III SEMESTER

BRACKISHWATER AQUACULTURE

(AQUACULTURE MAJOR-COURSE-8 e- CONTENT)

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In fond memory of

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1.1 Introduction to Brackish water Aquaculture

Brackish water aquaculture is a good practice that takes place in various regions of the world, including India and specifically in the state of Andhra Pradesh.

- This method of aquaculture involves the farming of aquatic organisms in water that is a mix of saltwater and freshwater.
- It is an important aspect of the fishing industry and plays a significant role in providing seafood for consumption.
- In India, brackish water aquaculture has gained prominence due to the favourable environmental conditions along the coastal areas.
- Andhra Pradesh, located on the southeastern coast of India, is one of the leading states in the country that practices brackish water aquaculture.
- One of the key advantages of brackish water aquaculture is its ability to support the cultivation of a diverse range of seafood products.
- In Andhra Pradesh, farmers engage in the cultivation of shrimp, crab, and various types of fish in brackish water ponds.
- These aquatic species thrive in the unique mix of saltwater and freshwater, allowing for successful farming practices and high yields.
- The process of brackish water aquaculture involves creating ponds or enclosures that are strategically designed to control the salinity levels of the water
- In Andhra Pradesh, the government has taken steps to promote and support the growth of brackish water aquaculture in the state. Various schemes and initiatives have been introduced to empower local farmers and enhance the sustainability of aquaculture practices.
- In general, brackish water aquaculture plays a vital role in meeting the increasing demand for seafood in India, particularly in states like Andhra Pradesh.
- By utilising the potential of brackish water environments, farmers are able to cultivate a wide range of aquatic species and contribute to the thriving fishing industry.
- With ongoing advancements and support from the government, brackish water aquaculture continues to be a promising sector for sustainable food production and economic growth in the region.

1.2 Overview of Brackish Water Aquaculture in India

- Brackish water aquaculture in India is the farming of aquatic organisms such as fish, shrimp, and crabs in water that is a mix of freshwater and saltwater.
- This practice has gained significant importance in recent years due to the increasing demand for seafood and the depletion of fish stocks in traditional fishing grounds.
- India's vast coastline and extensive network of rivers and estuaries provide ideal conditions for brackish water aquaculture to thrive.

Importance of Brackish Water Aquaculture

- Brackish water aquaculture plays a crucial role in meeting the rising demand for seafood in India.
- It provides an opportunity for sustainable seafood production while reducing the pressure on wild fish populations.
- By cultivating fish and shrimp in controlled environments, aqua culturists can ensure a steady supply of high-quality seafood to consumers across the country.

Current Status of Brackish Water Aquaculture in India

- India is one of the leading producers of brackish water aquaculture products globally.
- States like Andhra Pradesh, Tamil Nadu, and Gujarat are at the forefront of brackish water aquaculture activities.
- Shrimp farming, in particular, has seen significant growth in recent years, with many farmers adopting modern techniques to enhance production and quality.

Challenges Faced by Brackish Water Aquaculture

- Despite its growth, brackish water aquaculture in India faces several challenges.
- One of the primary concerns is the environmental impact of intensive aquaculture practices.
- Effluents from aquaculture ponds can pollute water bodies and harm local ecosystems if not managed properly.
- Disease outbreaks and fluctuating market prices pose risks to aquaculture farmers.

Government Initiatives to Promote Brackish Water Aquaculture

- The Indian government has taken several steps to promote sustainable brackish water aquaculture practices.
- Initiatives such as the Blue Revolution aim to boost fish and shrimp production through technological interventions and capacity building. Subsidies, training programs, and research support are provided to encourage farmers to adopt best practices in aquaculture.

Future Prospects of Brackish Water Aquaculture

- The future of brackish water aquaculture in India looks promising, with increasing demand for seafood and advancements in aquaculture technology.
- Sustainable practices, such as integrated multitrophic aquaculture and organic farming, are being promoted to ensure the long-term viability of the sector.
- Brackish water aquaculture plays a vital role in India's seafood industry, offering a sustainable alternative to traditional fishing practices.

1.3 Exploring Brackish Water as a Medium for Aquaculture: Biotic and Abiotic Factors

Brackish water, a unique blend of freshwater and saltwater, serves as a good medium for aquaculture due to its diverse variants of biotic and abiotic factors.

Abiotic Factors:

Salinity

- One of the key abiotic factors in brackish water is salinity, which refers to the amount of salt dissolved in the water.
- The salinity levels in brackish water are lower than seawater but higher than freshwater. This balance is essential for the survival of the various species that inhabit this ecosystem.

pH Levels

- The pH levels of brackish water are influenced by factors such as rainfall, runoff, and surrounding geology.
- Maintaining a proper pH balance is important for the health of aquatic plants and animals living in this environment.

Water Currents

- Water currents in brackish water play a vital role in nutrient distribution, oxygen levels, and the movement of organisms.
- Strong currents can impact the distribution of species and the overall ecosystem dynamics.

Nutrient Availability

- Nutrients like nitrogen and phosphorus are essential for the growth of plants and algae in brackish water.
- These nutrients support the food chain and provide energy for the diverse array of organisms that call this ecosystem home.

Biotic Factors:

In addition to abiotic factors, biotic factors in brackish water play a significant role in shaping the ecosystem.

Various aquatic species inhabit brackish water areas, each contributing to the intricate web of life within these environments.

Fish species like tilapia, mullet, and catfish are commonly found in brackish water and are often raised through aquaculture practices.

Apart from fish, brackish water is also home to a diverse range of invertebrates, crustaceans, and molluscs.

These species interact with one another, forming complex relationships that maintain the balance of the ecosystem. Predatory species, such as crabs and shrimp, help regulate populations of smaller organisms, ensuring a healthy ecosystem dynamic.

Brackish water serves as a dynamic medium for aquaculture, with the dynamic interactions of abiotic and biotic factors that support a wide variety of aquatic species.

Understanding and managing these factors are essential for sustainable aquaculture practices in brackish water environments.

With the exploitation of unique characteristics of brackish water, we can continue to explore and utilize this diverse ecosystem for the benefit of both aquatic life and human populations.

1.3 Types of Aquacultures based on the use of supplementary feed and the extent of water exchange

A.Traditional system of aquaculture:

This is the oldest system of aquaculture; in this system supplementary feed is not used similarly there is no water exchange from beginning to the end. Fish cultured in this system fed with the natural plankton available in the pond.

B. Extensive system of aquaculture:

This is the first developed system of aquaculture. In this system supplementary feed is given to the fish or prawn grown in pond at large intervals of one week or 15 days. Use of manures and exchange of water is very limited.

C. Semi intensive system of aquaculture:

This is the scientifically developed system. 2% supplementary feed per kg organisms will be given daily. Exchange of water is regulated at regular intervals.

D. Intensive system of aquaculture:

This is highly developed and scientific method of culture system. Supplementary feed is given at regular intervals. Water exchange will be carried out accordingly. Supplementary feed will be given at the rate of 5- 8 %. Optimum environmental conditions are maintained to obtain maximum yield.

E. Super intensive system of aquaculture:

This is the advanced and scientifically improved system. In this system culture will be carried out in the cement lined ponds or cement cisternae or PVC tanks. 100 % water exchange will be done at regular intervals. Use of supplementary feed and nutrients is more in this system.

Generally, prawn culture is carried out by the above extensive, intensive, semi-intensive, and super intensive systems of aquaculture.

UNIT II

CULTURE OF BRACKISH WATER PRAWN

2.1 CULTURE PRACTICES OF *PENAEUS MONODON/P. VANNAMEI*

There are **three on-growing culture practices**: **extensive, semi-intensive** and **intensiv**e, which represent low, medium, and high stocking densities respectively. Due to its benthic feeding habit *Penaeus monodon* is commercially cultured only in earthen ponds, under widely varying salinities from 2 to 30‰

Extensive Culture practice:

- Commonly found in Bangladesh, India, Indonesia, Myanmar, the Philippines and Viet Nam, extensive grow-out of shrimp is conducted in tidal areas where water pumping is unnecessary.
- Ponds with an irregular shape according

  to land boundaries are generally larger than five hectares and easily constructed by manual labour for cost reduction.
- Wild seeds, which either enter the pond through the gate by the tide or are purchased from collectors, are usually stocked at a density not exceeding 2/m².
- Shrimp feed on natural foods that enter the pond regularly on the tide and are subsequently enhanced by organic or chemical fertilizers.
- If available, fresh fish or molluscs may be used as supplementary feed.
- Due to the low stocking densities, larger sized shrimp (>50 g) are commonly harvested within six months or more.
- The yield is lowest in these extensive systems, at **<u>50-500 kg/ha/yr.</u>**
- Due to the increase in land costs and the shortage of wild seeds, almost no new extensive farms are being constructed today.

Semi-intensive Culture practice:

- Semi-intensive ponds (1-5 ha) are commonly stocked with hatchery-produced seeds at the rate of 5 to 20 PL/m².
- Water exchange is regularly carried out by tide and supplemented by pumping.
- The shrimp feed on natural foods enhanced by pond fertilization,

supplemented by artificial diets. Production yields range from **500 to 4 000 kg/ha/yr**.

***Intensive Culture practice*:**

- Intensive farms are commonly located in non-tidal areas where ponds can be completely drained and dried before each stocking.
- This culture system is found in all *Penaeus monodon* producing countries and is commonly practiced in Thailand, the Philippines, Malaysia and Australia.
- Ponds are generally small (0.1 to 1.0 ha) with a square or rectangular shape. Stocking density ranges from 20 to 60 PL/m².
- Heavy aeration, either powered by diesel engines or electric motors, is necessary for internal water circulation and oxygen supply for both animals and phytoplankton.
- Feeding with artificial diets is carried out 4-5 times per day followed by feed tray checking. Final FCR is normally between 1.2:1 and 2.0:1.
- Efficient feed management is the major criteria for a successful crop, since feed represents over 50 percent of the production costs in intensive systems.
- Water quality parameters such as pH, salinity, dissolved oxygen, alkalinity, Secchi disc, H_2S and unionised ammonia are regularly measured.
- If closed system culture is applied, stocking should be minimized, otherwise the pond must be harvested earlier (within 3.5 months instead of 4-5 months) and smaller shrimp will be yielded (20 g, instead of 30-35 g as achieved in semi-intensive and intensive systems with water exchange).
- Production yields of **4 000 to 15 000 kg/ha/yr.**

2.2 Brackish Water Prawns of India: Their Importance and Value

Brackish water prawns are special types of shrimp that live in water that is not completely salty and not completely fresh.

