Breeding biology and hatchery management of tiger shrimp (*Penaeus monodon)* 1

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Commercially important penaeid prawn:

Penaeus monodon :giant tiger shrimp/tiger shrimp

P. indicus: white shrimp

P. merguinsis: banana shrimp

P. japonicus: Kuruma shrimp

P. semisulcatus: green tiger prawn

P. penicillatus

P. Vannamei

P. chinensis

Metapenaeus monoceros

M. Dobsonii

M. Brevicornis

Parapenaeus sp., Parapenaeopsis sp., Trachypenaeous sp.

Among all the penaeid prawn, P. monodon is the most favoured candidate species for culture.

It has fast growth rate, attains large size, has high resistance to handling stress and hence exhibits high survival rate during culture.

It has also good consumer preference in domestic as well as in export market there by fetching maximum unit value.

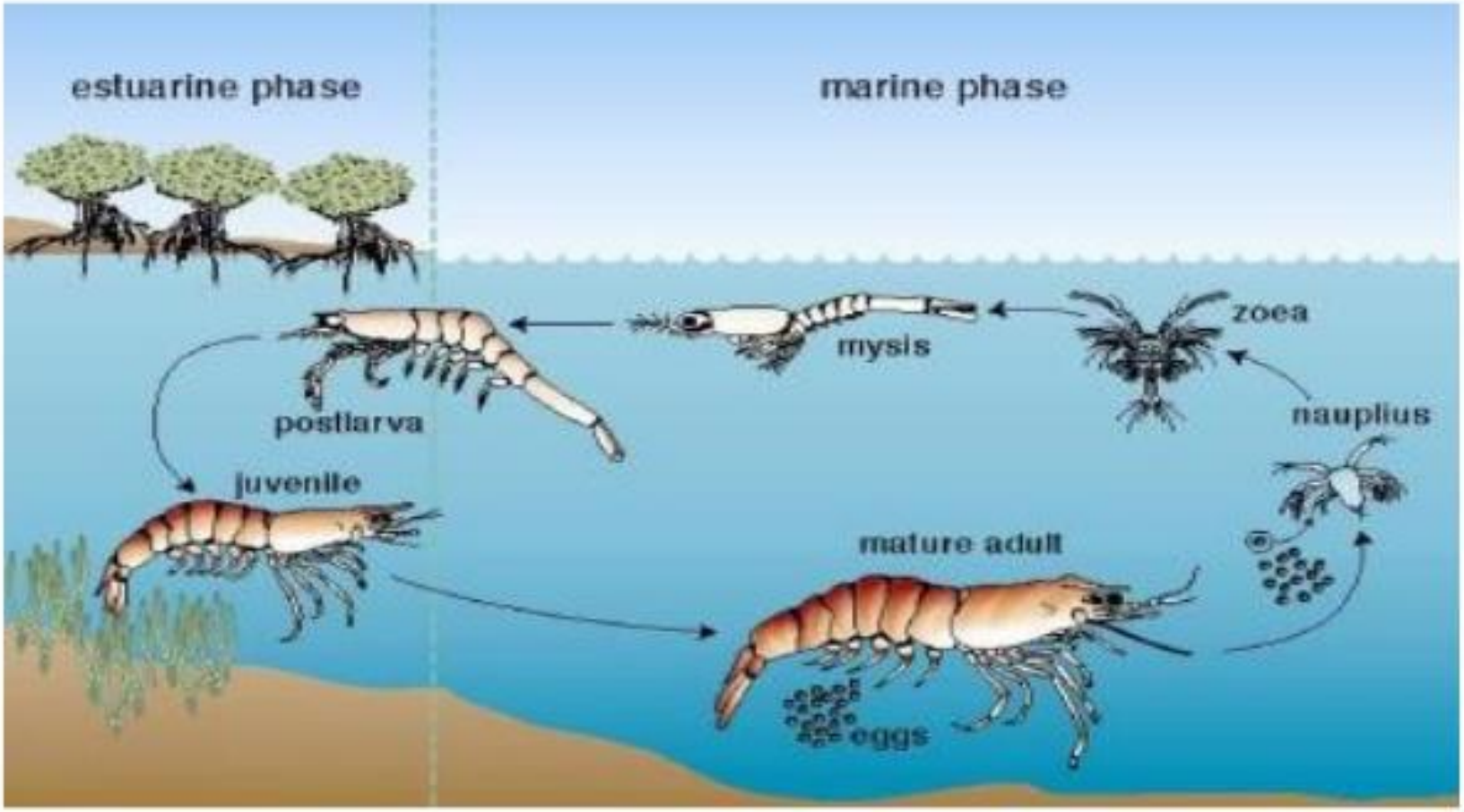
There are more than **50 species/ varieties** of shrimps available in marine waters, with a very wide distribution in both tropical and temperate ecosystems.

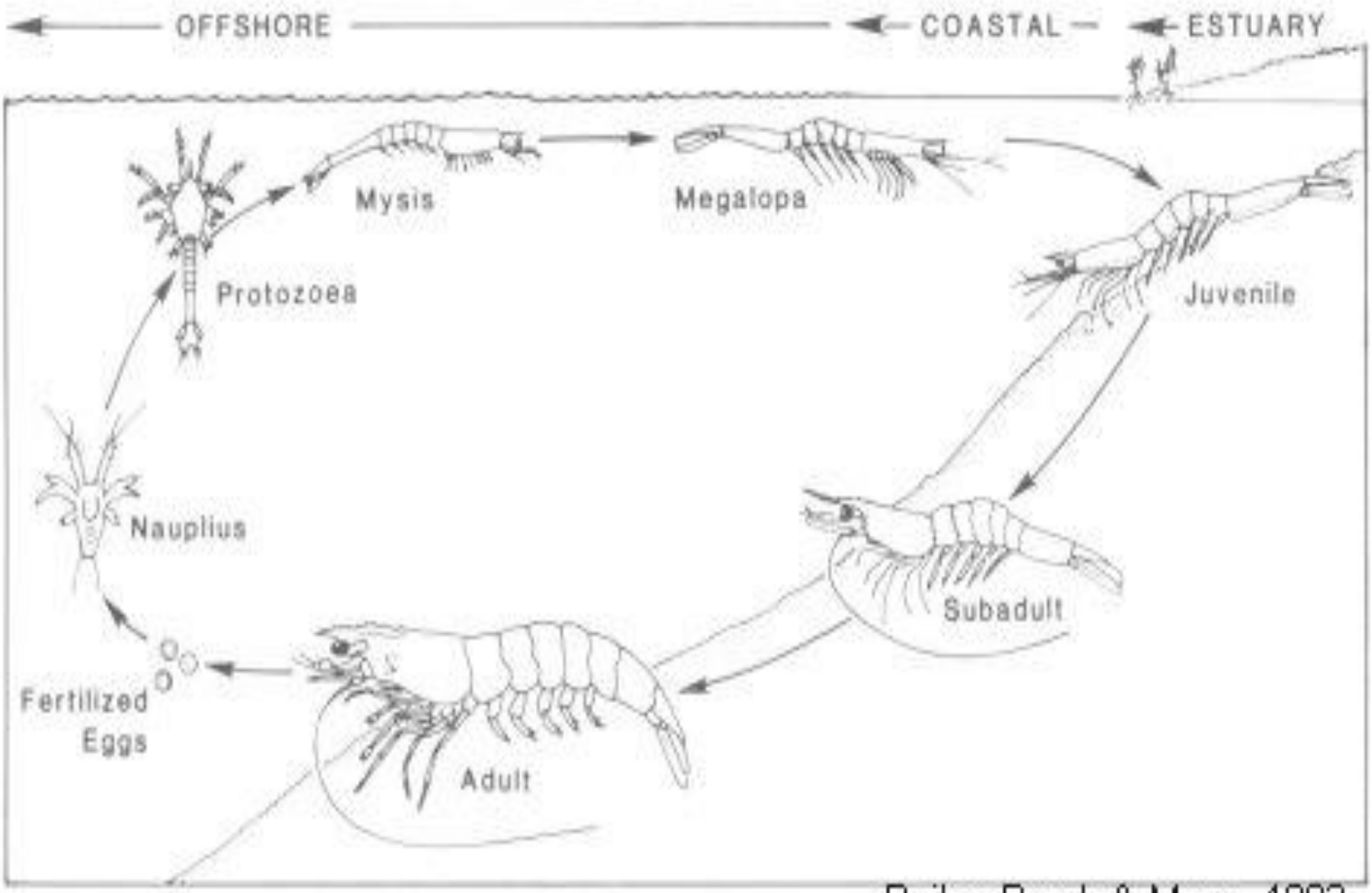
Most are very **small** and **not suitable for farming or human consumption**. However, the giant tiger shrimp (*Penaeus monodon), which is internationally known as tiger shrimp, has been* and continues to be the leading cultured species.

