

**Vocational Higher Secondary  
Education (VHSE)**

**SECOND YEAR**

**AQUACULTURE**

*Reference Book*



**Government of Kerala  
Department of Education**

**State Council of Educational Research and Training (SCERT),  
KERALA  
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## FOREWORD

*Dear Learners,*

*This book is intended to serve as a ready reference for learners of vocational higher secondary schools. It offers suggested guidelines for the transaction of the concepts highlighted in the course content. It is expected that the learners achieve significant learning outcomes at the end of the course as envisaged in the curriculum if it is followed properly.*

*In the context of the Right- based approach, quality education has to be ensured for all learners. The learner community of Vocational Higher Secondary Education in Kerala should be empowered by providing them with the best education that strengthens their competences to become innovative entrepreneurs who contribute to the knowledge society. The change of course names, modular approach adopted for the organisation of course content, work-based pedagogy and the outcome focused assessment approach paved the way for achieving the vision of Vocational Higher Secondary Education in Kerala. The revised curriculum helps to equip the learners with multiple skills matching technological advancements and to produce skilled workforce for meeting the demands of the emerging industries and service sectors with national and global orientation. The revised curriculum attempts to enhance knowledge, skills and attitudes by giving higher priority and space for the learners to make discussions in small groups, and activities requiring hands-on experience.*

*The SCERT appreciates the hard work and sincere co-operation of the contributors of this book that includes subject experts, industrialists and the teachers of Vocational Higher Secondary Schools. The development of this reference book has been a joint venture of the State Council of Educational Research and Training (SCERT) and the Directorate of Vocational Higher Secondary Education.*

*The SCERT welcomes constructive criticism and creative suggestions for the improvement of the book.*

*With regards,*

**Dr. P. A. Fathima**  
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## **PART - A**

### **AQUACULTURE**

### **ABOUT THE COURSE**

Aquaculture is the farming of aquatic living things such as fish, shellfish and plants. It refers to the breeding, rearing and harvesting of plants and animals in all types of water environment. According to Food and Agriculture Organisation, aquaculture is defined as the farming of aquatic organisms with some sort of intervention including the rearing process to enhance production, such as regular stocking, feeding and protection from predators.

Kerala was a forerunner in marine fish production and foreign exchange earnings through fishery exports even though we have only a lean stretch of land with coast line of 590 km. But nowadays due to diminishing capture production from marine sector, Kerala is facing a downfall in fish production and foreign exchange. Only viable alternative to tackle this problem is to cultivate fish by which Kerala can regain its prime position in fisheries sector again. The potential of Kerala in increasing aquaculture production lies greatly in developing and implementing scientific aquaculture practices. However some weaknesses and threats to this sector needs to be addressed like inadequate human resource development, weak extension activities, depletion of water resources in terms of quality and quantity and unscientific management of fisheries and aquaculture activities. In this context aquaculture course is very promising for fish production as well as for providing employment. For the aspirants of vocational education, aquaculture offer bright future in terms of employment generation and self-employment.

Aquaculture course deals with all relevant topics like basics of morphology and biology of fishes, general farm management measures, different aquaculture systems, culture of commercially important fishes and shell fishes, their hatchery seed production techniques, live and artificial feeding, disease management, ornamental fisheries etc. This curriculum offers skill generation for working in aquaculture sector as well as for entrepreneurship.

Aquaculture course provides immense job opportunities in various aquaculture industries such as farming and seed production of fin fish, shell fish and ornamental fishes. This curriculum enables the students to undertake different job roles in Government as well as Private sector. The production cum Training Centre (P.T.C.) and On the Job Training (O.J.T.) will provide hands on practical experience to the

students, which will enable them to deal with job situations and have entrepreneurship in the field of Aquaculture. This curriculum is suitable for career enhancement through higher education in Fisheries sector also.

### **Major Skills and Sub-skill**

- Skill in selection and management of carps brood stock
- Expertise in Induced Breeding of Carps
- Management of Happa system, Chinese hatchery system and Jar hatchery system
- Expertise in Induced breeding and selective breeding in Tilapia
- Knowledge in seed production of Pearl Spot in captivity
- Expertise in induced breeding of air breathing fishes
- Skill in selection and management of Asian Sea Bass brood stock
- Expertise in larval rearing and seed production of Asian Sea Bass
- Knowledge in seed production of commercially important marine fishes like Cobia and Pompano.
- Skill in packing and transportation of fish seeds
- Expertise in larval rearing and seed production of Penaeid shrimps
- Expertise in live feed culture
- Expertise in Induced maturation and spawning in Penaeid shrimps
- Expertise in selection and transportation of berried female prawns
- Expertise in larval rearing and seed production of Giant Freshwater Prawn
- Skill in packing and transportation of Shrimp seeds and Prawn seeds
- Knowledge in larval rearing and seed production of Crabs
- Knowledge in collection and transportation of Oyster and Mussel spats
- Skill in preparation of Oyster and Mussel ren
- Identification of aquarium fishes and aquarium plants
- Identification of the challenges in conservation of indigenous ornamental fishes
- Expertise in seed production of aquarium fishes
- Expertise in aquarium plant rearing and propagation

- Expertise in installation and usage of aquarium equipment's and accessories.
- Skill in making of glass tank
- Skill in setting up of an aquarium
- Expertise in aquarium management
- Identification of Common Aquarium Fish Diseases and its causative agents
- Knowledge in Quarantine, prophylactic and therapeutic measures against diseases
- Skill in maintenance of brood stock of aquarium fishes
- Skill in breeding of aquarium fishes
- Skill in Nursery rearing aquarium fishes
- Skill in live feed culture for aquarium/ ornamental fishes
- Identification of marine ornamental fishes
- Identification of marine ornamental invertebrates and other marine organisms
- Skill in setting up of marine aquarium
- Skill in maintaining marine aquarium

## SYLLABUS

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	Sexual dimorphism in Giant Freshwater Prawn	
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	Collection centres of brood stock from wild	
<b>3.9</b>	<b>Seed production of Mud Crab</b>	<b>10</b>
	Sexual dimorphism in Mud Crab	
	Water quality parameters	
	Familiarization of larval stages	
	Larval rearing techniques	
	Collection of water crabs for fattening	
<b>3.10</b>	<b>Seed collection of Bivalves</b>	<b>10</b>
	Commercial bivalve species (Oyster and Mussels)	
	Collection of Oyster and Mussel spats	
	Preparation of Oyster Ren and Mussel Ren	

#### **Module IV: Ornamental Fisheries and Aquarium Management**

<b>4.1</b>	<b>Aquarium fishes</b>	<b>30</b>
	Familiarization of aquarium fishes	
	Classification of aquarium fishes namely egg layers and live bearers	
	Exotic and indigenous varieties	
<b>4.2</b>	<b>Aquarium plants</b>	<b>20</b>
	Familiarization of aquarium plants	
	Aquarium plant rearing and propagation	
	Aquarium plant and water quality	

<b>4.3</b>	<b>Aquarium equipments and accessories</b>	<b>30</b>
	Familiarization of Aquarium equipments and accessories (Aerators, Heaters, Illuminating lamps, Sand filter bed, Submersible pumps and filters Bio filters, Drift wood, Rock & pebbles) Principle and functioning of Bio filter	
<b>4.4</b>	<b>Making of an aquarium tank</b>	<b>30</b>
	Measurements and cutting of glass pieces Glass tank making tools Making of glass tank Acrylic tanks	
<b>4.5</b>	<b>Assembling an aquarium</b>	<b>30</b>
	Assembling the aquarium	
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	Water quality management Usage of water test kits to measure chemical parameters (Dissolved O <sub>2</sub> , CO <sub>2</sub> , NH <sub>3</sub> , NO <sub>2</sub> , NO <sub>3</sub> , Alkalinity & Acidity)	
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	Ichthyophthiriasis Fin rot and Tail rot Saprolegniasis Dropsy Protozoan infections	
<b>4.8</b>	<b>Breeding and seed production of Aquarium fishes</b>	<b>80</b>
	Brood stock maintenance Breeding and spawning Life feed culture Nursery rearing	
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	Familiarization of marine ornamental fishes Familiarization of marine ornamental plants and organisms Marine aquarium accessories Water quality management	

## SCHEME OF WORK / YEAR PLAN

### MODULE III

#### SEED PRODUCTION AND HATCHERY MANAGEMENT OF FIN FISHES AND SHELL FISHES

Sl.no.	Month	Units Covered in the Month	Periods
1	June	Introduction to reproduction in fishes and shell fishes	30
2	June/July	Seed production of Carps	80
3	July	Seed production of GIFT	15
4	July	Seed production of Pearl Sport	15
5	August	Seed production of Air breathing fishes	15
6	August	Seed production of Asian Sea bass	15
7	August/ September	Seed production of Marine Penaeid Shrimps	100
8	October	Seed production of Fresh Water Prawn	50
9	October	Seed production of Mud Crab	10
10	October	Seed collection of Mussels and oysters	10
		<b>TOTAL</b>	<b>340</b>

### MODULE IV

#### ORNAMENTAL FISHERIES AND AQUARIUM MANAGEMENT

Sl.no.	Month	Units Covered in the Month	Periods
1	November	Aquarium fishes	30
2	November	Aquarium plants	20
3	November/ December	Aquarium equipments and accessories	30
4	December	Making of an aquarium tank	30
5	December	Assembling an aquarium	30
6	January	Aquarium management	40
7	January/ February	Fish Diseases-Prophylactic and therapeutic measures	40
8	February/ March	Breeding and seed production of Aquarium fishes	80
9	March	Marine Aquarium	40
		<b>TOTAL</b>	<b>340</b>

**PART - B****OVERVIEW OF THE MODULE III****Module III. Seed production and hatchery management**

This module deals with seed production of fishes like carps, Pearl spot, GIFT, air breathing fishes and shell fishes like Tiger shrimp, Vannamei shrimp, prawns and bivalves. The module covers the topics like brood stock maintenance, breeding, spawning, larval rearing of fin fishes and shell fishes. Module aims to impart basic knowledge, expertise and skill in various aspects of seed production. It addresses the skill requirements in Induced breeding technique, packing and transportation of seeds. The classroom transaction and practical activities are arranged in such a way that learner acquires knowledge as well as skill from the class room activities and ultimately polish the same through field visit, Production cum Training Centre and On the Job Training programme. The module, in curricular point of view paves the way for skilled manpower required in Aquaculture sector. Ultimately opportunities in this sector can be tapped by the VHSE pass outs.

**List of expected skills**

- Skill in induced breeding and seed production of fishes
- Skill in breeding and seed production of shell fishes
- Skill in preparation of Oyster and Mussel ren for Culture
- Skill in live feed culture
- Skill in packing and transportation of fin fish seeds and shell fish seeds

**Unit. 1 Introduction to reproduction in fishes and shell fishes**

The unit introduces the module with factors affecting natural reproduction in fin fishes and shellfishes. Before going through the artificial breeding and its techniques, learner gets the opportunity to understand the physiology of reproduction, phenomenon like sexual dimorphism, hermaphroditism, fish genetics, selective breeding and recent developments and advancements in seed production.

**Learning outcomes**

The learner :

Recognizes the factors affecting natural reproduction in fin fish and shell fish.

Understands the Physiology of reproduction

Understands Sexual dimorphism and hermaphroditism.

Understands the basic principles in Fish genetics.

Identifies recent developments in seed production

### **Detailing of Concepts**

Requirement for the culture of any species primarily needs availability of quality seed. Hence study of breeding and seed production is important. This unit deals with biology of reproduction and recent developments and advancements in this area.

Factors affecting natural reproduction in fin fishes and shellfishes.

Among the several factors affecting reproduction, following are dealt with -

- i. Environmental factors namely light, temperature, water quality parameters, water current, depth etc.
- ii. Intrinsic physiological factors namely hormonal control of reproduction
- iii. Nutritional requirements

Physiology of reproduction

Environmental factors influence the levels of hormones of hypothalamus, pituitary and other endocrine hormones which regulate reproduction.

Sexual dimorphism

Hermaphroditism

It is the phenomenon in which both the male and female sex organs are present in the same individual. Two types of hermaphroditism exist, viz synchronous and asynchronous hermaphroditism. In synchronous hermaphroditism, male and female ripe at the same time. In asynchronous hermaphroditism, either male or female ripe at a time. There are two types of asynchronous hermaphroditism viz. protandrous and protogynous.

Fish genetics

Genetics play an important role in increase fish productivity through genetic improvement methods like selective breeding, hybridisation etc.

### **Detailing of Practical**

- Identification of sexual dimorphism in fish and shrimp with morphological distinguishing characters and drawings made in record.

### **Assessment Activities**

Group discussion on factors affecting reproduction of fin fishes and shell fishes

Identification of male and female fish with morphological distinguishing characters and drawings made in record

Quiz on Fish Genetics

Seminar on Recent developments in the field of seed production

### **List of items in Portfolio**

- Report on Group Discussion
- Assessment of Previous knowledge by Quiz
- Questionnaire and answers
- Report on seminar
- Practical record

### **Additional information**

South East Asian countries are the fore- runners in the field of Aquaculture

### **TE Questions**

1. Pick the odd man out  
(Ovaprim ,HCG, PMSG, Pituitary extract)
2. Differentiate between protandrous and protogynous hermaphroditism with example.

## Unit. 2

### Seed production of Carps

This unit covers the basics of carp seed production. The unit gives emphasis on Induced breeding of Carps through sexual dimorphism in carps, brood stock management, breeding and spawning, larval rearing, packing and transportation. Materials and equipments used for induced breeding, hatchery systems like Happa system, Chinese hatchery system and Jar hatchery system are introduced during this module by practicals, field visits and OJT.