In India, these prawns are very important for both the environment and the economy. They are found in places where rivers meet the sea, such as estuaries and coastal areas.

Types of Brackish Water Prawns

There are several types of brackish water prawns found in India. Most common ones:

Penaeus monodon (Black Tiger Prawn)

- This prawn is large and has black stripes on its body.
- It prefers warm waters and is often found in coastal areas.
- The Black Tiger Prawn is highly valued and is one of the most commonly farmed prawns in India.

Penaeus vannamei (White Leg Prawn)

- This prawn is smaller than the Black Tiger Prawn and has a light colour.
- It can live in both brackish and fresh water.

- The White Leg Prawn is also very popular for farming because it grows quickly and is easy to raise. It is widely exported to other countries.

Meta Penaeus dobsoni (Indian White Prawn)

- This prawn has a smooth body and is usually smaller than the others.
- It is commonly found in shallow waters and muddy areas.
- The Indian White Prawn is important for local fishing and contributes to the livelihood of many fishermen.

Brackish water prawns play a significant role in both nature and the economy. Here are some reasons why they are important:

Commercial Importance

1. Export earnings: Brackish water prawns contribute significantly to India's foreign exchange earnings, with exports valued at over ₹20,000 crores (2019-2020).

2. Employment: The industry provides livelihoods for over 2 million people, directly and indirectly.

3**. GDP contribution:** Brackish water prawn culture contributes around 2% to India's GDP.

4. Food security: Prawns are an affordable source of protein for domestic consumption.

Production and Productivity

1. Production: India produces over 2.5 million metric tons of brackish water prawns annually.

2. Productivity: Average productivity is around 2-3 tons per hectare per year.

Major Producing States

1. Andhra Pradesh
2. West Bengal
3. Odisha
4. Tamil Nadu
5. Gujarat

Export Earnings

- India's brackish water prawn exports: ₹20,000-25,000 crores (2019-2020)
- Share in global prawn exports: 15-20%
- Major export destinations:
- USA (30-40%)
- EU (20-30%)
- Japan (15-25%)
- China (10-20%)
- Southeast Asia (5-15%)

Employment Generation

- Direct employment: 1.5-2 million people
- Indirect employment: 2-3 million people
- Employment opportunities in:
- Prawn farming
- Processing and packaging
- Exporting and trading

Brackish water prawns are not only delicious but also play a vital role in India's economy and ecology. By understanding the different types of prawns and their importance, we can appreciate these amazing creatures and work together to protect them for future generations.

2.3 BRACKISH WATER SHRIMP MORPHOTYPES

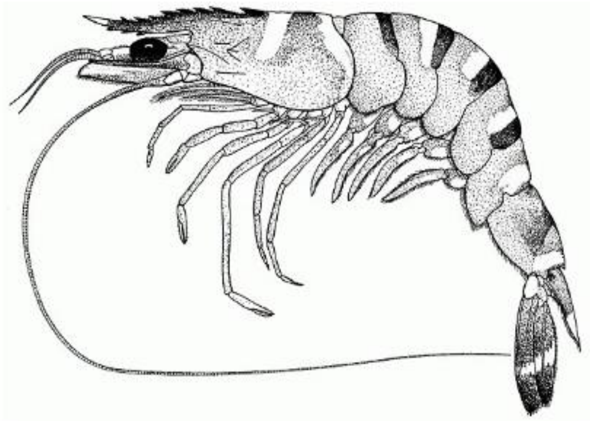
"A morphotype is a distinct form or shape of an organism or a group of organisms, characterized by specific morphological features that distinguish it from others."

Components for a morphotype:

- External morphology (shape, size, colour)
- Body shape and proportions
- Appendages (e.g., appendages, antennae)
- Texture and pattern of skin or exoskeleton

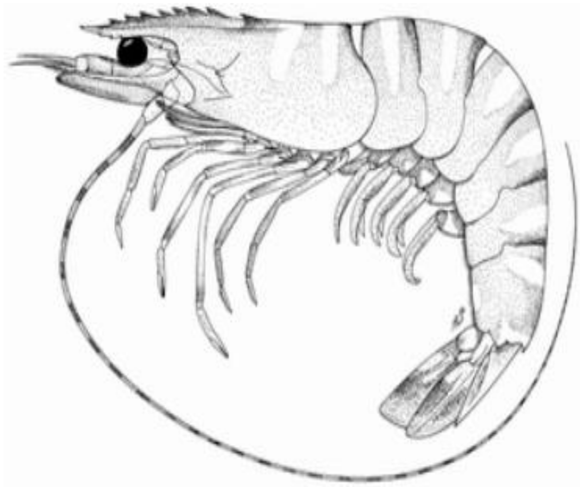
- Internal anatomy (e.g., skeletal structure)

1. ***Penaeus monodon* - Giant tiger prawn**



- Rostrum toothed on dorsal, as well as on ventral margin, rostrum armed with 7 or 8 teeth on dorsal and 3 or 4 (rarely 2) teeth on ventral margin
- Adrostral crest and groove extending as far as or slightly ahead, of epigastric tooth
- Postrostral crest well developed, almost reaching posterior margin of carapace, with or without a feeble median groove
- Antennal crest very prominent, ending above middle of hepatic crest
- Gastro-orbital crest extending over posterior half, or less, of distance between hepatic spine and orbital margin
- Hepatic crest straight, almost horizontal, distinctly separated from base of antennal crest
- Fifth pereopod without exopod.
- Petasma (in males) with distomedian projections slightly overhanging distal margin of costae
- Ventral costae generally unarmed, sometimes minutely serrate at tip
- Outer surface of lateral lobes generally unarmed; inner surface of lateral lobes armed with spinules.
- Thelycum (in females) with lateral plates, their median margin sometimes forming tumid lips; anterior process concave, rounded distally; posterior process subtriangular, partly inserted between thelycal plates.

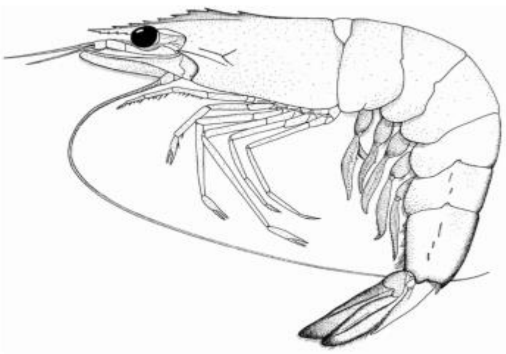
2. ***Penaeus semisulcatus* - green tiger prawn**



- No lateral keels on carapace;
- Cutting portion of mandible short and massive
- Rostrum toothed on dorsal, as well as on ventral margin, rostrum armed with 5 to 8 teeth on dorsal and 2 to 4 teeth on ventral margin
- Adrostral crest and groove extending beyond epigastric tooth; postrostral crest almost reaching posterior margin of carapace, with a distinct median groove
- Antennal crest very prominent, ending above posterior third of hepatic crest; gastro-orbital crest extending over posterior 2/3 of distance between hepatic spine and orbital margin
- Hepatic crest straight, sloping anteroventrally
- Fifth peropod with exopod.
- Petasma (in males) with distomedian projections reaching as far as costae; free border of ventral costae unarmed or minutely serrate near apex; outer surface of lateral lobes minutely tuberculate.

- Thelycum (in females) with lateral plates, their median margins forming tumid lips; anterior process with raised edges delimiting a depressed area; posterior process convex, partly inserted between lateral plates.

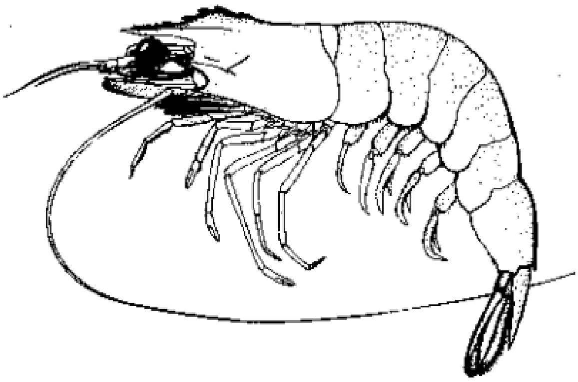
3. *Penaeus indicus* *(Fenneropenaeus indicus)* – *Indian white shrimp*



- Rostrum toothed on dorsal, as well as on ventral margin. Rostrum slender and long, with 7 to 9 teeth on dorsal and 4 to 6 teeth on ventral margin; blade of rostrum becoming moderately high in large specimens
- Adrostral crest and groove extending as far as, or just beyond epigastric tooth, the groove shallow; post-rostral crest ending distinctly before posterior margin of carapace; gastrofrontal and hepatic crests absent; gastroorbital crest extending over posterior 2/3 of distance between hepatic spine and orbital margin
- In adult males, dactyl of third maxilliped about as long as propodus (0.85 to 1.0 times). Petasma (in males) with distomedian projections overhanging distal margin of costae; ventral costae unarmed; outer surface of lateral lobes with a few rows of minute tubercles.
- Thelycum (in females) with lateral plates, their median margins forming tumid lips beset with papillae on their inner surface;
- Anterior process rounded distally; posterior process ill-calcified, almost completely inserted between lateral plates.

4. *Penaeus merguiensis* *(Fenneropenaeus merguiensis)* *Banana shrimp*

- Banana shrimp come in two varieties: redleg and white. Redleg banana prawns are more expensive and desirable.
- Banana shrimp have a light, sweet flavor and are often used in hot dishes.
- Banana shrimp are found in tropical and subtropical waters of the Indo-West Pacific region.
- Banana shrimp have a complex life cycle that involves spawning offshore and then migrating to mangrove-lined nursery grounds inshore.



- The top producers of banana shrimp are Indonesia, Vietnam, Thailand, the Philippines, Malaysia, Singapore, and Guam.

5. *Penaeus penicillatus* *(Fenneropenaeus penicillatus)* *Red Tail prawn*

- The redtail shrimp has a semi-translucent, greenish body with dark brown dots.
- It has light brown eyes with dark brown stripes, and reddish-brown to dark brown crests on its abdomen and rostrum.