P. monodon is also the ***largest (maximum length 363 millimeters)*** and **fastest growing** of the farmed shrimp species. In India, other than *P. monodon, species such as P. indicus* (white shrimp), *P. penicillatus (like white shrimp), P. semisulcatus (green tiger prawn) and P. merguiensis* (banana shrimp) are also farmed, but the two shrimp species – *P. monodon and P. indicus form the* mainstay of shrimp aquaculture in the country.

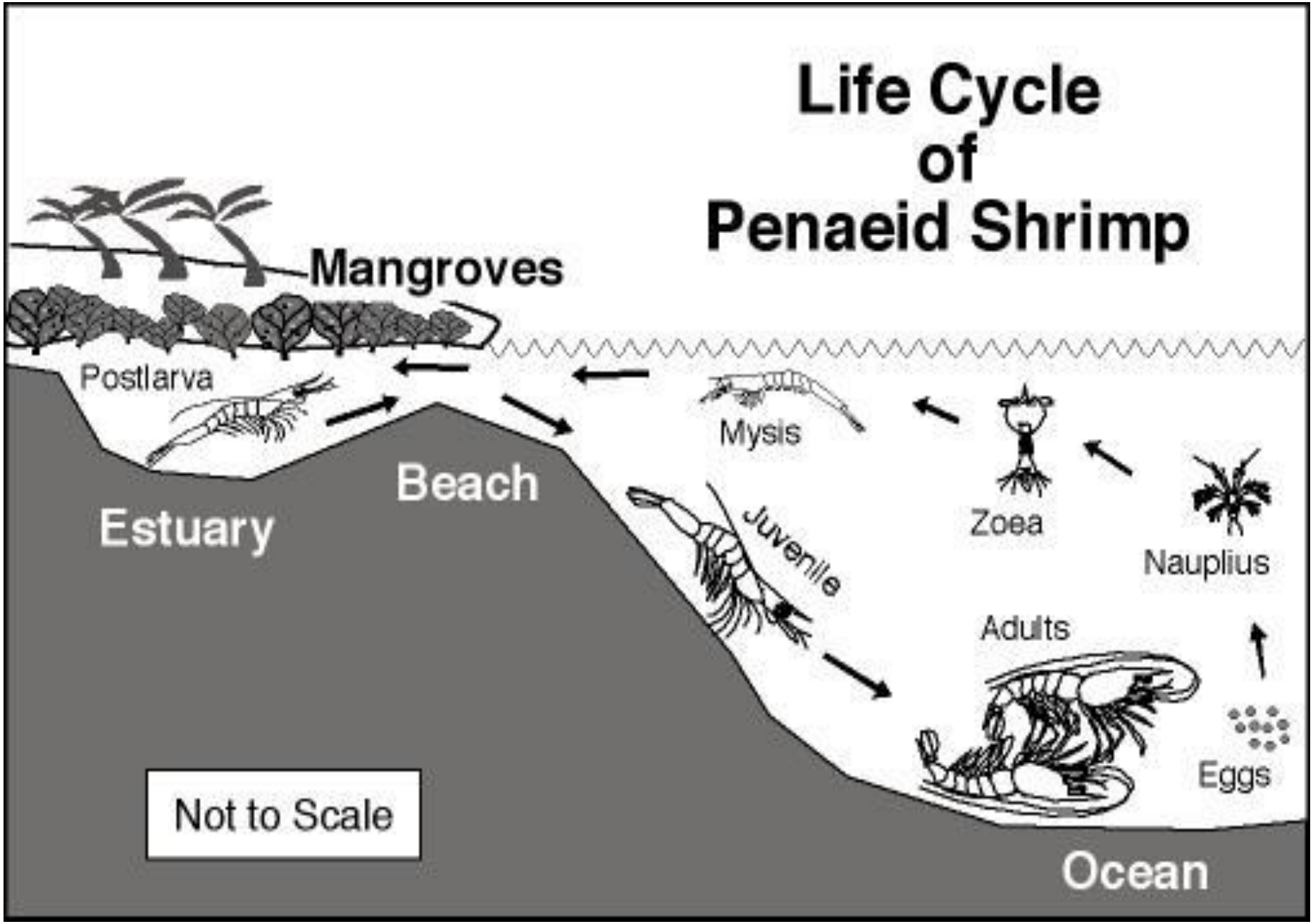
Assured supply of seed from hatcheries is one of the main reasons for this dependence. In traditional systems of farming, minor penaeid shrimps, which enter along with the tidal waters are also cultured.

Life Cycle of Penaeid Prawn





Bailey-Brock & Moss, 1992


Life Cycle
of
Penaeid Shrimp
Mangroves
Postlarva
Mysis
Beach
Estuary
Juvenile
Zoea
Nauplius
Adults
Eggs
Not to Scale
Ocean

Reproductive biology:

A) Age and size at first sexual maturity:

- ✓ According to Motoh (1981), in wild male mature at carapace length 37mm with body weight 35 gm and female at carapace length 47mm with body weight 68 gm,
- ✓ whereas in farm male mature at carapace length 31mm with body weight 20 gm and female at carapace length 39mm with body weight 41.3 gm.

According to Primavora (1988), male in both wild & farm mature at carapace length 38.5 mm with body weight 40 gm and

whereas female mature in wild at carapace length 46 mm with body weight 63 gm and in pond at carapace length 41 mm with 40 gm.

Male Reproductive system:

-There are a pair of testes located in the cephalothorax above the hepatopancrease.

-The testes is translusent, composed of six lobes, all the lobes are connected on inner margin leading to vasdeferens.

-Vasdeferens terminates in a muscular protion called as terminal ampoule which opens at the base of the coxa of 5^{th} pereipod.

-The produced spermatozoa are aggregated and stored in a bag like structure called spermatophores. Spermatophores are stored in the terminal ampoule.


0
10
30
40
50
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Female reproductive system:

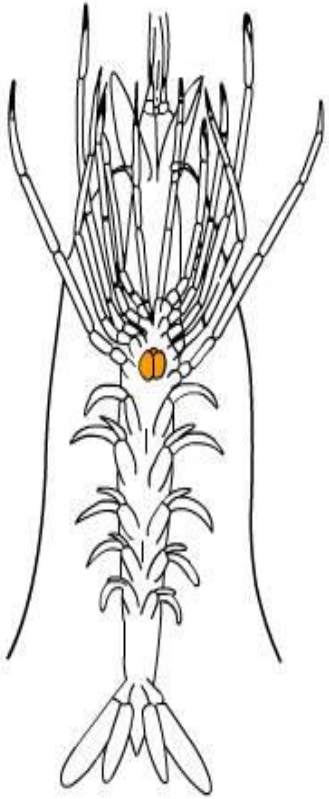
- There are a pair of ovaries which are partly fused extending almost the entire length of a mature specimen.
- Each ovaries consist of an anterior lobe, lateral lobes, located dorsal to the hepato-pancreas and an abdominal lobe lying dorso-lateral to the intestine.
- The oviduct originate from the sixth lateral lobe, leading to the external genital aperture located at the base of coxa of 3rd pereiopod.

EXTERNAL REPRODUCTIVE ORGANS

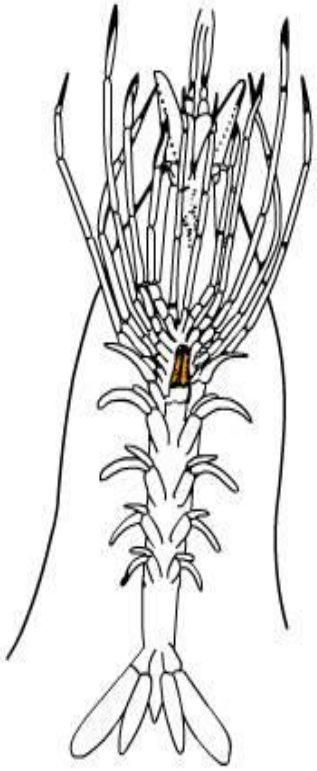
FEMALE

MALE

Adult Shrimps (Male & Female)



Female



Male

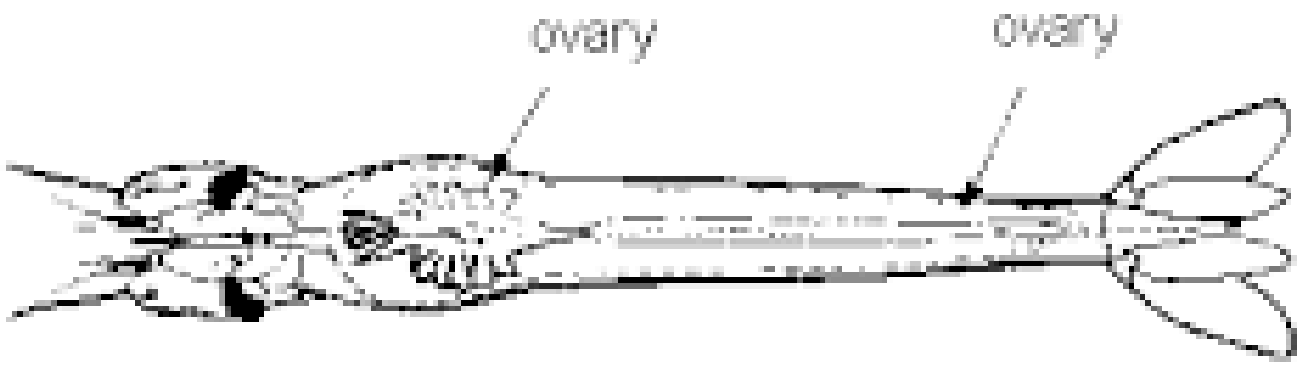
Five stages of the ovarian development are discernible based on changes in colour, size, shape and texture of the ovary in course of development.

