2nd SEM B.Sc. BOTANY
CALICUT UNIVERSITY

ECONOMIC ZOOLOGY
2019 - ADMISSION

Prepared by
Jasla Mol K.K & Jamshiya Jaithun C
Assistant professor
Department of Zoology

CPA COLLEGE OF GLOBAL OF STUDIES, PUTHANATHANI

SECOND SEMESTER B.SC. ZOOLOGY COMPLEMENTARY COURSE

SECOND SEMESTER B.Sc. ZOOLOGY COMPLEMENTARY COURSE

Theory Course- II
ECONOMIC ZOOLOGY
Code: ZOL2C02T
[36 hrs] [2 hours/week] [3 credits]

MODULE 1: Parasitism in relation to man (11 hrs)

Introduction, classification of parasites and hosts (2 hrs)
Obligatory, facultative, external, internal, hyperparasites. Definitive, intermediate, carrier and reserve hosts. Infection and infestation - Mention Hyper infection and Auto infection. Modes of infection - Inoculative, contaminative, direct and retroinfection, zoonotic diseases

Human Parasites (5 hrs)
Parasitic Protists – Plasmodium vivax, Entamoeba histolytica
Cestodes – Taenia solium, mention T. saginata and Echinococcus granulosus
Trematodes (Flukes) – Schistosoma haematobium
Nematodes – Ancylostoma duodenale, Wuchereria bancrofti and Enterobius vermicularis

Vectors of human diseases (4 hrs)
Insect vectors of human diseases and their control. Anopheles, Culex, Aedes, Xenopsylla, Cimex, Pediculus and Pthirus (Diseases like malaria, filariasis, yellowfever, typhus fever, dengue, plague, chikungunya, kala azar).

MODULE 2. Useful Insects, Insect Pests and their control (14 hrs)

Insect Pests (9 hrs)
Definition of Pests, Kinds of Pests, Causes of pest outbreak. Nature of damage to host plants and control measures of the following pests.
(Exclude structure and Life history of Pests).
a) Spodoptera sp. (rice swarming caterpillar)
b) Leptocorisa sp. (rice bug)
c) Rhynchophorus sp. (red palm weevil)
d) Opisina sp. (Black headed caterpillar, mention biological control)
e) Aceria sp. (Coconut mite)
f) Helopeltis sp. (tea bug)
g) Cosmopolites sp. (Banana rhizome weevil)
h) Bactrocera sp. (Fruit fly)
i) Batocera sp. (mango stem borer)

j) Sitophilus sp. (rice weevil)

Insect control (2 hrs)

Basic principles of chemical control and biological control. Integrated Pest Management (IPM)

Useful Insects (3 hrs)

Apiculture, Sericulture & Lac culture: Economic importance. Predatory insects, insect parasitoids.

MODULE 3. Aquaculture and Fishery Biology (11 hrs)

Brief Introduction mentioning its scope in Kerala. (1 hr)

Pisciculture (5 hrs)

Egg collection and hatching, induced spawning. Nursery ponds, manuring, feeding and harvesting, Ornamental fish farming (brief account). Mention common species.
Fish utilization

Prawn culture. (2 hrs)

Breeding and spawning of prawns, seed collection and culture, types of prawn farms, mention common species.

Mussel farming (2 hrs)

Seed collection, artificial collection of seeds, induced spawning, rearing of larvae, farming methods and harvesting.

Pearl Culture (1 hr)

Preparation of nuclei, preparation of host and graft tissue, implantation and nursing.

MODULE 1 : PARASITISM IN RELATION TO MAN

INTRODUCTION,CLASSIFICATION OF PARASITES & HOSTS

- Parasite is an organism which depends upon another organism of a different species for food, shelter and other vital physical and physiological requirements either during a part of its life or throughout its life.
- The organism which provides these requirements is called host.
- It is an antagonistic way of life in which one organism uses another one
- A successful parasite never kills or harms its host, but lives in harmony with it.
- Parasitism is very significant in that it plays some role in regulating population size and also in maintaining the balance of nature.
- The growth of the parasitic population is directly proportional to the growth of the host population.
- The growth of the host population is inversely proportional to the growth of the parasitic population.

Obligatory (compulsory) parasites

- Organisms which can live only as parasites, depending exclusively on hosts
- Once removed from the host, they will die.
- Eg:- endo parasites

Facultative (opportunistic) parasites

- Organisms which voluntarily take to a parasitic life only when an opportunity calls for such a mode of life.
- Atother times, they are free-living
- They are capable of leading a free life as well as a parasitic life.
- Eg;- Oyster prawn - they parasitize oysters & feed upon the mucus from the gills of the oysters without doing any harm to them

External (ecto) parasites

- The parasites which inhabit the body surface of the host.
- Head lice, body lice, fleas, ticks, mites, cattle leech, etc. are examples.

Internal (endo) parasites

- The parasites which live within the body of the host
- Eg:- Plasmodium, Entamoeba
- Some endoparasites are intracellular, living inside the cells of the host.
- Others are extracellular or intercellular - live outside or in between the cells of the host.

Hyperparasites

- The parasites which inhabit or parasitize other parasites
- Parasites of parasites.
- Eg:- bacteriophages (bacterial viruses)
- Hyperparasitism is common among insects

Definitive (primary) host

- The host which harbours the adult parasite, or the host in which the parasite undergoes sexual reproduction.
- For most human parasites (e.g., Taenia, Wuchereria,.), man is the definitive host.
- But for Plasmodium, female Anopheles is the definitive host and man is the intermediate host in the sense that sexual reproduction occurs in the mosquito.

Intermediate (secondary) host

- The host in which the parasite spends its larval or asexual phase of life.
- Pig is the intermediate host of Taenia solium, Culex mosquito is the intermediate host of Wuchereria.
- For some parasites, there may be more than one intermediate hosts.

Paratenic host (carrier host or vector)

- The invertebrate host which harbours the parasite and serves as an agent for the transmission of the parasite from one primary host to another.
- Mosquitoes and blood sucking flies are the carriers of some human parasites.

Reservoir (reserve) host

- A host which first gets infected with a parasite and then serves as a source of infection of other organisms.
- Dog, in some parts of the world (e.g., China), is supposed to serve as the reserve host of *Entamoeba histolytica*. Mammals, such as monkeys, apes, deers, etc., serve as the reserve hosts of *Trypanosoma.*

Infection and infestation

- ***Infection*** is the invasion of a host's internal environment by endoparasites and their subsequent establishment and survival there.
- ***Infestation*** is the invasion of a host's superficial tissues by ectoparasites for establishment and survival.

Hyperinfection or superinfection

- This is the parasitic re-infection in which a host that harbours a parasite gets infected again by the same species of parasite.

Autoinfection

- This is an instance of re-infection in which the host itself serves as the direct source and agent of repeated infection.
- Eg;- Infection of man by Enterobius (pinworm)
- Man gets the infection from his perianal region through his fingers, clothings, etc.

Modes of infection

- Parasitic infection is of several kinds.
- The commonest among them are direct infection, contaminative infection and inoculative infection

Inoculative or injective infection

- Parasites are injected to the host's body by blood-sucking intermediate hosts.
- e.g, Female *Anopheles* injects *Plasmodium*into the human body, tsetse fly injects *Trypanosoma*

Contaminative or ingestive infection

- Eggs, larvae and cysts of the parasites are passively ingested by the host along with food and drinking water.
- e.g., *Entamoeba histolytica.*

Direct or penetrative infection

- The parasite penetrates itself directly into the body of the host by its own powers.
- e.g., *Schistosoma* (blood-fluke), Ancylostoma (hookworm).

Retroinfection

- This is an instance of re-infection in which the host itself serves as the direct source and agent of repeated infection.
- Eg;- Infection of man by Enterobius (pinworm)
- Man gets the infection from his perianal region through his fingers, clothings, etc.

Zoonoses

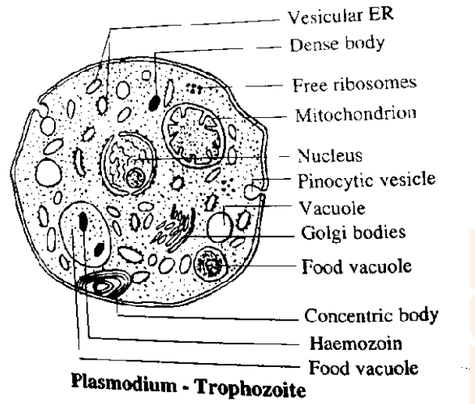
- Zoonoses are the diseases or infections, naturally transmitted from vertebrate animals to man.

- There are more than 150 known zoonotic infections of domestic & wild vertebrates that are transmitted to man
- Eg:- Bovine tuberculosis, ring worm, rabies,…

HUMANPARASITES

Parasitic protists

Plasmodium vivax



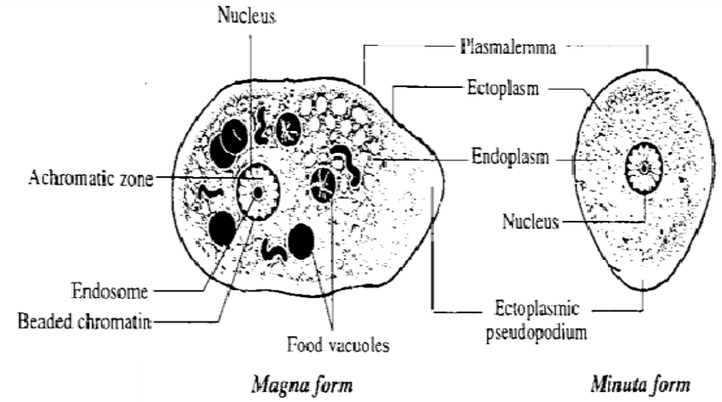
Plasmodium - Trophozoite

- Malarial parasite.
- Two host
  1. Female Anopheles mosquito – primary host – extracellular endoparasite in the gut cavity, salivary apparatus & haemocoel – undergo sexual phase.
  2. Man – secondary host – intracellular endoparasite in side RBC & parenchymatous liver cells – undergo asexual phase.
- ***Trophozoite*** – mature feeding & growing intracellular parasite in man.
- Amoeboid & uninucleate.
- Enveloped by ***plasmalemma***
- Cytoplasm is granular & vacuolated.
- Cytoplasm contains ER, golgi bodies, ribosomes, vacuoles, pinosomes,..
- ***Haemozoin*** – food vacuole contains dark residual pigment formed during the digestion of haemoglobin by parasite.

Entamoeba histolytica

- Commonly called ***dysentery amoeba***
- Lives in large intestine of man
- Causes ***intestinal amoebiasis***
- It occurs in three forms – ***trophozoite, pre cystic & cystic form***
- ***Trophozoite*** – large & irregularly shaped
  Fully mature feeding & growing vegetative form

Two forms – *magna & minuta*



Entamoeba histolytica - trophozoite

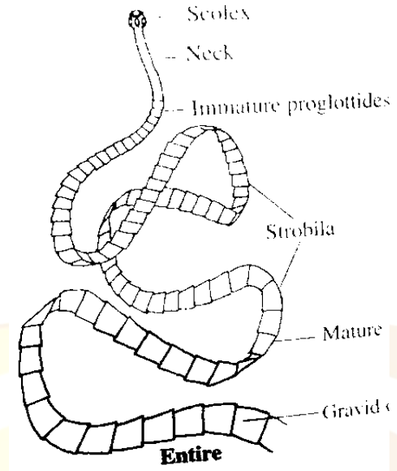
- *Pre cystic – transitory stage*
  Intermediate between trophozoite & cystic form
  Smaller & rounder in shape with large nucleus
  Blunt pseudopodium projecting to one side
- *Cystic form – encysted stage*
- Endoplasm contains a mass of glycogen & 1 or 2 refractile rods called ***chromatoid bodies***
- *E. histolytica* invades the intestinal wall, multiplies & causes the destruction & necrosis of intestinal tissues with the help of *histolysin* enzyme
- *Chronic amoebiasis* is characterized by nutritional disorders, amoebic granuloma, passage of blood & mucus in stools,..
- *Acute amoebiasis* is accompanied by deep ulceration, adhesion & perforation of intestinal wall, haemorrhage…

Cestodes

Taenia solium

- Pork tape worm
- Endoparasitic cestode in the small intestine of man.
- Thin, flat & tape like
- Exhibits pseudosegmentation
- Body has three regions : scolex, neck & strobili.
- ***Scolex*** – small, pin head like anterior part
- Four suckers & a rostellum – terminal retractile cone – armed with chitinous hooks
- ***Neck*** – short unsegmented region – budding zone
- ***Strobila*** – long, ribbon like, segmented posterior part
- Segments called proglottids – immature, mature & ripe

- Infection causes, adult – taeniasis, cysticerci – cysticercosis
- Caused by eating improperly cooked measly pork



Pathogenic effects

- Intestinal irritation and intestinal blockage, leading to indigestion, constipation, diarrhoea, abdominal discomfort, gastric disturbances, anaemia, etc
- Neurological problems due to the absorption of the toxic wastes of the worms.
- Puncture ofthe intestinal wall by the hooks, causing peritonitis.

Preventive measures

- Steam-cooking or deep-freezing of pig's meat to kill cysticerci.
- Scientific inspection of pig's meat in slaughter houses to ascertain that it is free from cysticerci.
- Avoidance of improperly cooked pork.
- Sanitary control of sewage disposal and effective treatment of infected individuals.

Treatment

- Administration of anti-helminthic drugs

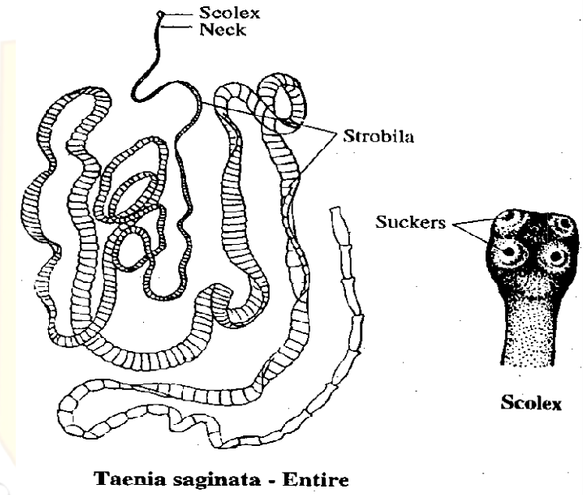
Parasitic adaptations

- Loss of locomotor, digestive, circulatory and respiratory organs.
- Presence of rostellum, hooks and suckers for adhesion and anchorage.
- Presence of a resistant and freely permeable covering, called tegument, for protection from host's enzymes and also for the absorption of nutrients.
- Great powers for anaerobic respiration
- Absence of brain and receptor organs.
- Hermaphroditism

- Enormous reproductive power.