- The distal half of its uropods are yellowish to greenish with reddish tips.
- The maximum body length for a female redtail shrimp is 21.2 cm, with a carapace length of 3.3 cm.
- For males, the maximum body length is 16.3 cm, with a carapace length of 3.1 cm.
- Juveniles live in mangrove inlets, intertidal mud flats, and far inshore waters.
- They swim freely, but are still planktonic in offshore waters. When they reach a body length of 0.8–1 cm, they enter estuaries and inshore waters, where they become benthic.
- As they grow, they move to deeper water, and eventually return to offshore waters when they are sexually mature.
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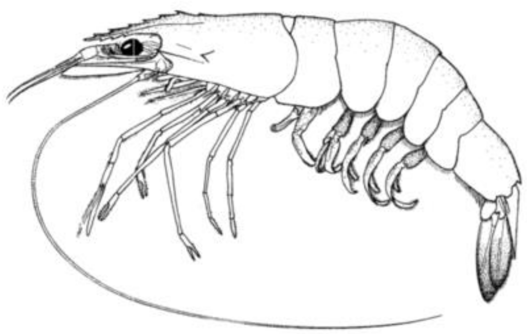


2.3.2 Brackish water shrimp harvesting

Brackish water shrimp harvesting refers to the process of capturing and collecting shrimp from brackish water environments, which are areas where freshwater and saltwater mix.

Brackish water shrimp are an important food source and are harvested for both domestic consumption and export.

Types of Brackish Water Shrimp

- *Penaeus monodon* (giant tiger prawn)
- *Penaeus indicus* (Indian white prawn)
- *Metapenaeus monoceros* (speckled shrimp)

Harvesting Methods

- Traditional fishing gear: nets, traps, and lines
- Mechanized fishing gear: trawls, dredges, and pumps
- Aquaculture: shrimp farming in brackish water ponds

Harvesting Techniques

- Tidal fishing: fishing during changing tides
- Stake net fishing: using nets attached to stakes in the water
- Trap fishing: using traps baited with fish or other attractants
- Hand collection: collecting shrimp by hand in shallow waters

Post-Harvest Handling

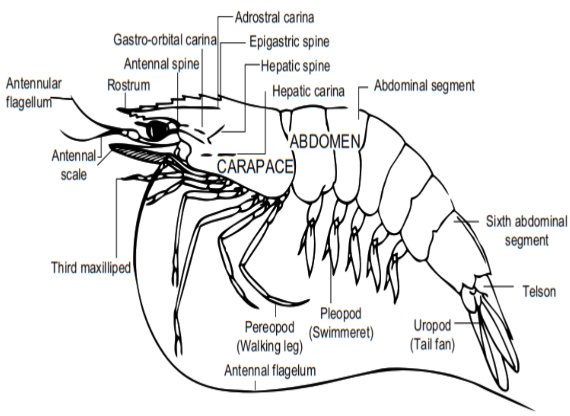
- Sorting and grading: sorting shrimp by size and quality
- Storage: storing shrimp in ice or refrigerated containers
- Transportation: transporting shrimp to markets or processing facilities
- Processing: peeling, beheading, and freezing or canning shrimp

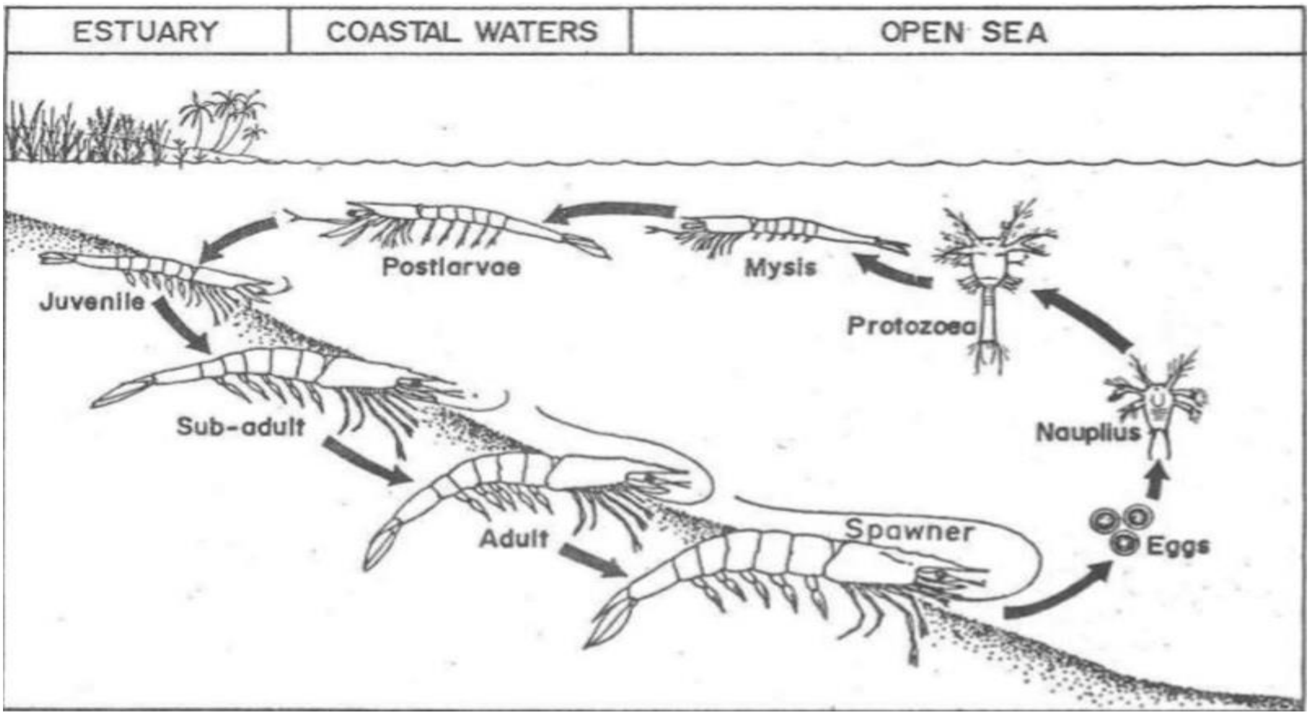
shrimp harvesting provides livelihoods for many communities

UNIT III

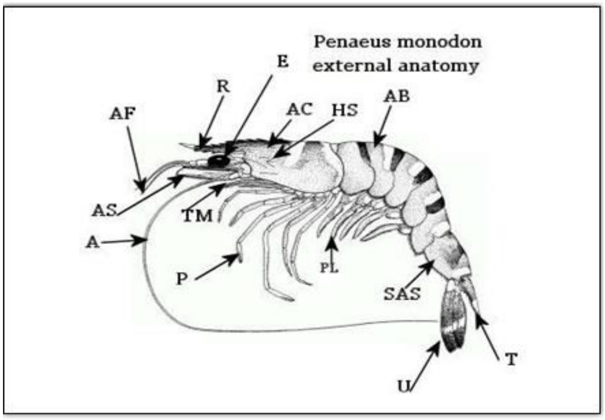
3.1 Biology of *Penaeus monodon*

Phylum: Arthropoda
Class: Crustacea
Order: Decapoda
Family: Penaeidae
Genus: Penaeus
Species: monodon





Habitat and behaviour:



Penaeus monodon is found at depths from 0 to 110 m, inhabiting bottom mud and sand. Giant tiger prawn lives in brackish, estuarine (juveniles) and marine (adults) environments *Penaeus monodon* appears to select muddy mangrove channels and often associates with marginal or floating vegetation.

Morphological characteristics

Penaeus monodon are generally dark coloured, with the carapace and abdomen transversely banded with black and white.

This is the largest commercially available shrimp, reaching 330 mm or more

Sexually mature males (with spermatophores) can be found from about 33 g body weight,37 mm carapace length, 134 mm total length.

Females sometimes have spermatophores in their thelycum from 60 g BW (47 mm CL, 164 mm TL).

Most females mature at a slightly larger size, around 82–97 g BW (180–190 mm TL)

Reproduction

Wild males produce spermatozoa from around 35 g BW and females becomes gravid from 70 g.

Mating occurs at night, shortly after moulting, while the cuticle is still soft, and sperm are subsequently kept in a spermatophore (sac) inserted inside the closed thelycum of the female.

Females of P. monodon are highly fecund, with gravid individuals producing as many as 500 000 to 750 000 eggs.

Spawning occurs at night and fertilization is external, with females releasing sperm from the thelycum as eggs are released in offshore waters. Nauplii hatch 12–15 h after fertilization.

Life cycle

The life history of *P. monodon* has an offshore planktonic larval phase of about 14 to 20 days, an estuarine, benthic post larval and juvenile phase of over 6 months (33 g); a coastal subadult phase of 5 to 6 months (60 g); and an inshore and offshore ocean adult and spawning phase (60 to 261 g)

Mating between a recently moulted (soft-shelled) female and a hard-shelled, smaller male occurs at night in the ocean. Adult *P. monodon* is found in offshore waters on sandy bottom at depths of 20–40 m.

The larvae move towards the coast, entering estuaries and mangrove swamps that serve as nursery grounds.

They then migrate to deeper water when they become adolescent. *Penaeus monodon* has six nonfeeding naupliar stages, three protozoeal stages and three mysis stages.

3.2 Biology of *Penaeus indicus*

Phylum: Arthropoda
Class: Crustacea
Order: Decapoda
Family: Penaeidae
Genus: Penaeus
Species: Penaeus indicus

Habitat and behaviour

Penaeus indicus is found at depths of 2 to 90 m, inhabiting bottom mud or sand. It is most abundant in shallow waters of less than 30 m depth, on sand or mud. The adults are marine and breed offshore, while post larvae and juveniles are estuarine

Morphological characteristics

The maximum total length of *P. indicus* is about 184 mm for males and 228 mm for females, although adult shrimp are usually much smaller (170 mm). The maximum carapace length is 56 mm.

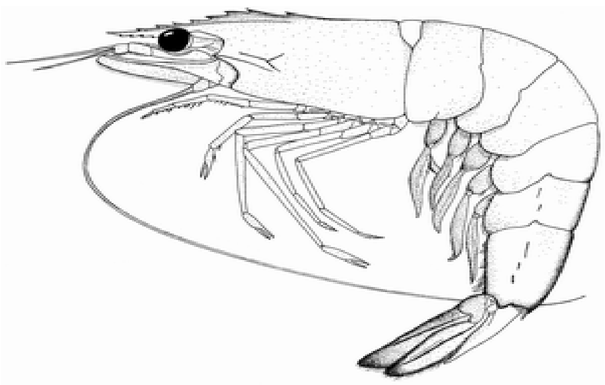
The eyestalks and antennal scales are bluish and the margins of the uropods are blue with a bright red fringe

The body is semi-translucent, with olive green to grey-blue speckles.

The carapace is hairless. The rostrum is slender and long, with 7 to 9 teeth on the dorsal and 4 to 6 teeth on the ventral margin, with the blade of rostrum becoming moderately high in large

Males are identified by a petasma. Females have a closed thelycum.

They are euryhaline and live in brackish, estuarine and marine environments.