Stage I: Immature stage:-

The ovary are thin, transparent and unpigmented. Ovaries are not visible through the dorsal exoskeleton.

Stage II: Early maturing stage:-

Externally, ovaries are flaccid (soft and weak not firm), white to light yellow to yellow green in colour. Through the exoskeleton, it is discernible (able to seen or understood or recognized) as a linear band.



Dorsal view of female, dissected to show ovaries

The yolk granules are also formed in the cytoplasm of the Oocyte.

it is at this stage that inhibitory hormones secreted by the X-organ-sinus gland complex located in the eye stalk prevent further ovarian growth when females are held in captivity in tanks.

Captive conditions stimulate the secretion of ovary inhibitory hormones. Unilateral eye stalk ablation is practiced at this stage, one of the X-Organ sinus gland complex which produces ovary inhibiting hormone so that block in ovarian development is removed.

Stage III: Late maturing stage:-

The ovaries are visible to the nacked eye as a thick dark, linear band through the exoskeleton. Maturing Ova are opaque due to the accumulation of yolk in their Ooplasm.

:

Stage IV: Mature stage:-

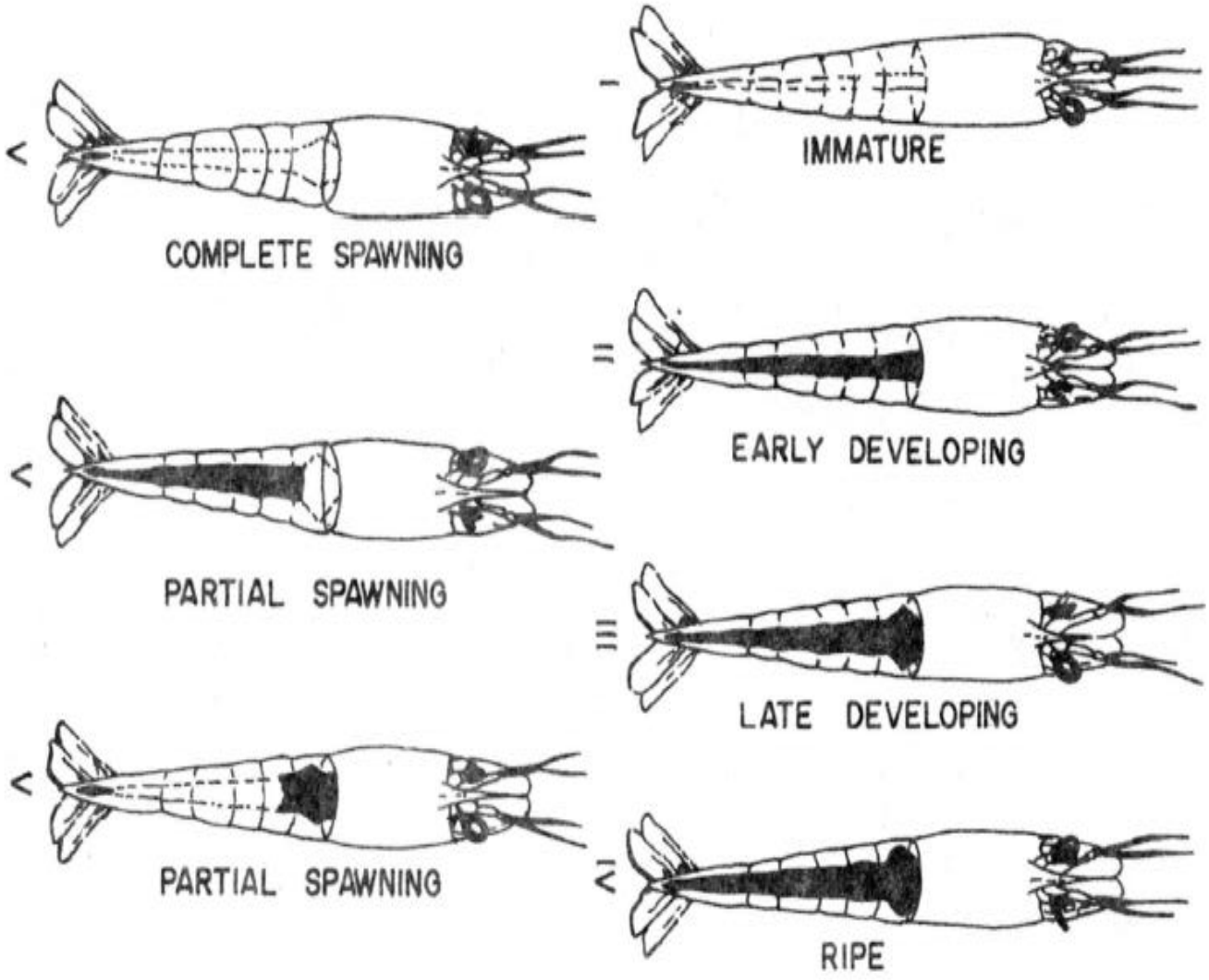
Ovaries are dark green in colour due to the accumulation of carotinoid pigmentation. In the first abdominal segment it assumed a distinct diamond shape which is called saddle.

The Oocyte develop cortical granules.

Oocytes are released into the oviduct during ovulation. Ovulation is followed by oviposition i.e. release of eggs from oviduct into water.

Stage V: spent/recovery:-

After extrusion of eggs, the ovaries reverts to immature condition. It appears as a thin linear band.