Taenia saginata

- Beef tape worm
- Intestinal endoparasitte in man
- Body is long, flat & ribbon like
- Differentiated into scolex, neck & strobili
- Longer than *T. Solium*
- Causes taeniasis, cysticercosis



Taenia saginata - Entire

Prophylaxis & treatment

- Avoidance of eating undercooked measly beef.
- Proper and sufficient cooking of beef to destroy cysticerci.
- Careful meat inspection in slaughter houses.
- Sanitary disposal of the human night soil to prevent the transmission of the eggs and embryos to the intemediate host.
- Proper sanitary control of sewage disposal and the effective treatment of infected persons.

Echinococcus granulosus

- Popularly known as the ***dog tape worm or the hydatid worm***
- Intestinal endoparasite in feline and canine carnivores
- Its intermediate hosts include a variety of herbivorous mammals
- Man is only an incidental host, which harbours only the larvae, and never the adult
- *Smallest of all tape worms.*

- Its body is differentiated into three regions, ***scolex, neck and strobila.***
- Scolex is globular or pyriform.
- It bears four ovoidal suckers and a protrusible and cone-shaped ***rostellum***.
- Rostellum is armed with a double crown of hooklets.
- Neck is a thick and narrow region.
- Strobila is composed of 3 to 5 proglottides, namely an immature proglottid, 1 or 2 mature proglottides, and 1 or 2 ripe proglottids
- It causes ***hydatid disease***

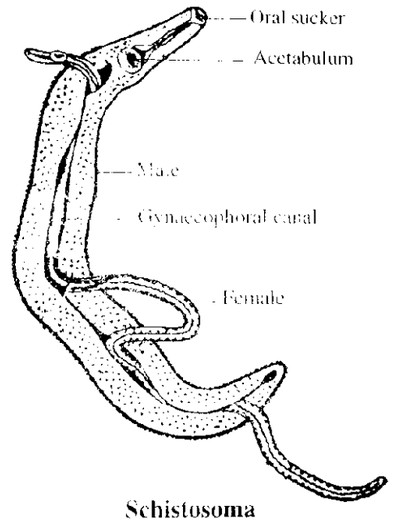
Prophylaxis

- Avoidance of contact & caressing of dogs
- Cleaning of hands before eating
- Sufficient boiling of vegetables during cooking
- Avoidance of feeding dogs with raw or improperly cooked flesh

Trematodes

Schistosoma haematobium

- Commonly called ***blood-flukes.***
- Blood -feeding endoparasitic helminths in man, inhabiting the lumen of small veins.
- *S. haematobium*, or the vesical blood-fluke, lives in the vesical and pelvic veins of man.
- It is a dioecious parasite and it exhibits distinct sexual dimorphism.



Schistosoma

- Male is shorter and stouter than female.
- Adult female is long and slender.
- She is carried by the male in a groove on his ventral side, known as ***gynaecophoral canal***.

- This groove is formed by the folding of the body wall.
- The body surface of both male and female is rough and spiny.
- At the anterior tip of the body is the mouth, surrounded by an oral sucker.
- A little behind the mouth on the ventral side is the ventral ***sucker or acetabulum***, used for attachment.
- Just behind is the gonopore.
- At the posterior tip is the excretory opening.
- The diseased condition caused by the infection of Schistosoma - schistosomiasis or bilhaziasis.
- The entry of cercariae into the human skin causes local inflammation, leading to cercarial dermatitis.
- This is characterized by pyruritus, erythematous rashes, itching and lesion at the sites of entry.
- The toxins liberated by adult flukes produce mild symptoms such as anorexia, headache, rise in temperature, night sweating, etc.
- The massive extrusion of spinous eggs into the urinary bladder may puncture blood vessels, resulting in haemorrhage. It may also rupture the wall of bladder and urethra and often cause terminal haematuria, hyperplasia and inflammation of urinary bladder.
- The chronic condition of these symptoms is often manifested by burning sensation during micturition, ulceration of urinary bladder, etc.
- Complications of the chronic condition include bladder stones, bladder cancer, etc.

Prophylaxis

- Safe disposal of human urine and faeces, or their treatment to destroy the eggs.
- Mass treatment of infected persons using anti-helminthic drugs.
- Destruction of snail vectors by appropriate methods.
- Avoidance of contact with infected water in endemic areas

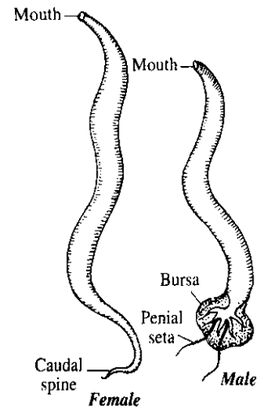
Treatment

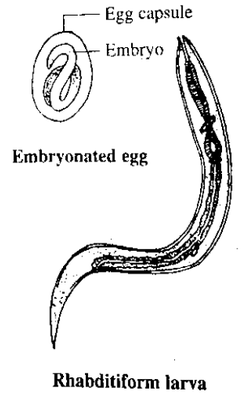
- Chemotherapy by trivalent antimony compounds

Nematodes

Ancylostoma duodenale

- Popularly known as the ***human hookworm***
- Endoparasiticnematode inhabiting the small intestine of man.
- Causes **ancylostomiasis or "hookworm disease".**
- Adult hook worm has a slender and cylindrical body, covered by cuticle
- Curved body, with a hook-like anterior end
- Buccal capsule is armed with four hook-like teeth and two knob-like dental plates or cutting plates.





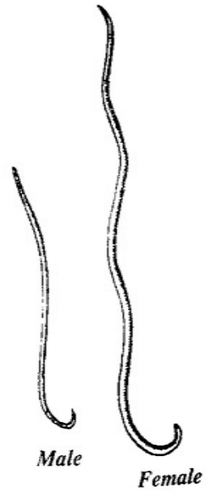
Hookworm

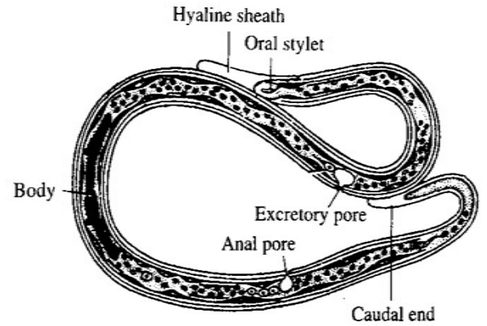
- Ancylostoma is dioecious.
- Male is shorter and stouter than female
- At the posterior end male has a cloacal opening, where as female has an anal opening
- Posterior end of the female is pointed with a caudal spine, while that of male is broad without caudal spine
- Male has a trilobed cuticular expansion around the cloacal opening, known as copulatory bursa or caudal bursa, to grip the female during mating.
- Protruding from the cloaca is a pair of long and slender copulatory spicules or penial setae in male.
- The percutaneous penetration of the larvae may cause severe itching and the formation of vesicular rashe - "***ground itch' or "water sore*** (*Ancylostoma dermatitis*). haemorthage,
- Adult hookworms in the intestine may feed on blood and body fluids and cause ancylostomiasis or hook-worm disease - characterized by chronic intestinal bleeding, abnormal fall in the haemoglobin content, severe and progressive iron deficiency anaemia, intestinal lesion and ulceration, vomiting, diarrhoea, etc,
- Treatment of ancylostomiasis involves the administration of antihelminthic drugs

---

Wuchereria bancrofti

- ***Filarial worm***
- Causes***lymphatic filariasis*** in man.
- Endoparasitic nematode, inhabiting the lymphatic system of man.
- Adult worms are long, slender, creamy white and translucent.
- Their body is covered by a smooth & transversely striated cuticle.





Microfilaria (enlarged)

Wuchereria bancrofti

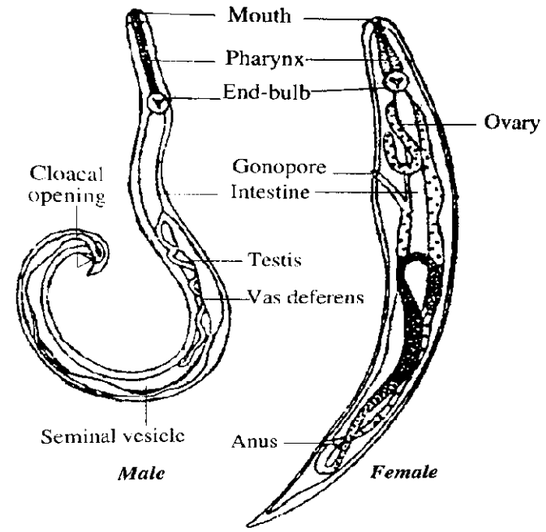
- Male and female exhibit some degree of sexual dimorphism.
- Male is much shorter than female.
- The posterior end of the male is curved downward and provided with 12-15 pairs of sessile papillae and two unequal spicules.
- The posterior end of the female is straight and without papillae and spicules.
- Posteriorly, male has a cloacal opening, where as female has anal opening.
- A separate gonopore is present in female, but absent in male.
- Usually, the male and female remain tightly coiled around each other.
- Filarial infection or filariasis is of two types, asymptomatic and symptomatic. In asymptomatic, detectable clinical manifestations are absent
- In symptomatic,there are detectable clinical signs and symptoms.
- Symptomatic filariasis is of three kinds, acute, chronic and occult. Acute filariasis manifested by episodic (irregular) or sporadic (occasional) lymphadenitis and lymphangitis (1nflammation of lymph glands and lymph vessels respectively), associated with fever.
- Chronic filariasis develops usually 10-15 years after the onset of the first acute attack.
- Occult filariasis is the filarial infection in which microfilariae are very seldom found in peripheral blood, although they may be seen in tissues.
- ***Elephantiasis*** is the late complication of filariasis

Prophylaxis

- Chemotherapy of infectedpersons
- Isolation of infected persons from mosquitoes
- Destruction of mosquitoes using insecticides

Enterobius vermicularis

- Popularly known as the ***pinworm, seatworm, or threadworm***
- Endoparasitic nematode living in the caecum, vermiform appendix and ascending colon of man.
- Adult worms are small-sized, white-coloured, fusiform, and thread-like, with pointed ends.
- Their body is covered by a finely striated cuticle.
- Mouth is surrounded by three wing like cuticular expansions, called ***'cervical alae'.***
- A true buccal cavity is absent.
- Pharynx has a bulb-like terminal dilation, called ***end-bulb.***



Enterobius vermicularis

- Male and female exhibit some degree of sexual dimorphism.
- Male is much smaller than female.
- Posterior end of the male is tightly curved, but that of the female is straight, sharply pointed and tail-like.
- Posteriorly, male bears a cloacal opening and a copulatory spicule, which are absent in female
- Female has a pre terminal anus
- Gonopore just behind the middle of the body
- Anus & gonopore are absent in male
- Male worm dies soon after mating, female live for 30-100 days

Pathogenicity

- Pinworm infection causes ***enterobiasis or oxyuriasis***.
- Symptoms - perianal irritation and itching, gastrointestinal discomfort, restlessness, insomnia, anorexia, eczematous skin around the anus, salpingitis (inflammation of oviduct),
- In children, nocturnal enuresis and daytime tiredness may also be observed.

- The attachment of adult worms to intestinal mucosa may cause inflammatory lesions - leading to haemorrhage and ulceration.

VECTORSOFHUMANDISEASES

Insect vectors of human diseases & their control

Anopheles

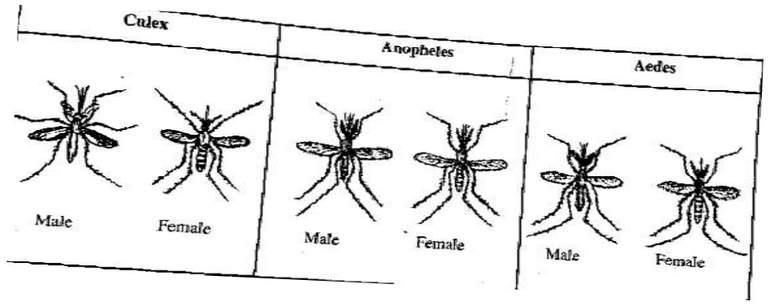
- Female Anopheles serves as the definitive host of Plasmodium and thereby spreads human malaria.
- The important Indian species of Anopheles which transmit human malaria include *Anopheles stephensi, A.minimus, A.culicifacies, Afluviatilis, A. varuna, A.annularis and A.sundaicus*.

Culex

- Female Culex serve as the vectors of the pathogens of several diseases, such as human filariasis, Japanese encephalitis, etc.
- The causative organism of human filariasis (bancroftian filariasis) is the nematode Wuchereria bancrofi.
- Its mosquito vectors include *Culex quinquefasciatus, C.fatigans, C.pipiens*, etc.
- The mosquito vectors of Japanese encephalitis viruses include *C.tritaeniorhynchus and C.vishnui*.

Aedes

- Female Aedes attack during daylight, and not at night.
- Their bite is persistently painful.
- Aedes mosquitoes are long-distance fliers.
- They breed in clean water, particularly in rainwater puddles.
- The female of Aedes aegypti spreads the viral diseases yellow fever, dengue haemorrhagic fever and chikungunya.