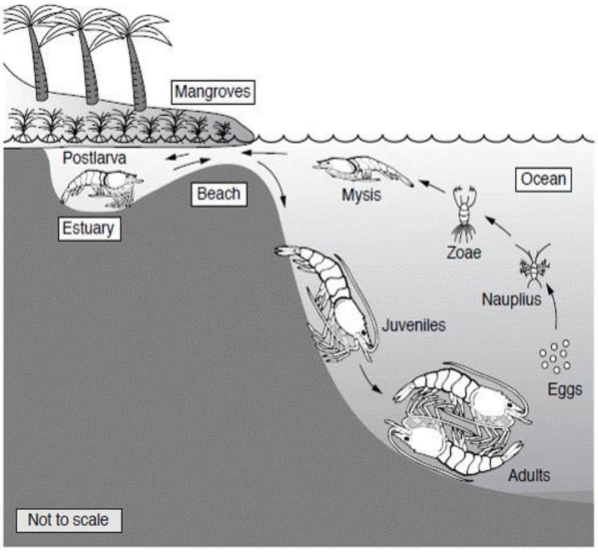
Life cycle

The life history of *P. indicus* has an offshore planktonic larval phase; an estuarine, benthic post larval, juvenile phase and an inshore ocean adult and spawning phase

Mating between a recently moulted (soft-shelled) female and a hard-shelled, smaller male occurs at night in the ocean

Penaeus indicus generally spawn on the surface at water depths of over 7 m and up to 36.6 m. Females produce between 212 800 and 1 254 200 eggs (18.26 cm shrimp) that hatch within 15 h.

Fecundity increases with prawn size. *Penaeus indicus* has six non-feeding naupliar stages, three protozoeal and three mysis stages Post larvae move towards the coast and enter estuaries and mangrove swamps that serve as nursery grounds.



Penaeus indicus females commence breeding at between 27 (137 mm TL) and 35 mm carapace length. This corresponds to 5–6.5-month-old females. The full life span of *P. indicus* is about two years

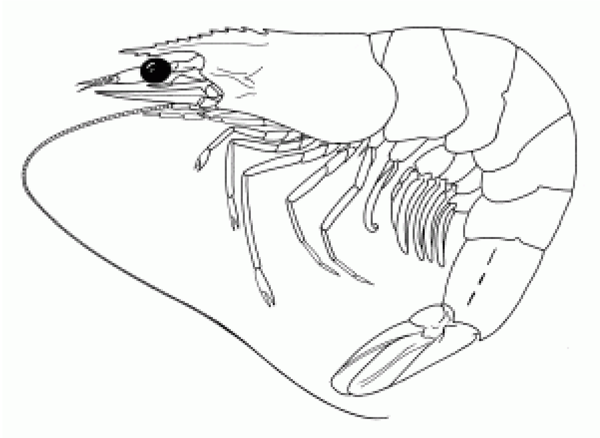
Males attained sexual maturity at 2.8 to 3.4 cm carapace length.

Larval stages

Penaeus indicus spawns most months of the year, with two annual spawning peaks.

The shrimp eggs hatch within 15 h as a nonfeeding naupliar stage. The unsegmented body has three pairs of appendages. The nauplius undergoes six moults within 50 h into a protozoea. The protozoea has three stages. Protozoea I (zoea I) has compound eyes under the carapace that are not externally visible (Zoea II has a pair of stalked compound eyes and zoea III has a pair of biramous uropods. After 4–6 days, the protozoea metamorphoses into a mysis. There are three mysis stages over 3 to 4 days. The mysis remain drifting in the water and metamorphose into post larvae.

3.3 Biology of *Penaeus vannamei*



Phylum: Arthropoda
Class: Crustacea
Order: Decapoda
Family: Penaeidae
Genus: Penaeus
Species: Penaeus vennamei

Morphological characters:

Penaeus vannamei live in tropical marine habitats. Adults live and spawn in the open ocean, while postlarvae migrate inshore to spend their juvenile, adolescent and sub-adult stages in coastal estuaries, lagoons or mangrove areas.

Males become mature from 20 g and females from 28 g onwards at the age of 6–7 months.

Life Cycle

P. vannamei weighing 30–45 g will spawn 100 000–250 000 eggs of approximately 0.22 mm in diameter.

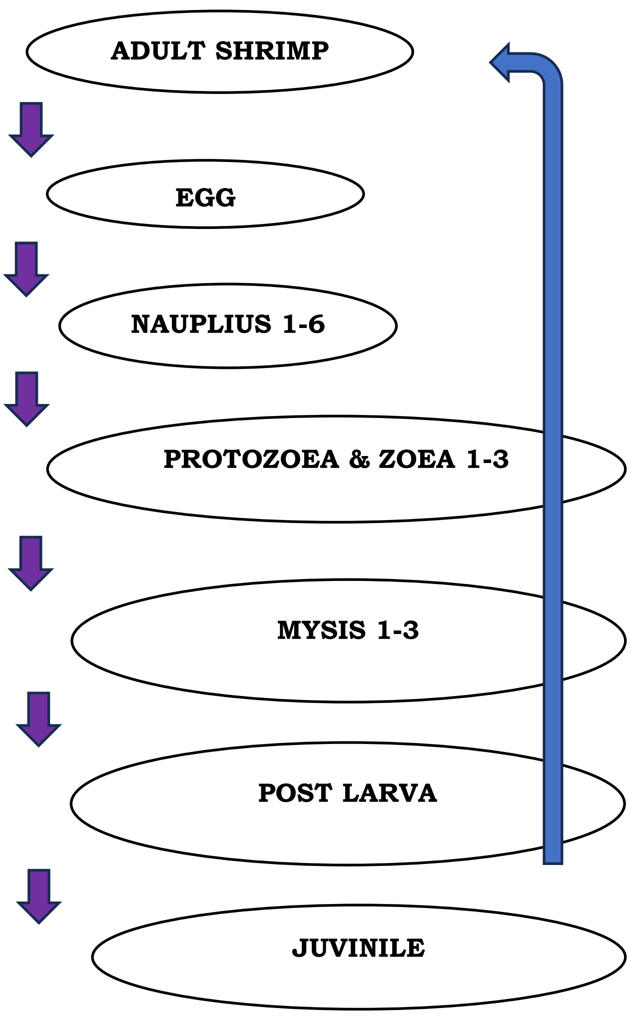
Hatching occurs about 16 hours after spawning and fertilization.

The first stage larvae, termed nauplii, swim intermittently and are positively phototactic.

Nauplii do not feed, but live on their yolk reserves. The next larval stages (protozoea, mysis and early postlarvae respectively) remain planktonic for some time, eat phytoplankton and zooplankton, and are carried towards the shore by tidal currents.

The postlarvae (PL) change their planktonic habit about 5 days after moulting into PL, move inshore and begin feeding on benthic detritus, worms, bivalves and crustaceans.

LIFE CYCLE OF SHRIMP



UNIT IV
MANAGEMENT PRACTICES

4.1. Nutritional Requirements of Cultivable prawns

Cultivable prawns primarily require a diet high in protein with moderate levels of lipids and carbohydrates along with essential vitamins and minerals.

Nutritional needs vary depending on the prawn's life stage like larvae, juveniles, adults, broodstock.

with the quality of both protein and lipids being crucial for optimal growth and survival; key nutrients include essential amino acids, fatty acids like EPA and DHA, calcium, phosphorus, and vitamin C.

Components of prawn nutrition:

Protein: The most important nutrient, with juvenile prawns needing a higher percentage compared to adults. Depending on species and life stage protein constitutes 30-50% of diet, protein component includes essential amino acids: arginine, histidine, isoleucine, leucine, lysine, methionine, phenylalanine, threonine, tryptophan, and valine

Lipids: Important for energy and should include a balance of saturated and unsaturated fatty acids. It is around 5-15% of diet, includes essential fatty acids like linoleic acid, linolenic acid, and arachidonic acid

Carbohydrates: Primarily used as an energy source, but not as critical as protein and lipids. Constitutes 20-40% of diet. Dietary source is starch, cellulose, and sugars

Vitamins: Vitamins important for prawn health and reproduction. The role of vitamins is:

Vitamin A: growth, reproduction
Vitamin C: Immunity, stress resistance
Vitamin E: Antioxidant, growth
Vitamin B12: Nucleic acid synthesis

Folate: Growth, reproduction

Minerals: Minerals play a crucial role in growth and development the role of different minerals is as following:

Calcium -shell formation, growth

Phosphorus -growth, reproduction

Magnesium -energy metabolism

Sodium & Potassium -osmoregulation

Micronutrients:

Micronutrients play an important role in different metabolic activities during the growth and development of the prawns, they paly a vital role in oxygen transport, shell development.

4.2 Natural food and artificial feed and their importance in shrimp culture:

4.2.1 Natural food in shrimp culture:

Shrimp are carnivorous crustaceans that feed on a variety of food sources in their natural habitat.

Natural Food Sources:

- **Algae:** Various types of algae, including phytoplankton and benthic algae.
- **Zooplankton & Small crustaceans**: Copepods, amphipods, and other small crustaceans.
- **Fish larvae**: Larvae of fish, such as planktonic fish eggs and larvae.
- **Detritus:** Decaying organic matter, including plant and animal remains.
- **Benthic organisms:** Organisms living on or near the seafloor, such as polychaete worms and other invertebrates.

Importance of Natural Food:

Natural feed plays a crucial role in shrimp farming and overall shrimp health.

Nutritional Balance: Natural feed sources, such as plankton and detritus, provide essential nutrients that are often more bioavailable than synthetic feeds.

Growth Promotion: The presence of natural feed can stimulate natural feeding behaviours in shrimp, leading to better growth rates.

Enhanced Survival Rates: Natural feeds often contribute to improved survival rates in shrimp populations.

Environmental Sustainability: Promoting natural feeding strategies supports ecosystem health and biodiversity.

Biodiversity: Natural feed supports biodiversity by allowing shrimp to coexist with other species in their ecosystem.

In aquaculture, understanding the natural feeding behaviour and nutritional requirements of shrimp is crucial for providing optimal feed and maintaining healthy cultures. This can involve supplementing commercial feeds with natural or organic alternatives to promote better growth, health, and sustainability.

4.2.2 Artificial feed in shrimp culture and its importance:

Artificial feed plays a vital role in shrimp culture, ensuring consistent and nutritious food supply.