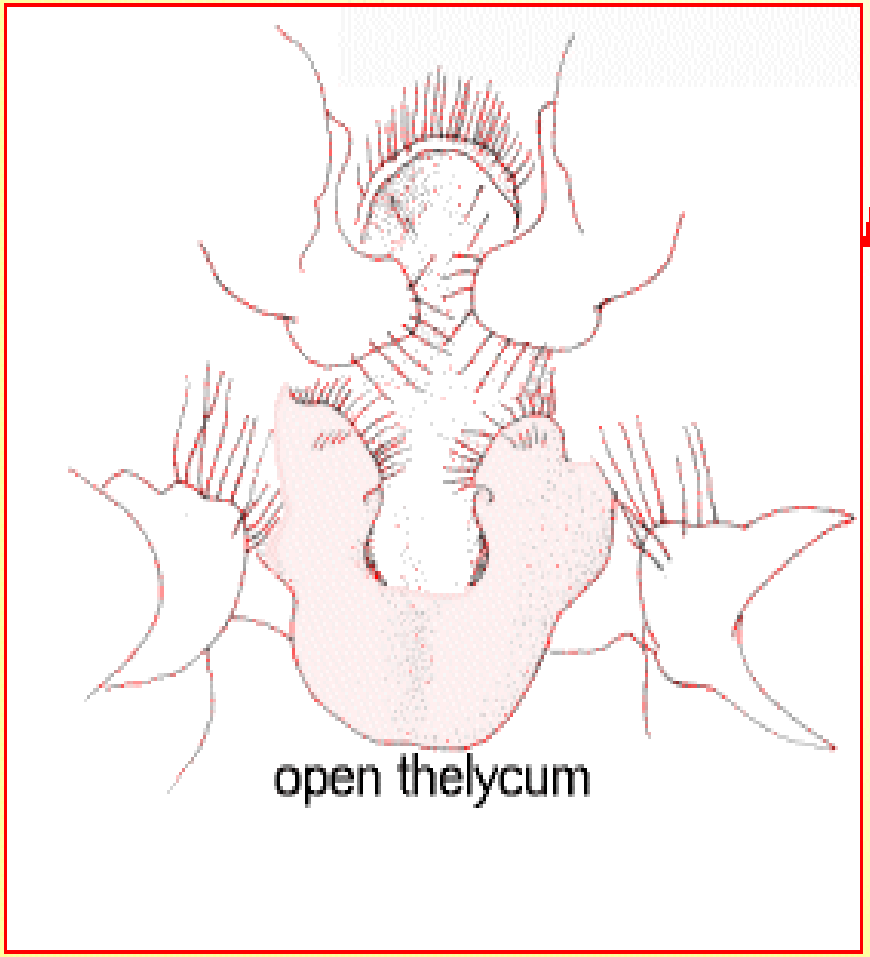

COMPLETE SPAWNING
IMMATURE
EARLY DEVELOPING
PARTIAL SPAWNING
LATE DEVELOPING
PARTIAL SPAWNING
RIPE

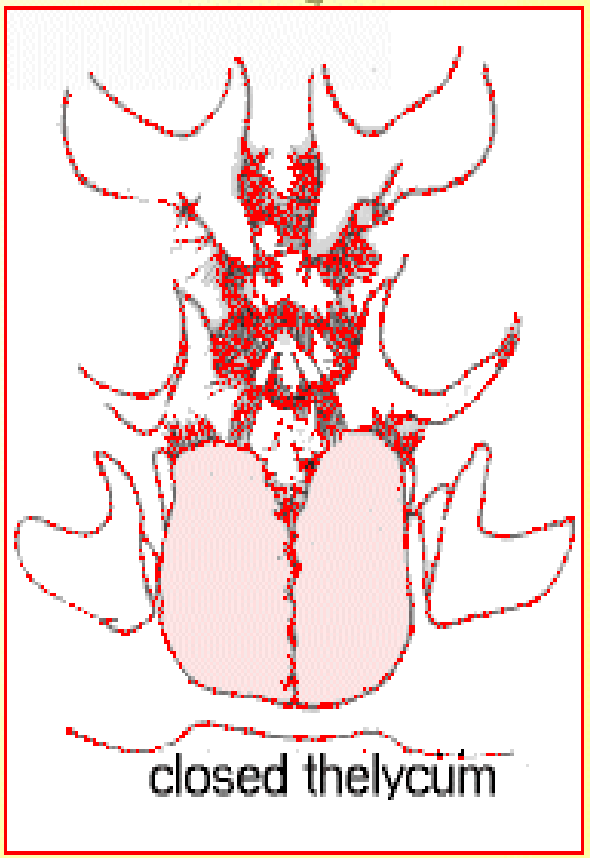
Sexual dimorphism:

Male	Female
❑ Presence of petasma in the first pleopod. (Petasma is formed by the fusion of endopodites of the first pleopod along their inner margin).	▪ Petasma is absent in the first pleopod in female.
❑ Appendix masculina is present in second pleopods.	▪ Appendix masculina is absent.

- Thelycum is absent.

- A thelycum is present in the thoracic sterna between pereopods IV and V. it is meant for storing the spermatophore. It consist two lateral plates and a median plates. The lateral plates enclose a seminal receptacle for storing spermatophores.


open thelycum


closed thelycum

- Gonopore is located at the base of 5^{th} walking leg.
- Smaller in size.

- Gonophore is located at the base of 3^{rd} walking leg.
- Larger than male of the same age group.

Mating:

Mating usually occurs between the hard shelled male and freshly moulted female. This facilitates the insertion of spermatophore from male into the seminal receptacle of the thelycum of female.

The spermatophore in the thelycum can be easily seen externally by vertical, milky white streaks on both sides of thelycum.

Breeding season

- Breeds throughout the year.
- In the case of P. monodon in Southeast Asian waters, there are two pronounced spawning season, from December to March and June to September with only one pronounced period, viz: June-September in the case of P. merguiensis and P. indicus.
- While spawners of these species of shrimps are supposedly available all year round, they are abundantly caught during the spawning season.

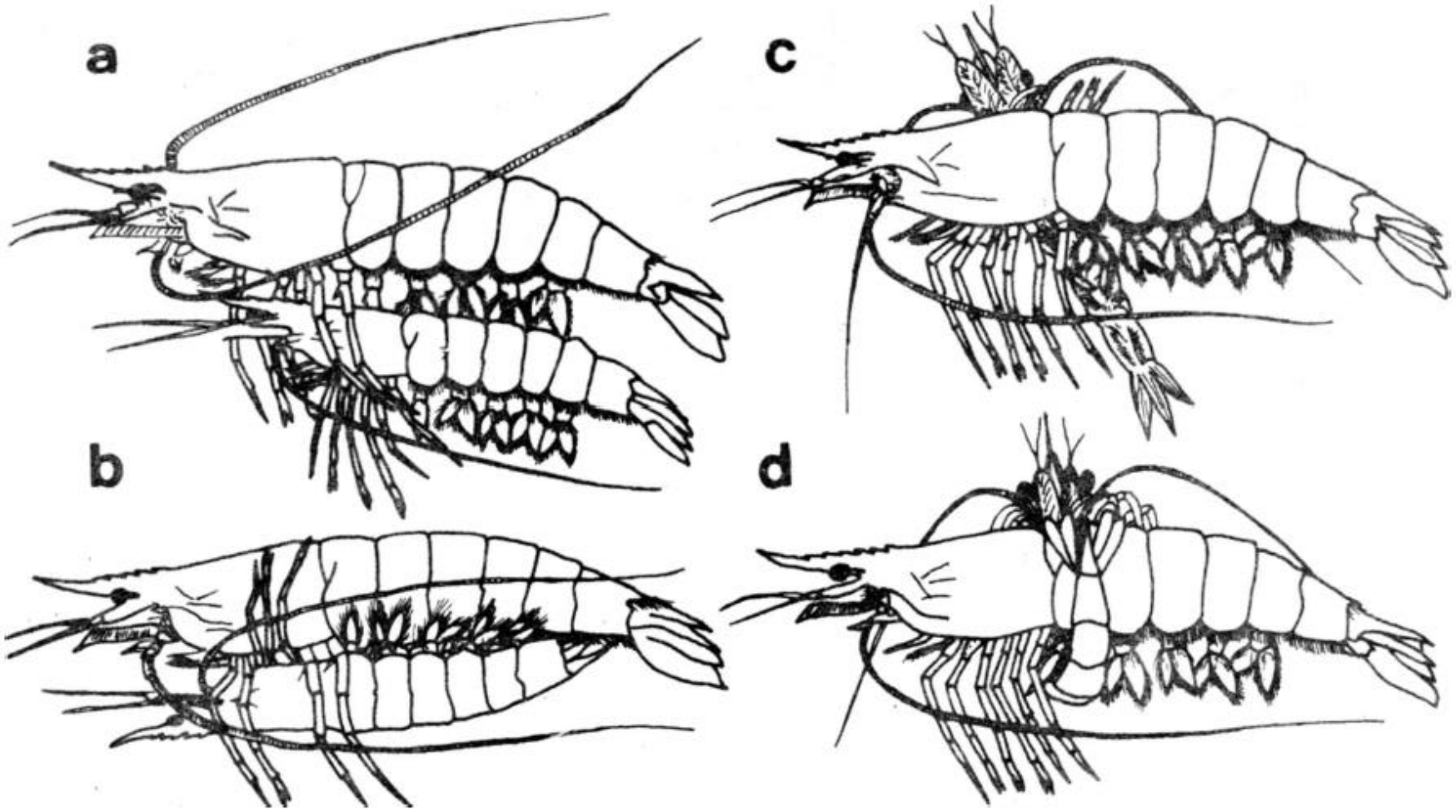


Fig. 3. Courtship and mating behavior in *Penaeus monodon*. (a)Female above-male below in parallel swimming; (b) Male turns ventral side up and attaches to female; (c) Male turns perpendicular to female; and (d) Male curves body in a U-shape around female and flicks head and tail simultaneously. (*Redrawn* from J.H. Primavera, *Crustaceana* 37:287-292. 1979.)

Spawning:-

A female with fully developed ovaries spawns during night between 10 pm to 2 am.

During spawning the shrimp bends it body posterior to 4^{th} abdominal segment and 3 pair of preopods are held tightly together and are flopped vigorously.

Release of egg is brought about by contraction of cephalothoracic and abdominal muscles as the eggs are extruded through the female gonophore located at the base of 3^{rd} pereiopod.

Side by side, stored sperm are also released from the thelycum to fertilize the eggs. Where the eggs appear as greenish and sperm whitish cloud extruding from beneath the female as she swims.

Fecundity:

The fecundity ranges from 2 to 10 lakhs per female with an average of 5 lakhs.

Egg:

Each newly laid egg is 250-300 µm in diameter and of irregular shape.