#### Learning outcomes

The learner :

Identifies the commercially important carps and its sexual dimorphism

Develops skill in selection and management of carp brood stock

Familiarize materials and equipments used for induced breeding

Develops skill in induced breeding technique

Identifies the life stages viz. fertilized egg, spawn, fry, fingerlings, juvenile and adult

Operates Happa system, Chinese hatchery system and Jar hatchery system

Optimises physical, chemical and biological parameters of water.

#### Detailing of Concepts

Sexual dimorphism in Carps

Carps are sexually dimorphic. The mature males have denticulation on the dorsal surface of the pectoral fin which is rough to touch. In males the abdomen is comparatively flat and the vent is not swollen. Pressing their abdomen, milt will ooze out.

The ripe females of the carp have soft and bulging abdomen with swollen pinkish genital opening. In Chinese carps, eggs can be collected by inserting a catheter through the genital opening of the fish. In Silver carp, mature eggs are pale blue in colour and that of Grass carp it is brownish coloured.

Brood stock management of carps

The brood stock should be quarantined by disinfecting with 40ppm formalin bath for 2 hours. Carps attain sexual maturity in 1- 2 years of age. Potential brood fish are stocked in earthen ponds at a stocking density of 1500-2000 kg/ha. The brood

fishes are fed with ground nut oil cake and rice bran in 1:1 ratio @ 2-3% of body weight. Sprouted grains and pellet feed having 30% protein can also be given. This will help in gonadal maturation of brooders. Male and female fishes are stocked separately in brood stock ponds.

#### Induced breeding and larval rearing

Success in induced breeding depends on environmental factors. The suitable water temperature range is 26-28°C with cool and drizzling weather. Circulation of fresh water with fair levels of DO promotes better success in spawning, fertilization and hatching.

The males and females are selected in a ratio of 2:1 by number or 1:1 by body weight. The selected breeders are kept in happas or pools for about 6 hrs. Stress to the brooders should be minimal for better results. After proper conditioning, the individual brood fish is collected using a hand net, weighed and placed on a soft cushion for receiving injection. A single dose of injection with synthetic hormones is given in the evening. The dose is given below.

Catla, Rohu	: 0.5 ml/kg
Mrigal, Common carp	: 0.3 ml/kg
Grass carp, Silver carp	: 0.6-0.7 ml/kg

After injection both male and female fishes are released into the breeding pool. The water outlets into the pool are opened in such a way that a circular current is created. The speed of water current is maintained at about 0.5m/ sec. The male fish chases the female with splashing of water. The female starts laying eggs and the male continuously oozes milt results in fertilization. Average fecundity per kg body weight of female fish in Carps are given below.

Catla	: 0.6-1.0 lakh
Rohu	: 1.2-1.5 lakh
Mrigal	: 0.8-2.0 lakh
Grass carp	: 0.06-0.13 lakh
Common carp	: 0.05-0.1 lakh

Fertilized eggs are transparent whereas the unfertilized eggs are opaque and whitish. The delay in removing unfertilized eggs causes Saprolegnia fungal infection. By the application of malachite green (20ppm) for 20-25 min the same can be controlled. The eggs are removed 8-10 hours after fertilization, when the embryo begins twitching

movement. The fertilized eggs are quantified and transferred to the incubation pool. Fertilization rate can be ascertained by microscopic observation of sample of eggs and counting the number of fertilized eggs. Usually fertilization rate is 85-100%.

In Silver carp and Grass carp, dry method of stripping is practiced. Before stripping, the fish is anaesthetized by 100ppm ethyl-m-aminobenzoate dip for 3-5 minutes. The maturity of eggs is checked by collecting eggs with the help of a catheter. The female fish is wrapped in a towel and stripped by gently squeezing the abdomen towards the tail to collect eggs. The eggs that flow easily are collected in a dry enamel tray/ plastic basin and are immediately fertilized by milt stripped from males similarly. The contents is mixed and stirred with the help of a feather for 5mts. The eggs begin to swell on contact with water. More water should be added so that there will be 3-5cm of water above the eggs. After 30min, the eggs should be washed with water and kept for incubation.

In the case of Common carp, eggs are adhesive. Hence, submerged weeds like Hydrilla or Najas are provided as egg collectors in breeding pools/ hapas. They breed naturally after 6-8 hours. The weeds attached with eggs are collected for incubation in separate tanks.

### Life stages of Carps

Fertilized eggs	4-5 mm
Spawn	5-10 mm
Fry	10-30mm
Fingerling	30-50mm

### Hatching Happa

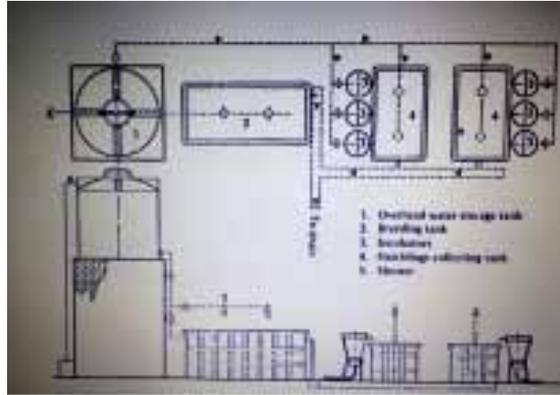
Hatching hapa comprises of two rectangular enclosures, the inner (1.75x.75x.45m) made up of mosquito net cloth and the outer (1.8x.9x.9m) made from cloth material.

The fertilized eggs are uniformly spread on the inner happa. The hatching happa is fixed in the ponds with the help of poles. The eggs hatch after 15-18 hours and the hatchlings swim and escape to outer happa. The dead eggs and shells along with inner happa are removed.



## Chinese hatchery system

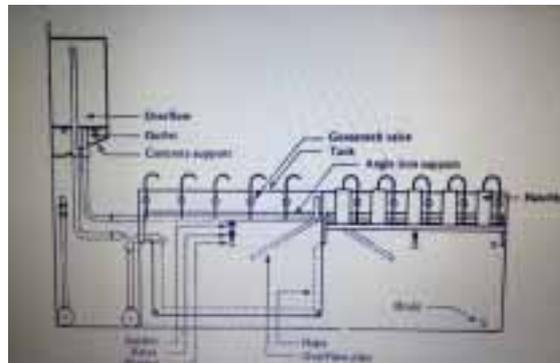
Main components of a Chinese hatchery are Overhead Tank, Spawning/Breeding pool and Incubation pool. Circular breeding/spawning pool of size 4m (diameter) is ideal to hold the injected breeders for spawning and fertilization. An overhead tank/water reservoir ensures continuous supply of freshwater for running the hatchery system.



The wall of the breeding pool is fitted with duck mouth inlet pipes fitted at an angle of  $45^\circ$  for water circulation. Water is brought to this pool from an overhead reservoir of sufficient capacity through shower outlets. Incubation pool holds the fertilized eggs flown in gravitationally from the Spawning/Breeding pool. These pools have a diameter of 2.9m, depth of 0.8m and a total capacity of 4.6 m<sup>3</sup>. The stocking density of the pool for spawn is 7-8 lakhs/m<sup>3</sup>.

## Jar hatchery system

Jars are made up of transparent acrylic plastic sheet. The height of the jar is 50cm and diameter 15cm and a capacity of 10 litres. Around 30,000 eggs can be stocked for hatching in the jars. The water flow rate of the jar is 0.7-1litre/minute for carps. After 15-16 hours egg hatches out and hatchlings escape from the jar to the spawnery through top of the jar.



A fine meshed mosquito cloth spawnery of size 2x1x1m immersed in a plastic pool is functioned as spawnery.

## Detailing of Practical

- Measurement of physical, chemical and biological parameters of water in larval rearing.

Water quality parameters in larval rearing tank are measured and analysed during OJT/ PTC/ Field visit. Measured values can be compared with Optimum range. Data can be recorded in practical record.

- Identification of the commercially important carps and it's sexually dimorphism (characters)

Sexual dimorphism in carps studied with the help of carp specimens. Drawings made in records.

- Identification of life stages viz. fertilized egg, spawn, fry, and fingerlings, juvenile and adult

Egg, spawn and fry are observed using microscope, similarly morphological features of fingerlings, juvenile and adult are observed and documented. Through this the learner identifies the species of carp in fingerling level.

- Familiarization of materials and equipment used for induced breeding

Catheter, feather, breeding hapa, hatching hapa, tissue homogeniser, hand centrifuge, hypodermic syringe are introduced to learners for familiarization. Use of each item is explained through demonstration.

- Demonstration of preparation of Pituitary gland extract

Pituitary gland is collected from fishes like tilapia, carps etc. Collected pituitaries are stored in acetone. Pituitary glands are macerated, centrifuged and decanted for collecting the hormone extract.

- Methods of injection for induced breeding

Caudal peduncle, below dorsal fin and intra peritoneal injections are conducted in specimens.

- Model preparation of Happa / Chinese hatchery / Jar hatchery

Components of Happa / Chinese hatchery / Jar hatchery is familiarized by field visit and models are made during practical

- Demonstration on packing and transportation of seeds

Packing of fish seeds in polythene bags are repeatedly practised during OJT/ PTC/ field visit.

### **Assessment Activities**

Seed production of Carps

Identification of male and female fish with morphological distinguishing characters and drawings made in record

Group Discussion on Brood stock management

Interaction with expert at carp hatchery through OJT/field visit

Familiarization of materials and equipments used for induced breeding through practical/OJT/field visit

Interaction with expert at carp hatchery through OJT/field visit

Identification of life stages viz. fertilized egg, spawn, fry, and fingerlings, juvenile and adult through practical/OJT/field visit

Operation of Happa system, Chinese hatchery system and Jar hatchery system at hatchery during OJT/field visit

Measure and analyse physical, chemical and biological parameters in larval rearing by field visit/practical/ OJT

### **List of items in Portfolio**

- Report on Group Discussion
- Report on ICT enabled teaching activity
- Report on Field visit/ OJT
- Practical record

### **Additional information**

Hybridization and selective breeding has helped in evolving new strains with improved qualities in Carps

### **TE Questions**

1. Write the uses of the following equipments  
Catheter, Syringe
2. Write note on sexual dimorphism in carps
3. Define fecundity, write the fecundity of Indian Major Carps
4. List out the life stages in Carps

## Unit.3

### Seed production of Tilapia (Genetically Improved Farmed Tilapia)

This unit deals with important topics related such as Sexual dimorphism in Tilapia, Induced and selective breeding in Tilapia, Hormonal sex reversal of Tilapia, Physical, chemical and biological parameters of water for larval rearing. Through this unit student will acquire knowledge, expertise and skill in breeding of a globally cultivated fast growing species.

#### Learning outcomes

The learner :

Understands sexual dimorphism in Tilapia

Expertise in Induced breeding and selective breeding in Tilapia

#### Detailing of Concepts

Sexual dimorphism in Tilapia

In mature tilapia, sexual dimorphism is very clear. The mature males have a conspicuous red, blue or black colouration with white or bright dorsal and caudal fin margins, while in female, colouration is less evident. The ready to spawn females is distinguished by its soft bulged belly with pink coloured genital pore. The genital papilla in male tilapia has only one opening (urino-genital aperture) while female has two openings.

Induced breeding and selective breeding in Tilapia

The male and female brood stock is maintained separately for 2-3 weeks in happas (3x3x1m) at a density of 10 /m<sup>2</sup>. During conditioning of brooders, they are fed at 2-5% of their body weight with diets having 30% protein. To prevent injuries during mating, upper lip of male should be clipped before mating. For clipping of mouth, male brooders should be anesthetised using 50 ppm clove oil. After mouth clipping, the wounds may be treated with 10% betadine solution.

Brooders stocked in ponds at a density of 2 / m<sup>2</sup>, are fed twice at a rate of 0.5 to 2% of body weight with feed having 32% protein. The ideal ratio of male to female is 1:2. Spawning takes place inside the breeding happa when they are released into it. After mating, the fertilised eggs will be either in happa or in the mouth of females. The ideal time for egg collection is early morning to reduce stress and mortalities.

Collected eggs should be washed, cleaned and disinfected with 3 ppt saline water. Eggs collected from the breeding happa are incubated in indoor incubation jars. A 20 litre incubation jar can hold 300-500g of the fertilised eggs. Hatching takes place in 72-96hrs after fertilization, if optimum temperature of 31-32°C is maintained. A continuous water flow of 2 litre/ hour should be maintained in the jars. Fertilised egg develops to free swimming fry by the 7-10th day of incubation. The young one is reared in indoor cement/ FRP tanks having 1-10 ton capacity. The hatch-out fry is fed with micro-particulate feed of less than 500 $\mu$  having 40-45% protein. For all male production, the sex reversal of female population is achieved by mixing the hormone (17 alpha methyl-testosterone at a dose of 40 mg/kg feed) of male sex hormones through feed. The hormone treated fry are reared either in happas installed in earthen ponds or outdoor concrete tanks. Usually one lakh fry are stocked in 10x3x1m happa. It is fed at a rate of 20% of body weight initially and gradually reduced to 10%.

### **Detailing of Practical**

- Identification of species (GIFT) and its sexual dimorphism

Sexual dimorphism in GIFT studied with the help of specimens. Drawings made in records

### **Assessment Activities**

Seed production of Tilapia

Identification of male and female fish with distinguishing morphological characters and drawings made in record

Group Discussion on selective breeding and induced breeding

ICT enabled teaching activity on induced breeding and selective breeding in Tilapia

Simulated practicals on induced breeding of Tilapia

### **List of items in Portfolio**

- Report on Group Discussion
- Report on ICT enabled teaching activity
- Report on panel discussion
- Report on Field visit/OJT
- Practical record
- Vocational diary

**Additional information**

Tilapia is the most preferred fish for research and studies because of its adaptive characters

**TE Questions**

1. Name the fish commonly used for monosex culture.
2. Buccal incubation (Parental care) is seen in .....
3. Recent advancements in breeding and seed production of Tilapia culture is gaining momentum worldwide. Briefly explain the techniques.