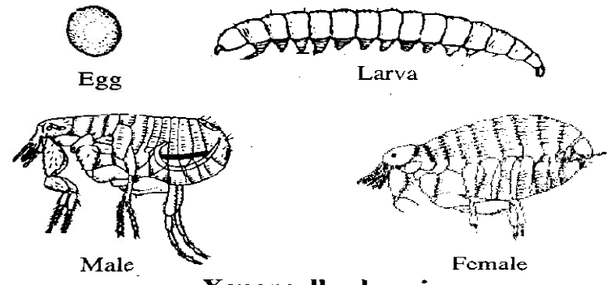


Control

- Adult mosquitoes can be destroyed by direct killng, fumigation, spraying of chemical insecticides, etc.
- Multiplication of mosquitoes can be checked by the reclamation or draining of stagnant water bodies, which are their common breeding grounds.
- Destruction of the larvae and pupae of mosquitoes can be effected by frequent cleaning of drainage canals, ditches, etc.
- Spraying of kerosene, crude oil and other emulsion oils over stagnant waters
- Release of larvivorous fishes (Aplochilus, Macropodes, Gambusia, etc.) into stagnant waters for biological control

Xenopsylla

- Xenopsylla is a blood-sucking ectoparasite, commonly infesting rats.
- Its body is small, yellowish or brownish, wingless, heavily chitinised and tough, and equipped with backwardly directed spines and bristles.
- The body is laterally compressed to facilitate gliding between the hairs of the host.
- Hind-legs are exceptionally long with elongated coxae - they are adapted for jumping.
- Mouth-parts are piercing and sucking, armed with three piercing stylets.
- The stylets also form a canal for the flow of saliva into the host.
- Their piercing bite causes itchy & irritating skin lesions
- Serve as principal vectors in the transmission of typhus fever, plague,..



Xenopsylla cheopis

Control

- Occasional spraying of 2% chlordane, 1% lindane and 0.5% malathion on floors is effective for controlling rat fleas.
- The most reliable way of controlling rat fleas and plague is the destruction of rats.

Cimex

- ***Bed bug***
- Bloodsucking ectoparasite on birds, man and other mammals
- Cimex is nocturnal in habit,commonly found in human habitations.
- The body of bed bug is thin, flat and wingless, and reddish-brown in colour.

Adult

- Mouth-parts are piercing and sucking, modified for blood-sucking.
- There is a sucking tube, called ***proboscis or rostrum.***
- It is formed of labium and it encloses mandibles and maxillae.
- Maxillae are highly modified. When closely apposed, they form two tubes, one for drawing blood from the host, and the other for pumping saliva to the host.
- Once fed to its full satisfaction, a bed bug can starve for more than six months.
- Bed bug has a pair of stink glands, opening ventrally on the metathorax
- Their secretion gives the animal a pungent and unpleasant odour.
- Bite of bugs causes allergic irritations, itching, burnings and local swellings.
- This is because of the action of their venomous saliva.
- Continued bug bites may sometimes cause anaemia, insomnia, nervousness, etc.

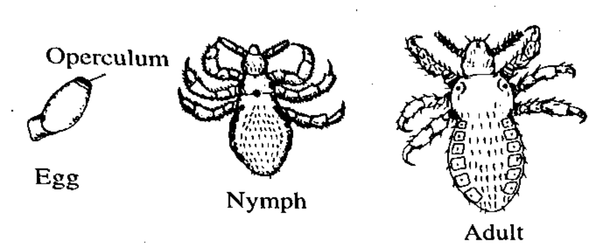
Control

- Bed bugs can be controlled by spraying 1% malathion or 0.1% lindane on infested matresses, coats, walls, furniture, etc.
- For badly infested rooms, fumigation with hydrocyanic acid is more desirable.

Pediculus

- ***Human louse.***

- Blood-sucking ectoparasite on man.
- Body is small, flat and wingless, with a highly sclerotised integument.



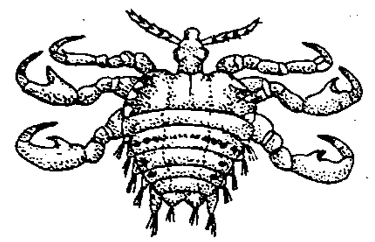
- Head is narrow, and antennae are short.
- Legs are short, stout and provided with hook-like terminal claws for grasping
- Mouth-parts are piercing and sucking
- Apart from sucking, it causes irritations
- Serve as vector of several pathogens
- Spread typhus fever, trench fever,…

Control

- Personal hygiene
- Proper cleanliness & sanitation of the surroundings
- Application of 1% lindane powder
- 1% thymol, lorexane, 2% lindane in coconut oil,.. are most effective

Phthrius

- ***Pubic louse or crab louse***
- Blood sucking ectoparasite
- Inhabits the hairy parts of body, usually in pubic region
- Body is broad, long & greyish white in colour



Phthirius pubis

- Head is small, legs are stout with sharp terminal claws
- Mouth parts are piercing & sucking

- It remains attached to the same point for several days, with its mouth parts inserted into the skin of the host
- The bite is highly irritating
- Continued infestation causes pruritis & discolouration of the skin – **Phthiriasis / Pubic pediculosis**

Control

- Sexual contacts of the infested person should be examined
- Wash clothing & bedding using hot water (130° F).
- Do not share clothings

equipping with excellence
CPA COLLEGE OF GLOBAL STUDIES

MODULE 2 : USEFUL INSECTS , INSECT PESTS & THEIR CONTROL

PESTS

- Harmful species whose population size goes beyond the *damage threshold level* either throughout the year or during specific seasons , adversely affecting the availability , quality and value of useful human resources

KINDS OF INSECT PESTS

1. **Potential pests**

With inherent potential to rise to the pest status though under natural regulations

2. **Key pests**

Major pests of specific crops

3. **Occasional pests**

Occur above the damage threshold level rather infrequently

4. **Regular pests**

Key pests on a crop above damage threshold level most frequently

5. **Persistent pests**

Key pests, which spend whole of their lifetime on specific crops

6. **Sporadic pests**

Occasional pests , rise to pest status unexpectedly

7. **Major pests**

Seriously damaging pest species whose general equilibrium position (GEP) is close to economic injury level(EIL) & sometimes both at same level

8. **Minor pests**

GEP is lower than EIL & Damage Threshold Level

9. **Monophagous pest**

Subsist on single species of host plant

10. **Polyphagous**

Subsist on wide range of host plants

CAUSES OF PEST OUT BREAK

- There is a balance between pest and their natural environment
- Pest outbreak : population size of some species : increases beyond the damage threshold and become pests
- Major causes :
    1. Destruction of forests , conversion of forest areas into farm lands , changes in land use
    2. Destruction of natural enemies
    3. Monoculture
    4. Intensive and extensive cultivation of crops
    5. Introduction of new crops
    6. Improved agronomic practices
    7. Improper plant protection method
    8. Introduction of new species

9. Accidental introduction of foreign pests
10. Resurgence of sucking pests

PESTS : NATURE OF DAMAGE & CONTROL

1 . *Spodoptera mauritia* (Rice swarming caterpillar)

1. Spodoptera mauritia(Rice swarming caterpillar)

Pest **Damage**

- Pests of paddy
- Leaf eater
- Direct development and complete metamorphosis

Damage

- Sporadic pest
- Defoliation
- Larvae cut the seedlings in large scale
- Cattle grazed appearance is found at severely infested fields
- They feed gregariously and march from field to field
- Makes Leafless stumps

Management:

- Drain the water and Spray chlorpyriphos 20 EC 80ml + 20 lit of water for 8 cents
- Physical removal using hand nets
- Allow ducks into the field to feed on the larvae
- Spraying DDT , BHC, endosulphan
- Flood the nursery to expose the hiding larvae to the surface for birds to pick them up.
- Kerosenate water during irrigation to suffocate and kill the larvae.
- Drain water from nursery and spray chlorpyriphos 20 EC 80 ml during late evening

---

2. *Leptocorisa acuta* (Rice bug / paddy stink bug)

2.*Leptocorisa acuta*(Rice bug)

Pest **Damage**

- Pests of paddy
- They are diurnal but most active during morning and evening when they look for the flowering crops. Their presence can be easily detected by the characteristic foul odour that they emit.

Damage :

- Sporadic pest which appears before flowering stage and stays upto milky stage; attacks at milky stage
- Nymphs and adults are destructive
- The pest immigrates in the crop in the flowering stage and feeds on the milky grains and on the sap of the peduncle and leaves.
- Feed on sap of tender stem , peduncle and milky grains
- Some grains on the ear heads appears chaffy
- Yellow spots appear on the leaves due to excessive sucking.
- The empty grains turn whitish and show a puncture mark.
- The characteristic damage is called chaffy grains. Infestation is severe in irrigated and heavy rainfall areas.

Control:

- Collection and destruction of the bugs by netting or in light traps can be done in smaller areas.
- Removal of grasses and other weeds from bunds and surrounding areas reduces population.
- Spraying DDT , BHC
- Light traps
- Dusting of the crop with 5% BHC, Malathion or aldrin @ 15 kg per hectare effectively controls the pest. Application of granules of carbofuran or diazinon has also been found effective.
- Biological control : tiger beetles and robber flies

***3. Rhynchophorus ferrugineus* (Red palm weevil)**

2. *Rhynchophorus ferrugineus*(Red palm weevil)

Pest **Damage**

- Pests of coconut

Damage

- Holes on trunk with with brownish ooze
- Yellowing of inner leaves
- Gradual wilting of central shoot in the crown
- Brownish oozing
- Central shoots wilting - Later
- Leaf damage - Initial

Management

- Remove and burn all wilting or damaged palms in coconut gardens to prevent further perpetuation of the pest.
- Burn off severely affected palms
- Avoid injuries on stems of palms as the wounds may serve as oviposition sites for the weevil. Fill all holes in the stem with cement.
- Avoid the cutting of green leaves. If needed, they should be cut about 120 cm away from the stem.
- Fill the crown and the axils of top most three leaves with a mixture of fine sand and neem seed powder or neem seed kernel powder (2:1)
- Setting up of attractant traps (mud pots)
- Install pheromone trap

4. ***Opisina arenosella (Black headed caterpillar***)

Opisina arenosella


- Pests of paddy

Damage

- Dried up patches on leaflets of the lower leaves
- Galleries of silk and frass on under side of leaflets.
- Burnt appearence

Management

- The parasitoid should be released @3000/ha under the coconut trees when the pest is in the 2nd or 3rd instar larval stage. Parasitoid release trap may be used to release the parasitoid at the site of feeding. Parasitoids should not be released in the crown region since they will be killed by predators like spiders and reduviid bugs.
- Remove and burn all affected leaves/leaflets.
- Spray malathion 50 EC 0.05% (1mi/lit) to cover the undersurface of the leaves thoroughly in case of severe epidemic outbreak of the pest in young palms.
- Root feeding for the control of coconut Black headed caterpillar:

5. ***Aceria guerreronis (*Coconut Eriophyid mite*)***

Aceria guerreronis

- Pests of paddy

Damage

- Suck in sap from growing tender nuts and desap
- Initial symptom : Triangular pale or yellow patches close to perianth
- Necrotic tissues
- Brown colour patches, longitudinal fissures and splits on the husk
- Oozing of the gummy exudation from the affected surface
- Reduced size and copra content.
- Malformed nuts with cracks and hardened husk.
- Eriophyid mite damage in young developing buttons

Management

- Biopesticides : neem seed oil and garlic soap emulsion
- Apply urea 1.3 kg, super phosphate 2.0 and muriate of potash 3.5 kg/palm/year
- Neem cake @ 5 kg and organic manure 50 kg/palm/ year
- Borax 50 g + gypsum 1.0kg + Manganese sulphate 0.5 kg/palm/ year
- Biological control : ***Hirsutella thompsonii (***mite attacking fungus)

6. ***Helopeltis antonii (*Tea mosquito bug)**

Helopeltis antonii

- Pests of tea & cashew

Damage

- Nymphs and adults suck sap from tender parts
- Toxic saliva injected during sucking causes necrosis and appearance of black / brown patches
- Leaves curl , dry and drop
- Shoot dries ; and plant becomes broom like

Control measures

- Chemical control : spraying malathion ,parathion and other contact insecticides

- Physical : collecting and killingnymphs and adults using hand nets

7. ***Cosmopolites sordidus*** **(Banana weevil)**

Cosmopolites sordidus


- Pests of banana

Damage

- Grubs are destructive
- Bore into rhizome , make tunnels inside , feed on the tissues
- Makes plant weak
- Causes death of unopened leaves , decoloration and premature withering of leaves
- Decaying of heart and ultimate death of plant

Control measures

- Uprooting and destroying of infested plants
- Addition of BHC , aldrin , etc into plantation pits
- Selective use of pest free suckers for planting

8. ***Batocera rufomaculata*** **(Mango stem borer)**

Batocera rufomaculata


- **Pests of mango**
- Mango boring beetle
- They are serious pests of mango,fig,jack, rubber..etc
- Adult are large sized,well built and pale grey longicorn beetles,with long legs tip of the body on each side.
- Two concentric orange yellow spots on prothorax,and several yellow spots on the fore wings

Damages

- Caused by grubs
- Bore into the stem
- Cut tunnels or galleries and feed on the Woody tissues.

- Kill branches and causes the wilting and sometimes the death of the tree.

Control measures

- Closing of the bore holes with cotton plugs, soaked in kerosene or petroleum and then plastering them with mud
- Injection of chloroform, carbondisulphid ,endrin, methyl parathion etc. to kill the grubs
- Removal and destruction of the affected part

***9. Dacus dorsalis / Bactrocera sp.*(Fruit fly)**


- Pests of mango
- Commonly called mango fruit fly or oriental fruit fly.

Damage

- Maggots alone cause damage to fruit.
- They feed on fruit pulp, making the fruit unsuitable for human consumption.
- The infected fruit may be crowded with maggots

Control measures

Frequent spraying of the plant with a mixture of malathion and molasses or dimethoate during the fruiting period

10. Sitophilus oryzae (Rice weevil)

1.***Sitophilus oryzae***(Rice weevil)

Pest **Damage**


- Pests of stored products

Damage

- Adults and larvae bore into grains & feed on their interior , hollowing them/emptying out
- Cause complete destruction

Control measures

- Maximum drying of grains before storing
- Cleaning of go-downs/store rooms before storage
- Fumigation

- Dusting BHC & other insecticides

INSECT PEST CONTROL

NATURAL PEST CONTROL

- Natural pest control involves the operation of natural factors, without significant influence of human activities.
- Factors include *climatic (*temperature, humidity ,rainfall etc*), topographic* (deserts, large water bodies etc)and *biological factors (*predators & parasites*).*

1. **Pest control by climatic factors**
   - Climatic factors which control insect pest populations include the influence of temperature, humidity, rainfall, wind, air currents, etc.
   - Temperature- every insect requires an optimum range of temperature for each stage of its life cycle. If the temperature goes above or below the optimum range it will have damaging effect on the insect population and sometimes it may even kill the insects.
   - Rainfall- Too much or too little of rainfall can kill the insects.
   - Eg-life of red hairy caterpillars of cutworms.
   - Humidity-it helps the development of entomophagous fungi which turn, check the insect population.
   - Eg-growth of *Cephalosporiumlecanii.*
2. **Pest control by topographic factors**
   - Geographical barriers, such as mountain ranges, large water bodies, vast deserts, dense forests, etc.,limit or restrict the dispersal of insects.
   - These factors influence considerably the climate of an area and thus interfere with the growth of insect populations.
3. **Pest control by biological enemies**
   - There are natural enemies for every insect. They may be parasites(mites,disease - causing viruses, bacteria and fungi),pathogens, or predators(spiders,birds, reptiles, fishes and mammals).
   - Predators pathogens and parasites keep the insect population in dynamic equilibrium at its optimum size.
   - But any change in the size of the insect population, or in the population of the natural enemies, will disturb the equilibrium.