The first meiotic division takes place after 2-5 minutes and second meiotic division takes place 8-14 minutes after spawning.

After it comes in to contact with water, it extrudes jelly like substance from the cortical crypts of the eggs and the same is completed within 8 minutes.

The jelly like substance harden in to a tough transparent shell-the hatching envelop by 12 to 15 minutes post spawning.

This envelope is supposed to act as a protective envelope, acting as a shield against pathogenic organisms and toxicants.

The male nucleus united with female nucleus and the zygote nucleus is formed.

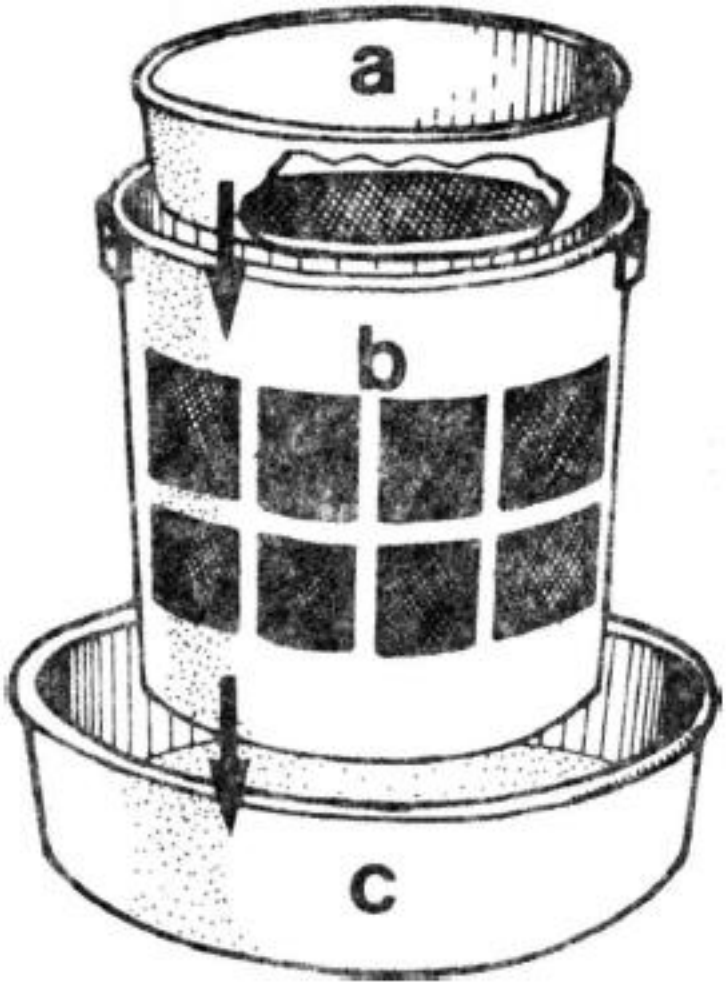


Fig. 9. Egg washer for *P. monodon* (arrows indicate flow of water). Container A (0.35 mm mesh) retains scum and large particles but allows eggs to pass through. Container B (0.25 mm mesh of windows) retains eggs but allows fine particles to pass through. Container C holds both A and B; it keeps eggs immersed in seawater.

Cleavage:

First cleavage is holoblastic and equal and it takes place 30-60 minutes after spawning.

Unfertilised eggs has either not divided or assymetrically.

Incubation period:

Hatching occurs after 12-13 hr of spawning. Egg hatch into nauplius and pass through different larval stage.

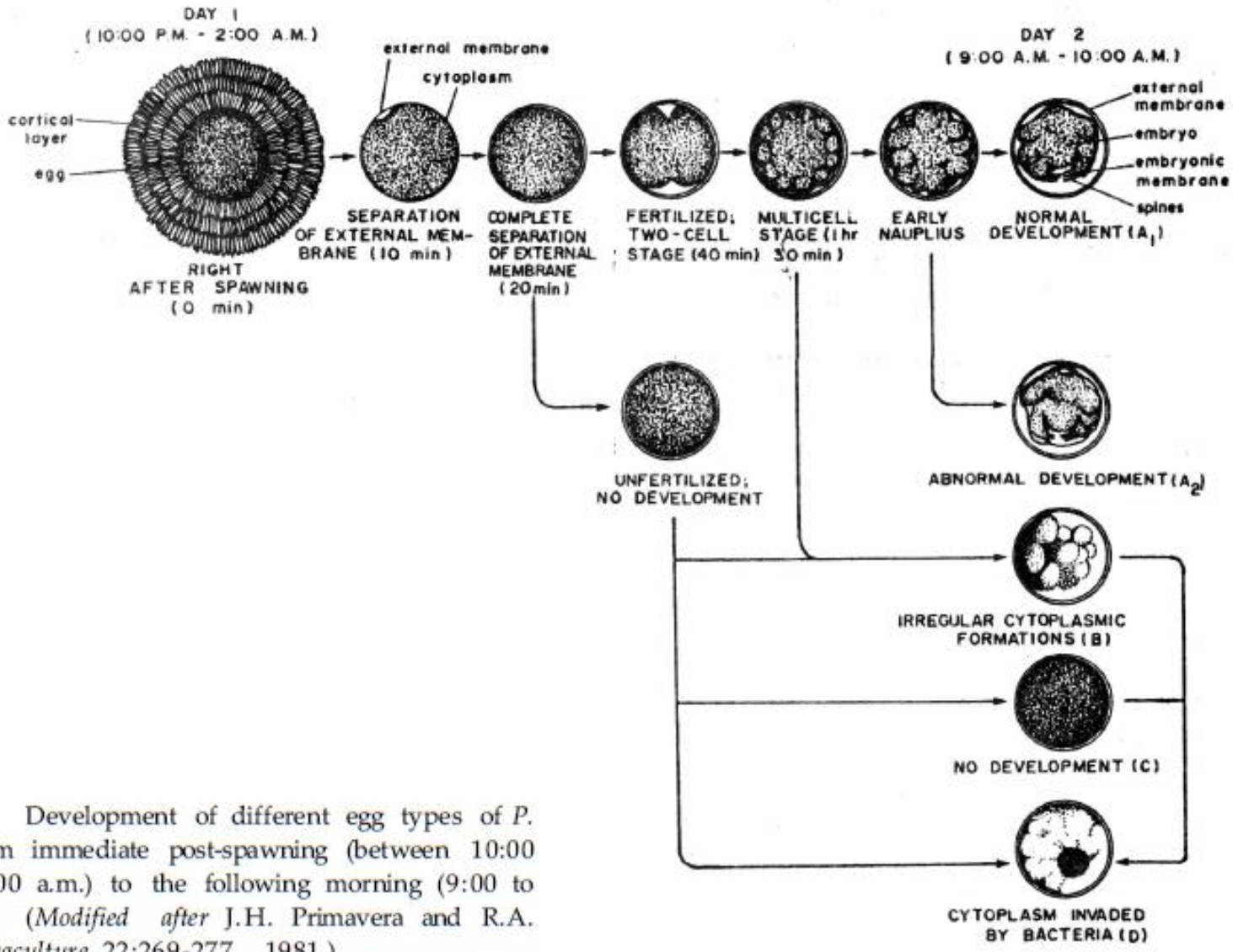


Fig. 5. Development of different egg types of *P. monodon* from immediate post-spawning (between 10:00 p.m. and 2:00 a.m.) to the following morning (9:00 to 10:00 a.m.). (*Modified after* J.H. Primavera and R.A. Posadas. *Aquaculture* 22:269-277. 1981.)

Larval stages:

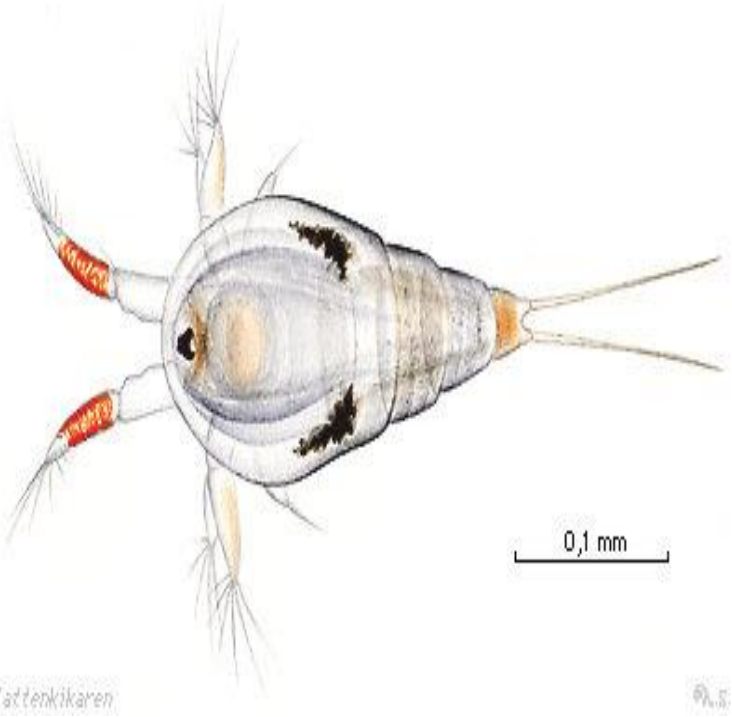
Nauplius- 6

Protozoea- 3

Mysis- 3

Postlarva.