## Unit. 4

### Seed production of Pearl Spot

Pearl spot is highly soted after indigenous food fish which is considered as the state fish of Kerala. High demand for the fish makes seed production of pearl spot important. Here the unit covers Sexual dimorphism in Pearl spot, Breeding of under captivity/cages, Physical, chemical and biological parameters of water suitable for larval rearing and collection of seeds from wild.

#### Learning outcomes

The learner :

Understands sexual dimorphism in Pearl spot

Understands the methodology of breeding Pearl Spot in captivity

Optimizes physical, chemical and biological parameters of water for larval rearing of Pearl Spot

#### Detailing of Concepts

Sexual dimorphism in Pearl Spot

Genital papillae in males are longer and pointed while it is broader and rounded in females.

In mature males the colouration is more intense and accompanied by the appearance of black occipital stripes between eye and operculum

Breeding under captivity

Cement tanks made of bricks having the size of 4x2x1m are suitable for breeding Pearl spot under captivity. Bottom of the tank is demarcated with a single line of brick and filled with sand. Then, clean suitable egg attaching substrata like broken stones, tiles, hollow bamboo pieces, coconut shells, asbestos sheets, PVC pipes etc are placed in the sandy area for attachment of eggs. For good plankton production, one kg of cow dung in perforate sack can be placed.

The brood fishes weighing 150-200g are stocked in the breeding tank at the rate of 6pcs/ tank with male and female in the ratio 1:1. They can be fed with conventional artificial feed prepared with 45% rice bran, 40% groundnut oil cake, 15% fish meal fortified with 1% vitamin and mineral mix. Feeding can be done at the rate of 3-5% of fish biomass either in pellet or in dough form in feeding trays morning and evening.

Excess feed and excreta should be siphoned out and a partial water exchange of 20-30% is done on regular basis to maintain water quality. It is expected that 50% of the fish stocked will form spawning pairs. Water transparency should be maintained around 40-50cm which plays a major role in determining spawning success. In 72-96 hours, the eggs hatch out. The hatchlings remain in breeding pit up to 5-7 days and there after come out. Those hatchlings out of pit are collected and transferred to cement tanks for rearing for a short duration.

The young-ones can be initially fed with 100 $\mu$  particle size feed and freshly hatched artemia nauplii. To maintain the algal growth the water should be fertilized. The fry with 20mm size can be reared in natural earthen ponds to fingerling sizes. The pond should be prepared and fertilized as in the case of a carp nursery. The young-ones can be stocked at the density of 100nos/sq.m. It can be fed with 32% protein diet with particle size of 800 $\mu$  initially and 1.2mm subsequently.

The fry can be harvested and conditioned in FRP tanks for 12-24 hours before packing. Pearl spot is a euryhaline species, and can be easily acclimatized to the salinity of water body to be stocked. An acclimatization time of 30 minutes each is required for adjusting every 5 ppt salinity.

Physical, chemical and biological parameters of water for larval rearing

The water quality parameters of breeding tanks and rearing tanks should be regularly monitored and necessary steps should be taken to maintain the same.

Water salinity	15ppt
Water depth	1.2-1.5m
Dissolved O <sub>2</sub>	4-5 ppm
pH	7-8
Temperature	24-32°C
Transparency	above 50cm
Ammonia	less than 1ppm

### **Detailing of Practical**

- Identification of species (Pearl Spot) and its sexual dimorphism

Sexual dimorphism in Pearl spot studied with the help of specimens. Drawings made in records

### **Assessment Activities**

Seed production of Pearl Spot

Identification of male and female fish with distinguishing morphological characters and drawings made in record

ICT enabled teaching activity on breeding of Pearl spot in captivity

Measure and analyse physical, chemical and biological parameters in larval rearing by field visit/ practical/ OJT

### **List of items in Portfolio**

- Report on ICT enabled teaching activity
- Practical record
- Vocational diary

### **Additional information**

Breeding of Pearl spot is possible even in Cages by providing a suitable substratum for attaching eggs

### **TE Questions**

1. Identify the fish with following features-
  - i. Shows parental care
  - ii. Attach eggs to hard substratum
  - iii. State fish of Kerala.
2. Briefly give an account of seed production of Pearl spot.

## Unit. 5

### Seed production of Air breathing Fishes

Air breathing fish culture is gaining importance as they can adapt even the most fluctuating culture atmosphere. The ever depleting water resources in terms of quality and quantity also give immense scope to these fishes in culture scenario. The unit deals with sexual dimorphism in Air breathing fishes and Induced breeding of Air breathing fishes.

#### Learning outcomes

The Learner :

Identifies air breathing fishes and its sexual dimorphism

Develops skill in induced breeding of air breathing fishes

Optimizes physical, chemical and biological parameters of water for larval rearing

Acquire skill in packing, transportation of seeds

#### Detailing of Concepts

Sexual dimorphism in Air breathing fishes

Female is larger than the male and have a shorter and blunt papilla which becomes soft and swollen during breeding season. Mature female can also be easily identified by their swollen abdomen and egg oozes-out on applying slight pressure on the highly distended abdomen. In males, the genital papilla is conical, long and pointed, becoming protruded and highly vascularised during the breeding season. However, the ripe male do not discharge milt on applying pressure on the abdomen. In female, the genital papilla is small and stumpy. Adult male fishes are slightly yellow in colour while females are dark in colour.

Induced breeding in Air breathing fishes

Mature females and males in the ratio of 1:2 can be put together for induced breeding in spawning tank. Spawning can be induced by intramuscular injection of synthetic hormones like Ovaprim as a single dose of 1 ml/ kg body weight. The injection is given near the base of dorsal fin above the lateral line of male and female using an insulin syringe preferably in the evening. A temperature of 25-28°C is most conducive for breeding.

After hormone injection, each set of brooders can be released into the breeding tank in which water level is maintained at a depth of 45 cm. Adequate quantity of submerged weeds like Hydrilla can also be provided as a cover for the fish to hide and to facilitate a natural breeding habitat. Brooders start responding to the hormone after 6- 8 hours of injection and display prolonged and intermittent spawning and courtship behaviour extending for about 6 hrs. The fertilized eggs are moderately adhesive, demersal, golden-yellow in colour, spherical in shape with heavy yolk and have a size of 1.2-1.5 mm.

The spent parents and aquatic plants should be removed from the breeding tank soon after the completion of spawning to avoid clogging and damage of eggs. The fertilized eggs can then be carefully siphoned out and transferred to a specially designed flow-through hatching system for incubation. Continuous freshwater flow at a rate of 30 litre/hour can be maintained in each basin to keep the eggs devoid of contamination. Care must be taken to avoid crowding of eggs as it leads to fungal infection and clogging of hatchling. The period of incubation is 17-20 hours at a temperature of 27°C. Fecundity is 8000-16000 eggs/180g female.

The hatchlings are acclimatized in the incubation tank by providing aeration with least disturbance. Water quality parameters should be maintained by 50% of water as and when required. The hatchlings are stocked in a rate 3000-4000 nos/m<sup>2</sup>. After 10-12 days it starts vertical movements to gulp in air. Hence, the aeration of water should be stopped and the level of water in the tank should be reduced to 8-10 cm. The hatchlings can be fed 4-6 times a day with micro-encapsulated feed, Artemia or plankton (Daphnia, Cyclops and Moina).

For rearing moderate stocking is 300-400nos/cum is done. It can be fed with minced liver, macerated yolk and fish meal. It can also be fed with commercially available shrimp larval feeds of varying sizes. In addition, mixed diet consisting of clam meat, prawn meat, chopped fish can also be used. Fry rearing can also be carried-out in earthen ponds.

Packing and transportation of fish seed

One day prior to the harvesting, feeding can be stopped. Harvesting can be done, when the fish attains a size of 40-50 mm. The fishes can be harvested with a fine meshed (1.5 mm) drag net in cool morning hours.

### **Detailing of Practical**

- Identification of species (Air Breathing Fishes) and its sexual dimorphism  
Sexual dimorphism in Air Breathing Fishes studied with the help of specimens.  
Drawings made in records

### **Assessment Activities**

Seed production of Air breathing Fishes

Identification of male and female fish with distinguishing morphological characters and drawings made in record

Measure and analyse physical, chemical and biological parameters in larval rearing by field visit/ practical/ OJT

Field visit to hatchery

Engage in packing process during the Field visit/ OJT in hatchery

### **List of items in Portfolio**

- Report on seminar
- Practical record
- Vocational diary
- Report on Field visit/OJT

### **Additional information**

Air breathing fishes are gaining importance in culture scenario since water resources are depleting in quality and quantity

### **TE Questions**

1. Write the sexual dimorphism in Stinging Cat Fish

## Unit. 6

### Seed production of Asian Sea bass

As a state is bestowed with vast brackish and marine environments, culture of brackish water and marine fishes has good scope in Kerala. Since there is a clear preference to marine and brackish fishes over freshwater fishes in Kerala, culture of these fishes offer good prospects. This unit highlights sexual dimorphism in brackish water and marine Fishes, induced breeding, management of water quality parameters in larval rearing and also collection of wild seeds.

#### Learning outcomes

The Learner :

Understands sexual dimorphism in Sea Bass

Optimizes physical, chemical and biological parameters of water for larval rearing

Acquires expertise in larval rearing of Sea Bass

Acquires knowledge in seed production of commercially important marine fishes

#### Detailing of Concepts

Sexual dimorphism in Asian Sea bass

Sea bass shows protandrous hermaphroditism. Initially the fishes of 2- 4kg size mature as male. Fishes weighing more than 4kg size are mostly female. The bloodstock can be collected from wild or from farms. Morphological identification of sex is difficult except during the spawning season. The male fishes show dimorphism in their dorsal side of the head, looks concave. Catheterization is also done to determine the sex.

Induced breeding and larval rearing of Asian Sea bass

The fishes are injected with LHRH-analogue at the rate of 25µg/kg body weight to both male and female fish for induced spawning. The eggs are released by the female after 34-36 hours of injection and at the same time the male also releases the milt. Fertilization takes place in water. The fertilized eggs can be kept in small tanks for incubation which hatch out after 12-15hrs. Rearing of hatchlings is done in indoor tanks having the capacity of 3-10 ton. It is the most critical phase in seed production. A live feed culture facility is to be maintained in the hatchery. The larvae are fed with rotifer, *Brachionus plicatilis* and *Brachionus rotundiformis*. The microalgae such as marine *Chlorella*, *Nannochloropsis*, *Isochrysis* etc. are maintained for feeding the live feed organisms like rotifer. After 8 days the fish larvae is fed with artemia nauplii. Subsequently, the larvae are weaned to artificial diet.

The fry having the size of 1-1.5cm is reared to the size of 7cm. It can be done in indoor/ outdoor tanks, hapas or cages. In the case of tanks, there must be provision for continuous aeration and daily 100% water exchange. The fry is to be fed with formulated artificial diet for 3-4 times at the rate of 20% of the body weight.

Grading should be done in 7-10 days to avoid cannibalism. Stocking density can be adjusted according to the biomass. Duration of fry rearing period is around 35-40 days. Survival of fry rearing will be 60%.

### **Detailing of Practical**

- Identification of species Sea Bass and its sexual dimorphism

Sexual dimorphism in Sea Bass studied with the help of specimens. Drawings made in records

### **Assessment Activities**

Seed production of brackish water and Marine Fishes

Identification of male and female fish with distinguishing morphological characters and drawings made in record

Measure and analyse physical, chemical and biological parameters in larval rearing of Asian Sea Bass by field visit/ practical/ OJT

Interaction of students with hatchery expert and training during Field visit/OJT

Seminar on Seed production of commercially important marine fishes

Case study on seed production of any marine fish species (Cobia and Pompano)

### **List of items in Portfolio**

- Report on seminar
- Report on case study
- Practical record
- Vocational diary

### **Additional information**

*Cobia* and *Pompano* are the two important species with mariculture prospects

### **TE Questions**

1. Name two hormones used in the induced breeding of Asian Sea bass
2. Grading is done during the rearing of young ones in Sea Bass. Give reason.

## Unit.7

### Seed production of Penaeid Shrimps

India is now emerging as prospective shrimp producing nation with Penaeid species namely *Penaeus monodon* and *Litopenaeus vannamei*. This in turn results in huge demand of shrimp seeds. Skilled manpower is still a limiting factor in hatchery sector of shrimp seeds. This unit deeply covers all aspects of seed production of shrimps namely sexual dimorphism, spawning, familiarization of larval stages, larval rearing, live feed culture, induced maturation and packing of seeds.