Importance of artificial feed:

- **Consistent nutrition**: Provides balanced and standardized nutrients.
- **Increased growth rates**: Optimized feed formulations enhance growth and productivity.
- **Improved survival rates**: Reduced mortality rates due to consistent nutrient supply.
- **Cost-effective:** Large-scale production reduces costs compared to natural feed.
- **Year-round availability:** Unaffected by seasonal changes or natural food scarcity.
- **Better water quality**: Formulated feeds minimize waste and nutrient losses.
- **Disease management**: Some feeds contain immunostimulants or probiotics.

Types of Artificial Feed:

- Commercial pellets or crumbles
- Extruded feeds
- Live food supplements (e.g., Artemia, brine shrimp)
- Semi-moist feeds
- Biofloc technology-based feeds

These artificial feed types cater to various shrimp species, growth stages, and aquaculture systems, promoting efficient and sustainable shrimp production

4.3.1. SHRIMP CULTURE POND PREPARATION

Growing of shrimp in an improperly prepared pond may lead to difficulty in pond management during the culture period, which could result in a decrease in production capacity of the pond.

Before a pond can be stocked for a new crop, the excessive wastes, which accumulate in the pond during the previous crop, must be removed and the soil and water conditioned.

Pond preparation includes the following steps

- **Pond cleaning**
- **Pond Liming**
- **Eradication of Predators**
- **Fertilization**
- **Aeration**

Pond Cleaning

The cleaning of a pond or removal of the wastes, especially the organic and phosphatic wastes that have accumulated in the pond bottom could be, accomplished by drying, liming and ploughing.

There are **two methods** for cleaning a pond according to the possibility of the pond to be dried:

1. Dry Method

This method is used when the pond bottom can be dried completely. The pond is drained and left to dry in the sun for a period of 10-30 days. Then the waste is removed, either manually or mechanically, and transported to the waste dumping area.

2. Wet Method

In areas where the pond cannot be dried completely, pressure washing can be used to flush out the wastes. This method takes a shorter time and is more efficient than the dry method.

Liming

The types of lime to be used depend on the water pH. It is recommended that agricultural lime ($CaCO_3$) or dolomite [$Ca\ Mg\ (CO_3)_2$] should be used in a pond with water pH near neutral and the hydrated lime [$Ca\ (OH)_2$] should be used in a pond with water pH below 5.

The amount of lime to be used should be carefully calculated to avoid inducing an excessively high-water pH, which may increase ammonia toxicity and result in the mortality of the shrimps.

Eradication of Predators

After liming, the pond should be filled to the maximum depth through a screen with fine mesh to prevent the predators and competitors from entering the pond. These predators, including fish, crustaceans and some invertebrates, may compete for food, prey on the shrimp or carry diseases and parasites. They may establish themselves in the pond that is not effectively screened effectively or is left for a long period of time.

Some chemicals should be used to eradicate these animals in the pond before stocking.

Snails can be eliminated by the application of quick lime (CaO) at 530 kg. /ha. and sun dried for 2-3 days.

Then the pond should be filled with water and the other pests eradicated.

Fertilization

The pond must be fertilized with either organic or inorganic fertilizer to stimulate the plankton bloom in order to provide shade to the pond bottom and utilize the nitrogenous and phosphate wastes within the pond.

After fertilization, the plankton should bloom within a few days and the colour of the water becomes slightly green.

The fertilizer, either the organic or inorganic, should be applied daily in the pond at 5-10 % of the initial amount to maintain the plankton bloom.

Aeration

A 0.5-1.0 ha pond would require, four aerators installed at the corners of the pond, approximately 3-5 m from the bottom of the dike and positioned at an angle that will encourage the maximum water flow within the pond.

The aerators should be switched-on 24 hrs before the PL are stocked to allow enough time to create the current and clean up the feeding area.


Sludge in pond bottom (Indicated by an arrow)


Thick layer of black soil


Ploughing on dry soil using tractor


Ploughing in wet soil using tiller


Liming pond bottom


Liming over water surface


Pumping water into the grow out pond


Optimum algal bloom for stocking post larvae


Healthy hatchery reared PL for stocking

4.3.2 Stoking in Shrimp culture

The most suitable species for culture in India are the Indian white prawn *Penaeus indicus* and tiger prawn *P. monodon*.

The stocking density varies with the type of system adopted and the species selected for the culture.

As per the directives of Supreme Court only traditional and improved traditional shrimp farming can be undertaken within the Coastal Regulation Zone (CRZ) with a production range of 1 to 1.5 t/ha/crop with stocking density of 40,000 to 60,000/ha/crop.

Seed selection

Selection of good quality seed for stocking into a pond is the first important step of the shrimp grow-out management.

The **following parameters** should be taken into consideration in purchasing shrimp seed for stocking.

(i) Size

Seeds of PL 15-20, indicated by the appearance of 4-6 spines on the rostrum, are recommended for stocking in a pond. The healthy PL should have the muscle-to-gut ratio in the sixth abdominal segment of about 4:1 or the thickness of the gut should be about the thickness of the muscle.

(ii) Morphology

The post larvae should have normal appearance of trunk, appendages and rostrum. The abdominal muscle must be clear, no discoloration or erosion on any parts of the body, the gut should be full of food, and the muscle should fill the carapace.

(iii) Colour

Post larvae with the presence of pigment cells in the uropods should be used since this indicates the stage of development. PL that will have high survival and growth rates will be light grey, brown to dark brown and black in colour. Signs of red or pink coloration are normally related to stress.

(iv) Behaviour

Healthy seed swim straight, respond rapidly to external stimuli such as a tap on the side of the basin, actively swim against the current when the water is stirred, and cling to the sides rather than aggregate or be swept down into the centre of the container when the current has subsided.

(v) External Fouling

Seeds should be free from external parasites, bacteria and other fouling organisms.

(vi) Pathogen Free

Seed should be checked for the presence of viral occlusion bodies. Seed with large numbers of occlusions indicate stress conditions and will not so vigorous in the pond.

Stocking Density

When a farm is ready for operation, the optimum stocking density of PL in a pond should be determined in accordance with the production capacity of the farm and the culture system, which include the soil and water quality, food availability, seasonal variations, target production, and farmer's experience.

The stocking density between 10-20 PL/m2 is usually practiced in a semi-intensive culture.

In an intensive culture, a well-managed pond with consistent good water quality can stock up to 25-30 PL/m2 at 1.2 m water depth and up to 40-50 PL/m2 at 1.5 m water depth or deeper.

Technique of Stocking

Proper stocking techniques will prevent unnecessary mortality of seed. The following methods have shown excellent results.

(i) Transportation

Seed are normally transported in plastic bags. The bags are usually filled up to 1/3 with water, oxygenated and then placed inside Styrofoam boxes.

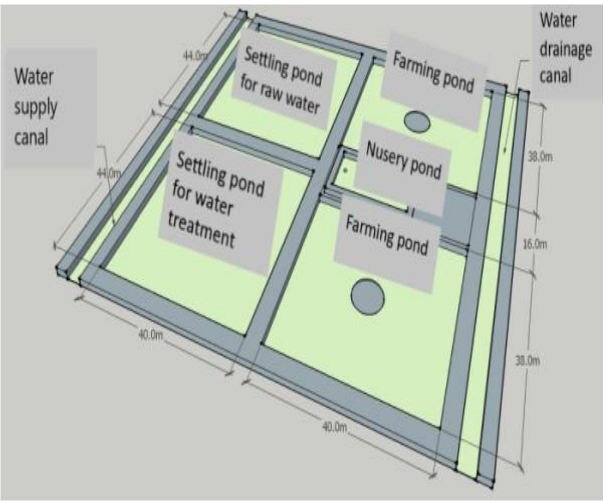
(ii) Acclimation

To eliminate stress, the seed should be maintained in water of constant salinity for at least 1-week prior to transfer. The adjustment of salinity by about 3 ppt daily is advisable. Acclimation of seed to the water pH and temperature of the pond must be rendered upon arrival.

(iii) Nursing of Shrimp Post Larvae

To ensure high survival and adequate feeding of seed during the first 2-3 weeks, some farms may stock the PL in a separate nursing pond or a small impoundment, usually 5-10 % of the total pond area, within the culture pond. The nursing system will help in concentrating the seed in a limited area until they reach PL 30-40 and in more accurate monitoring for survival and feeding of the PL.

4.3.3 Shrimp hatchery pond management



Shrimp hatchery pond management is crucial for ensuring healthy shrimp production and maximizing yield.

1. Site Selection and Pond Preparation

- Choose areas with good soil conditions (clay loam or sandy clay), reliable water sources, and access to power.
- Conduct tests to ensure pH and nutrient levels are optimal.

2. Pond Design

- Typically, 1-1.5 meters depth for optimal light penetration and temperature regulation. smaller ponds (0.5-1 hectare) are easier to manage. Install aerators for oxygen distribution.

3. Cleaning and Drying

- Drain and remove debris. Dry ponds to kill harmful pathogens and pests. Treat the bottom with lime (quicklime or agricultural lime) to maintain soil pH.

4. Water Management

- Ideal pH range is 7.5–8.5. Adjust salinity based on shrimp species (e.g., 15–35 ppt for *Penaeus monodon*). Maintain DO above 4-5 mg/L.

5.Stocking

- Use high-quality, disease-free post-larvae (PL) from a reliable hatchery. Gradually adjust PL to pond water conditions (temperature, salinity).

6. Harvesting

- Stop feeding 12-24 hours before harvesting. Lower water levels gradually to avoid shrimp stress. Harvesting Methods.
- Use nets or harvest basins for efficient collection. Minimize physical damage to shrimp during handling. Clean and chill shrimp immediately to preserve quality.

Effective shrimp pond management leads to healthier shrimp, better yields, and sustainable operations.

4.3.4 Shrimp nursery pond management

Shrimp nursery pond management is a critical intermediate step in shrimp aquaculture, **where post-larvae (PL) are reared before transferring them to grow-out ponds.** This phase allows for better survival rates, faster growth, and disease resistance.

1. Nursery Pond Design

Smaller ponds (500–2000 m^2) or tanks are easier to manage and monitor. With a typical depth of 1–1.5 meters to allow for better water quality control.

2. Pond Preparation

- Dry the pond thoroughly between cycles. Remove organic matter and disinfect using quicklime or bleaching powder (30 ppm). Use agricultural lime to maintain soil pH between 7.5 and 8.5. Fill the pond with filtered seawater (15–35 ppt salinity, depending on species). Fertilize with organic (e.g., rice bran) or inorganic fertilizers to stimulate natural plankton growth.

3. Stocking

- Use high-quality, pathogen-free PL (e.g., PL10–PL12). Slowly adjust temperature, salinity, and pH of PL to match pond conditions.