APPLIED CONTROL OR ARTIFICIAL CONTROL

Prophylactic methods

- Prior protection of crop from pest attack
- It includes,
  - Field and plant sanitation

- Scientific agricultural methods
- Use of pest-resistant varieties of plants and seeds
- Time adjustment

Curative methods

- Direct destruction of pest after infestation
- It includes,
  - **Cultural methods** : deliberate modification of the agricultural practices to the disadvantage of pest populations either to destroy insect pests or to prevent them from destroying the crop.It includes , crop rotation ,trap cropping , mixed cropping , tillage operation
  - **Mechanical methods** :procedure in which members of the pest species are trapped or killed by mechanical means or are prevented from gaining access to the crop plants by making barriers. It includes , killing of eggs, larvae ; trapping of pests ; sieving and winnowing (stored products pests) ; flooding etc.
  - **Physical methods** : deliberate modification of some physical factors to slow down the growth of the pest populations or to minimize or prevent pest infestation .It includes , use drie-die , use of lethal temperatures , ionizing radiations , light traps etc.
  - **Legal methods** : control of pest through the enactment of laws and regulations and enforcement of legal restrictions . It includes foreign quarantine , domestic quarantine etc
  - **Biological methods** : eradication or suppression of a pest species using natural enemies like predators , parasites , or pathogens. It involves 3 main steps : inoculation , augmentation and conservation of natural enemies
  - **Chemical methods** : controlling pest using toxic chemicals called pesticides

BIOLOGICAL CONTROL

The four approaches are:

- **Natural biological control,** i.e., the natural suppression of potential insect pests by resident natural enemies that requires no human facilitation
- **Importation biological control**, i.e., the deliberate importation and establishment of specialized natural enemies from the region of origin of an exotic invasive insect pest to provide long-term suppression over broad geographic regions
- **Conservation biological control**, i.e., the localized manipulation of the crop environment to protect or enhance the activity of resident natural enemies for short-to longer-term suppression of insect pests
- **Augmentative biological control**, i.e., the mass production and localized release of resident natural enemies to augment their abundance for either immediate (inundation) or season-long (inoculation) suppression of insect pests.

Merits:

- Harmless to beneficial and non-target organisms

- Highly specific
- Development resistance is slow
- Self sustaining system and brings down expenditure
- No residual effect
- No environment problem
- Does not cause ecological imbalance
- Adds to stability of ecosystem
- Maintain dynamic balance of nature
- Promotes adaptation

Demerits :

- Needs very high initial expenditure
- Needs full scale ecological evaluation
- Slow and time consuming
- Heavy economic loss
- Unpredictable climatic changes : affects
- Degree of biological control by natural enemies is rarely adequate

CHEMICAL PEST CONTROL

- Chemical pest control is the controlling of pest populations using toxic chemicals, called pesticides, which can kill, deter, attract, or influence pests to check their ravages
- The pesticides used to control insect pests are called insecticides.
- Chemicals are often used in both preventive and curative methods of pest control.
- These chemicals kill pests by their toxic and lethal effects.
- But their other effects they alter the behaviour of pests, induce sterility in them, interfere with their metabolism, impair their normal activities, or disrupt and distort their development.
- A broad-spectrum pesticide, that can kill many species of organisms : ***biocide***.
- Generally, narrow-spectrum pesticides, that attack only specific types of pests, are preferred in agricultural pest control.

Classification based on application

1. Attractants

- Attractants are the chemical substances towards which insects make preferential and oriented movements.
- Use of insect attractants :
- Synthetic chemical attractants, specific for insect pests, are important in insect pest control. Insects respond to them either for feeding purpose, or egg-laying, in the former, both males and females are attracted, while in the latter only mature females are attracted.
- Chemical insect attractants are used as an ingredient of insecticides, as a constituent of poison baits, or as a part of mechanical trapping devices.

2. Repellents

- Repellents are offensive chemicals which repel insects away from them.
- Use of insect repellents :

- Chemical repellents are effective for the protection of man and domestic animals from blood-sucking insects. However, they have never been successful for controlling the pests of plants. This is because their continuous emission is essential for effective protection.

3. Synthetic pheromones

two major kinds of synthetic pheromones are used in pest control

- **Alarm pheromones** : alarm pheromones are sometimes used against sap-feeding aphid pests. They cause the insects to drop from the plant,
- **Sex attractant pheromones** : sex attractant pheromones are mostly male-attractants. They are highly species-specific. Their high potency and extreme selectivity and specificity are of great significance for the manipulation of selected pests.

4. Deterrents

- Suppress behavior of pests

5. Auxiliary substances

- Substances that are mixed with insecticides to boost up the action of the later

6. Insecticides

- Chemicals used to kill insect pests

Classification of insecticides based on chemical nature :

Their major active groups include

- Organochloride
- Organophosphates
- Carbamates
- Synthetic pyrethroids
- insect growth regulators
- plant derivatives, oils etc.

A. Inorganic insecticides

Inorganic insecticides are mainly made up of elemental sulphur and mineral compounds.

a) Arsenic compounds

- These are the major inorganic insecticides. T
- heir insecticidal property depends mainly on their total arsenic content and the proportion of water-insoluble arsenic

eg, Lead arsenate , Calcium arsenate

b) Fluorine compounds

- They are primarily stomach poisons.

Eg,Sodium fuoride (NaF)

c) Sulphur

- Sulphur is used in inorganic insecticides, always mixed with other insecticidal dusts. It prevents that balling of the dust.

d) Lime sulphur

This is the solution of calcium polysulphide in water.

e) sodium tetra borate or borax

B. Organic insecticides

a) Hydrocarbon oils

These are the insecticides, formed of hydrogen and carbon, Mineral (petroleum)oils and coal-tar are examples. Mineral oils are obtained from sedimentary rocks.

b) Organic insecticides of animal origin
there are only very few insecticides of animal origin.

c) Organic insecticides of plant origin
Organic insecticides of plant origin are generally called "**botanicals"**

➢ **Nicotine**

- Nicotine, the main alkaloid present in tobacco, is well known for its insecticidal property.
- There are about 12 alkaloids in tobacco of which nicotine amounts to 97% .
- Nicotine is a neurotoxin and it can enter into the body of insect pests through cuticle, spiracles and ingested food.
- It can be sprayed as a solution with soap, lime, or ammonium hydroxide, The solution can be prepared by boiling 1 kg of tobacco waste in 10 litres of water for 30 minutes and then by diluting it into 30 litres and adding 90 gm of soap

➢ **Pyrethroids**

- Pyrethroids are the extracts of the plants Chrysanthemum coccineum and C.canneum.
- The insecticidal property of pyrethroids is due to the presence of esters.

➢ **Rotenoids**

- Rotenone (C23H22O6) is a compound present in the roots of the plants Derris and Lonchocarpus (the root of Derrris elliptica is used as a fish poison).

d) Synthetic organic insecticides

These include organochlorines, organophosphorus compounds, carbamates, synthetic pyrethroids, insect growth regulators, organic thiocyanates and dinitrophenols.

➢ **Organochlorines**

Also called chlorinated hydrocarbons. As the name suggests, they consist of aliphatic or aromatic hydrocarbon nucleus and varying numbers of chlorine atoms attached to it.

➢ **Organophosphorus compounds** (organophosphates)

These are organic pesticides, with an invarible phosphorus - containing central core in each molecule.

➢ **Carbamates or urethanes**
➢ **Synthetic pyrethroids**
➢ **Insect growth regulators(IGRs)**

Classification of insecticides based on the mode of entry

➢ Contact Insecticides :oral / dermal .Eg. DDT
➢ Stomach poisons : Oral .Eg. arsenic
➢ Fumigants : volatile .Eg. Hydrogen cyanide
➢ Systemic insecticides :get absorbed to the sap stream of plants from leaves , fruits , stem and roots and moves along vascular system

Mechanism of action of insecticides

The mechanism of action of insecticides is highly variable.In general, they may act as physical poisons, protoplasmic poisons, never poisons, respiratory poisons, or as asphyxiating agents.

Spectrum of insecticide activity

The range of the pest species, affected by an insecticide, is known as its spectrum of action.Some have broad spectrum of action while others have narrow spectrum of action

Insecticide resistance

Some populations or strains of insects may exhibit a natural tolerance to particular insecticide.

Pesticide hazards

- In Modern times, pesticides are considered as major pollutants, contaminating air soil and water.
- The pollution problem, associated with the use of pesticides, started with the extensive use of DDT and other organochlorines.
- Kills natural enemies
- Causes sec outbreak of pest
- Pesticide poisoning of top soil kill soil microorganisms
- Aquatic environment pollution : affects primary productivity , ecological energetic and dynamics of ecosystem
- Destroy insect pollinators
- Increases susceptibility of organisms to diseases
- Biological magnification
- Interfere with enzyme action , metabolic processes and behavior of animals
- Pesticides, in general, seriously affect human health.
- Their effects include *short-term effects and long-term effect.*

Pesticide residue

- *Pesticide deposit*: quantity of an insecticide remaining attached to the plant surface or other surfaces soon after the application
- *Pesticide residue* : Pesticide deposit progressively decreases due to chemical breakdown , volatalization and other weathering processes . The amount still remaining at crop maturity
- Expressed in parts per million (*ppm)* fresh weight of produce
- *Tolerance level*: max permissible insecticide residue level in harvested produce
- Insecticide residues can be maintained by *waiting period*
- Factors affecting :
  - Nature and method of application
  - Environmental factors
  - Agricultural practices
  - Plant characters

INTEGRATED PEST MANAGEMENT (IPM)

- Ecologically based pest-control strategy
- Advocates application of a combination of techniques and relies more on natural enemies , weather , cultural control and restricted use of pesticides
- Specific times-specific pest- specific crop

Features :

- 2 or more techniques in an integrated manner
- Max use of mortality rates
- Based on ecological principles
- Applies specific control measures only when they become unavoidable

Advantages :

- Reduces chemical pesticide usage – reduces environmental pollution-no pesticide residue
- Least possibility of developing resistance by pests
- Reliable because it considers ecological aspects and population dynamics of pests

USEFUL INSECTS

Apiculture : Economic importance

1. Honey
   - High nutritive value
   - Contains levulose, dextrose , maltose, vitamins ,enzymes ,minerals & water
   - Medicinal : antibacterial drug, analeptic , used in folk medicine , mild laxative,
   - Improves circulation
   - Reduce hyper acidity
   - Stimulates growth of laboratory plants
   - Antiseptic and sedative property
   - Used in gastrointestinal disorders
   - Used as food
   - Used in production of cakes & flavouring agents
2. Beeswax
   - Used in the manufacture of cosmetics,paints , candles,crayons & ointments
3. Propolis
   - Bee-glue: resinous , mildly sweet and whitish plant fluid
   - Anti-bacterial & antibiotic
   - Used in folk medicine
   - Used in ayurvedic medicines
   - Preparation of lipbalms , ointments & tonics
4. Royal jelly
   - Brood food: super-concentrated & nutrient-rich material
   - Royal jelly in alcohol : reduce cough & cold
   - Dilate blood vessels
   - Lower BP
   - Improve appetite
   - Treats leukemia, anaemia
5. Bee bread
6. Bee venom(apitoxin)

Seri culture : Economic importance

- Rearing and management of domesticated silk moths and silkworms for commercial silk production
- Silk worms have silk glands and spinnerets
- Silk is composed of : fibroin (75-80%) & sericin (20-25%)
- STEPS:

a) Selection of silk moth
b) Moriculture
c) Rearing of silk worms
d) Collecting and processing cocoons

Lac culture : Economic importance

- Abdominal glands (lac glands) of lac insect produces a protective resinous substance called lac
- Composition : resin (70-80%) , water, sugar, proteins , wax etc
- Uses : lac is a versatile resinous substance
- Shellac is used in paints , polishes, varnishes , sealing wax,electrical insulating materials , toys etc
- Used as a thermoplastic moulding material
- Raw material for manufacturing glazed paper ,optical frames , crayons etc

PREDATORY INSECTS, PARASITOIDS

PREDATORY INSECTS

- predatory insects stands out among natural enemies for having biological characteristics that make them potentially important agents for the biological control of crop pets.
- This insects can completely prevent or greatly limit the pest problems of the farmers of gardeners.

Benefits

- Pest control (biological pest control).
- No need to use some insecticides or pesticides that can harm the human's health.
- Eg:-bumble bee,fly wasp,Lady bird beetles or Lady bugs,praying Mantis (best insect predator) etc..

PARASITOIDS

- Parasitoid is an insect whose larvae live as parasites that eventually kill their hosts by absorbing sap and nutrients(typically other insects).
- Adult parasitoid leaves the host to find mates and new host to lay her eggs.