#### Learning outcomes

The learner :

Identifies species (*Penaeus monodon* & *Litopenaeus vannamei*) and its sexual dimorphism

Identifies the larval stages in Penaeid shrimps

Optimizes physical, chemical and biological parameters of water

Acquires expertise in larval rearing techniques

Acquires expertise in live feed culture

Acquires expertise in Induced maturation and spawning in Penaeid shrimps

Acquires skill in packing and transportation of shrimp seeds

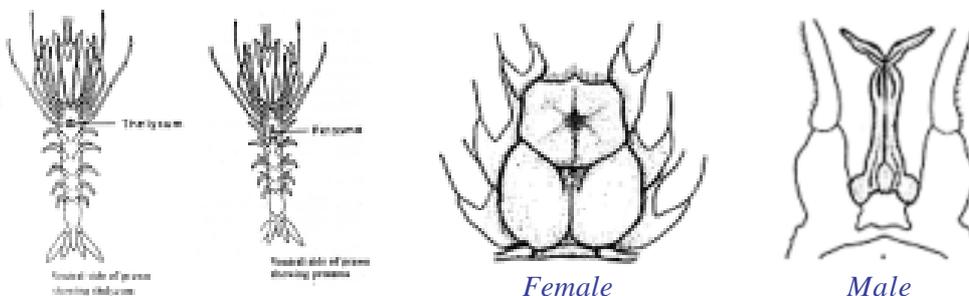
#### Detailing of Concepts

Sexual dimorphism in Penaeid Shrimps

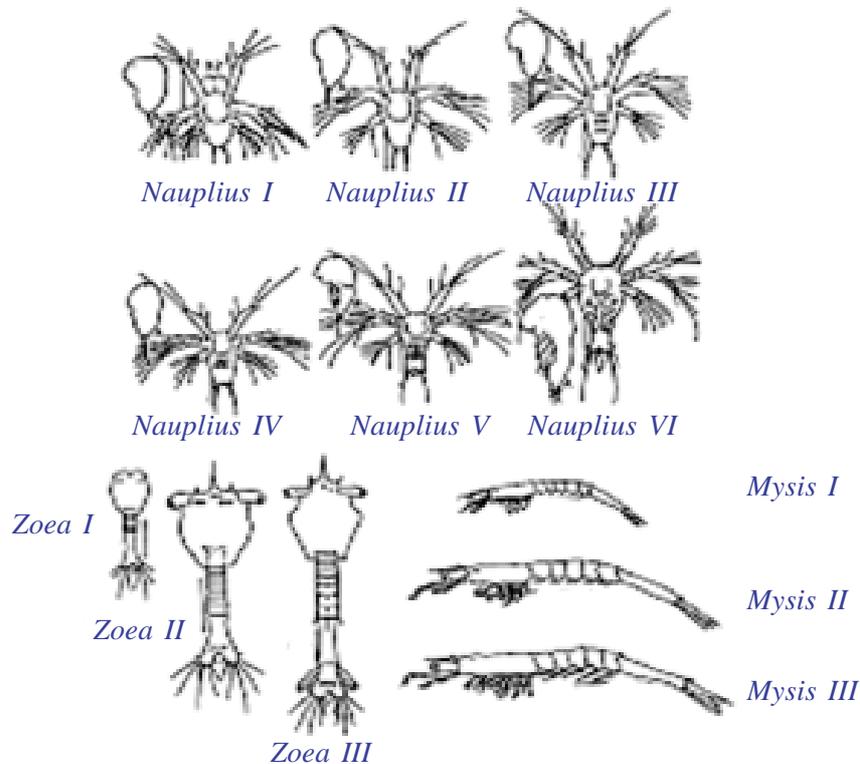
In male, appendages of first abdominal segment is modified to petasma while in female, there is thelycum placed between fourth and fifth pair of walking leg.

Gonophore is present at the base of fifth pair of walking leg in male, while in female it is present in the base of third pair of walking leg.

Sexual Dimorphism in Penaeid Shrimps



## Familiarization of larval stages



The nauplii collected after spawning are transferred to the tanks in larval rearing section. The three larval stages of tiger shrimp are completed in a period of 8- 10 days. In hatcheries, the nauplii produced elsewhere should be given dip treatment with formalin (50ppm for 30 sec), washed in clean seawater, counted and acclimatized to the rearing water condition.

The larval rearing tanks (LRTs) are stocked @ 100 nauplii/ litre. The LRTs are half filled with clean, disinfected and filtered seawater at the time of stocking. No water exchange is done for the first six days of larval rearing; water level in the tank is gradually raised until the larvae reaches Mysis-1 stage. Further, daily water exchange of 30% is provided until the larvae finally metamorphose to Post Larvae. Post larvae are either retained in the LRTs or shifted to Post larval rearing tanks (PLRTs) which are usually large outdoor tanks. About 50% of the water is exchanged on a daily basis during the rearing of post larvae which lasts until the harvest. Unconsumed feed, faecal matter and other organic materials are siphoned out daily during the rearing of Post Larvae. This is done by turning off the air blower, which allows the settlement of the debris to the bottom and makes the PL move to the water surface.

Assessment of larval health is one of the most important activities carried out in the hatchery. Observations are made on the larval stage, health, activity, behavior and abundance of feed and faeces both in the water and the larval body.

Live feeds should be supplemented with artificial dry or liquid diets to achieve optimum larval production of larvae. Quantity of artificial diets should be based on observations of the larval feeding habits and water quality. Care should be taken to avoid overfeeding as it may lead to water quality problems and fouling of larvae.

Live diatom (*Chaetoceros sp* or *Skeletonema sp.*) is the feed for the early larval stages of shrimp- Zoea and Mysis. It helps in maintaining the water quality by utilizing ammonia and carbon dioxide produced in the tanks in addition to providing complete nutrition. Algal density of 50,000 cells/ml is maintained in the larval rearing tanks. Alternatively Spirulina and encapsulated feeds are given at 3 hours interval.

#### Induced maturation and spawning

Induced Maturation is carried out when there is a scarcity of gravid females. Maturation tanks are stocked with healthy adult shrimps (female to male ratio 2:1). The daily water exchange is in the order of 200–300%. Sea water having salinity of 30-35 ppt is used for brood stock rearing. Maintenance of constant temperature (28-29°C) and pH (7.5-8.5) are critical in the successful maturation of the brooders. Shrimps are fed with fresh feeds like polychaete worms, squid, bivalve, molluscs, enriched adult artemia or high quality prepared brood stock feeds at the rate of 5% body weight.

**Eye stalk ablation:** The brooders should be given a week's time to recover from transportation stress before eye stalk ablation. In the case of shrimps, in pre-moult or post-moult stages, an extra week is provided to enable the animal to withstand the ablation stress. The eye can be either cut with hot pincers or tied with string or cut off with scissors or a sharp knife. After ablation, the area around the cut eye is treated with iodine solution. An ablated female typically takes 3-7 days for spawning. The water level in the tanks is reduced after 3 days of ablation and the matured females are identified with the help of underwater torch and transferred to the spawning section of the hatchery.

**Spawning:** Good quality water should be used for spawning and hatching. The spawning tank should be filled with clean sea water treated with 5-10 ppm EDTA. The mature females are transferred into the spawning tanks. Spawning usually occurs in the night hours and a scum is formed in the side of the tank. After spawning, the female is immediately transferred to the maturation tank. Any faecal matter released by the female should be siphoned out from the spawning tank. The eggs are siphoned out, washed with clean seawater and stocked into hatching tank and are kept in

suspension by providing mild aeration with manual mixing of the water until hatching. The aeration is increased after hatching. Hatching takes place usually 12-15 hrs after spawning. Average fecundity of female may range from 3-5 lakhs depending on the size of the female. Only healthy nauplii which are attracted to light are harvested and transferred to the larval rearing tanks.

#### Packing and transportation of shrimp seed

Harvest and transport of Post Larvae should be done with minimum stress to ensure a good survival rate on stocking in grow-out ponds. The Post Larvae should be acclimatized before stocking. Such salinity adjustments should be done only after PL-10 stage by adding freshwater. The Post Larvae were harvested by draining the water and harvested using a scoop net. The Post Larvae is then packed in polythene bags filled with one third water of the desired salinity. The PL is transferred to the bag and then pure oxygen is filled into the bag. The bags are then sealed with elastic bands and packed in container boxes for transport. The number of PL in each bag depends on the size of the seed and duration of travel. Usually, packing densities of PL-15 is 2000-2500 no's/bag containing 5 litre of water for duration of 3-4 hours of transport. Efforts should be made to transport the seed at night when the temperature is low, thereby reducing the stress during transportation.

#### Detailing of Practical

- Identification of species (*Penaeus monodon*) and its sexual dimorphism  
Sexual dimorphism in *Penaeus monodon* identified with the help of specimens.  
Drawings made in records
- Identification of larval stages Penaeid shrimp with specimens  
Larval stages are observed using microscope, morphological features are observed and documented. Chart showing larval stages of Penaeid shrimp is prepared.
- Identification of live feed organisms (*Chaetoceros/Skeletonema/Artemia*)  
Live feed organisms are observed using microscope, morphological features are observed and documented.
- Simulated experiment on eyestalk ablation with shrimp specimens  
Eyestalk ablation of shrimp specimens are done with the help of electro cautery apparatus. Procedure is documented.
- Practicals on shrimp health analysis  
Morphological observation, fresh water test and formalin test of shrimp health screening on PL<sub>15</sub>- PL<sub>20</sub> stage is conducted and documented.
- Preparation of layout of shrimp hatchery

- Arrange a field visit to shrimp hatchery and learners familiarise each section and its operation. Layout is prepared.

### **Assessment Activities**

Seed production of Penaeid shrimps

Identification of male and female Shrimps with distinguishing morphological characters and drawings made in record

Identification of larval stages in Penaeid shrimps through microscopic observation during OJT/Field visit

Preparation chart showing larval stages of Penaeid shrimp

Measure and analyse physical, chemical and biological parameters in larval rearing by field visit/ practical/ OJT

Interaction of students with hatchery expert and training during Field visit /OJT

Interaction of students with hatchery expert and training during Field visit /OJT

Simulated experiment of eyestalk ablation during practical with specimens

Engage in packing process during the Field visit/ OJT in hatchery

Demonstration on packing of live shrimp seeds

### **List of items in Portfolio**

- Report on Group Discussion
- Report on ICT enabled teaching activity
- Practical record
- Vocational diary
- Report on Demonstration
- Chart showing larval stages

### **Additional information**

Vannamei shrimp is gaining momentum in Shrimp culture as the single largest species in India with highest production

### **TE Questions**

1. Name the life stages / larvae of Penaeid shrimps
2. Explain the decapsulation and hatching of artemia nauplii with the help of schematic diagram
3. Write down the procedure followed in the process of induced maturation of Penaeid shrimps

## Unit.8

### Seed production of Giant Fresh water Prawn

The Giant Fresh water Prawn widely known as Scampi is facing extinction in natural habitat due to human interventions. The seed production of scampi is so significant in terms of huge demand from culture segment and necessity of the replenishment of scampi in natural environment. This unit imparts knowledge in sexual dimorphism, breeding, spawning and larval rearing of Scampi in detail.

#### Learning outcomes

The learner :

Identifies species (Giant Freshwater Prawn) and its sexual dimorphism

Understands the procedures in brood stock management

Optimizes physical and chemical and biological parameters of water for larval rearing

Identifies larval stages of Giant Freshwater Prawn

Acquires expertise in larval rearing of Giant Freshwater Prawn

Detailing of Concepts

Sexual dimorphism in Giant Freshwater Prawn

Male is larger than female at a given age group. Females are comparatively smaller.

In adult Males, chelipeds are longer, more robust with larger spines. Second chelipeds are extra ordinarily large while in Female, chelipeds are smaller and weaker with small spines. Second chelipeds are of normal size.

Males possess appendix musculina in between endopods of second pleopod. Females doesn't have this additional structure.

Brood stock Management of Prawns

Berried prawns are collected from the wild or grow-out ponds. The berried female is held in PVC pipes or cylinders capped on both sides with netting to prevent puncturing of the bag. The rostrum and telson may be banded or capped with protective rubber tubes. Starving of prawn for a few hours before packing may reduce accumulation of metabolites during transport.

Incubation: Immediately on arrival in the hatchery, the berried prawn is given with dip treatment in 100-200 ppm formalin for 10mts followed by rinsing in freshwater. Berried brood stock is kept at 6ppt for hatching. The berried prawn is fed with

oyster/ clam meat. At every morning left over feed and faeces are removed from the tank and half of the water is replaced. Mild aeration is provided continuously. Initially the colour of the egg is yellow then changed to bright orange to pale grey, and further darkens to slate grey by the time of hatching. Once, the egg colour turns dark grey, hatching starts and the larvae can be collected in the early morning hours using a scoop net. According to the size of the prawn, the number of eggs may vary from 0.2- 2lakhs. Incubation is usually completed in 19-20 days.

#### Water quality parameters in larval rearing

Rearing is carried-out in 50 litre FRP tanks. The hatched larvae are stocked at a density of 100 nos/lit. Water quality parameters for the larval rearing are given below.

Temperature	:	28 ± 2°C
Salinity	:	12 ± 1 ppt
DO	:	5- 6 ppm.
PH	:	7.0- 8 .5
Alkalinity	:	40-60 ppm.
Nitrate	:	< 20 ppm.
Nitrite	:	< 0.1 ppm.
Ammonia	:	< 0.1 ppm.
Hardness	:	100 ppm.

Filtered seawater and freshwater are mixed to prepare 12 ppt salinity water. Sodium hypochlorite solution is added to the prepared 12 ppt water for chlorination, which is then de-chlorinated. Excess chlorine can be removed by treating the water with sodium thiosulphate.

In India, the hatcheries are usually operated in 'clear water' system. Live *Artemia nauplii*, egg custard and formulated feed are fed to the larvae. On every morning, left over feed, detritus and dead larvae are removed by turning off the aeration and siphoning the settled particles from the tank bottoms. Daily, 50% of the water may be replaced.

#### Detailing of Practical

- Identification of species (Giant Freshwater Prawn) and its sexual dimorphism  
Sexual dimorphism in Giant Freshwater Prawn studied with the help of specimens. Drawings made in records

- Identification of larval stages of Giant Freshwater Prawn with specimens  
Larval stages are observed using microscope, morphological features are observed and documented. Chart showing larval stages of Giant Freshwater Prawn is prepared.
- Preparation of egg custard for larval rearing of Giant Freshwater Prawn  
Prepare egg custard feed using locally available ingredients.

### **Assessment Activities**

Seed production of Giant Freshwater Prawn

Identification of male and female Prawns with distinguishing morphological characters and drawings made in record

Mock presentation in procurement of brood stock (Berried Female)

Measure and analyse physical, chemical and biological parameters in larval rearing of Giant Freshwater Prawn by field visit/ OJT

Identification of larval stages in Giant Freshwater Prawn by microscopic observation during Field visit/ OJT

Preparation chart showing larval stages of Prawn

Field visit/ OJT in larval rearing of Giant Freshwater Prawn

### **List of items in Portfolio**

- Report on Field visit/OJT
- Practical record
- Report on Mock presentation
- Vocational diary
- Chart Drawing on Larval stages
- PTC product

### **Additional information**

Giant Freshwater Prawn is facing extinction in its natural habitat, Vembanad Lake due to the construction of 'Thanneermukkam Barrier' which hinder their catadromous breeding migration

### **TE Questions**

1. Suitable salinity for larval rearing of Freshwater Prawn
2. Write in detail the steps involved in the process of preparation of Egg custard for larval rearing of Freshwater Prawn

## Unit.9

### Seed production of Mud Crab

As a highly priced variety, Crab offers good profitability in culture systems. Expertise and skill in Crab seed production is in a growing stage in India. Here the unit gives emphasis on sexual dimorphism, water quality requirements, familiarization of larval stages, larval rearing techniques and packing of seeds. Unit also introduces the method of collection of water crabs for fattening.