Nauplius:



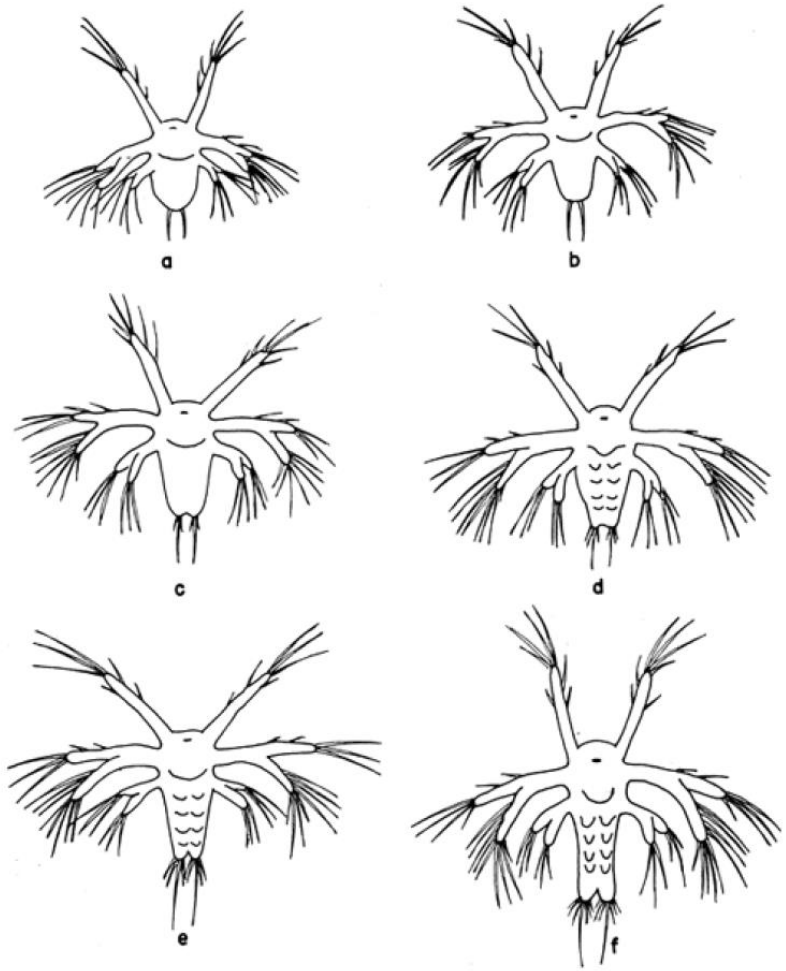


Fig. 16. NAUPLIUS STAGES

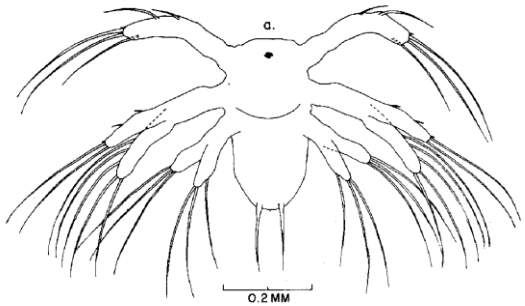
a. Nauplius I
b. Nauplius II
c. Nauplius III
d. Nauplius IV
e. Nauplius V
f. Nauplius VI

Nauplius:

- A newly hatched nauplius larva is 0.34 mm in size and dark yellow in colour.
- The first larval stage is known as nauplius. The unsegmented body which is pyriform in shape possesses three pairs of appendages. The nauplius undergoes six moltings within 50 hours into a protozoea.
- It is oval in shape having 3 pairs of appendages- a uniramous antennule, biramous antenna and a mandible. The appendages are locomotory in function, antenna being most active.
- They are attracted toward light.

- when at rest, it keeps its dorsal side down, remaining in water in a perpendicular position with 3 pairs of appendages slanting upwards.
- The nauplius is a non-feeding stage as it utilises the reserve nutrients of the egg stored in it. As it grows it moults once in 4-6 hrs. there are six naupliar stages, each stages is formed after the moulting of previous stage.
- The duration of the nauplius stage is 36-48 hrs.

Nauplius I:



Size – 0.29 to 0.32 mm

Furcal formula- 1+1

First antenna- inner seta two numbers-distal one longer than proximal. Terminally two long and one rudimentary seta. Outer distal margin has one long seta.

Second antenna- exopodite has 5 long setae along inner margin. Endopodite with 2 short inner lateral setae and terminally 2 long setae and a minute setal rudiment.

Mandible- 3 long setae are present on exopodite and also on endopodite

Duration- 3-4 hr.

Nauplius II:

Size – 0.31 to 0.32 mm

Furcal formula- 1+1

First antenna- Outer terminal and outer lateral setae are comparitavely shorter. Rudimentary seta of stage I develops into a seta. Another setal rudiment added to outer distal portion.

Second antenna- on exopodite, 4^{th} seta from proximal end is bifurcated.

Mandible- same as in stage I

Duration- 3-4 hr.

Nauplius III:

Size – 0.31 to 0.34 mm

Furcal formula- 3+3

First antenna- outer terminal seta is shorter than inner terminal. Outer lateral seta is short. Another seta is short. Another seta added proximal to inner lateral seta.

Second antenna- Exopodites has six plumose setae and a setal rudiment. Setal rudiment of endopodite has grown into short non plumose setae.

Mandible- same as in stage I.

Duration- 3-4 hr.

Nauplius IV:

Size – 0.34 to 0.36 mm

Furcal formula- 4+4

First antenna- Outer distolateral seta lost. Inner terminal seta is longer.

Second antenna- Exopodite exhibits faints segmentation. Setal rudiment of stage III develops into seta and another 2 setal rudiments are developed one terminally, another proximally in inner margin. The endopodite has longer, inner terminal seta and another setal rudiment developed terminally.

Mandible- Base of mandible is swollen.

Duration- 5-6 hr.

Nauplius V:

Size – 0.36 to 0.41 mm

Furcal formula- 6+6

First antenna- Minute seta is added on outer lateral margin. Proximal half exhibits faint segmentation.

Second antenna- Exopodite with outer most seta longer but still non plumose.

Mandible- same as stage IV.

Duration- 10-12 hr.

Nauplius VI:

Size – 0.46 to 0.53 mm

Furcal formula- 7+7

First antenna- Two more setae added to outer margin.

Second antenna- Exopodite develop 2 more setae. Endopodite with 4 terminal setae out of which 3 are long and one short. Another short seta is added to base.

Mandible- Basal swelling more prominent. Cutting edge of mandible seen

Duration- 15-16 hr.

Protozoea:

- As the nauplius grows to protozoea, it starts feeding. It moults three times, there by distinguishing three stages such as protozoea I, protozoea II and protozoea III.
- The body becomes elongated with a distinct cephalothorax. The early protozoea stage has a pair of protruded compound eyes, the next stage is characterized by the presence of a rostrum and the late protozoea stage has a pair of uropods.
- After 4–6 days, the protozoea finally metamorphoses into a mysis.

