* 51(1): 117-138.

Walford, J., and Lam, T. J. (1993). Development of digestive tract and proteolytic enzyme activity in Seabass (*Lates calcarifer*) larvae and juveniles *Aquaculture* 109(2): 187-205.

Wallace, J. C., and Aasjord, D. (1985). An investigation of the consequences of egg size for the culture of Arctic char (Salvelinus alpinus). *Fish Biology* 24: 427-435.

Walter, H. (1984). Proteinases: methods with haemoglobin, casein, and azocoll as substrates. In: Bergmeyer HV (ed) Methods of enzymatic analysis, Vol. 5, , pp 270-227. Weinheim, Germany. Verlag Chemie Publishers.

Wang, C., Xie, S., Zheng, K., Zhu, X., Lei, W., Yang, Y., and Liu, L. (2005). Effects of live food and formulated diets on survival, growth and protein content of first-feeding larvae of Plelteobagrus fulvidraco. *Journal of Applied Ichthyology* 21(3): 210-214.

Wankowski, J. W. (1979). Morphological limitations, prey size selectivity and growth response of juvenile Atlantic salmon, *Salmo salar*. *Journal of Biology* 14: 89-100.

Watanabe, T., and Kiron, V. (1994). Prospects in larval fish dietetics. *Aquaculture* 124: 223-251.

Williams, D. M. B., Halford, A., Cheal, A., and Ryan, J. D. (2004). Resilience to large- scale disturbance in coral and fish assemblages on the great barrier reef. *Ecology of fresh water fish* 85(7).

Worthington, T. M. (1982). Enzymes and Related Biochemicals. Biochemical Products Division. Worthington Diagnostic System Inc. Freehold, New Jersey.

Woynaryovic, E., and Horvat, L. (1980). The artificial propagation of warm water finfish. A manual for extention (Vol. 20). FAO: Rome.

Xie, S., Zhu, X., Cui, Y., Lei, W., Yang, Y., and Wootton, R. J. (2001). Compensatory growth in the gibel carp following feed deprivation: temporal patterns in growth, nutrient deposition, feed intake and body composition. *Fish Biology* 58: 999-1009.

Yeager, L., and Bryant, R. T. (1983). Larvae of the longnose gar, *Lepisosteus osseus*, from the Little River in Tennessee. *Journal of the Tennessee Academy of Science* 58(1-2): 20-22.

Yi, B., Yu, Z., and Liang, Z. (1966). *A comparative study of the embryonic development of grass carp, black carp, Silver carp, big head carp and other fishes with drifting eggs in the Yangtze River, in Fisheries research committee of the western Pacific*. Paper presented at the 8th symposium, Fisheries Research Committee of the Western Pacific, Beijing Sep 16-20. Science Press, Beijing.

Yin, M. C., and Blaxter, J. H. S. (1986). Morphological changes during growth and starvation of larval cod (*Gadus morhua L.*) and flounder (*Platichthys flesus L.). Journal of Experiments Marine Biology Ecology* 104: 215-228.

Yousefian, M., and Mosavi, H. (2008). Spawning of South Caspian Kutum (*Rutilus frisii kutum*) in Most Migratory River of South Caspian Sea. *Asian Journal of Animal and Veterinary Advances* 3 (6): 437-442.

Yousefian, M., Najajpour, S., Farah, S. V., and Najajpour, G. D. (2010). Artificial Spawning and Early Development of *Acipenser persicus*. *World Journal of Fish and Marine Sciences* 2(3): 258-263.

Youson, J. H. (1988). First metamorphosis. In Fish physiology, Vol. XI, Part B, pp. 135-198. New York: Academic Press.

Yúfera, M., and Darias, M. J. (2007). The onset of exogenous feeding in marine fish larvae. *Aquaculture* 268: 53-63.

Yúfera, M., Polo, A., and Pascual, E. (1993a). Larvae reared in the laboratory. Changes in chemical composition and biomass during the transition from endogenous to exogenous feeding of (*Sparus aurata* L.). *Journal of Experiments Marine Biology Ecology* 167: 149-161.

Zaidi, M. K., and Mustafaev, I. (2003). Radiation safety problems in the Caspian region (Vol. IV). Netherland: kluwer Academic Publishers.

Zambonino- Infante, J. L., and Cahu, C. (1994). Development and response to a diet change of some digestive enzymes in sea bass (*Dicentrarchus labrax*) larvae. *Fish Physiology Biochemistry Journal* 12: 399-408.

Zambonino-Infante, J. L., and Cahu, C. (2001). Ontogeny of the gastrointestinal tract of marine fish larvae. *Journal of Comparative Biochemistry Physiology* 130C: 477-487.

Zarbalieva, T. S. (1987). Information on the feeding of the kutum, *Rutilus frisii kutum*, along the western coast of the southern Caspian Sea. *Journal of Ichthyology* 27(4): 170-173.

ZarinKamar, H. (1996). Feeding physiology and feeding habits in *Rutilus frisii kutum* in the Bandar Anzali region. Master of Science Thesis. Islamic Azad University.

Zwilling, R., and Neurath, H. (1981). Invertebrate proteases. *Methods Enzymology* 80: 633- 664.