Benefits

- Ability to search out pest insects and their ability to persist over multiple years.
- Each female parasitoid holds hundreds of eggs,meaning these natural enimies can rapidly destroy a pest population if conditions are right.
- Eg:-Telenomes wasps,*Trichogramma, Netelia producta*(orange caterpillar parasite)

MODULE 3. AQUACULTURE AND FISHERY BIOLOGY

INTRODUCTION OF AQUACULTURE

- Aquaculture is commercial farming,husbandry and harvesting of economically important aquatic animals and plants in suitable breeding grounds in water bodies
- It's purpose is large-scale production of food fishes and edible shellfish
- It provides commercially valuable products ,such as pearls ,shells etc
- It can convert agriculturally undesirable and unproductive wastelands,marshes and reservoirs to highly productive farming areas at a relatively low capital inverstment and low maintenance expenditure

SIGNIFICANCE OF AQUACULTURE

- It supply of the desired food species
- Traditional agriculture in food production
- Culturing of fishes and shell fishes
- Integrated fish culture
- Provide higher income and employment for rural population
- Recycling agriculture and domestic wastes

1. Classification of aquaculture based on environment

Freshwater Aquaculture

- In which selected species are cultivated in freshwater bodies such as ponds ,lakes,rivers etc

Brackish Water Aquaculture

- Farming of aquatic organisms in brackish water
- Cultivated items are milk fish,prawns etc

Mariculture

- It's called coastal aquaculture
- Cultivation of organisms in the marine environment
- Marine fishes,shrimps,sea weeds etc

2. Classification based on temperature

Warm water aquaculture

- Water bodies of the tropical regions and plains where the temperature of water is above 20 degree celsius

Cold water aquaculture

- The farming of aquatic organisms in the cold water streams ,ponds,lakes etc

3. Classification Based On Economic Aspects

Extensive aquaculture

- Traditional method of farming organisms in natural ponds,rice field etc without providing supplemental feeding ,care and protection

Intensive aquaculture

- Which targets maximum yield or returns from a limited area of water through intensive effort

Semi-intensive aquaculture

- it is intermediate between extensive and intensive aquaculture methods

3. Classification Based On Techniques

Pond Aquaculture

- Aquaculture in natural and artificial freshwater ponds

Cage culture

In which aquatic organisms are kept in cages,made of metal frames

Pen Culture

- Pens are fixed enclosures ,constructed in shallow water near river banks and shorelines

raft culture

- Culturing of mussels and oysters in the sea with the help of raft made fiberglass

Pole Culture

- Culturing of marine organisms ,such as muscles and oysters with the help of poles

Rack culture

- Which makes use of racks

Long-line culture

- For culturing of bivalve molluscs in open seas

5. Classification based on the number of species

Monoculture

- Rearing of organisms of the same species in a culture system

Polyculture

- It's called composite or mixed farming
- Together of different species of organisms in the same culture system

6. Classification based on organisms

- Classified based on the type of organisms cultured Eg : fish culture , crab culture , prawn culture etc

AQUACULTURE IN KERALA

- Kerala, with a precious bounty of unique water bodies, represented by 30 brakish water estuaries, 44 rivers, 25 odd major reservoirs etc
- Kerala ranks first in marine fish landing. And fisheries sector plays a crucial role in the economy of the state.
- The Government of Kerala launched a programme in 1997, called '*Janakeeya malsyakrishi '*.

Aquaculture method suitable for Kerala

- Mariculture and coastal aquaculture: e.g. Shrimp culture, mussel culture, pearl oyster culture, lobster culture,edible oyster culture, sea weed culture etc.
- Brakish water aquaculture : e.g. Shrimp culture, brakish water fish culture,crab culture,edible oyster culture, clam culture etc
- Freshwater aquaculture : e.g. Freshwater fish culture, prawn culture, tortoise culture, crocodile culture,frog culture, ornamental fish culture etc.
- Cold water aquaculture : e.g. cold water fish culture and ornamental fish culture

Aquaculture in kerala

- Kerala is gifted with precious bounty of unique water bodies,represented by 30 brackish water estuaries,44 rivers,25 odd major reservoirs,several fresh water lakes and innumerable ponds.
- Among the maritime states and Union territories of India,Kerala ranks first in marine fish landings.

- The fisheries sector plays a crucial role in the economy of the state as a whole.
- More than 10 lakh people are engaged in fisheries and aquaculture activities directly or indirectly.
- Annual fish production in kerala is around 5.50 lakh tonn
- Traditional brackish waterprawn farming called prawn filtration has been prevalent in kerala from thepast few hundred years onwards. Presently, Traditional prawn culture is in operation in nearly 12,000ha.area in the state.
- The fisheries sector department has identified 3,300 ha of ponds,30,000 ha of reservoirs and 65,000 ha of brackish water bodies as suitable areas for aquaculture.
- Judicious exploitation of these water bodies for aquaculture operations would enhance the fish production in state.
- The government of kerala launched a program in 1997 called **Janakeeyamalsyakrishi.**
- Aquaculture operations are proposed to be carried out with the participation of local people under the supervision of local government bodies.
- The fisheries department will provide necessary guidelines and technical support.

Benefits of aquaculture

- The main essential benefits of aquaculture is oxygen generation, coastal protection, climate moderation,course seafood.
- Source if food**.**
- Provides valuable non food products.

PISCICULTURE

- **Pisciculture**:Rearing and management of fishes under controlled conditions
- It involves the control of growth, breeding and quality of the fish in cultural systems

Desirable Qualities of Culturable Fishes

1. Adaptations to thrive in changing environmental conditions such as temperature,pH, turbidity,CO2 and dissolved oxygen
2. High reproductive potential to maintain high population density throughout life
3. Fast growth and high rate of food conversion to grow to full size in a short time
4. Ability to live with other species in polyculture or mixed farming systems
5. Adaptations to live in crowded conditions
6. Ability to accept any type of artificial breed
7. Small and handy size
8. Ability to spawn(reproduce) in captivity,large eggs, simple larval development and single larval stage
9. Endurance to withstand rough handling and transportation
10. High resistance against pathogens and diseases
11. High food value, excellent table quality and great demand in the local market

Common Culturable species

Carps- commonest and the most popular freshwater fishes

Sl. No.	Scientific name	Common name	Local name
	(i) Indian Major Carps		
1.	*Catla catla*	Catla	കരകട്ട്ല/കട്ട്ല
2.	*Labeo rohita*	Rohu	രോഹിത
3.	*Cirrhinus mrigala*	Mrigal	മൃഗല
	(ii) Exotic (Chinese) Carps		
4.	*Hypophthalmichthys molitrix*	Silver carp	സിൽവർമീൻ
5.	*Ctenopharyngodon idella* (Currently *C.idellus)*	Grass carp	പുമീൻ
6.	*Cyprinus carpio*	Common carp	സാധാരണ കാപ്പ്

	(iii) Minor Carps		
7.	*Labeo bata*	Bata	ബാറ്റ
8.	*Labeo calbasu*	Black rohu	കാക്ക മത്സ്യം
9.	*L.cirrhosa*	White carp	വള്ളിരഞ്ഞൻ
10.	*Labeo fimbriatus*	Cauvery carp	
11.	*Labeo kontius*	Pig-mouth cap	പിരിച്ചമണ്ടൻ
12.	*Puntius sarana*	Sarana	പന്നിവായൻ
			പരൽ
	(iv) Cat-fishes		
13.	*Wallago attu*	Freshwater shark	ആറ്റുവാള
14.	*Aorichthys aor*	Long-whiskered catfish	മഞ്ഞതല
15.	*Aorichthys seenghala*	Giant river catfish	കരട്ട, കരട്
16.	*Pargasius pargasius*	Pargash	
17.	*Heteropneustes fossilis*	Singhi	കാരി
18.	*Clarias batrachus*	Magur	മുശി
	(v) Murrels		
19.	*Channa marulius*	Giant snake head	വാകവരാൽ
20.	*Channa striatus*	Striped or common murrel	സാധാരണവരാൽ
	(vi) Gouramy		
21.	*Osphronemus gouramy*	Giant gouramy	ഗൗരാമി
	(vii) Milk Fish		
22.	*Chanos chanos*	Milk fish	പൂമീൻ
	(viii) Mullets		
23.	*Mugil cephalus*	Grey mullet	തിരുത
24.	*Liza parsia*	Parsia mullet	കണമ്പ്
25.	*Liza tade*	Tade mullet	കണമ്പ്
	(ix) Cichlids		
26.	*Oreochromis mossambica*	Tilapia	തിലാപ്പിയ
27.	*Etroplus suratensis*	Pearl-spot	കരിമീൻ

	(x) Trouts 28. *Salmo trutta fario* 29. *Salmo gairdneri gairdneri* 30. *Tor khudree* 31. *Tor putitora* 32. *Tor tor*	Brown trout Rainbow trout Mahseer Yellow mahseer Red-finned mahseer	ബ്രൗൺട്രൗട്ട് മാരിപാൽ ട്രൗട്ട് മാസീർ മാസീർ മാസീർ
33.	**(xi) Tench** *Tinca tinca*	Tench or doctor fish	ടഞ്ച് മത്സ്യം

PISCICULTURE IN PONDS AND ITS PRE-REQUISITES

- Pond culture is a very popular piscicultural practice in the rural sector for farming several species of food fishes.
- A modern pond culture complex consists of different types of ponds, hatcheries and live feed culture systems.

Major features of pond culture

1. Construction of culture ponds
2. Management of culture ponds
3. Collection of fish seed
4. Hatching of fish seed
5. Induced breeding
6. Stocking
7. Artificial feeding
8. Harvesting

Construction of ponds

- Pisciculture primarily depends on construction of culture ponds.
- A well-irrigated agricultural land, with perennial water supply and the facilities for transportation, electricity, cheep labour, etc.
- Alternatively, Natural ponds, lakes, reservoirs and shallow brackish water areas can also be best suited.
- Fine – texture soils, with high water holding capacity and rich mineral content.
- The soil pHshould be between **7** and **9**.
- In areas of water scarcity seepage, cement pond can be constructed .
- Small and medium sized ponds can be more easily to handle.
- Ensure drainage facilities
- Pond should be exposed to moderate sunlight.
- Water temperature should be kept moderate.

Factors to be considered in pond construction

Important factors are **topography of the location, soil type, water supply, construction method, etc.**

Topography of the location

- Selection of suitable site
- Unused barren lands, swamps, irrigated agricultural field can also selected for fish farming.

Soil supply

- Soil should be impervious, such as clay, silt or loam
- Rocky bottom, sand, gravel and lime stone areas should be avoided.
- Where soil is porous and water table is low, are unsuitable

Water supply

- Pond should be constructed near streams, reservoirs, well, etc.
- If used natural source, ensure the water is not polluted

Construction method

- In areas of water scarcity and seepage, fish culture could be done in cement ponds.
- The bottom of the cement pond should be covered by a bed of soil
- Typical earth pond must have provisions for structures, such as bund or dike, Harvesting pit, core trench, inlet, outlet, etc
- Bunds are the protecting structures of ponds
- The main bund is the highest part and it is constructed in the deepest part of the pond area
- Extra height above water level to prevent waves and flood. The extra height is called *free board.*
- Slope of bund is an important factor, it is subjected to erosion
- The area of the culture pond is more than 0.5,a platform like ridge, called berm
- Sandys or gravelly soil is not ideal for bund construction
- A mixture of silt, sand and clay in the ratio 1:2:3 is ideal for the construction of strong bunds
- The core trench is made to prevent seepage of water through the bund and to strengthen it
- A gradual slope must be provided at the bottom from one end to the other
- Large pond should have water inlet and outlet provisions in order to ensure smooth inflow and easy drainage of water
- Inlet to ponds are generally simple structure use to bring water into the pond and also to prevent the entry of unwanted organisms
- Outlet is a structure installed at the lowest plane of the pond.
- It is a box-like structure whose outer edge is connected to a pipe which runs straight through the bund to the outside.
- The water level is regulated by the height of the wooden blocks.
- The space between these blocks may be packed with wet clay to check the leakage of water.
- In order to fill and drain the pond easily, 30-50 cm deep drainage ditches are dug in the pond bottom
- These ditches are meant for draining water from the pond easily during harvest

Types of ponds

Fish ponds may be classified into nursery pond, rearing ponds and stocking ponds or production ponds, based on purpose for which they are used.

1. Nursery ponds

- These are small and shallow ponds, used for nursing the hatchlings(young fish just hatched from egg).
- The hatchlings are kept in nursing ponds for a short period of 2-3 weeks, till they become fry(2.5 - 4 cm).
- The water column should have a height of 1 - 1.5 m and the hatchlings are stocked at a density of about 100 million per hectare.
- The ponds are used only for a short interval of time, they could be used 2 or 3 times in a single breeding season.
- Nursery ponds may be converted in to production ponds in other seasons.

2. Rearing ponds

- These are the ponds used for growing the fry till they become fingerlings (4 - 10 cm) .
- Their normal size is 25 m × 12 m × 1 m. They should be free from predators and toxic substances.
- Rearing ponds can also be used as production ponds.

3. Stocking ponds or production ponds

- These are the ponds in which the fingerlings are grown to large marketable fish.
- The size of production pond varies from 0.1 to 2.0 ha. or even larger.
- The depth of the water column may be between 2 and 3 m.
- The size of the production pond, depth of water, etc could be determined only after selecting the fish species.

Management of ponds

Maintenance of ideal conditions in culture ponds for the heathy growth of the fish population.

- Permanent supply of unpolluted water.
- Periodic liming and manuring to maintain the potentiality of ponds to support and sustain fish population.
- Periodic monitoring of the turbidity, temperature, pH and the chemical quality of water.
- Regular clearing of unwanted vegetation.
- Periodic emptying, cleaning and drying of ponds.
- Periodic assessment of the growth, health and population density of the fish stock.
- Permanent protection from unfavourable environmental conditions and invading predatory fishes, amphibians, snakes, birds and mammals.

1. **Water supply**
   - Water for culture pond collected from spring, well water, rain water, etc.
   - The desirable height of water column - 1.5m to 2m.
   - Optimum temperature for rearing of warm water tropical fishes - between 20 and 37°c.
   - Temperature for rearing of cold water fishes - below 20°c.
   - Most ideal pH of pond water for healthy growth of fish is neutral or slightly alkaline - 7 to 9.
   - Turbidity of pond water is undesirable factor for pond culture.

2. Manuring

- Manuring is the application of fertilizers or organic manure to enhance the productivity of the ponds.
- This favours luxuriant plank tonic life which may serve as food for the fishes
- Both organic manures and inorganic fertilizers are used for manuring the ponds.