4. Feeding and Nutrition

- Start with high-protein feeds (crumble or micro-pellets). Supplement with natural feed like Artemia, algae, or plankton. Feed 4–6 times daily for optimal growth and minimal waste.

5. Water Quality Management

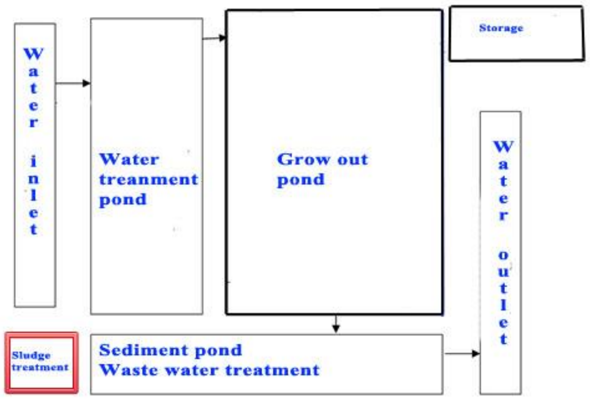
- Maintain DO above 5 mg/L. Keep pH between 7.5 and 8.5. Ideal range of temperature is 27–32°C. Ensure sufficient aeration to support high stocking densities. Use probiotics to control harmful bacteria and improve water quality.

6. Disease Prevention and Biosecurity

- Use disinfected water and equipment. Restrict access to the nursery pond to prevent contamination. Regularly inspect shrimp for signs of stress or disease. Quarantine any PL showing unusual behaviour or appearance. Regular application of probiotics enhances gut health and immunity.

Proper shrimp nursery pond management ensures a smooth transition to grow-out systems, contributing to higher yields and profitability.

4.3.5 Shrimp Grow out pond management



Shrimp grow-out pond management is a critical stage in shrimp farming, **where juvenile shrimp from nursery ponds is raised to market size.**

Effective management ensures optimal growth, high survival rates, and profitability.

1. Pond Design

Pond Size: Typical grow-out ponds range from 1 to 5 hectares.

Depth: Maintain 1.2–2 meters for optimal temperature and oxygen control.

Aeration: Use paddlewheel aerators (10–20 HP/ha, depending on stocking density) to ensure uniform oxygen levels.

2.Pond Preparation

Cleaning: Dry the pond completely to eliminate predators and pathogens. Remove black soil or sludge from the bottom.

Disinfection: Apply lime to adjust soil pH (ideal: 7.5–8.5).

Water Conditioning: Fill with filtered and treated seawater. Fertilize to stimulate plankton growth for natural feed.

3. Stocking Management

Acclimatization: Gradually adapt shrimp juveniles (post-larvae or juveniles from nursery ponds) to grow-out pond conditions (salinity, temperature, and pH).

Stocking Density: Depends on farming intensity:

- Extensive: 5–10 shrimp/m².
- Semi-intensive: 15–25 shrimp/m².
- Intensive: 50–100 shrimp/m².

4. Water Quality Management:

Maintaining stable water quality is vital for shrimp health and growth.

Dissolved Oxygen (DO): Maintain above 4 mg/L. Use aerators to distribute oxygen evenly.

pH: Ideal range is 7.5–8.5. Monitor daily and adjust using lime if necessary.

Salinity: Maintain 15–35 ppt, depending on species and local conditions.

Ammonia, Nitrite, and Nitrate: Ammonia < 0.1 ppm. Nitrite < 0.25 ppm. Use probiotics and regular water exchange to control levels.

Water Exchange: Regularly exchange 10–20% of water weekly or as needed, especially in intensive systems.

Plankton Management: Maintain a stable plankton bloom for natural feed and water clarity. Avoid over-fertilization to prevent harmful algal blooms.

5. Feeding Management: Proper feeding practices are crucial for growth and water quality.

Feed Quality: Use high-protein commercial feeds suitable for shrimp growth stages.

Feeding Schedule: Feed 4–5 times a day to match shrimp activity. Monitor feeding trays to avoid overfeeding and reduce waste.

Supplementation:

- Add probiotics, vitamins, and minerals to enhance shrimp health and growth.

Aim for an FCR of 1.2–1.6 in well-managed ponds.

6. Disease Management:

Preventing disease is critical to maintaining high survival rates.

Control pond access to prevent pathogen entry. Use disinfected water and equipment

Check shrimp regularly for signs of disease (e.g., unusual behaviour, discoloration). Use probiotics to outcompete harmful bacteria. Avoid overuse of antibiotics and follow local regulations.

7. Harvesting

Harvesting should be planned to maximize yield and shrimp quality.

- Stop feeding 24 hours before harvest to reduce waste in the shrimp gut.
- Gradually lower water levels to minimize stress.
- Use nets, traps, or drain harvesting methods.
- Avoid rough handling to reduce physical damage.
- Chill shrimp immediately after harvesting to preserve quality.
- Grade and pack shrimp for transportation or processing.

Proper management of shrimp grow-out ponds ensures healthy shrimp, high survival rates, and a profitable harvest.

4.3.6 Shrimp harvesting

Brackish water shrimp harvesting refers to the process of capturing and collecting shrimp from brackish water environments, which are areas where freshwater and saltwater mix.

Brackish water shrimp are an important food source and are harvested for both domestic consumption and export.

1. Types of Brackish Water Shrimp

- *Penaeus monodon* (giant tiger prawn)
- *Penaeus indicus* (Indian white prawn)
- *Metapenaeus monoceros* (speckled shrimp)

2. Harvesting Methods

Traditional fishing gear: nets, traps, and lines

Mechanized fishing gear: trawls, dredges, and pumps

3. Post-Harvest Handling

Sorting and grading: sorting shrimp by size and quality

Storage: storing shrimp in ice or refrigerated containers

Transportation: transporting shrimp to markets or processing facilities

Processing: peeling, beheading, and freezing or canning shrimp

4. Food Safety Considerations

Contaminant monitoring: monitoring for contaminants like heavy metals and pesticides

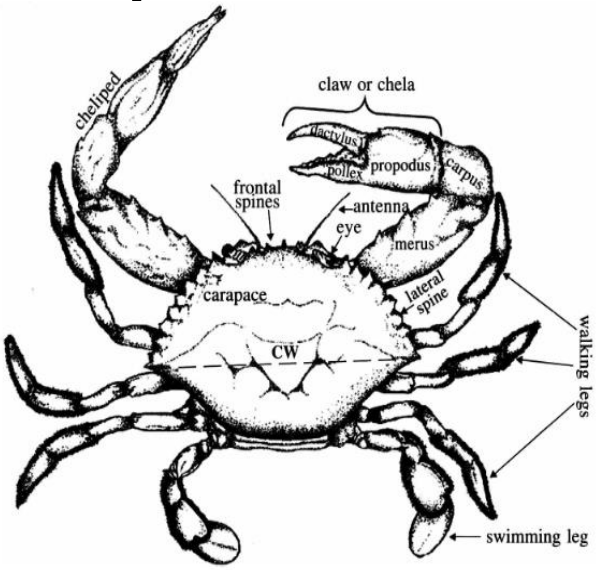
Handling and storage: ensuring proper handling and storage to prevent contamination

Processing and packaging: ensuring proper processing and packaging to prevent contamination.

UNIT V

5.1 Species of crabs cultured

5.1.1. *Scylla serrata*



- Typically associated with mangroves in estuaries and sheltered coastal habitats, they are found in soft muddy bottoms where they dig deep burrows.
- Courtship and mating occur in estuaries.
- Mature *S. serrata* migrate offshore (up to 50 km) to spawn.
- Spawned eggs attach to the pleopod hairs of the abdominal flap.
- Eggs hatch into zoea and pass through five zoeal stages, after which they become megalopa.

- The megalopa moult once and assume the appearance of a crab.
- Crab instars to juveniles are found in estuaries, tidal flats and mangroves, where they burrow in mud or sand or seek shelter under fallen leaves, twigs, etc.
- Crab instars undergo several moults before attaining full maturity. As the male crab matures, the claws enlarge and the testes become massive, filling the cavity under the carapace.
- Males can grow up to 3 kg with 28 cm carapace width (CW).
- Mature females have wide and dark abdomens and dark orange ovaries that fill the cavity under the carapace.
- Mud crabs may spawn at any time during the year.
- The number of eggs produced may range from 1 to 6 million eggs in a single spawning. The spermatophores that have been deposited by males during mating are retained by the female even after moulting. One female can produce at least three batches of eggs with an interval of 41-46 days between the first and second spawning and 34 days between second and third spawning in the case of S. serrata.
- The zoea and megalopa feed on zooplankton. Small crabs feed mainly on crustaceans, molluscs, worms and rarely on fish and plant matter.
- The sub-adult and adult crabs mainly eat molluscs and small crabs.

5.1.2 Biology of Scylla *serrata*

Scylla crabs dig and inhabit burrows in mangroves and soft-bottom shallow intertidal waters (hence, the name mud or mangrove crab).

Life History:

The life cycle of the mud crab is illustrated here under.

Courtship and mating occur in brackish waters. Mature *S. serrata* females migrate offshore to spawn. The three other species of *Scylla* spawn in lagoons, bays, inlets and coastal seas within a few kilometres of mangrove habitats.

Spawned eggs attach to the pleopod hairs of the abdominal flap. Eggs hatch into zoeae and pass through five stages (zoea 1 to 5), after which they become megalopae. The megalopa moults once and assumes a crab-like appearance. Small crabs are found in estuaries, tidal flats, and mangroves where they burrow in mud or sand, or hide under fallen leaves and other shaded areas during the day. Crab instars and juveniles undergo several moultings until full maturity

The zoea and megalopa feed on Zooplankton. Small crabs feed mainly on crustaceans, molluscs, worms, fish, and plant matter. The sub-adults prey on bivalves.

Adult crabs eat mainly burrowing and attached bivalves, and small crabs.

Moulting: Crabs moult in order to grow. The exoskeleton is soft immediately after moulting. The crab expands its body and limbs by taking in water before the new shell hardens. The crab moults frequently when small but less often when bigger. The newly moulted crab is vulnerable to cannibalism; hence, it seeks shelter or burrows to escape predation.

A crab may voluntarily snap off its legs at the base when these are badly damaged or seized by other animals. Crabs are able to regenerate lost limbs.