#### Learning outcomes

The learner :

Identifies species (Mud Crab) and its sexual dimorphism

Familiarizes larval stages of Crab

Optimizes physical, chemical and biological parameters of water for larval rearing

Acquires expertise in larval rearing techniques

Identifies collection centres of water crabs for fattening

#### Detailing of Concepts

Sexual dimorphism in Mud Crab

Male and female mud crabs can be distinguished based on the structure of abdominal flap, which is slender and triangular in male and broad and almost semi-circular in female.

Familiarization of larval stages

Eggs hatch into Zoea larvae before metamorphosing into Megalopa larvae. Megalopa metamorphose into tiny crabs called Crab instars. The rearing of larvae is carried out in tanks with clean filtered sea water. The larvae are stocked at a density of 100nos/litre. The Zoea is fed with *Nannochloropsis* and *Brachionus* initially and artemia nauplii in later stages. The Megalopa is fed with fish/mussel meat or killed adult artemia biomass. Larval development is completed in 25-30 days.

Larval rearing techniques

Collection of water crabs for fattening / culture

Direct strong sunlight should be avoided for larval rearing. But they feed better during day time. This natural lighting should be the primary light source for larval rearing areas. Rearing should be well ventilated with reasonably high ceiling to minimize the humidity. Conical or spherically round tank/parabolic rectangular tank is used for rearing. Larvae grown in black tank have significantly higher survival rate. Crabs are sensitive to temperature fluctuation so water temperature has to be stable

as possible. Live feed used are rotifers and artemia. Larvae are fed 2-3 times/day

Collection of water Crab for fattening

After moulting, muscles of Crab take some time to grow to fill its new shell. The shell is also soft. So the Crab is referred to as Water Crab. It is collected either from wild or from hatchery. It is fed for a period of only few weeks, by then the muscle is fully grown and ready to harvest.

### **Detailing of Practical**

- Identification of species (Mud Crab) and its sexual dimorphism

Sexual dimorphism in Mud Crab studied with the help of specimens. Drawings made in records

### **Assessment Activities**

Seed production of Mangrove Crab

Identification of male and female crabs with distinguishing morphological characters and drawings made in record

Identification of larval stages in crab through microscopic observation during OJT/ Field visit

Preparation chart showing larval stages of crab

Measure and analyse physical, chemical and biological parameters in larval rearing by field visit/ practical/ OJT

Interaction of students with hatchery expert and training during Field visit /OJT

With the help of political map of India, students identify the seed collection centres

### **List of items in Portfolio**

- Report on Field visit
- Practical record
- Vocational diary
- Chart Drawings of larval stages
- Mapping of collection centres in Map

### **Additional information**

Larval rearing and seed production of Mud Crab recently got standardized in India.

### **TE Questions**

1. Pick the odd man out  
(Zoea, Phyllosoma, Nauplius, Mysis)
2. Young ones of crabs are known as.....
3. Write down the significance of sunlight in larval rearing of Crabs

## Unit. 10

### Seed collection of Mussels and Oysters

Bivalves are varieties which have good demand in local as well as in foreign market. At present brackish water resources in Kerala are blessed with spats/seeds of Mussel and Oyster. Hence the unit gives focus on collection techniques of Oyster and Mussel spats. It also covers the identification of commercial species (Oyster and Mussels) and preparation of Oyster Ren and Mussel Ren

#### Learning outcome

The learner :

Identifies species (Oyster and Mussels)

Understands the methodology of collection and transportation of Oyster and Mussel spats

Develops skill in preparation of Oyster and Mussel ren

#### Detailing of Concepts

Identification of commercially important bivalve species (Oyster and Mussels)

Indian backwater Oyster (*Crassostrea madrasensis*)

Green Mussel (*Perna viridis*)

Collection and Preparation of Oyster and Mussel spats

In the case of Oyster, brackish water bodies with higher salinities above 25ppt oyster larvae are seen naturally. Oyster shells, tiles coated with lime are placed in shallow waters. Larvae get attached to this substratum and start growing there. The collectors later tied in the Racks or Rafts for culture.

Unlike in Oyster, Mussel spats are embedded in hard substratum near intertidal region of sea as well as estuary. The spats are attached to the hard substratum with the help of byssis thread. With a sharp knife spats are chipped by cutting the byssis thread. The removed spats are given moisture support with sea water till they are processed in the form of ren for culture. Mussel spats are placed over highly perforated cotton cloth which permits water movement are used for ren preparation. Coir or roughened artificial rope is used for ren preparation. Perforated cotton cloth is covered over the spat and rope and tied properly as a seeded rope.

### **Detailing of Practical**

- Identification of species (Oyster and Mussels) and its spat with specimens  
Identify the species with the help of morphological characters. Drawings made in records
- Preparation of Oyster and Mussel ren with live specimen  
Preparation of Oyster and Mussel ren with the help of farmer or expert. Steps involved are recorded.

### **Assessment Activities**

Seed collection of Bivalves

Identification of cultivable species of Oyster and Mussels with morphological characters and drawings made

Interaction of students with mussel farmers during Field visit

Panel discussion on collection of oyster and mussel spats. (Like environmental, social, economic etc)

Practical experience with farmers in making Mussel/Oyster rens during Field visit

### **List of items in Portfolio**

- Report on panel discussion
- Report on Demonstration
- Practical record
- Mapping of collection centres in Map

### **Additional information**

Mussel and Oysters are natural filtering organisms which can be used in culture systems for improving water quality

### **TE Questions**

1. Young ones of Mussel are called.....
2. Scientific name of edible Oyster.....
3. With the help of a diagram explain the Rack culture and Raft culture of Mussel/Oyster

### List of Extended Activities in Module III

Training and technical assistance in seed production of ornamental fishes can be given to Self Help Groups by the Vocational faculty of the school. Students will be benefitted by associating with the programme.

- The schools having Production Cum Training Centres on aquaculture courses can offer short term training programmes. Venue can be offered to various departments for conducting Training Programmes of on fisheries sector will be beneficial to students too. This can be arranged in consultation with heads of concerned departments. By this the students will get good exposure. The interaction of students and teachers with the stakeholders will build up confidence.
- Spat collection and ren preparation mentioned in the course can be easily simulated inside the class room with live specimen
- Exposure in the field of Aquaculture can be achieved by arranging visits to Exhibitions on the same too. This will also help the students and teachers to update knowledge in the field.

### List of Practical Activities in Module III

- Measurement of physical, chemical and biological parameters of water in larval rearing
- Identification of the commercially important carps and it's sexual dimorphism (characters)
- Identification of life stages viz. fertilized egg, spawn, fry, and fingerlings, juvenile and adult
- Familiarization of the materials and equipments used for induced breeding
- Demonstration of the preparation of Pituitary gland extract
- Methods of injection for induced breeding
- Model preparation of Happa / Chinese hatchery / Jar hatchery
- Demonstration on packing and transportation of seeds
- Identification of species (GIFT) and its sexual dimorphism
- Identification of species (Pearl Spot) and its sexual dimorphism
- Identification of species (Air Breathing Fishes) and its sexual dimorphism
- Identification of species (Sea Bass, Cobia and Pompano) and its sexual dimorphism

- Identification of species (*Penaeus monodon* & *Litopenaeus vannamei*) and its sexual dimorphism
- Measurement of physical, chemical and biological parameters of water
- Identification of larval stages Penaeid shrimp with specimens
- Preparation of chart showing larval stages of Penaeid shrimp
- Identification of live feed organisms (*Chaetoceros/Skeletonema/Artemia*)
- Simulated experiment on eyestalk ablation with shrimp specimens
- Practicals on shrimp health analysis
- Preparation of layout of shrimp hatchery
- Identification of species (Giant Freshwater Prawn) and its sexual dimorphism
- Identification of larval stages of Giant Freshwater Prawn with specimens
- Preparation of chart showing larval stages of Giant Freshwater Prawn
- Preparation of egg custard for larval rearing of Giant Freshwater Prawn
- Field visit to collection centres of brood stock from wild
- Identification of species (Mud Crab) and its sexual dimorphism
- Identification of larval stages with specimens
- Preparation of chart showing larval stages of Mud Crab
- Identification of species (Oyster and Mussels) and its spat with specimens
- Preparation of Oyster and Mussel Ren with live specimen

## OVERVIEW OF THE MODULE IV

### Ornamental Fisheries and Aquarium Management

Ornamental fish farming and aquarium management is a promising sector in fisheries field. This module includes topics like identification of commercially important fresh water and marine ornamental fishes, importance of conservation of indigenous ornamental fishes, familiarization of important aquarium plants and invertebrates, seed production and disease management. Setting up of aquarium, aquarium management and familiarization of aquarium accessories are also dealt in detail. Marine aquaria, an emerging fast growing segment also finds a place in this module. The learner can go through the module with great enthusiasm, which makes the module attractive to students. Knowledge and skill aimed by the module surely help the learners in finding jobs or to have entrepreneurship in this sector.

#### Expected Skills

- Identify fresh water and marine ornamental fishes, invertebrates and plants.
- Knowledge in Breeding and seed production of ornamental fishes
- Skill in aquarium setting and management.
- Skill in water quality management.
- Recognition of disease by observing symptoms
- Applying prophylactic and therapeutic measures against diseases
- Skill in packing and transportation of ornamental fishes and organisms

#### Unit.1 Aquarium fishes

Aquarium keeping is the second largest hobby in the world. Aquarium is the place where fishes, plants, other organisms or objects are exhibited as aquatic habitat for enjoyment. Fishes are the main component around which all aquariums exist. Fishes are beautiful, fascinating, and enhances the beauty of home or shops. From entrepreneurial point of view, familiarisation of ornamental/aquarium fishes are very important. In this unit the learner acquires knowledge in classifying the fishes into live bearers and egg layers, which is a very important prerequisite for seed production of these fishes. Thorough knowledge in exotic and indigenous ornamental fish varieties will help in recognizing the challenges in conservation of indigenous ornamental fishes.

#### Learning outcomes

The learner :

Familiarizes ornamental/aquarium fishes

Classifies the aquarium fishes into live bearers and egg layers- different types

Categorises exotic and indigenous ornamental/ aquarium fishes

Identifies the challenges in conservation of indigenous ornamental fishes

## Detailing of Concepts

### Gold Fish

Cyprinidae family consists of well-known aquarium favorite fishes such as barbs, danios, rasboras, and various freshwater sharks.

Gold fish belongs to Cyprinidae family. Gold fish body is oval shaped with metallic orange red in colour and caudal fin is large lobed. Commonly found varieties of gold fish are comet, fan tail, veil tail, telescope Moore, Oranda, Lion head, Bubble eye etc.



### Denison barb

Most important species among barbs is *Sahyadria denisonii* (Denison barb, Red-line torpedo barb, or Roseline shark). This is a species endemic to the fast-flowing hill streams and rivers of the Western Ghats in India. The fish is characterized by a torpedo-shaped body with silver scales, a red line running from their snout, through the eye, back towards the middle of the body; and below the red line, a black line that runs the length of the fish to the tail.



### Zebra fish

The Zebra fish (*Danio rerio*) is a tropical freshwater fish belonging to the Family Cyprinidae. Its body shape is fusiform and laterally compressed, with its mouth directed upwards. The zebra fish is named for the five uniform, pigmented, horizontal, blue stripes on the side of the body.



### Red piranha

The Red-bellied piranha or Red piranha (*Pygocentrus nattereri*) belongs to the Subfamily Serrasalminae belonging to the family Characidae. This is a group of



medium to large-sized characids and includes other closely related omnivores such as pacus. These fishes are characterized by deep, lateral compressed bodies and long dorsal fins.

### Neon tetra

The Neon tetra (*Paracheirodon innesi*) is a freshwater fish of Family Characidae. The Neon Tetra has a light-blue back over a silver-white colour over the abdomen. The fish is characterized by an iridescent blue horizontal stripe along each side of the fish from its nose to the base of the adipose fin, and an iridescent red stripe that begins at the middle of the body and extends posteriorly to the base of the caudal fin.



### Swordtail

The Swordtail (*Xiphophorus hellerii*) is a species of freshwater/brackish fish in Family Poeciliidae. The fish has the name 'swordtail' as it has an elongated lower lobe of the male's caudal fin (tailfin). Sexual dimorphism is moderate, with the female being larger than the male, but without the 'sword'.



Angelfish (*Pterophyllum scalare*) is a small fish belonging to the Family Cichlidae. Angel fish body is greatly laterally compressed, with elongated triangular dorsal and anal fins.



The Oscar (*Astronotus ocellatus*) is a species of fish from the Family Cichlidae. The body of the fish is laterally compressed with large mouth and thick lips. The colour of the body is dark with bright orange opercle margin and ventral parts of the lateral sides of the body with a black rounded blotch with orange margin at caudal fin base.



Gouramis or gouramies (*Trichogaster trichopterus*) are a group of freshwater fishes that comprise the Family Osphronemidae. Gouramis have an elongated ray at the front of each of their pelvic fins. Many species show parental care and some are mouth brooders,



The Guppy (*Poecilia reticulata*), is a small elongated fish that is available in many different colours and pattern variations. It is a member of the Family Poeciliidae. Males possess colourful tail. The mouth is up-turned and the head is small.