Organic manures

They are three types

- ➢ Liquid manures (e.g.urine)
- ➢ Farm manures(e.g.cowdung)
- ➢ Green manures(e.g.compost,oil seed cake)
- The use of organic manure may causes depletion of oxygen and increased production of toxic gases
- The organic content of soil is less
- The organic manure may be applied at the rate of 20-30 tons

The inorganic fertilizers used in fish pond

- ➢ Lime and lime-containing fertilizers
- ➢ Phosphate fertilizer
- ➢ Nitrogenous fertilizers
- ➢ Potassium fertilizers
- ➢ Magnesium fertilizers
- ➢ Trace element fertilizers
- In general npk combination in the ratio 18:10:4 is recommended.
- It is applied at regular intervals alternative with organic fertilizer.
- Application of fertilizers may be suspended in case of algal bloom in the pond.

3. Liming

- Lime may be applied in the production pond in the form of lime stone(**$CaCO_3$**),quick lime ,calcium Cyanamide and Caustic Lime or hydrated lime
- Quick lime is the most effective of all these.
- Liming is primarily meant for reducing the soil acidity of the pond bottom.
- And also Stabilizes the pH of the pond water & enhances the effectiveness of manuring.
- Most ideal time for liming is just before or shortly after the drying of the ponds.

Liming is required under the following conditions :

- Very low pH of the water.
- Increased presence of organic matter in water.
- Depletion of dissolved oxygen.
- Outbreak of diseases.
- Bottom soil is in poor condition.
- As a method of prophylaxis.

Lime is applied in two ways,

- Lime is applied directly to the bottom soil, after draining the water and drying the pond.

- Lime is directly added to pond water.
- An excessive presence of lime is toxic to aquatic organisms
- to be on the safer side, liming should be done a few weeks before stocking the fish in the pond.

FISH SEED COLLECTION

- Fish seed is the term used to denote all stages of the life cycle of culturable fish species,from eggs to young ones.
- Fish seed include spawn(fertilized and developing egg),hatchling(just hatched young one,with yolk sac),fry(young one without yolk sac-usually 2.5-4.0 cm) and fingerling or juvenile(young one looking like adult,usually 4-10 cm).
- Fish farmers in many Asian countries collect eggs,fry and fingerlings from natural water bodies for stocking in culture ponds.
- This is usually done during south-west monsoon seasons,when rivers are flooded and millions of fish eggs and fry drift in surface water.
- Seeds are usually collected from the mid-reaches of rivers.special nets, usually made of mosquito netting cloth,are used for collecting the seed.

Collection of fish seed from nature has the following disadvantages.

- Fish seeds may not be available in sufficient quantities from natural water bodies to satisfy the increasing demand.
- Populations of economically important fishes are declining in nature.
- Transportation of fish seeds from natural water bodies to distant places may not be economically feasible.
- Usually,the seeds collected from nature may not be homogeneous,since they will be a mixture of the eggs of different species, including those of predators or weed fishes.
- Identification of fish seeds and the separation of the desirable ones require great skill and expertise.

HATCHING

The eggs collected from natural water bodies are hatched in special hatching pits, and cement hatcheries

Hatching pits

- Hatching pits are small (nearly 450 x 250 x 50 cm) excavated pits on river banks, with provisions for continuous water supply to aerate the eggs.
- They are meant for hatching the fertilized eggs, and should be located nearby the egg-collecting centres in the river.
- Each pit can lodge about 1 lakh to 2 lakh cggs.
- The hatching rate is very low, 2.5-25%.

Hatching hapas

- Hapa is a large rectangular ‘double- tray’ device,used for hatching the eggs.
- The hatching Hapa is kept in the river near the banks were water current is not too strong.

- It is double-walled, with outer and inner hapas.
- The outer hapa, measuring 180 cm (length) x 90 cm (width) x 90 cm (height) is made up of ordinary coarse cloth.
- The inner hapa (150 x 75 x 45 cm) is formed of round- meshed mosquito netting.
- Using bamboo poles, hapas are fixed in a perfectly horizontal position, within the other. The inner hapa should be immersed in water.
- Fertilized eggs are uniformly spread over the fully spread bottom of the inner
- The eggs hatch out in 15-18hrs at a temperature of 26-30°C.
- The hatchling move to the outer hapa through the meshes of the mosquito netting in the inner hapa.
- The unfertilized or dead eggs in the inner hapa are removed.
- The hatchlings are retained in the outer hapa for conditioning.
- The hatchlings are kept in the outer hapa for a period of 3 days. During that period, they subsist on the yolk in their yolk sac. After three days, they are ready for stocking in nursery ponds. The survival of eggs in the double-walled hapa ranges from 32-50%.

Hatcheries

- Hatcheries are small ponds, cement tank, or PVC tank, constructed near natural water bodies for culture ponds for hatching the eggs.
- Large hatcheries, with provision for aeration, can store huge number of eggs.

INDUCED BREEDING

Induced breeding is a technique by which the economically important fish are breed through artificial stimulation.

Steps

1. Collection of pituitary extract :- pituitary gland is collected from a fully mature fish, which is called as a donor fish.
2. Selection of breeders
3. Injection of pituitary extract :- the amount of the pituitary extract depend upon the weight and maturity of the recipient fish. After the injection, the male and female breeders are introduced into the breeding hapa. Ovaprim is the bottled pituitary extract available in market for this purpose.
4. Spawning in breeding hapa :- Spawning take place 3-6 hours after the second dose injection. A successful spawning results in the formation of large numbers of fertilized eggs, which appear transparent and pearl like. The unfertilized eggs are appear opaque and white. They removed from the hapa.
5. The eggs are then transferred to a hatching hapa for hatching.

Advantages of induced breeding

- A supply of the ‘pure’ seeds of a desired species could be maintained. This reduces the chance of mixing of various species.
- Induced breeding ensure the availability of sufficient numbers of seed fishes at the desired time.
- The technique is very useful for breeding those fishes, which do not breed in culture pond.

- The mortalities involved in transporting fish seeds could be avoided, since hatcheries are usually located near the culture ponds.
- The technique of induced breeding is very simple and even lay man can do this without much training.
- The cost involved in induced breeding is much less, as compared the involved in collecting seeds from nature.

FEEDING IN PISCICULTURE

- Fishes subsist on a variety of natural food, such as plankton, algae, small crustaceans and detritus.
- These natural food may not be sufficient for the rapid growth of fishes.
- Artificial nutrient rich feeds prepared from cheap raw materials are preferred for maximising fish growth in limited time.
- Feed with high contents of proteins, fats, carbohydrates, vitamins and minerals are preferred in cultural systems.
- Major ingredients of feed include rice bran, wheat bran, oil cake, corn meal, soyabean powder, fish meal, silk worms, wheat flour, etc...with minerals and vitamins.
- Feed powder form is sprinkled in water, or made into paste and kept at different regions of the pond.
- Pelleted feed is easy to handle and store and it has long shelf life.
- Feeding is usually done twice in a day, early in the morning and late in the evening.

Powdered feed has different disadvantages

1. Major share of feed wasted in water
2. Excess feed may could the pond and water
3. Powdered feed has only lesser shelf life

HARVESTING

- Harvesting and sale of produce form the final phase of fish farming cycle.
- It's a complex operation
- If all the fishes in the pond are to be harvested at the same time, the water level must be lowered.
- Water is drained from the pond gradually and the fishes are harvested using suitable nets.
- Fishes, escaping from the pond along with the outflowing water, are caught using a bag net.
- When the pond is completely drained, all the remaining fish could be collected from the pond bottom by hand.
- After harvesting, the pond is dried out and then treated with lime to kill unwanted animals, weed plants, pathogens and parasites.

COMPOSITE FISH CULTURE

- Also called polyculture or mixedfarming
- Composite of fish culture is the process of rearing different species of fish the same tank or fish pond

- Nearly 5-6 different species are groon together in a single fish pond
- A typical example is carp culture. They included,
    i. Surface feeders-(catla)
    ii. Column feeders-(rohu)
    iii. Bottom feeders-(mrigal)

Significance of composite fish culture

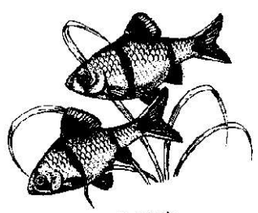
- Increase the yield of fish.
- Facilitates the supply of different food fishes by a single effort.
- Enables the maximum exploitation of all most resources of available niches in the culture system.
- Enables much higher fish production from a compsite much limited culture area.
- Artificial feeds supplied to the culture system will not be wasted at any stage, because they will be taken from the surface water by surface-feeders, from mid-water by column-feeders, and from the bottom by bottom-feeders.
- The total fish yield from a composite culture system will several times greater than that from monoculture in the same system.

ORNAMENTAL FISH FARMING

Ornamental fish farming or culture is the culture of attractive, colourful fishes of various characteristics,which are reared in a confined aquatic systems.Farmers and hobbyists mainly grow it
Some freshwater ornamental fishes:-

1.Tiger Barb(*Puntius tetrazona):*-

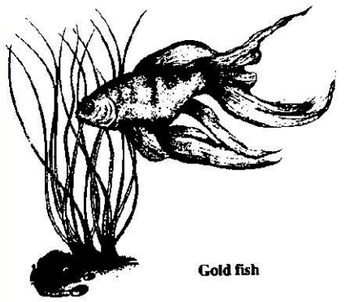
- This fish is a native of Indonesia
- It has a pinkish yellow body with four definite vertical black hands,one of which passes through the eye
- Tiger barbs grow to 7.5cm in size
- Sexes can be distinguishes very easily
- Males are more colourful with the central fin,coloured red throughout.
- In female ,the margins of the ventral fin are transparent
- Females are also fuller in the belly during spawning period
- Tiger barbs are to be kept in large numbers in a relatively large aquarium for spawning
- The bottom should be covered with pebbles and adequately planted.Adult have to removed as soon as spawning is over and the water level reduced 10 cm.
- The incubation period in 36 hours



Tiger barb

2.Gold fish (*Carassius auratus*):-

- Gold fish has origin in East Asia Siberia and China
- It grows to 45 cm in the wild
- It can tolerate wide fluctuations in pH and hardness
- It is an omnivore and can submit on both live as well as dried animal and vegetable manner
- Males are generally slender than females
- The only reliable mark of sex distinction is the presence of small sand like projections on the operculum of males after maturation
- Before breeding male and female should be kept for a week in the same tank,but with partition in between.This is for conditioning
- The eggs released by the female and fertilized by the male
- The adhesive, gelatinous egg stick on to the plants.The plants with eggs can be transferred to a nursery tank with water level around 20 cm.Eggs hatch in 3 to 5 days



Gold fish

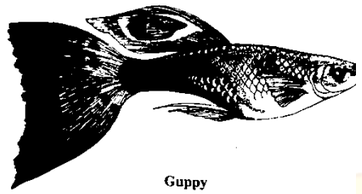
3.Angel fish (*Pterophyllum (*spp.):-

- No aquarium is complete without angel fishes
- Angel fishes reach maximum of 15 cm
- Their food comprises both animal and plant matter
- A deep , thickly planted aquarium with large swimming space is required for breeding angel fishes
- It is difficult to distinguish their sex.Usually females become large-bellied just before spawning
    - The genital papilla is pointed in male and rounded in female
    - Male and female show parental care
    - Eggs hatch in two days

4.Guppy(*Poecilia reticulata*):-

- Guppy or million fish ,hailing from Central America,is one of the most popular freshwater fishes

- Colour of both male female varies greatly
- Tail pattern of male also exhibits gross variations
- Females grow to 5 cm in size,while males reach only around 3 cm
- Guppies are omnivores.and they can be reared on a diet of artificial feed.
- They are profilic breeders and most often it is difficult to stop them from breeding
- Male possess a very flexible gonopodium,which aids in copulation
- Fertilization and hatching are internal



Guppy

CONSTRUCTION OF AQUARIUM TANKS

Aquarium

A transparent tank of water in which live fish and other water creatures and plant are kept.

Aquarium tanks

- Large metal framed & rectangular glass tank are most ideal ,they are strong and durable &handledeasily.
- The water in the tank is heavy the tank should have a strong supporting stand(wooden/iron stand)
- Some times, framless glass tubes are used, they look very attractive
- But they have problem of visual distortion,&to repair damages is very difficult.
- Location of aquarium tank is very Important
- Tanks away from direct sunlight(to avoid overheating)
- The tank must be placed near the window

Requirements

- Floor of the aquarium tank must have a bed of sand, gravel, pebbles, mosaic chips etc
- Mild coloured and medium sized gravels Are most ideal .
- Stones which disintegrate or dissolved in water should avoided.eg.lime stone

Water in aquarium

- Water quality is very important
- Type of pure and unpolluted natural water
- Chlorinated tap water is harmful to fishes
- Harmful effect of chlorine can be neutralised by exposure to Intense sunlight and strong aeration or by adding sodium thiosulfate
- Optimum desirable hardness and pH
- light and temperature
- keep Tanks away from direct sunlight
- Artificial light offers more safety and attraction.

- Lamps can be mounted on the aquarium cover which may serveas reflector.
- Tropical fishes -Water temperature between 22°C and 25°C
- Thermostats and heaters are usually used in cold regions to maintain an optimum range of temperature.
- Temperature changes in aquaria can be measured by using thermometers.

Purity of water

- Water in an aquarium may get polluted by the accumulation of waste.
- Excreta of fishes , decomposition of dead plants and animals, uneaten food.
- Ammonia is the major pollutant.
- Exists concentration of ammonia is toxic to fishes.
- Ammonia has to convert to nitrite and nitrate.It absorbed by aquarium plants and their nutrients.

Filtering of water

- Aquarium water has to be removed and renewed filtered .
- Biological filters which favour the growth and multiplication of bacteria are most ideal
- This bacteria can convert nitrite and nitrate.

Aeration of aquarium

- it is essential
- During night, when the carbon dioxide level goes high.
- Easy gas exchange between CO_2 in the water and O_2 in the air above the water

Aquarium plants

- Have a dual rule , serve as water purifiers & beautifiers.
- They remove CO_2 and release O_2 through photosynthesis.
- Absorb nitrates as nutrients , provide shade and shelter for the spawning of fishes & Inhibit the growth of algae.
- Eg.*Limnophila, elodia, cabomba, vallisneria*,etc.