Sexual Maturity

Male

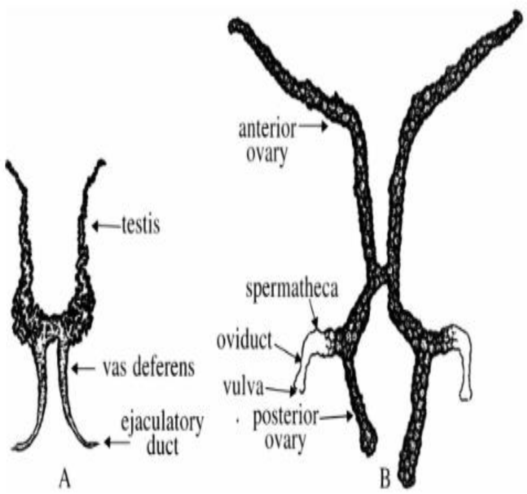
The testes (Fig A) are paired organs next to the hepatopancreas under the carapace. Each testis connects to a vas deferens (a thin white, coiled tube) and to an ejaculatory duct that opens at the base of the first gonopods.

As males mature, the claws enlarge after pubertal moult, the spermatophores appear in the vas deferens, and the testes become bigger. Mature males have massive testes that fill up the cavity under the carapace.

Female

A female crab has paired ovaries (Fig. B) and oviducts under the carapace. The oviduct also serves as the spermatheca or seminal receptacle that opens to the outside through the vulvae.

A female crab is considered mature when it has undergone pubertal moult with accompanying widening and darkening of the abdomen. Immature ovaries are thin and transparent to yellow. Mature ovaries are dark orange and fill up the cavity under the carapace. Without dissecting the female crab, mature ovaries can be seen by carefully depressing the first abdominal segment adjacent to the carapace.



Mating

In portunid crabs, mating occurs soon after moulting of a mature female. The male mounts the back of the female and turns the female around so that their under surfaces meet with abdomens extended. With the aid of the gonopods, the spermatophores are released through the ejaculatory duct and inserted into the vulvae of the female and stored in the spermathecae.

Copulation lasts only a few days, but the male may continue to protect the female until the shell hardens.

The spermatophores can be retained through a moult and remain viable for long periods. The sperm received during one mating can fertilize 2-3 batches of eggs. However, the third batch of eggs may have lower fertilization rate.

Spawning

Mud crabs spawn anytime during the year. A female about to spawn raises its body away from the bottom, and opens its abdominal flap to facilitate release of the eggs. The eggs are fertilized as they pass through the spermatheca. The eggs pass through the vulvae and attach to the pleopod hairs of the abdominal flap. The newly spawned eggs appear opaque brilliant orange.

Females carrying eggs are sometimes called berried. With the development of the chromatophores and the eyes, the egg mass darkens to greyish orange and finally to grey.

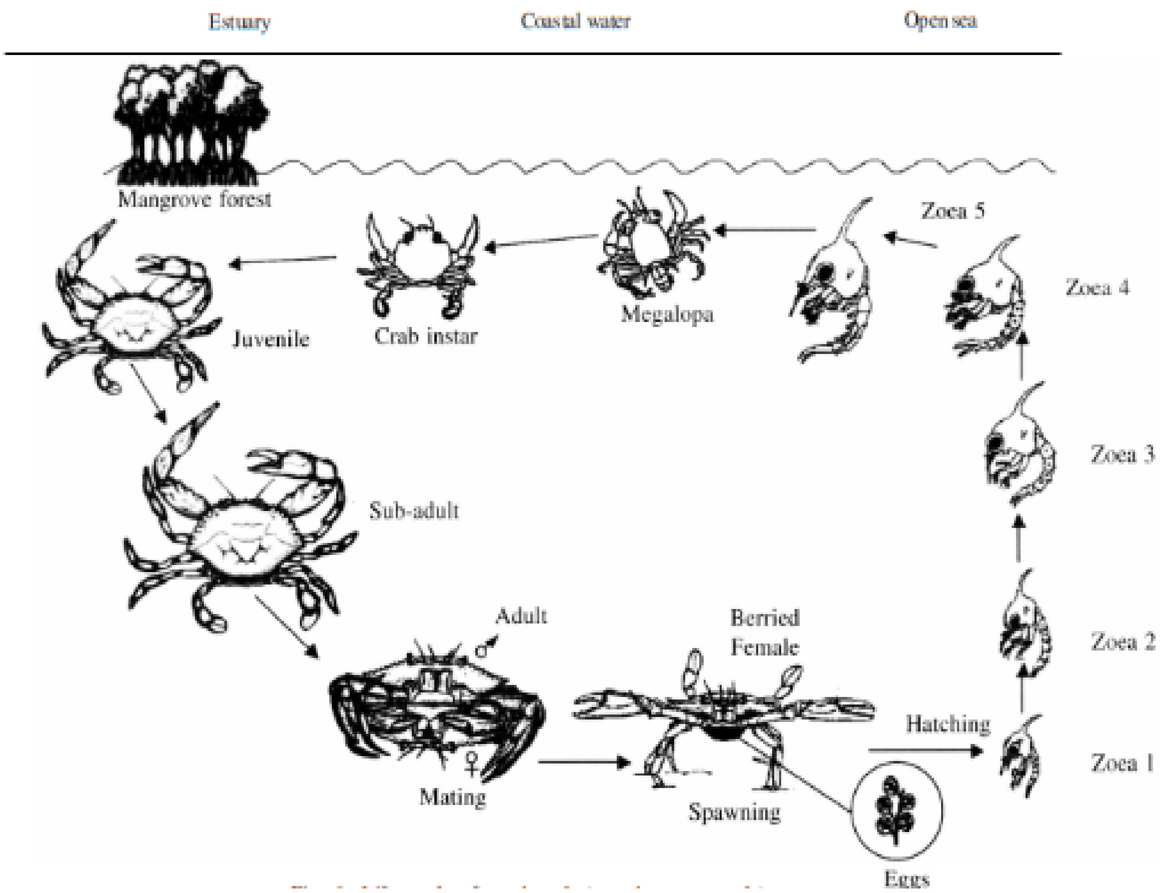
The number of eggs produced by a female increase with size and may range from 1 to 6 million eggs per female in a single spawning. One female can produce at least three batches of eggs.

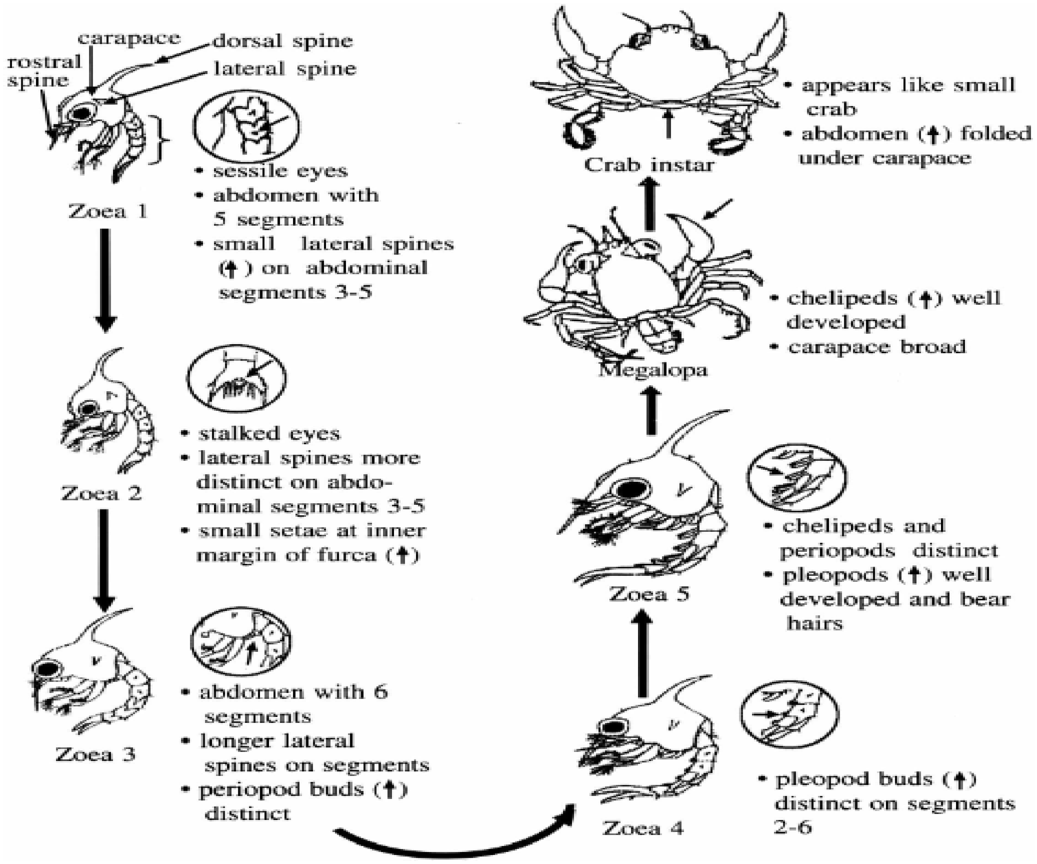
Embryonic Development and Hatching

The eggs are almost spherical. Newly spawned eggs measure 0.33 to 0.35 mm in *S. serrata*. Embryonic development takes 9-14 days for mud crab eggs to hatch. The duration of embryonic development varies with temperature and other factors.

Larval Development

Zoea has long rostral and dorsal spines, and short lateral spines on the carapace. Larval development of mud crab takes 16-18 days from zoea 1 to megalopa stage and another 7-10 days to the first crab stage.


Estuary
Coastal water
Open sea
Mangrove forest
Juvenile
Crab instar
Megalopa
Zoea 5
Zoea 4
Zoea 3
Sub-adult
Zoea 2
Adult
Berried
Female
Hatching
Zoea 1
Mating
Spawning
Eggs


carapace
dorsal spine
rostral
spine
lateral spine
Zoea 1
• sessile eyes
• abdomen with
5 segments
• small lateral spines
(↑) on abdominal
segments 3-5
Zoea 2
• stalked eyes
• lateral spines more
distinct on abdo-
minal segments 3-5
• small setae at inner
margin of furca (↑)
Zoea 3
• abdomen with 6
segments
• longer lateral
spines on segments
• periopod buds (↑)
distinct
Crab instar
• appears like small
crab
• abdomen (↑) folded
under carapace
Megalopa
• chelipeds (↑) well
developed
• carapace broad
Zoea 5
• chelipeds and
periopods distinct
• pleopods (↑) well
developed and bear
hairs
Zoea 4
• pleopod buds (↑)
distinct on segments
2-6

5.1.3 Culture techniques of mud crab:

Mud crab farming is done by two methods.

1. Grow- out culture:

In this method, young crabs are grown for a period of 5 to 6 months till they attain desirable size.

Mud crab grow-out systems are generally pond based, with or without mangroves.

The pond size varies between 0.5-2 ha, with proper bunds and tidal water exchange.