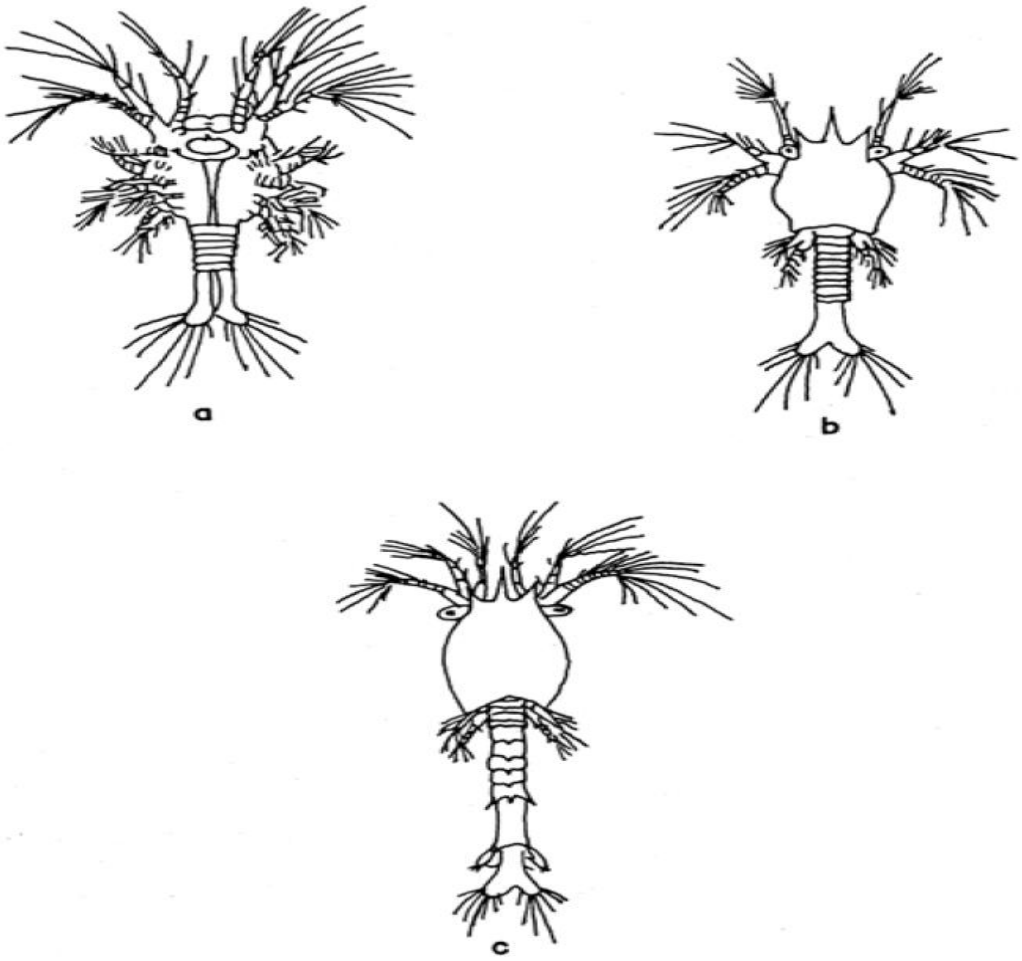


Fig. 17. PROTOZOEAL STAGES

a. Protozoea 1

b. Protozoea 2

c. Protozoea 3

Protozoea I:

It has an elongated body anterior part of which is covered by a carapace. Behind the carapace there is slender thorax which is six segmented.

Average total length is 1.06 mm and carapace length is 0.47 mm.

Posseses sessile compund eye.

The rostrum and spines on the carapce are not developed.

Appendages

- first antenna is three segmented, proximal segment is further subdivided into five segments.
- second antenna: the exopodite has 9 to 10 segments and endopodite is two segmented, both bear setae.
- Mandible: it has incisor and molar process, with free teeth in between.
- first maxilla: it has a protopodite with 2 segments- proximal segment with six and distal segment with four setae. Exopodite has four feathery setae; endopodite is three segmented with setae.

- second maxilla: the protopodite with five endites each having setae. Endopodite is four segmented. Exopodite with five feathery setae.
- Maxilliped: the first two maxillipeds are develpoped, protopodite with two indistinct segments, endopodite is four segmented, expodite unsegmented, 3rd maxilliped absent.
- Pereiopods and pleopods are absent.
- telson is not distinctly seperated from last abdominal segments, uropods are absent. Setae of telson 7+7.

Protozoea II:

The body is distingusible into anterior carapace, middle six segmented thorax and posterior abdomen which is five segmented.

Posses stalked compound eye.

Develop rostrum and supraorbital spines which are bifurcated

Appendages: all appendages are same as protozoea I but mandible get more developed.

Size: total length 1.06 mm and carapace length 0.72 mm.

Protozoea III:

The body is elongated and distinguishible in to anterior carapace, middle six segmented thorax and posterior six segmented abdomen.

Each of the first five abdominal segments develop dorsal spines, 5^{th} with additional postero lateral spine, 6^{th} with the additional postero-lateral and ventrolateral spine.

Telson get separated from the last abdominal segment.

Appendage:

First antenna: five basal segments are fused into one.

Second maxilla: same in stage II

Mandible: right with two and left with six standing teeth.

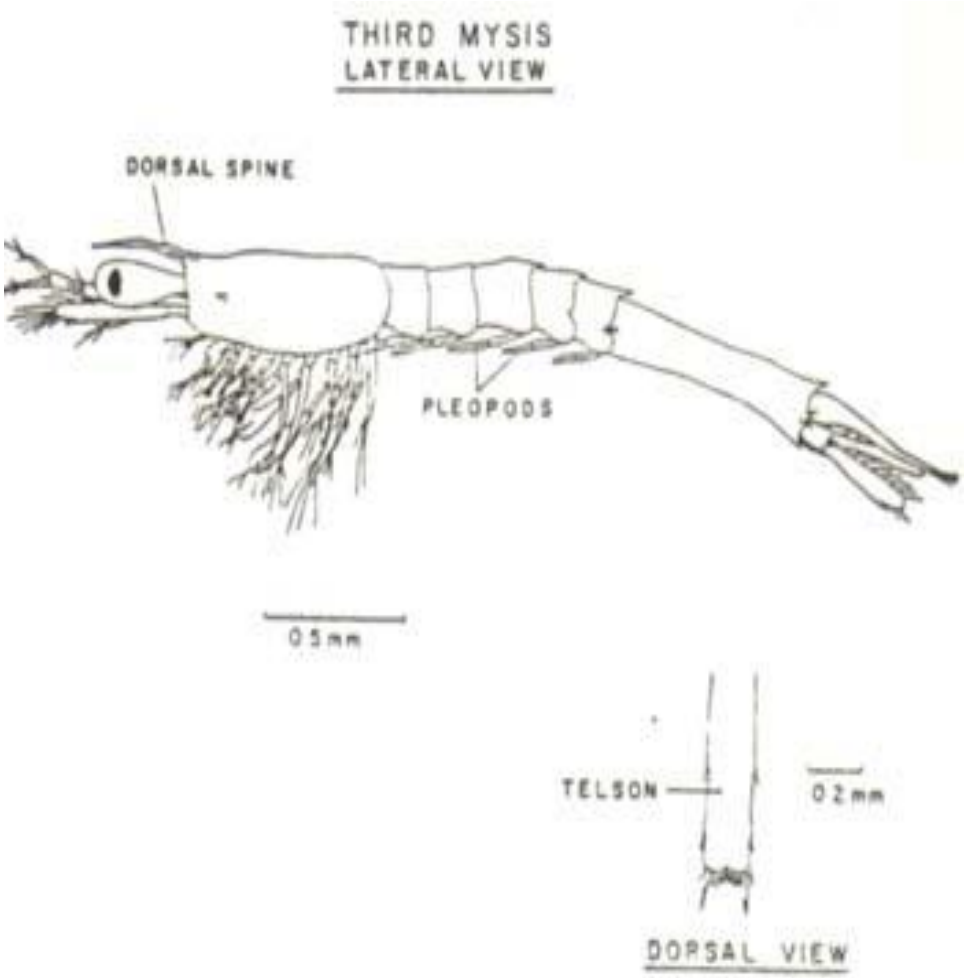
First Maxilla and second maxilla: same as in stage II but more setae appear.

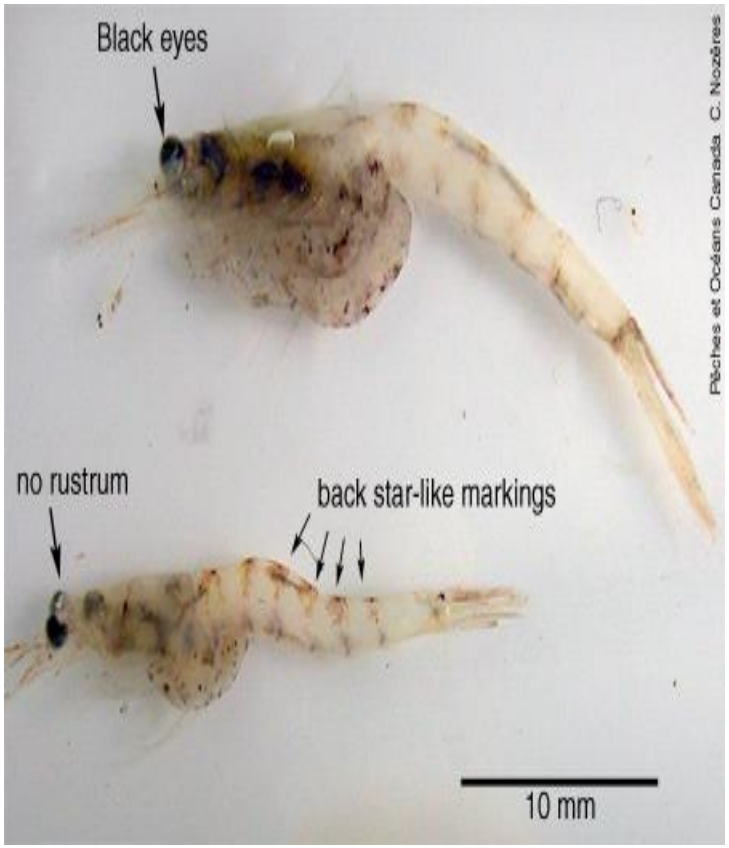
Maxillipeds: first two maxillipeds develop more setae and third maxilliped appear.