Selection and introduction of aquarium fishes

- Avoid the fishes which show signs sluggishness or Abnormal in swimming behavior
- Avoid the fishes with abnormal or destroyed parts example. Drooping fins, cloudy eyes
- Avoid the fishes which are Reluctant to accept the feed.
- Avoid too small and too large Fishes

Feeding of Aquarium fishes

- Aquarium fishes arefed with live or artificial feeds.
- Aquarium fishes include brine shrimp ,water flea, earthworms,etc.
- Artificial fed includes preparations in the form of powder,flakes ,granules,pellets&liquids
- Aquarium fishes are fed twice a day 1)Early morning & 2)late in the Evening
- Feed given at a time must be limited to the quantity which can be consumed within 5 minutes.
- Over feeding & under feeding are equally harmful.
- Excess and unused feed in the aquaria must be removed immediately to avoid pollution.

FISH UTILIZATION

NUTRITIVE VALUE OF FISHES

- Fishes are highly nutritious.
- Nutritive value of fishes is equal or even higher than mutton, pork etc...
- They consumed either fresh or in the form of preserved product.
- Their flesh are highly digestible and easy to cook.
- Fish flesh is rich in variety of organic and inorganic constituent.
- Major organic components
  - protein
  - Lipids
  - Vitamins
- Major inorganic components
  - Water
  - Minerals

1.Protiens

- Fish flesh is an excellent source of highly digestible proteins.
- Fish proteins are almost equal to chicken proteins.
- It have high biological value, due to the presence of considerable quantities of almost essential amino acids required by man.
- Common amino acids: valine, methionine,lysine.

2.Lipids

- Lipid contents of fish vary greatly.
- Amount of unsaturated fatty acid is very high.
- 2.9% of lipids is unsaturated fatty acid which is essential to growth and normal body function of man.
- Polyunsaturated fatty acid present in fish flesh reduce the blood cholesterol level in humans.
- Unsaturated fatty acids : oleic acid ,therapinic acid & zoomaric acid
- Saturated fatty acid : palmitic acid , stearic acid & myristic acid

3.Vitamins

- Vitamins A,D,E and some B complex vitamins are found in fishes

4.Water

- Fishes contain large quantities of water
- Varying from 55-90%

5.Minerals

- minerals contained in fish flesh : Na,Ca,Fe,K,Cl,Cu.....
- According to a report that 300g of raw fish can supply 50% of the total proteins and fats
- 25% of the calories needed in a balanced daily diet of an adult human being.

FISH BY PRODUCTS

•Most of the captured fishes are utilised as food in fresh condition.

•Some of the economically important by products produced from them are the following:-

1.Fish liver oil
2.Fish body oil
3.Fish meal
4.Fish silage
5.Fish protein concentrate
6.Fish glue and gelatin
7.Isinglass
8.Fish leather
9.Pearl essence
10.Fin soup
11.Biochemical and pharmaceutical products

Fish liver oil

1.Liver, discarded from processing plants, is generally utilized for producing liver oil.
2.Fish liver oil is a rich source of fats and vitamins A and D.
3.The other liver oil constituents include vitamin E, hydrocarbons, cholesterol, pigments, fatty alcohols and glycerol ethers.
4.As fish liver oil is rich in vitamins A and D, it will promote the growth of bones and teeth, and will help in preventing vitamin deficiency diseases.

1.In Kerala, shark is the potential yielder of liver oil.
2.Oil is extracted from liver by steaming floatation method and alkali-enzyme method.
3.The oil, formed at the end of these methods, is purified and processed.
4.Diseased and discoloured livers are used for the production of technical grade oil.
5.Liver oils of low potency are used as vitamin supplements in animal feeds. Those of high potency are used as medicinal oils, or are processed to obtain vitamin concentrates.
6.In India, liver oil industry is mainly based on cartilaginous fishes, such as sharks and rays.

Fish body oil

1.For preparing body oil, the entire body of the fish is used.
2.five kg of fish yields about half kg of body oil.
3.Compared to liver oil, body oil is poor in vitamins A and D. Like liver oil,
4.it also contains the glycerides of both saturated and unsaturated fatty acids.
5.Oils, containing small amounts of these, may be used in pharmacy and also for human consumption.
6.Oils, containing vitamins, are used inanimal and poultry feeds. Body oil, rich in iodine, is unfit for human consumption and
7.it is mainly used in the manufacture of soaps, candles, paints, varnishes, cos-metics, lubricants, printing inks, plastics and various chemicals (the iodine value of sardine oil is very high).

Fish meal

1.Fish meal is prepared either from whole fish, or from the fish waste collectedfrom markets and fish oil manufacturing units.
2.The proteins of fish meal have high digestibility and great biological importance.
3.Fish meal is rich in calcium, phosphorus and iodine.
4.Vitaminsconsist of A, B, D, E and K. Vitamin B12, which promotes growth in animals, is thepredominant vitamin in fish meal.
5.The other B complex vitamins include thiamine,riboflavin, nicotinic acid, pantothenic acid, pyridoxine, choline and inositol.

Fish silage

1.Fish silage is a product, closely allied to fish meal, though liquid in nature.
2.It is made from whole fish or parts of fish by adding formic acid.
3.It has very good storage qualities.
4.It contains all the water present in the original fish.
5.Almost all species of fishes can be used to make fish silage.
6.Fish silage may be converted into solid food materials by mixing with rice bran, tapioca powder, sea weed powder, etc in appropriate proportions.
7.Since fish silage is a liquid product, handling and transportation costs are high.

Fish protein concentrate
(Fish flour)

1.Fishes are esteemed for their highly digestible, superior quality proteins.
2.For preparing fish protein concentrate, protein from the flesh is extracted in its purest form, free from fat.
3.High-quality FPC forms an excellent supplement to human diet.
4.It can be incorporated with vegetables and curry powders to enhance the taste and aroma of a number of foods.
5.It is also used as an ingredient in some pharmaceutical products.

Fish glue and gelatin

1.Fish glue is a preparation of the skin, fins and bones of fishes.
2.The skin of cod,haddock and shark is its main raw material.
3.It is first washed and soaked in freshwater to remove salt and dirt.
4.Then it is treated with caustic soda or saturated lime to open the fibre bundles and to remove the cementing materials.
5.Fish glue is used as an adhesive in book binding, carpentry works, etc. High-quality fish glue has application in photo-engraving.

Isinglass

1.Isinglass is a high-grade collagen produced from the gas bladder of some fishes.Isinglass is used primarily for the clarification of beverages.
2.It also finds use as an adhesive base in confectionery products, Indian ink and as an adhesive for glass,pottery and leather.
3.It is a good substitute for gelatin.

Fish leather

1.The skin of large fishes, such as cod, salmon, sharks and rays, is tanned andmarketed as ornamental leather.
2.Thick leather is used for the manufacture of shoes, wallets, bags, etc.
3.The dried shark skin is known as shagreen.
4.It is used as an abrasive for polishing purposes.

pearl essence (Guanine)

1.Guanine is deposited in the epidermal layer and scales of most pelagic fishes .
2.Pearl essence is used for making imitation pearls.
3.It could be mixed with plastic for making decorative articles, such as toilet sets, jewellaryboxes, umbrella handles, etc.

Fin soup

1.Fin soup is prepared from the fin rays of large sharks.
2.Pectoral, dorsal, ventral and caudal fins are used for preparing soup.
3.They are washed in clear water and dusted with salt.

4.The skin is then scrapped off, rinsed with water and heated again washed to remove acid, and dried in sun or in an artificial dryer.
5.The dried rays are then sealed in polythene bags.
6.Fin rays are exported to Singapore, Hong Kong and the United Kingdom where they are used for shark fin soup, a prized table delicacy in these countries.

Biochemical and pharmaceutical products

1.A variety of materials, such as nucleic acids, nucleosides, protamine, insulin, cortisone, glutathione, bile salts, proteolytic enzymes, etc ., have been isolated from various tissues and organs of fishes.
2.Protamine, in combination with insulin, forms a compound for the treatment of diabetes.
3.Protamine is found in the sperms of various fishes.
4.insulin from fishes normally remains stable even after the death of the fish.
5.Tunas and bonits are ideal fishes for the extraction of insulin.

PRAWN CULTURE

Breeding & spawning of prawns

- Millions of prawn seeds, required tor stocking in culture ponds, cannot be collected from nature easily.
- Most of the penaeid prawns attain sexual maturity only in natural water bodies.
- Removal of eye stalk (eye stalk ablation) from female prawn has been reported to accelerate the growth and maturation of ovaries.
- Sexual maturation and breeding of prawns are regulated by certain hormones produced in the endocrine system.
- The endocrine organs of shrimps, such as the medulla terminalis X-organ (MTGX), sensory papila X-organ (SPX) and the sinus gland, are located in the eye stalk.
- The sinus gland is believed to store gonadotroppic hormones, responsible for the maturation of gonads.
- Removal of eye stalk or sinus gland during the non-breeding season results in the rapid growth of ovaries.
- Eye stalk ablation is carried out using an electro – cautetary apparatus.
- As a general rule, only one eye stalk is removed. Mortality rate in single eye stalk ablation is negligible.
- Cautetarised females and double the number of acclimatized males are transferred to tanks for the maturation of gonads.
- This brood stock is fed with nutritious diet.
- Water is aerated properly and pH is maintained around 8.
- Sexual maturation may be attained within one week after the ablation.
- Then, eye stalk ablated females are transferred to spawning tanks.
- For collecting seeds, fully mature females, carrying fertilized eggs may also be collected from nature, or from culture ponds.
- Specimens with dark or grey coloured egg mass are usually selected.
- The collected shrimps are released into spawning tanks containing clear, fresh and filtered water.
- ***Macrobrachium rosenbergi***, though a freshwater species, spawn only in slightly brackish water.
- Hence, this species is released into the waters of nearly 12 ppt salinity.
- ***Penaeus indicus***and ***P.monodon*** breed in sea water of 28 -35 ppt salinity.

Seed collection & culture

- Post-larvae and small juveniles form the seeds of prawn culture.
- The seeds are collected from natural water bodies, such as rivers, estuaries and coastal lagoons.
- Fine-meshed bag nets, with a receptacle at the cod end are used to collect the seed.
- There is difficulty in getting sufficient number of seeds for stocking in culture systems.

- The collection may contain larvae of slow growing, undesirable species of shrimps and predatory fishes also.
- Sorting of the seed is a laborious process, and it demands expertise.
- Extensive collection may also affect the natural population

Types of prawn farms

- Shrimp farming is a very profitable business, compared to agriculture and animal husbandry.
- Shrimp grows fast in culture systems and reach marketable size within 6 months.
- There are four major methods of prawn culture, namely traditional culture, extensive culture, intensive culture and semi-intensive culture.
- Prawn culture in the pokkali rice fields of Kerala and the bheries of West Bengal are examples of traditional farming.

Extensive culture

- Extensive prawn farming is carried out in large (1-5 ha), specially made ponds, stocked with fast-growing varieties of prawns in low densities.
- Feeding and pond management are not necessary.
- The annual production rate is 2-3 tonnes per hectare.

Intensive culture

- In intensive prawn farming, fast-growing and high-quality prawns are cultured in relatively small (0.03-0.1 ha) and well aerated ponds.
- These ponds are stocked with prawns in high densities (5-10 lakhs per hectare) and are subjected to daily waterchange.
- Application of nutrient-rich feeds and scientific pond management are necessary.
- The annual production rate is as much high as 20-30 tonnes per hectare.

Semi-intensive culture

- Semi-intensive prawn farming is carried out in small (0.2-0.5 ha) ponds, stocked with prawns in high densities (1-5 lakhs per hectare).
- Pond management, supplementary feeding and daily water change are necessary.
- The annual production rate is 8- 10 tonnes or more per hectare.

Traditional prawn culture in rice fields

- The traditional brackish water prawn farming technique, prevalent in Kerala is called prawn filtration.
- In this method, the prawn seeds, coming from the brackish water areas and the sea along with the tidal water flow, are collected in large stretches of rice fields, called pokkali rice fields
- Pokkali is a variety of rice capable of growing tall in flooded waters with varying salinities.
- During the south-west monsoon (June- September), the salt content ofthe field gets washed awayby the rain water, making the field fit for rice cultivation.
- After the mild north-east monsoon (September-mid November), water in the fields becomes more brackish (salty) due to the tidal inflow of water
- The sluice gates, fixed at the bunds of rice fields, are kept open during high tide, allowing the entry of prawns into the field

- A bamboo mat or net is placed inside the sluice to prevent the escape of prawns.
- The trapped prawn seeds are allowed to grow in the rice fields.
- Harvesting is done by the middle of April or May, either early in the morning or late in the evening and a few days before or after full moon.
- For harvesting, water is filtered through a large conical bag net. The mature prawns, collected at the cod end (posterior end), are separated.

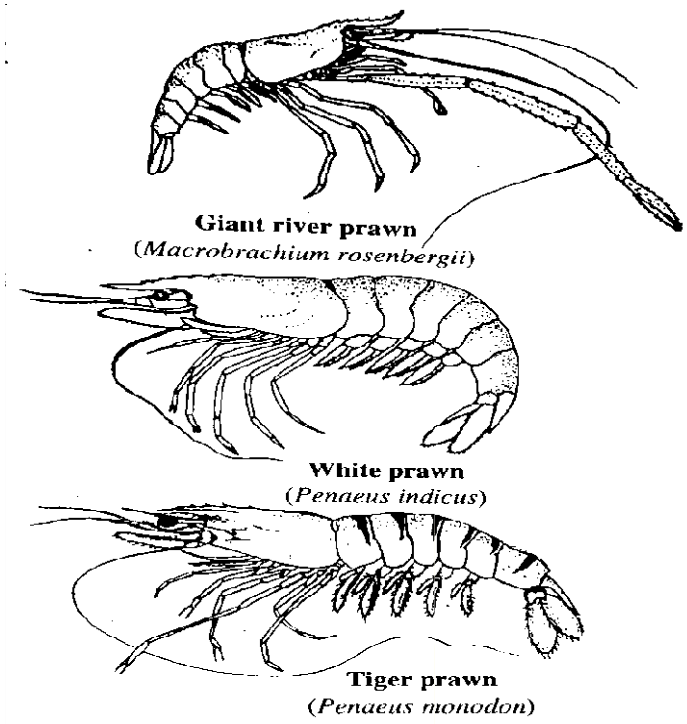
Traditional culture in bheries

- Bheries are embanked brackish water enclosures, used for aquaculture.
- Bheries are deeper than pokkali fields.
- Duringhigh tide, water along with fish and prawn seed, is allowed to enter the bheries though sluices.
- Inverted V or W-shaped screens are fixed at the sluice gates in such a way that they allow the entry of shrimps during high tide and prevent their escape during low tide
- Culture begins in January-February, when bheries are stocked with fry.
- Occasional harvesting is done in May - June period and the main harvesting during Sepember - November period.