Arowanas (*Osteoglossum bicirrhosum*) are known as bony tongues belonging to the Family Osteoglossidae. The head of the fish is bony and elongated. Body of the fish is covered by large, heavy scales, with a mosaic pattern of canals. The dorsal and anal fins have soft rays having long base. Pectoral and ventral fins of this fish are comparatively small.



The Siamese fighting fish (*Betta splendens*) belongs to the Family Anabantidae. Shape of the body is streamlined with long dorsal and anal fins. The fish's body is covered with scales that overlap each other which consist of thin, transparent plates.



### Detailing of Practical

- Familiarization of aquarium fishes with the help of morphological characters and drawing

Practical on familiarization of aquarium fishes with available specimens and photo-exhibition of aquarium fishes by students. Documentation made on practical records.

### Assessment Activities

Familiarization of aquarium fishes with the help of morphological characters and drawing

Group Discussion on nature of reproduction in Aquarium fishes

Photo-exhibition of aquarium fishes by students

Seminar on exotic and indigenous ornamental/ aquarium fishes

Panel discussion on Environmental impacts of Exotic Ornamental Fishes/Challenges in conservation of indigenous ornamental fishes

### List of items in Portfolio

Practical record

Report on Group Discussion

Photo Exhibits

Report on Seminar

Report on Panel discussion

### **Additional information**

Aquarium fishes are used to control mosquito by allowing feed their larvae in ditches and swamps

### **TE Questions**

1. Pick the odd man out  
(Guppy, Gold fish, Angel fish, Siamese fighter)
2. Name two live bearers from aquarium fishes
3. Name two egg layers from aquarium fishes

## Unit.2

### Aquarium plants

Aquarium plants are the main component of an aquarium which gives the aquarium a natural look. Apart from improving the aesthetic look of aquarium, plants provide oxygen; they absorb the harmful nitrogenous wastes excreted by the fishes and maintain water quality for the very existence of fishes. This unit also gives awareness on aquarium plants, it's rearing and propagation.

#### Learning outcomes

The learner :

Familiarizes aquarium plants

Develops expertise in aquarium plant rearing and propagation

Understands role of aquarium plants in maintaining water quality in aquarium

#### Detailing of Concepts

Familiarization of aquarium plants

Commonly found aquarium plants such as Vallisneria, Cobamba, Hydrilla, Echinodorus, Myriophyllum, Javamooss, Ludwigia, Ceratophyllum

#### Aquarium Plants

*Vallisneria* is a grass like freshwater aquatic plant, commonly called eelgrass or tape grass. *Vallisneria* is a submersed plant that spreads by runners. *Vallisneria* is used for planting on the sides of the aquarium. Leaves arise in clusters from their roots.



*Cabomba* is an aquatic plant commonly found in Kerala. It has divided submerged leaves in the shape of a fan. They are usually planted as bunches in aquarium. They are also used in breeding of egg scatters.

*Hydrilla* is common aquarium plant with narrow leaves and short stem. Leaves are arranged in whorls of two to eight around the stem. Leaves are with serrations or small spines along the margins.



*Echinodorus* is commonly known as Amazon sword plant. Leaves of *Echinodorus* are sessile, triangular, blade with translucent markings as dots or lines. These plants are large and robust. They are mostly planted in pots in aquarium.



*Myriophyllum sp* is a flowering plant commonly called water milfoil. Leaves are arranged around the stem in whorls of four to six. The emergent stems and fine leaves are the most distinctive trait of this plant. These plants are also used for breeding of egg scatters.

Java moss is commonly used in freshwater aquariums as attached to rocks, roots, and driftwood. It has short stem and pointed leaves giving look of a green mat. In aquariums it improves the aesthetics and natural appearance. In aquariums these plants are planted where there is good water current. Java moss has clinging nature which is used for hiding pipes and air tubes.



*Ludwigia* is an amphibious plant that can grow fully submersed or partially submersed. It posses slender stem and broad leaves. This plant's spade-shaped leaves range in color from dark green to brownish-red. The top side of the leaves are typically olive green in colour, whereas the undersides are reddish-brown to deep red.

*Ceratophyllum* are submersed plants with spiky leaves and robust stem. The leaves are brittle and stiff to the touch in some species, softer in others. The plants usually have no roots. But sometimes they develop modified leaves with a root like appearance, which help to anchor the plant to the bottom.



## Aquarium plant rearing and propagation

### Media for planted aquariums

Different media used for planted aquarium includes different types of clays, synthetic nylon, culti wool, composted materials like straw etc. This medium acts as anchorage and source of nutrients. Usually red soil is placed at the bottom of the tank and it is covered with gravel so that the it will not get disturbed. Red soil is mixed with nutrients so that that nutrients will be available to the rooted plants.

Reproduction of aquatic plants is of two types sexual and asexual. Sexual propagation involves flowers and seed formation.

### **Asexual Propagation/vegetative propagation**

Asexual propagation is called vegetative propagation as it is without seed but through runners, offsets, and plantlets. Most of the aquarium plants reproduce asexually producing off springs that are genetically identical to the parent plant. This is also known as vegetative propagation. There are three different ways of asexual propagation.

- **Runners:** In this method plants produce runners (horizontal stem like process), which grow out from the base of the parent plant and then produce slips (daughter plants). These slips can anchor themselves in the substrate and survive on their own.
- **Offsets:** Off sets is similar to runner but they grow extremely close to the parent plant.
- **Adventitious plantlets:** Small plantlets grow on any part of the plant, i.e. nodes, roots, leaves, or stems. These small plants on the parent plant are called adventitious plantlets.

### **Artificial Propagation**

Plant propagation techniques done with cuttings or rhizome dividing is artificial propagation. Aquatic plants tend to favour asexual (vegetative propagation) or artificial propagation. Artificial Propagation can be done mainly by two ways. Cutting from the stem and dividing rhizomes. Cutting from the stem is by simply cutting part of it off and replanting it. The best place to take cuttings is from the top stems. Next method is by dividing the rhizome and replanting the pieces

### **Seed Propagation**

Propagating plants by way of seeds is often difficult method to do if you are trying to reproduce plants that propagate sexually.

Importance of carbon dioxide in planted aquariums and preparation of carbon dioxide producer.

Carbon dioxide is needed for aquarium plants for its healthy growth hence optimum levels of carbon dioxide are needed in the aquarium water. Carbon dioxide can be supplied using a readymade carbon dioxide cylinder or carbon dioxide producer using sugar solution fermented with yeast.

Aquarium plants and water quality of aquarium

Aquarium plants absorb the nitrogenous wastes formed from the organic wastes in an aquarium thereby improves water quality. Aquarium plants synthesis oxygen through photosynthesis.

### **Detailing of Practical**

- Familiarization of aquarium plants with the help of morphological characters and drawing

Practical on familiarization of aquarium plants with available plant specimens and photo-exhibition of aquarium plants by students. Documentation made on practical records.

- Practical/PTC on planting and propagation of Aquarium plant

Practical on planting technique of aquatic plants in artificial sand beds of aquarium.

Vegetative propagation of aquatic plants is practiced during practical/PTC.

### **Assessment Activities**

Familiarization of aquarium plants with the help of morphological characters and drawing

Photo-exhibition of aquarium plants by students

Practical/PTC on planting and propagation of Aquarium plant

Group Discussion on the role of aquarium plants in maintaining water quality in aquarium

### **List of items in Portfolio**

Practical record

Report on Group Discussion

Photo Exhibits

### **Additional information**

As in agriculture, tissue culture technique is used for the propagation of aquarium plants

### **TE Questions**

1. Name the commonly aquarium plant used for egg adhesion of gold fishes.
2. Write shot note on aquarium bed preparation for aquarium plants

## Unit.3

### Aquarium equipments and accessories

Aquarium is an artificial ecosystem created for keeping aquatic organisms. For creating artificial ecosystem suitable equipments are required to maintain the environment stable. Hence familiarization of aquarium equipments such as Aerators, Heaters, Illuminating lamps, Sand filter bed, Submersible pumps, filter, Bio filters are very important.

#### Learning outcomes

The learner :

Familiarizes aquarium equipments and accessories.

Understands the use of aerators, heaters, illuminating lamps, sand filter bed, submersible pumps, bio filters in an aquarium

Acquires knowledge in principle and functioning of bio filter in an aquarium

#### Detailing of Concepts

Aquarium equipments and accessories

**Aerators:** When AC current is applied the polarity of the magnetic field changes resulting in the vibrations of the lever attached to air pump. The rhythmic up and down movement of the bellows cause continuous air out discharge.

**Heaters:** Consists of a heater, thermostat and control knob. Temperature can be set for a specific value by adjusting the control knob and the thermostat regulates the switching on and off of the heater.

**Illuminating lamps:** It is ideal to use at least 80W tubes in a combination of various colours including a balanced day light tube and a plant growth enhancing tube among them in a normal way on aquarium hood of aquarium

**Sand filter bed:** It consists of perforated sheet or pipe with a vertical pipe at one end or corner which reaches above the water level. The filter plate is covered by gravel (3-5mm size), driven by an air pump or power head, circulation of water is established such that aerated water passes through the sand bed. Nitrifying bacteria converts ammonia to nitrite and nitrate.

**Submersible pumps and filters:** Sponge filter, power filter, Bio balls, power filter.

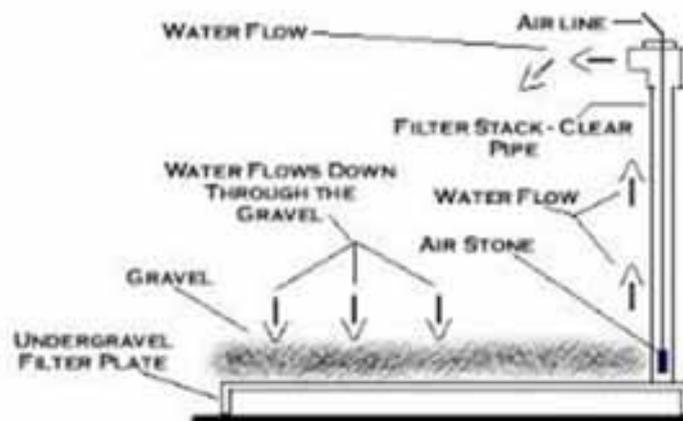
## Air pump

An air pump is a device used to move air, possibly under pressure. Typical aquarium air pumps move air by using an electromagnet to rapidly vibrate a rubber diaphragm.



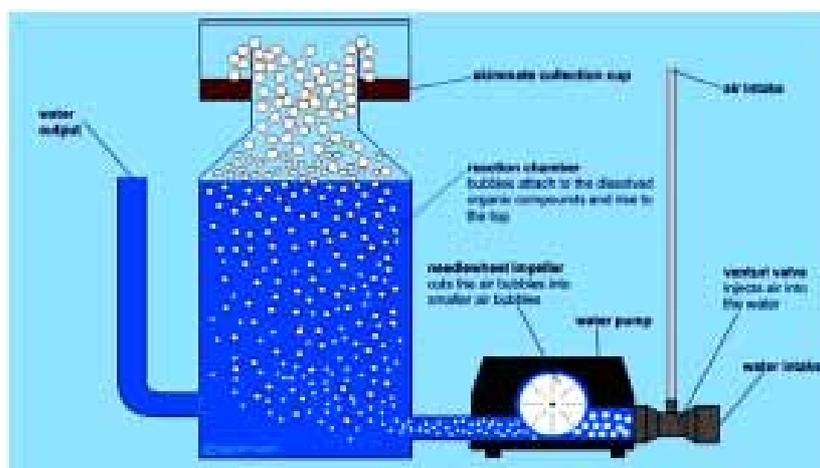
## Sand filter bed

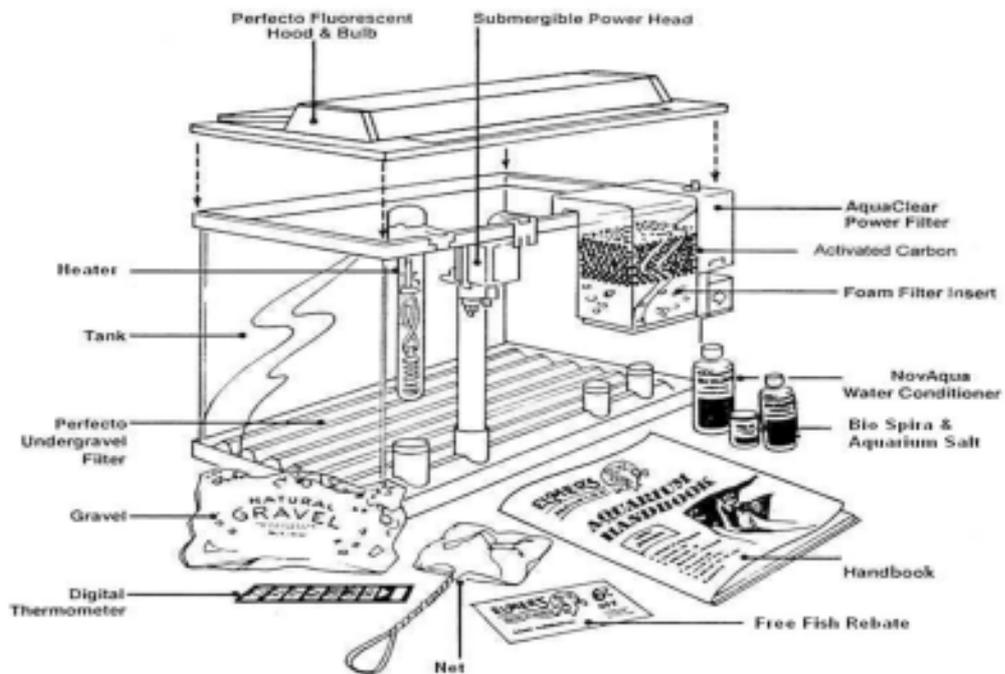
Sand filter bed helps in the filtration of aquarium by mechanical and biological methods.