Five pereiopods appear.

Uropods appear

Mysis:


THIRD MYSIS
LATERAL VIEW
DORSAL SPINE
PLEOPODS
0.5mm
TELSON
0.2mm
DORSAL VIEW


Black eyes
no rustrum
back star-like markings
10 mm
Pêches et Océans Canada. C. Nozères

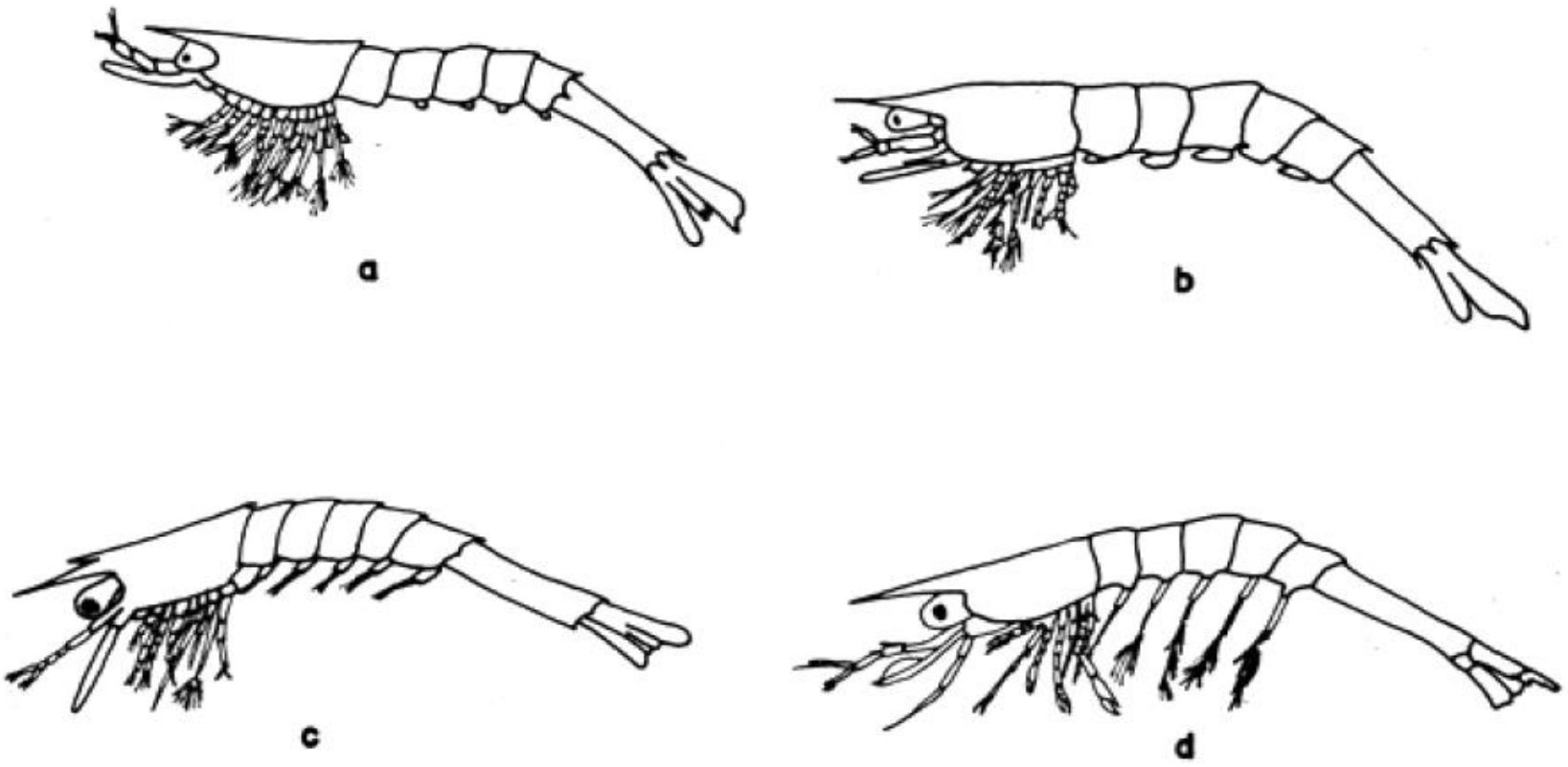


Fig. 18 A & B. Mysis and post larval stages

a. MYSIS 1
b. MYSIS 2
c. MYSIS 3
d. POSTLARVAE 1

At this stage, the larvae assumes the form of a juvenile shrimp at which the pleopods are to develop. At this stage, tiny protrusion known as pleobases, are seen on the ventral side of the abdominal segments.

The next stage is marked by the development of first segment of the pleopods development.

The mysis remain drifting in the water column until they metamorphose into post larvae within 10–12 days.

Presence of a well developed carapace covering the thorax also

Functional 3rd maxilliped and 5 periopods each having exopodites.

1st three pereiopods have rudimentary chela

Presence of rudimentary pleopods having no setae.

Exopodite of antenna is scale like, losting its segmentation.

Telson is well developed and notched medially.

Length of rostrum is more than half the length of carapace

The first and second antenna are olfactory in function.

Five pairs of pleopods are locomotory in function assisted by three pairs of maxillipeds. It measures 3.28 to 4.87 mm in length.

Mysis swims with their head down, telson up, keeping the body in a slanting position. They are not attracted toward light.

Mysis stage last for three days during which they moult 3 times.

Clear cut morphological differences donot exist between 3 substages of mysis except due to difference in size of the body, length of pleopods and number of setae in the antennal scale, maxillary exopod and uropod.

At end of 3rd stage, mysis attain a size of 3.1 mm to 4.5 mm.

At post larval stages, **the pleopods become fully developed and functional.**

The animals grow very fast in terms of size and are able to swim freely although early postlarvae are still planktonic in offshore waters.

At a body size of 0.8–1 cm in body length, they enter estuaries and inshore shore waters where they first adopt a benthic existence.

The shrimps spend their juvenile, adolescent and sub-adult stages in estuarine waters and then gradually move toward deeper water as they grow and eventually returning to offshore water when they attain sexual maturity.

Feeding:

Nauplius- not feeding stage

Both protozoea and mysis are filter feeder as their mouth parts are adapted for the same. The maxillae has numerous close set setae on the endopodite. Each seta has fine setule pinnately arranged on either side. This form filtering apparatus.

Unicellular algae are the choice food of protozoea and mysis.

Protozoea I prefer isochrysis.

Protozoea II prefer chaetoceros & cylindrotheca

Protozoea I prefer platymonas & spirulina

During mysis stage larvae feed on unicellular algae and also on zooplankton like brine shrimp nauplii.

Post larvae:

Mysis metamorphose into postlarvae.

Transformation in mouth: mandible develop sharp cutting edge in place of loose serrated teeth. Maxilla loses the filtering setae, endopodite become highly reduced. Protopodite of 1st maxilliped develop stiff bristles.

Chela on pereopod become functional.

Later five pairs of pleopods get fully developed and are used for swimming.

Uropods assist in balancing.

Pereopods are used for walking and grasping.

Characteristic larval behavior:

1) Attraction toward light:

Nauplius: attracted toward light

Protozoea: attracted toward light

Mysis: not attracted toward light

postlarvae: not attracted toward light

2) Locomotion:

Nauplii remain with ventral side up in water. They swim with help of antennule, antenna and mandible.

Protozoea is a very active swimmer and it swims with dorsal side up.

During mysis stage, it is relatively sluggish, hanging with anterior end pointing oblequely downwards. It hovers around, suddenly jumps back flexing the abdomen. Post larvae swim horizontally because of plumose (feather like structure) setae on pleopods.

Habitat:- in nature, the larvae remain in the bottom layers upto mysis stage. They come to surface only in the postlarval stage. They gradually drift towards the coasts carried by water current and are found in swarms. They become euryhaline and are found in coastal water creeks, estuaries and lagoons.