Modernised culture in ponds or tanks

- Modern large-scale shrimp farming is carried out in special ponds or tanks.
- These ponds have hatchery and nursing and rearing units.
- They are usually rectangular and about I to 5 ha. in area, with depths of 0.8 to 1.2 m.
- Even though earth ponds are widely used, rearing ponds made of concrete or bricks, or lined with plastic sheets may also be used.
- Different types of shelters and artificial substrata are provided in ponds, including water plants, hollow bricks, plastic pipes, etc.
- These substrates offer hiding places for small-sized shrimps and also for just-moulted ('soft") shrimps.
- Intensive shrimp farming is practised in tanks.
- Water from such tanks is periodically removed and heavily aerated.
- Circular tanks, with sufficient surface area (up to 2000 m^2) and adequate water circulation

Common prawn species



Macrobrachium rosenbergii

- Fresh water prawn, inhabiting rivers, from the upper to lover reaches.
- Omnivorous species prefers a shallow, muddy environment and grows up to a maximum size of 32 cm, and a weight of 200 g.
- Adults have sharp, upturned rostrum
- In culture systems, males grow to a maximum size of 25 cm and females, 15 cm,
- Though a freshwater form, river prawn migrates down stream to the estuaries (salinity 5 to 20 ppt.) for breeding.
- The young ones mi- grate upstream from estuaries to freshwater habitats.
- River prawn is cultured for a period of 5-6 months.

Penaeus indicus

- Commonest marine shrimp species of Indian waters.
- Body has pale white, creamy, or pale yellow coloration.
- Though smaller in size, it is highly delicious.
- The optimum salinity for its growth is 20-30 ppt.
- *P. indicus* prefers culture systems with sandy bottom.
- Culture period is about 3- 4 months.

Penaeusmonodon

- *P. monodon or tiger prawn*
- Fastest growing of all prawn species and hence it is cultivated most commonly in culture systems throughout the world.
- Body is reddish or brownish with thick black lines across the abdomen; hence the name tiger prawn.

- Tiger prawn is euryhaline
- The optimum salinity for its growth is l10-25 ppt.
- This species grows to a maximum length of 32 cm, weighing up to 400 g.

MUSSEL FARMING

Seed collection

- Young mussels, known as ***spats*** form the seeds of mussel culture.
- Seeds can be collected in large numbers during spawning season from the mussel beds of coastal waters.
- Estimates reveal that about 10-15 kg of mussel seed is available per square meter of rock substratum.
- Seeds may be collected using suitable collectors, such as cultches, ropes, poles, bamboo stakes, coconut shells, etc
- Large scale mussel farming cannot rely solely on the seeds from nature because
    1. The distribution of mussels is mostly restricted to rocky shores.
    2. Even though the spat fall occurs in abundance in nature, only very few larvae get a chance to settle and the rest suffer from heavy mortality.
    3. Massive seed collection may disturb the natural mussel populations, especially in areas with poor population density.

Artificial collection of seeds

Induced spawning

- For large-scale seed collection, mussels are induced to spawn artificially and the larvae are reared in hatcheries.
- For induced breeding, mature mussels are collected either from natural beds or from culture systems
- Induced spawning is relatively easy in mussels even slight disturbances during handling and cleaning may prompt mussels to spawn.
- Physical, chemical, thermal or electrical methods are employed for induced spawning.

Some of the common methods are the following.

1. Rough handling of adult mussles
2. Opening of the shell and pocking of adductor muscles.
3. Transfer of adult mussles to fresh sea water soon after dipping them in 6% H_20_2 solution at pH9 for 1 or 2 hours.
4. Dipping of adult mussels in ammonium chloride or barium chloride.
5. Gradual raising of the water temperature by 4°C - This method is safe and more successtul than the other methods

- ln most cases of induced spawning, males spawn first and this stimulates the females to spawn.

Rearing of larvae

- As soon as the male and female mussels start spawning
- They are transferred to tanks with pure sea water.
- The fertilized eggs develop into free swimming larvae.
- The larvae are reared in hatcheries by feeding them with unicellular algae.

- The larvae settle as spat from the 20th day onwards for a period of 5-10 days.
- Materials, such as coir rope, nylon nets, shells of large bivalve molluscs and coconut shells, are used for collecting the spat.
- They grow as young seed, feeding on phytoplankton.

Farming methods & harvesting

Culture techniques

- The commonest methods of mussel culture include bottom culture, pole culture, rack culture, raft culture and long-line culture.

Bottom culture

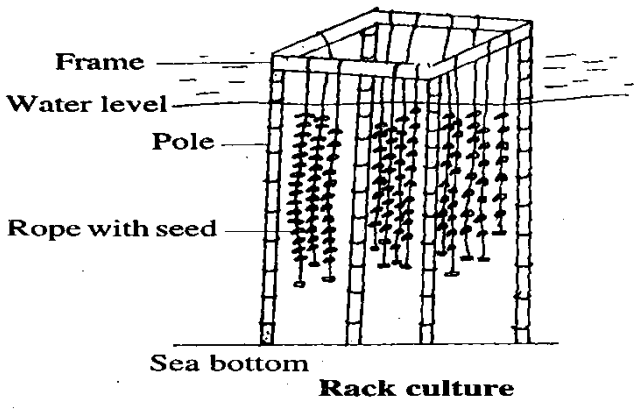
- This culture methodis suitable for shallow and enclosed areas with stable and hard bottom.
- It is not prevalent in India.

Pole culture or stake culture

- This is a method of mussel farming suitable for muddy coasts with gentle slopes and marked tidal variation.
- A series of 5-6m long wooden or bamboo poles are driven into the bottom of the intertidal zone of the selected area.
- The bottom of each pole is covered with a smooth plastic sheet to prevent the entry of predators.
- Seeds are collected on ropes which are then placed in plastic net tubings and wrapped around the poles, or are suspended from a metallic nail fixed at the top of each pole.
- Mussels are harvested after 12-18 months when they grow to 6-8 cm in length.

Rack culture

- Rack is a fixed structure made up of several wooden poles driven into the sea bottom.
- A wooden platform, called rack, is made on the top of the poles, usually 0.5 m above the water level.
- From this platform or rack, 10-15 mm long ropes with mussel seeds are suspended.
- Mussel seeds are usually placed in synthetic mesh tubings of various mesh sizes.



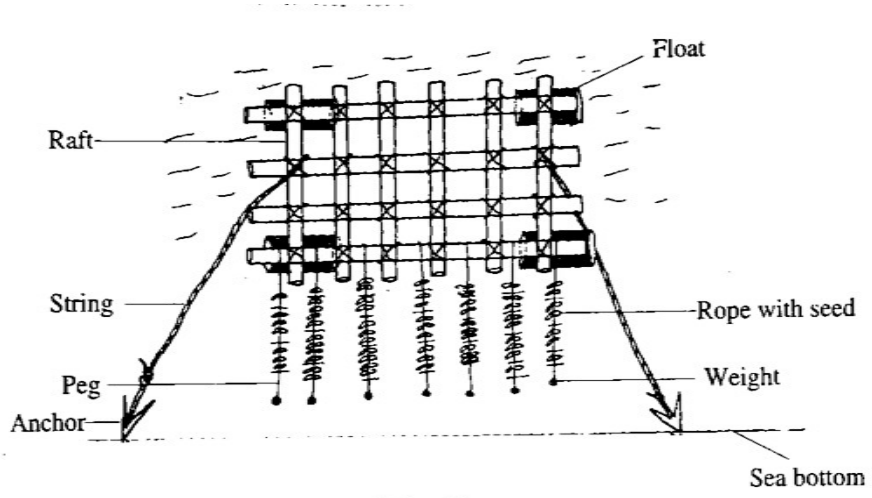
Rack culture

- Rack culture method is common in shallow coastal waters.

Raft culture

- Commonest method of intensive mussel farming

- Rafts are usually made with bamboo poles or wooden poles, tied together with ropes.
- Concrete or steel platforms with fibre glass floats are used in some countries

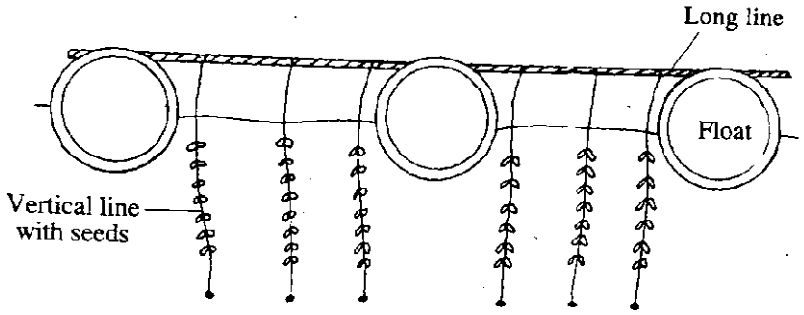


Raft culture

- Wooden rafts are placed over floats (usually air-tight barrels), which are attached to the under surface of the corners or the raft.
- The raft is anchored to the bottom using long and strong chains.
- Ropes, with the young mussel seeds collected from natural mussel beds, or from mussel farms, are hung vertically from the raft.
- The ropes may have large pegs at regular intervals to prevent the mussels from slipping down from the rope.
- Each rope may be provided with a terminal weight to keep it vertically hanging.
- Raft culture is carried out in protected seas with steep coastal areas
- Harvesting is done nearly 18months later, specifically before spawning.

Long-line culture

- This culture technique makes use of a series of horizontal and vertical lines, which are kept floating by a number of floats.
- These floats are provided with anchoring devices.
- The long horizontal lines are called long lines.
- They are usually 150 m long and are made up of 16-20 mm wide synthetic ropes.
- Each main rope, or long line, is usually 150m long and it may have large barrels or floats at every 5 m length.
- Verticallines, loaded with seeds, are suspended from the long line.



Long line culture

- Long-line method is more suitable in shallow estuaries and bays with very little tidal variations.
- Fast growth rate and higher production have been reported in this method.

Harvesting

- When the cultured mussels reach marketable size, the ropes are removed manually.
- In raft culture, the rafts may be brought to the shore for removing the ropes.
- The ropes are washed with water and the mussels are dislodged with a sharp wooden wedge and sorted according to size and marketed

PEARLCULTURE

Preparation of nuclei

- Nucleus is a foreign particle which can irritate and induce the oyster to secrete pearly material around it.
- The nacreous layer of the shells of other species are used for the preparation of nucleus.
- The shell is made into small spherical beads of 2-8 mm diameter using machines.
- These beads may be polished slightly, but never very smoothly.

Preparation of host & graft tissue

Preparation of host

- Healthy and adult oysters, preferably above 45 mm size, are ideal for the production of culture pearls.
- The selected oysters are then placed in specially made cages and immersed in 6 - 8 m deep sea water for 20 - 30 days.
- This is to acclimatize them with the controlled conditions within the cages.
- The oysters thus conditioned are taken out for the insertion of nucleus.

Preparation of graft tissue

- Graft tissue is a piece of the mantle epithelium from a donor oyster.
- It is used to wrap the nucleusbefore implantation.
- The graft tissue is taken from a healthy donor.
- The donor is opened carefully and its mantle is removed.
- The dirt and mucus on the mantle are removed using the blunt edge of a scalpel.
- A 2-3 cm wide strip is then cut out from the pallial zone of the mantle.
- The strip is then cut into 2-3 mm squares.
- These mantle strips are kept in filtered and sterilized sea water.
- It is better to use the graft tissue within 10-15 minutes after preparation.

Implantation & nursing

Implantation

- There are three common methods of nucleus implantation namely extra pallial, intra pallial &gonadial implantation.
- The entire operation has to be completed within 30 minutes.

Extra pallial implantation

- The graft tissue bag, containing the nucleus, is inserted or grafted into the space between the shell and the mantle.
- The graft tissue gets embedded or implanted in the mantle.
- This stimulates the nacre secreting gland cells of the pallial epithelium to secrete pearl around the nucleus.

Intra pallial implantation

- The graft tissue bag is inserted into the pallial tissue.
- During this, a small hole, or an incision, is made in the mantle and into that the graft tissue bag is inserted.

- The graft tissue gets implanted in the mantle tissue.
- This stimulates the glandular mantle cells to secrete pearl around the nucleus.

Gonadial implantation

- Gonad is the best site in the oyster for the implantation of nucleus.
- The reason is that the rate of pearl secretion is very high in gonads.
- During gonadial implantation, a small incision is made in the gonad with utmost care and unerring precision.
- Into this incision, the graft tissue bag containing the nucleus is inserted.
- The graft tissue gets embedded in the gonad, stimulating the gonadial cells to secrete pearl around the nucleus.
- The number of nuclei to be inserted depends upon the size of the nucleus.
- Two to five nuclei are inserted into an oyster, if they are 3 mm or less in diameter; only one nucleus is inserted when it is larger than 3 mm.

Nursing

- After the implantation of nucleus, the wooden plug placed between the shell valves is removed and the oyster is released from the mounting stand.
- After nuclear implantation, oysters are placed in a plastic tub, filled with sea water
- This is for recovering from the effect ofmenthol.
- Water should be changed periodically or provisions should be made for steady flow of water.
- After 50 - 60 minutes, the oysters are placed in nylon baskets and immersed in large tanks in the seawater.
- The operated oysters are kept there under observation for a few days.
- Those oysters showing disease symptoms and those rejecting the nuciel are removed
- During this period, the oysters recover from the operational shock & repair injuries.
- The oysters are then placed in culture cages of 40 x 40 x 10 cm size and transferred to the farm.
- The healthy and nucleus-implanted oysters are farmed by raft culture or long line culture method.
- After a few months of post-operation culture, the oysters are x-rayed to check the presence of pearls.
- When the cultured pearl oysters attain full growth and maximum size, they are collected, brought ashore and killed.
- Then their shells are removed and the partially decomposed body is washed repeatedly in suitable containers, with several changes of water.
- Now , water is removed and pearl settled at the bottom is collected and marketed according to quality

equipping with excellence
CPA COLLEGE OF GLOBAL STUDIES