## Protein skimmer

Protein skimmer uses air bubbles for removing organic and inorganic suspended matter as froth.

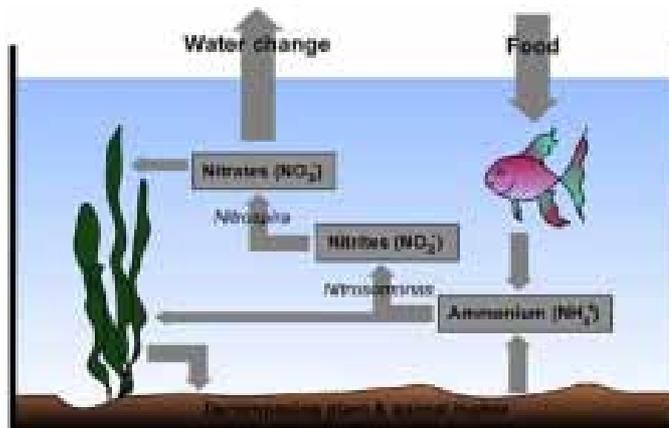




Components of a model aquarium

### Principle and functioning of Bio filter

Aquarium tank water is polluted mainly by nitrogen compounds such as ammonia, nitrite and nitrates from excreta of fish, organic matter from plants, dead organisms etc. Bio filter helps in the conversion of toxic nitrogen compounds to less toxic compounds using live bacteria such as *Nitrosomonas* and *Nitrobacter*. Water circulation through a media (like gravel, bioballs, sponge etc) helps in the accumulation of these bacteria and helps in biological filtration.



## **Detailing of Practical**

- Familiarisation of aquarium equipments and accessories with exhibition of the same

Familiarisation of aquarium equipments and accessories through exhibition. Learners get the opportunity to get familiarized well with all equipments and accessories.

- Demonstration on setting up of bio filter in an aquarium

Bio filter can be installed in an aquarium inside the classroom. Expertise in setting the bio filter can be achieved by this activity.

## **Assessment Activities**

Aquarium equipments and accessories

Familiarisation of aquarium equipments and accessories with exhibition of the same

Demonstration of aquarium equipments and accessories - use and method of operation

ICT enabled teaching activity on principle and functioning of Bio filter

Practical on setting up of bio filter in an aquarium

## **List of items in Portfolio**

Practical Record

Report on demonstration

Photo Exhibits

Vocational Diary

## **Additional information**

Computerized monitoring of aquariums is in place and such sophisticated instruments are common in foreign countries

## **TE Questions**

1. Write notes on the importance of aerators in aquarium
2. Explain the principle and functioning of bio filter in aquarium with the help of the diagram.

## Unit.4

### Making of an aquarium glass tank

Glass is the main component used for making aquarium tank. Here measurements and cutting of glass pieces determines the quality of the tank.

Familiarisation of glass tank making tools and fixing of glass tank with silicone gel is the prime requisite for aquarium making.

#### Learning outcomes

The learner :

Understands the measurements and method of cutting glass pieces

Familiarizes Glass tank making tools- gun, silicone gel etc

Develops skill in making of glass tank

#### Detailing of Concepts

Making of an aquarium tank

A glass tank comprises of 5 glass panels (Base panel, 2 side panel, one each of the rear and front panels). The glass panels are thoroughly cleaned and washed. Then base panel is placed on a levelled surface. Joining edges of glass panels are applied with a narrow line of silicon sealant. Rear panel is fitted first, then 2 side panel and last the front panel. Panels secured tightly using jute twine or cellophane tape. A continuous glue of line is applied through the inner edges. The sealant gets cured and sticks well in 24hrs.

Acrylic aquariums are becoming popular nowadays due to its easiness in handling and safety.

Glass tank making tools

Silicone gel gun, cello tape etc are required for making a glass tank.

Measurements and cutting of glass pieces for aquarium glass tank

Size of the tank mainly depends on the size and number of fishes to be maintained and position of the aquarium in the room. Thickness of glass depends on the water holding capacity of the aquarium, mainly the height of the tank. As a thumb rule, height of the tank should be greater than breadth of the tank.

## **Detailing of Practical**

- Practical on calculation of measurements/cutting of glass pieces for glass tank

Prior to the practical, measurements and calculations are practiced by the learners. Expertise in cutting the glass is achieved by practicing the same under an expert. Familiarization of glass tank making tools also archived during the practical namely silicone gel, gun etc.

- Practical on making of glass tank

PTC/practical can be conducted for making aquarium tanks

## **Assessment Activities**

Making of an aquarium glass tank

Practical on calculation of measurements/cutting of glass pieces for glass tank

Practical on familiarization of Glass tank making tools

PTC/ practical on making of glass tank

## **List of items in Portfolio**

Practical record

Vocational Diary

PTC product

## **Additional information**

Recently acrylic tanks are in place instead of glass tanks. Risk of breakage is so less at the same time the clarity is very high in these tanks.

## **TE Questions**

1. Write steps in glass aquarium making.
2. Write the equipments used for making a glass tank.

## Unit.5

### Assembling an aquarium

Beauty of the aquarium depends on the setting up of the aquarium. Hence sound knowledge in setting an aquarium is important to make an attractive aquarium.

#### Learning outcome

The learner :

Develops skill in assembling an aquarium

#### Detailing of Concepts

Assembling of an aquarium

For setting of an aquarium, keep the aquarium tank in a permanent position over a strong and level cushion (polystyrene sheet) of aquarium stand. Place the under-gravel filter and spread gravel to a height of 5cm giving a small slope towards front. Fill the tank with water to one fourth and arrange plants, rocks, drift, wood etc aesthetically. Slowly fill water just above the lower edge of the hood. Connect the accessories like air pumps, lamps and place the hood. Run the filter for a few weeks with some hardy fishes. Introduce the other aquarium fishes after quarantine period. Gradually build up the fish stock.

#### Detailing of Practical

- Practical on assembling of an aquarium

PTC / Practical on assembling an aquarium. Students can be grouped into three or four batches and entrust them in setting the aquarium.

#### Assessment Activities

Interaction of students with expert in the class room.

PTC/practical on assembling an aquarium

#### List of items in Portfolio

Report of expert session

PTC product

#### Additional information

Nowadays setting up of paludariums by incorporating aquatic and terrestrial components is becoming popular.

#### TE Questions

1. List out the equipments required for the running of aquarium.

## Unit.6

### Aquarium management

Aquarium is a restricted aquatic environment where several complex processes work to keep the aquarium healthy. It is important to know the aquatic processes going on inside the aquarium and also the interventions to keep it healthy. Hence the scientific study of aquarium maintenance is important. Sound knowledge in water quality management, usage of water test kits to measure chemical parameters, (Dissolved  $O_2$ ,  $CO_2$ ,  $NH_3$ ,  $NO_2$ ,  $NO_3$ , Alkalinity & Acidity), measurement of physical parameters and assessing biological parameters are essential in the management of aquariums.

#### Learning outcome

The learner :

Develops expertise in aquarium management

#### Detailing of Concepts

Management of Aquarium

Main practices in aquarium management include feeding of the fishes and water quality management. Feeding is done with formulated feeds with a limited quantity. Artificial feed may be substituted by live feeds which are beneficial in maintaining water quality. Weekly siphoning can be done along with 10-20% aquarium water. Working of all equipments may be checked daily. Pruning the branches of aquarium plants can be done in a planted aquarium. To control algal bloom either algal scrubber or scavengers like sucker cat fish can be introduced. Regular monitoring of water quality parameters should be done.

For regular maintenance of aquarium, important points to be looked into are:

- i) Regular water exchange (20 to 30% every two to four weeks)
- ii) Cleaning of algal scum from the glass at periodical interval
- iii) Removal of dead fishes, if noticed inside the aquarium
- iv) Raking the surface layer of the substrate and removal of dirt etc by vacuuming device every week.
- v) Pruning of excess plant growth, when noticed.

- vi) When unhealthy fishes are noticed, they should be removed from the tank and treated separately.
- vii) Don't use tap water directly; it should be aerated overnight to remove chlorine. Chlorinated water is harmful to fishes.
- viii) Overfeeding of fishes should be avoided at all cost. It reduces the quality of water resulting in death of fishes.

### **Detailing of Practical**

- PTC/ practical on management of an aquarium

Practical on water exchange, cleaning of algal scum from the glass, raking the surface layer of the substrate and removal of dirt by vacuuming.

### **Assessment Activities**

PTC/ practical on setting up of an aquarium

### **List of items in Portfolio**

PTC product

Practical record

### **Additional information**

Unlike individual measurement of water quality parameters there are equipments by which multiple parameters can be measured at a time.

### **TE Questions**

1. Write short notes on management of an aquarium.

## Unit.7

### Fish Diseases-Quarantine, prophylactic and therapeutic measures

Being in a restricted environment makes aquarium fishes vulnerable to diseases. Once disease occurs in tank to one fish then it will spread to other fishes and kill them. To avoid mass mortality it is better to understand the disease symptoms of the disease at the earliest. Quarantine is the most important measure to keep aquarium devoid of diseases. Commonly found fish diseases are Ichthyophthiriasis, Fin rot & Tail rot, Saprolegniasis, Dropsy and Protozoan infections .

#### Learning outcomes

The learner :

Identifies the symptoms of Fish Diseases-Ichthyophthiriasis, Fin rot, Tail rot, Saprolegniasis, Dropsy, Protozoan infections.

Recognizes the Fish Diseases and its causative agent

Understands the Quarantine, prophylactic and therapeutic measures against diseases

#### Detailing of Concepts

Important ornamental fish diseases, causative agents, symptoms and therapeutic measures.

Diseases	Causative organism	Symptoms	Treatment/therapeutic
Ichthyophthiriasis	Protozoan parasite Ichthyophthirius multifiliis	Pin head sized white spots on the body and fins	Increase temperature, treat with 5% methylene blue
Saprolegniasis	Fungi including Saprolegnia	White clumps with cotton like appearance	Dip treatment or permanent bath. Using 5% malachite green or methylene blue.
Exophthalmus	Bacteria, virus fungi, sometimes together	Swollen eyes	1% silver nitrate and 1% potassium permanganate
Dropsy	Bacterial	Swollen abdomen, erected scales	Antibiotics
Gyrodactyliasis	Parasite gill fluke	Operculum sticking out, unusual swimming	Formaldehyde 5-6 drops per litre
Lernaeiasis	Lernaea sp.	Ecto parasite on body	Bath with 1-2% potassium permanganate
Argulosis	Argulus	Ecto parasite on body	Bath with 1-2% potassium permanganate
Fin rot and tail rot	Pseudomonas, Aeromonas(bacteria)	Broken fins and tail	Antibiotics and fresh water treatment

Fishes to be introduced in an aquarium should be quarantined before their introduction to the aquarium. Diseased fishes should be culled. Fishes are to be treated with 2% potassium permanganate or 5% sodium chloride solution before introducing them to aquarium tank. They should be properly acclimatised by mixing with aquarium water. Same procedure should be followed while introducing new stock.

### Fish diseases



*Ichthyophthiriasis*



*Saprolegniasis*



*Exophthalmus*



*Dropsy*



*Gyrodactyliasis*



*Lernaeasis*



*Argulosis*



*Fin rot and tail rot*

### Detailing of Practical

- Identification of symptoms of Fish Diseases with the help of Exhibition of diseased specimens and photos

By the identification of symptoms of the diseased fish specimens students identify the disease. A photo exhibition also can be conducted on fish diseases in classroom.

- Familiarization of prophylactic and therapeutic agents against ornamental fish diseases (Chemicals, antibiotics and Herbs).

Commonly used chemicals like methylene blue, malachite green, sodium chloride, potassium permanganate, formalin etc can be familiarized. Antibiotics which are permissible to use in aquarium fishes can also be shown and familiarized. Herbs like neem, turmeric, garlic etc and their dosage against various diseases be familiarized with learners.

## Assessment Activities

Fish Diseases-Quarantine, prophylactic and therapeutic measures

Identification of symptoms of Fish Diseases with the help of exhibition of diseased specimens and photos

Seminar on common Fish Diseases and it's causative agents

Group Discussion on Quarantine, prophylactic and therapeutic measures against diseases

Familiarization of prophylactic and therapeutic agents against ornamental fish diseases

## List of items in Portfolio

Practical Record

Report on Group Discussion

Report on Case study

## Additional information

Herbs like Neem, Garlic, Turmeric etc also can be used instead of antibiotic and chemicals in aquarium fishes as well as culture fishes

## TE Questions

1. From the information given below identify the disease and write its remedial measures.

Symptom- White clumps with cotton like appearance on the body of aquarium fish.

2. Name any two disease caused by ecto- parasite in aquarium fish.
3. Match the following

A	B
Ichthyophthyrriasis	Protozoan parasite Ichthyophthirius
Saprolegniasis	Fungi including Saprolegnia
Exophthalmus	Bacteria, virus fungi, sometimes together
Dropsy	Bacterial
Gyrodactyliasis	Parasite gill fluke

## Unit.8

### Breeding and seed production of Aquarium fishes

Breeding of fishes occurs inside the aquarium or such situation is avoided by keeping such brooders separately. It is the best thing for a fish lover to see a fish breeds and give birth to young ones. Breeding behaviour of fishes differ in all respects. But basic knowledge in fish breeding is necessary for an aquarium hobbyist. Seed production of any fish involves brood stock maintenance, breeding, spawning, and nursery rearing

#### Learning outcomes

The learner :

Develops skill in maintenance of brood stock of aquarium fishes

Develops skill in breeding of aquarium fishes

Develops skill in Nursery rearing aquarium fishes

Develops skill in live feed culture for aquarium/ ornamental fish breeding

#### Detailing of Concepts

Brood stock maintenance of aquarium fishes

Mature and healthy fishes are selected and kept separately as male and female. Separated fishes are fed with protein rich diet including live feed. For ornamental fishes generally male to female ratio followed is 2:1.