2. Fattening

Soft shelled crabs are reared for a period of a few weeks till their exoskeleton gets hardened. These 'hard' crabs are locally known as "mud" (meat) and fetch three to four times better price than the soft crabs. It is of two types

a. Fattening in ponds

Fattening can be done in small tidal ponds between 0.025-0.2 ha with a water depth of 1 to 1.5 m.

b. Fattening in pens and cages

Fattening also can be carried out in pens, floating net cages or bamboo cages in shallow estuarine waterways and inside large shrimp ponds with good tidal water influx. HDPE, netlon or bamboo splits can be used as the netting material.

Between these two methods, Fattening is more advantageous since the culture period is short and profitable, when enough stocking material is assured.

In India, grow-out culture is not popular, mainly due to non-availability of crab seeds and commercial feed.

5.1.4 Crab culture prospects in India

Crab culture in India has significant prospects, driven by growing demand, suitable species, and government initiatives. However, addressing challenges like disease management, water quality management, and regulatory frameworks is crucial for the industry's growth.

Species Suitable for Culture:

1. Mud crab (Scylla serrata): Native to Indian waters, high demand, and potential for large-scale culture.

Cultivation Methods:

1. Pond-based culture: Suitable for small-scale and large-scale farming.
2. Cage culture: Suitable for coastal areas with good water quality.
3. Recirculating aquaculture systems (RAS): Suitable for intensive culture and reducing water pollution.

Prospects:

1. Employment generation: Crab culture can create employment opportunities in rural areas.

2. Income generation: Crab culture can provide a lucrative income source for farmers.

3. Foreign exchange earnings: Increased crab exports can earn foreign exchange for India.

4. Diversification of aquaculture: Crab culture can diversify India's aquaculture industry.

Government Initiatives:

1. National Fisheries Policy (2020): Encourages crab culture and provides support for infrastructure development.

2. Pradhan Mantri Matsya Sampada Yojana (PMMSY): Provides funding for aquaculture infrastructure, including crab culture.

5.2 Species of edible oyster cultured

5.2.1 *Crassostrea madrasensis*

Edible oyster species suitable for culture in India.

The Indian backwater oyster is an irregularly shaped oyster with straight shells. The shell has a deep left valve and concave right valve. The hinge which joins the shells is narrow and long. The animal has a right and left mantle lobe which encloses the mantle cavity which in turn encloses the rest of the organs.

Biology

It is a euryhaline brackish water oyster, inhabiting backwaters, estuaries, ports and harbours. It also occurs occasionally in open sea as thick bed. It is found in intertidal zones at depths of around 4 m. It grows to a maximum size of 212 mm and larger ones are available in estuaries.

Oysters have separate sexes generally but hermaphrodites are also present. In one spawning, a female of length 80-90 mm size releases 10-15 million eggs. The eggs and sperm are discharged directly into the water, where fertilization and development take place. Larvae drift for few weeks and attach to substrate, when they are one-third millimetre long.

Breeding and larval development:

Males spawn first, which induces the females to spawn. The fertilized eggs settled at the bottom and reached morula stage within 4 h.

The 'straight hinge' or 'D' shell larval stage was observed after 20 h of fertilization and the larvae measured 66 μm in length on first day. Early umbo stage (100 μm) was obtained on 3rd day and late umbo stage between 12-15 days. Eyed and pediveliger stages were observed on 13-17 and 14-18 days, respectively. At pediveliger stage, the larvae developed functional foot, sank to the bottom. The pediveliger larvae settled down, losing the Velum totally.

The shell edges grew hexagonally and the larvae developed the characteristic adult features and metamorphosed into spat of 450 μm in length.

5.2.2 Culture techniques of edible oysters

Oyster seed are collected from estuaries by placing suitable collectors called **cultch** in the water column at appropriate period.

Cultch is the term used for spat / seed collector.

Selection of farm site

For site selection several factors are to be considered. Sheltered areas offering protection from strong wave action are preferred. From intertidal region to areas extending up to about 5 m depth can be considered for adopting suitable culture method. Similarly, the culture technique is adopted depending upon the type of substratum.

There are two types of oyster culture

1. **On-bottom culture method**
2. **Off-bottom culture**

On bottom culture

The oysters are grown either in the intertidal or subtidal area directly on hard substratum. For intertidal culture a minimum of 16 hours submergence is suggested to ensure adequate food supply. Oyster seed attached to the collectors are planted on the bottom and allowed to grow for the market.

Off-bottom culture

a. **Rack and Ren Method**

It is also called ren method. The racks are constructed in 1 to 2.5 m, depth There are several variations in the types of racks. The single beam rack consists of a beam placed and secured to the top of posts driven into the bottom.

A series of single beams are placed in a row. The crossbeam rack is constructed by placing cross bar on top of single posts and two long beams are secured on the end of cross beams. In the farm, the shell strings are suspended from racks. The mortality (including those fallen) is about 45%.

b. Rack and Tray Method

The nursery-reared single spat (cultch-free) measuring about 25 mm are transferred to trays of size 40 x 40 x 10 cm at a density of 150 to 200 oysterlings/ tray.

The tray is knitted with 2 mm synthetic twine of appropriate mesh and is suspended from rack. Once the oysters reach 50 mm length they are segregated and transferred to rectangular tray of size 90 x 60 x 15 cm these trays are placed on the racks.

c. Stake culture

A stake is driven into the substratum and on the top end one nail and on the sides two nails are fixed. The nail holds in position a shell with spat attached. The stakes are placed 60 cm apart.

In this method, the nursery rearing of spat is carried on the same stake. The growth rate of the oysters in this method is the same as that of the oysters raised by the string method. The production is estimated at 20 t/ha/year.

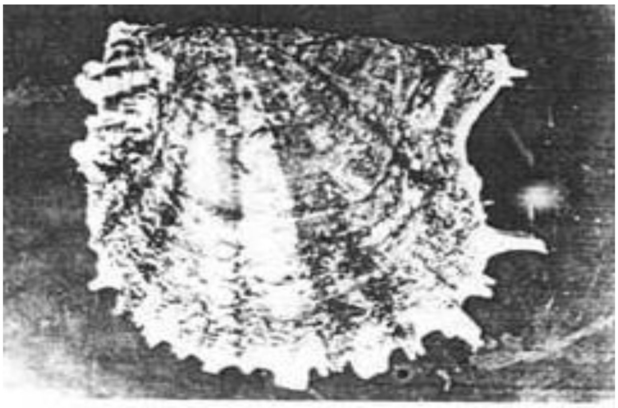
5.3.1 Important species of pearl oysters pearl oysters

The true pearl oyster belongs to the genus Pinctada (Roding) under the family Pteriidae, order Dysodonta.

Members belonging to the Pteriidae family are characterized by a straight hinge with 1–2 small tooth-like thickening. Six species of pearl oysters,
Pinctada fucata (Gould),
P. margaritifera (Linnaeus),
P. chemnitzii (Philippi),
P. sugillata (Reeve),
P. anomioides (Reeve) and
P. atropurpurea (Dunker)
occur along the Indian coasts.
Morphological characteristics are:

Pinctada fucata (Gould)

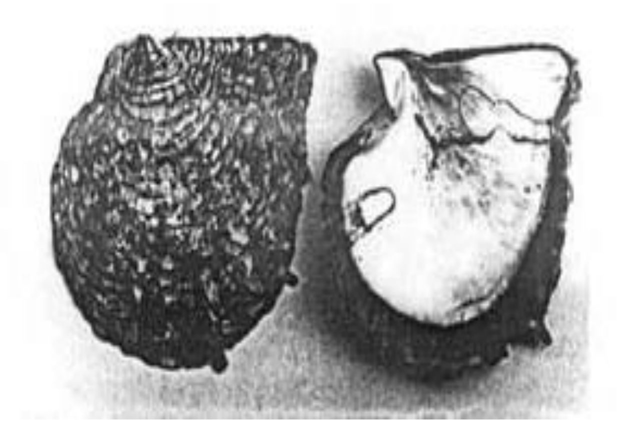
- The hinge is fairly long and its ratio to the broadest width of the shell is about 0.85 and that to the dorsoventral measurement is about 0.76.
- The left valve is deeper than the right. Hinge teeth are present in both valves, one each at the anterior and posterior ends of the ligament.
- The anterior ear is larger than in the other species, and the byssal notch, at the junction of the body of the shell and the ear, is slit-like.
- The posterior ear is fairly well developed. The outer surface of the shell valves is reddish or yellowish-brown with radiating rays of lighter colour.
- The nacreous layer is thick and has a bright golden-yellow metallic lustre.



Pinctada margaritifera (Linnaeus)

- The hinge is shorter than the width of the shell and has no teeth.
- The anterior border of the shell extends in front of the anterior lobe.
- The byssal notch is broad. The anterior ear is well developed while the posterior ear and sinus are absent.
- The posterior end of the shell meets the hinge almost at a right angle.
- Shell valves are moderately convex. Externally, the shell is dark greyish-brown with radially disposed white spots.

- The nacreous layer is iridescent with a silvery lustre except distally where it is black.
- This pearl oyster is also known as the Black-lip pearl oyster due to the dark marginal colouration of the shell.
- The width of the nacreous region at the hinge is about 2/3 that of the broadest part of the valves.



5.3.2. Method of artificial pearl production

Different species of oysters are used for pearl cultivation depending on the desired pearl characteristics

Artificial pearl production, also known as **<u>cultured pearl production, involves a surgical procedure called "grafting" where a smal</u>**l, foreign object (nucleus) is surgically implanted into the mantle tissue of a pearl oyster, causing the oyster to naturally secrete layers of nacre (mother-of-pearl) around the nucleus, creating a pearl over time; essentially mimicking the natural pearl formation process by introducing a controlled irritant.

<u>Steps in the process:</u>

1. Selecting the oyster:
Choosing healthy pearl oysters of suitable species.

2. Preparing the nucleus:
Creating a small, round bead made from a material like shell that will act as the core of the pearl.

3.Grafting procedure:
Anaesthesia is administered to the oyster. A small incision is made in the mantle tissue. The nucleus is inserted into the incision. A small piece of mantle tissue from a donor oyster (graft) may also be inserted alongside the nucleus to stimulate nacre secretion.

4.Post-grafting care:
Returning the oyster to a controlled water environment. Monitoring the oysters for signs of infection or rejection.

5.Harvesting:
After a period of time (usually several years), the oysters are harvested and the pearls are extracted.

Factors like the size, shape, and quality of the nucleus, as well as the care provided to the oysters, significantly impact the final quality of the cultured pearls.

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