Breeding and spawning of aquarium fishes

#### Gold fish

Gold fishes are egg scatterers without any parental care. Secondary sexual characters include females with mature eggs, abdomen more swollen than male. Male possess tubercles on operculum and pectoral fin base becomes rougher. Genital opening of females become round and protruding. For males it is small. They mature in 6 months.

Identified male are transferred to male brood stock ponds. Healthy male oozes milt and female with bulged belly are selected for breeding. Female to male ratio is 1:2 (form breeding set). Introduce breeding set into spawning concrete or glass tank. Cleaned coconut fibres, aquatic plants or synthetic fibres can be used as egg collector.

Spawning takes place in the morning. The plants show adhesive eggs and the parents are removed. Eggs hatch out in 2 days. Hatchling will be 5-7mm in size. Free swimming larvae after yolk absorption on the 3rd day start exogenous feeding and are raised on feeds like infusoria, egg yolk, brine shrimp or powdered artificial feeds.

### **Angel fish**

Sexual dimorphism is not so prominent in angel fish. In nature male and female pair up and swim close together to establish their territory. Each pair is placed in breeding tank. Feed them with mosquito larvae or any other live feed. Smooth surface like PVC, slate, tile or wooden piece can be used for adhesion of eggs. 8-10 months old fishes are selected for breeding. Spawning interval is 3-6 weeks. Angel fish shows parental care. Substratum with eggs is transferred to hatching tank. Angel lays 400-600 eggs that hatch out in 2 days and start free swimming in 5 days. Fry accept brine shrimp or Monia. Adult fry can be reared in cement tanks or earthen ponds artificial feeds and plankton.

### **Guppy and Platy**

Guppy and platy are live bearers. Males are small and colourful. They attain maturity in three months and fertilization is internal. The sperm is stored in the reproductive track of female and fertilized 5-6 batches of the eggs. Hide outs or dense aquatic plants can be provided in breeding tank to prevent them being eaten by their parents.

Live feed culture for aquarium/ ornamental fish breeding

Artemia decapsulation is done using liquid bleach or mixture of sodium hypochlorite and sodium hydroxide till the shell colour turns orange. The process ensures disinfection of the cyst too. Decapsulated artemia cysts are incubated in clean cylindro-conical tanks at the rate of 2g cysts/litre. Continuous vigorous aeration is provided to prevent the cysts from settling. Sufficient lighting is provided to enhance hatching. The nauplii are harvested after 18-24 hrs of incubation. Prior to the harvest of artemia nauplii the aeration is turned off. The photo tactic nauplii are attracted towards the illuminated translucent bottom of the tank and collected in a 100 micron mesh. The collected nauplii are washed thoroughly in clean running fresh water or seawater before feeding.

### **Detailing of Practical**

- Practical on breeding of aquarium fishes (Gourami/Fighter fish /Angel fish / Gold fish)

- Practical/PTC on breeding, nursery rearing and seed production of preferably one egg layer and live bearer.
- Practical on live feed culture of Infusoria/ Artemia/ Tubifex/ Chironomid larvae/ Microworms/ Earthworms etc

Practical/PTC on live feed culture of any two of the following can be practiced.

### **Assessment Activities**

Breeding and seed production of Aquarium fishes

ICT enabled teaching activity on breeding of selected aquarium fishes

PTC / practicals on maintenance of brood stock

PTC / practicals on breeding of aquarium fishes

PTC / practicals on nursery rearing aquarium fishes

PTC / practicals on live feed culture of infusoria/ artemia/ tubifex/ chironomus larvae/ microworms/ earthworms etc

### **List of items in Portfolio**

Report on Group Discussion

Practical record

PTC product

Report on ICT enabled teaching activity

### **Additional information**

Sea horses are the wonders of animal kingdom where male take care of their young ones in their brood pouch

### **TE Questions**

1. Write the sexual dimorphism in any two ornamental fishes.
2. Explain breeding of gold fish
3. Write the method of preparation of live feed for aquarium fish –infusoria.

## Unit.9

### Marine Aquarium

Marine Aquarium is a highly unstable aquatic environment which attracts more attention than freshwater aquarium. Apart from attractive fishes marine aquarium exhibits beautiful marine invertebrates and marine plants. Maintaining water quality is also tough that it requires more sophisticated equipments also.

#### Learning outcomes

The learner :

Identifies marine ornamental fishes

Identifies marine ornamental plants and other organisms

Familiarizes marine aquarium accessories

Develops skill in maintaining marine aquarium

#### Detailing of Concepts

Familiarization of marine ornamental fishes

1. Clown fish (*Amphiprion sp.*)
2. Big eye Squirrel fish (*Myripristis murdyan*)
3. Spotted cardinal (*Apogon maculotus*)
4. Grey grouper (*Epinephelus tauvina*)
5. Pennant Coral fish (*Heniochus acuminatus*)
6. Blue Surgeon (*Acanthurus leucosternon*)
7. Black trigger fish (*Odonus niger*)
8. Longhorned cowfish (*Lactariacornuta*)
9. Seahorse (*Hippocampus kuda*)
10. Blue damsel (*Abudefduf assimilis*)

Familiarization of marine ornamental invertebrates and other marine organisms

Sea anemone, Octopus, Cuttle fish, Sea urchins, Star fish.

Marine aquarium accessories

Protein skimmer, Aerators, Heaters, Illuminating lamps, Sand filter bed, Submersible pumps and filters.

Water quality management

Check the water quality parameters namely pH, temperature, salinity, ammonia, nitrate, alkalinity, calcium on regular basis. Compensate for evaporative loss. Maintain the equipments. Make 10-20% water exchange. Add trace elements, calcium etc. Introduce fish only after quarantine.

## Marine ornamental Fishes

### Clown fish (*Amphiprion sp.*)

Clownfish or Anemone fish are fishes belonging to the Family Pomacentridae. In the wild, they all form symbiotic mutualisms with sea anemones.



Depending on species, anemone fishes are overall yellow, orange, or a reddish or blackish colour, and many show white bars or patches.

### Big eye Squirrel fish (*Myripristis murdyan*)

Squirrel fish belongs to the Family Holocentridae. Their body is silver red, with orange-gold body stripes. Eyes of squirrel fishes are very large, which is characteristic feature. The rear dorsal fin is pronounced and sticks up. The anal fin has a strongly elongated third spine, from which this squirrelfish gets its name.



### Pennant coral fish, (*Heniochus acuminatus*)

The Pennant coral fish also known as the Long fin banner fish, Reef banner fish belong to the Family Chaetodontidae. Its body is compressed laterally, the first rays of its dorsal fin stretch in a long white filament. The background colour of its body is white with two large black diagonal bands.



### Surgeon fishes (*Acanthurus leucosternon*)

Surgeon fish is a marine tropical fish belonging to the Family Acanthuridae, or Surgeon fishes. Its common names are Powder blue tang and Powder blue surgeonfish. The body has an oval shape and is compressed laterally.



### Black Triggerfish (*Odonus niger*)

The Black triggerfish is a blimp-shaped triggerfish with bright white lines running along its dorsal and anal fins.



They belong to the Family Balistidae.

### **Seahorse (*Hippocampus kuda*)**

**Seahorse** is the name given to 54 species of small marine fishes belonging to the Family Sygnathidae. Male carry the young ones in the brood pouch.



### **Greasy grouper (*Epinephelus tauvina*)**

The greasy grouper (*Epinephelus tauvina*), also known as the Arabian grouper belongs to the Family Serranidae. The species inhabit clear water areas on coral reefs. Its head and body are pale greenish grey or brown with round spots, varying from orange-red to dark brown. A group of black spots may be visible on the body at the base of the rear of the dorsal fin. Five vertical darker shaded bars may also be present on the body.



### **Spotted cardinal (*Apogon maculotus*)**

Spotted cardinal (*Apogon maculotus*) is a species of fish belonging to the Family Apogonidae. The male cardinal fish incubates the eggs in its mouth until they hatch.



### **Longhorn cowfish (*Lactoria cornuta*)**

The **longhorn cowfish**, *Lactoria cornuta*, is a variety of boxfish from the Family Ostraciidae, recognizable by its long horns that protrude from the front of its head. They are omnivorous, feeding upon benthic algae, various microorganisms, sponges, polychaete worms from sand flats, mollusks, small crustaceans, and small fishes, able to feed on benthic invertebrates by blowing jets of water into the sandy substrate.



### **Damsel fishes (*Abudefduf assimilis*)**

Damsel fishes comprise the Family Pomacentridae. The Blue Damsel fish is also a great choice for reef aquariums with invertebrates. The Blue Damsel fish, also known as the Blue Devil Damsel fish, is an extremely popular marine fish because it is readily available and is very hardy.



## Marine Invertebrates

### Sea anemone

Sea anemones are a group of water-dwelling organisms that belongs to the Phylum Cnidaria.. Sea anemone is a sessile polyp attached at the bottom of the surface by an adhesive foot, with a column-shaped body ending in an oral disc. They can have tentacles ranging from a few tens to a few hundred.



### Octopus

The octopus is a cephalopod belonging to the Phylum Mollusc. Octopuses are characterized by their eight arms, usually bearing suction cups.



### Starfish

Starfish or sea stars are star-shaped Starfish which are marine invertebrates belonging to the Phylum Echinodermata. They typically have a central disc and five arms, though some species have a larger number of arms.



### Sea urchins

Sea urchins or urchins small, spiny, globular animals that, of the Phylum Echinodermata .Sea urchins have a round shaped body and with long spines that come off it. Sea urchins are members.



### Soft Corals

Soft Corals are stinging celled animals belonging to the phylum cnidaria. The familiar aquarium soft corals belong in the Family Alcyoniidae. Soft corals are some of the most attractive corals found in the world's oceans. Soft Corals, include the Leather Corals, Gorgonians, Sea Pens, Blue Coral, and the Organ Pipe Coral.



### Jellyfish

Jellyfish or jellies are the major non-polyp form of individuals of the Phylum Cnidaria. They are typified as free-swimming marine animals consisting of a gelatinous umbrella-shaped bell and trailing tentacles. The bell can pulsate for locomotion, while stinging tentacles can be used to capture prey.



## **Detailing of Practical**

- Familiarization of marine ornamental fishes, marine ornamental invertebrates and other marine organisms

Familiarization of most common marine ornamental fishes, marine ornamental invertebrates and other marine organisms and drawings made in record

- PTC on maintenance of marine aquarium

Marine aquarium can be maintained in schools so that the students will get experience in maintaining the same

- Workshop on use and method of operation of marine aquarium accessories.

## **Assessment Activities**

Familiarization of marine ornamental fishes

Familiarization of marine ornamental invertebrates and other marine organisms

PTC on managing Marine aquarium

Workshop on method of operation and use of aquarium accessories.

Field visit/OJT on Marine aquarium

## **List of items in Portfolio**

Practical record

Report on Workshop

## **Additional information**

Oceanariums are massive marine aquariums which houses small and large marine organisms which can be viewed through transparent viewing panels

## **TE Questions**

1. Name any two commonly found marine ornamental fishes.
2. Write short notes on the invertebrates used in marine aquarium.
3. Write about the significance of submerged plants in breeding and seed production of gold fish.
4. Name two ornamental fishes with parental care.
5. Write steps involved in decapsulation and hatching of artemia cysts.

### **List of Extended Activities in Module IV**

- Farming of ornamental fishes can be arranged in association with Self Help Groups by students.
- Give technical assistance to SHG's by students with the help of Vocational faculty of the school.
- The schools having Production Cum Training Centres on Ornamental Fishes can offer short term training programmes on Ornamental fisheries to farmers. By this students will get hands on experience in practical aspects. The interaction of students and teachers with the farmers will help them in knowing the latest scenario in the field.
- Selected students with aptitude in the field of Ornamental Fishes will be send to commercial farms as apprenticeship trainee
- Exposure in the field of Ornamental Fishes can be achieved by arranging visits to Commercial Exhibitions on the same too. This will also help the students and teachers in updating knowledge in the field. By this, learners will get hands on experience in latest practices.

### **List of Practical Activities in Module IV**

- Familiarization of aquarium fishes with the help of morphological characters and drawing
- Photo-exhibition of aquarium fishes by students
- Familiarization of aquarium plants with the help of morphological characters and drawing
- Photo-exhibition of aquarium plants by students
- Practical on sand planting and propagation of Aquarium plant
- Familiarisation of aquarium equipments and accessories with exhibition of the same
- Demonstration of aquarium equipments and accessories - usage and method of operation
- Practical on setting up of bio filter in an aquarium
- Practical on calculation of measurements of glass pieces for glass tank
- Practical on familiarization of Glass tank making tools
- Practical on making of glass tank

- Practical on setting up of an aquarium
- Identification of symptoms of Fish Diseases with the help of exhibition of diseased specimens and photos
- Identification of prophylactic and therapeutic agents against ornamental fish diseases (Chemicals, antibiotics and Herbs)
- Practical on breeding of aquarium fishes (Gourami/Fighter fish /Angel fish / Gold fish)
- PTC / practicals on nursery rearing of aquarium fishes
- Practical on live feed culture of Infusoria / Artemia / Tubifex / Chironomid larvae / Microworms / Earthworms etc
- Familiarization of marine ornamental fishes
- Familiarization of marine ornamental invertebrates and other marine organisms

### **List of Reference Books**

- Encyclopaedia of Aquaculture - Robert R. Stickney
- Fish and Fisheries of India - V.G. Jhingran
- Artificial reef and sea farming technologies - CMFRI Bulletins
- Culture of Brackish water fin fishes and shell fishes - Susheela Jose
- Aquaculture: Principles and practices -TVR Pillai
- Freshwater Aquaculture – Santhanam & Natarajan
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- Encyclopaedia of Aquaculture - Robert R.Stickney