Breeding biology and hatchery management of giant freshwater prawn (*Macrobrachium rosenbergii*)

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- About 125 species of Macrobrachium are distributed in tropical and subtropical region out of which 49 species are of fisheries importance and 15 species are of cultural significance.
- Found in fresh water area like river, lakes, swamp, canal, ponds and estuarine areas.
- Large species are: *M. rosenbergii, M. americanum , M. carcinum, M. malcomsonii*

- Most species require brackish water in the initial stages of their life cycle (and therefore they are found in water that is directly or indirectly connected with the sea) although some complete their cycle in inland saline and freshwater lakes.

- Some species prefer rivers containing clear water, while others are found in extremely turbid conditions. *M. rosenbergii is an example of the* latter.

M. rosenbergii- Giant fresh water prawn

M. malcomsonii- Indian river prawn

M. Americanum- Cauque river prawn

M. carcinus - Painted river prawn

M. choprai - Ganges river prawn

M. lar - Monkey river prawn

M. Malcolmsonii- Monsoon river prawn

M. Vollenhovenii -African river prawn

MACROBRACHIUM ROSENBERGII

Macrobrachium rosenbergii

Fresh water prawn (Scampi)

SYSTEMATIC POSITION

Class-Crustacean

Order- Decapoda

Family- Palaemonidae

Genus- Macrobrachium

Species- *M.rosenbergii*

MACROBRACHIUM ROSENBERGII

- It has a very long rostrum, with 11-14 dorsal teeth and 8-10 ventral teeth (the ventral characteristics are especially important).
- The tip of its telson reaches distinctly beyond the posterior spines of the telson.
- The adult male has very long second chelipeds in which all segments are elongate and have blunt spines.
- The movable finger of the second chelipeds of the adult male is covered by a dense velvet- like fur (except the extreme tip) but this fur is absent from the fixed finger and the rest of the cheliped.
- It is the largest known of all Macrobrachium species, adult males having been reported with a total body length of up to 33 cm, and adult females of up to 29 cm.

General Biology

- Generally male(320 mm) larger than female(250 mm)-FAO.
- Nocturnal, hiding under shades in day time, omnivorous bottom feeder, found in extremely turbid conditions.
- Lives in tropical freshwater environments influenced by adjacent brackishwater areas.
- Food includes algae, mollusc, aquatic insects, worms, and other crustaceans.

- Larvae mostly consume zooplankton (mainly minute crustaceans), very small worms, and larval stages of other crustaceans.
- Three distinct male morphotypes exist: small male (SM), orange claw males (OC), and blue claw males (BC).
- Rostrum: 11-14/8-10
- Salinity range: 0-20ppt
- Temperature range: 25°C-34°C
- Grow 40-50 g in 5 months.(male grow faster than females)

Reproductive Biology

Sexual dimorphism

Male

- Larger, 2nd pereopod much larger and thicker.
- Cephalothorax larger, abdomen narrower.
- Appendix masculina and appendix interna at endopodite of 2nd pleopod.
- Genital pores at the base of 5th walking leg.

Female

- Smaller, 2nd pereopod thinner and shorter.
- Cephalothorax smaller, abdomen broader.
- Appendix masculina is absent.
- Genital pores at the base of 3rd walking leg.

Reproductive Biology

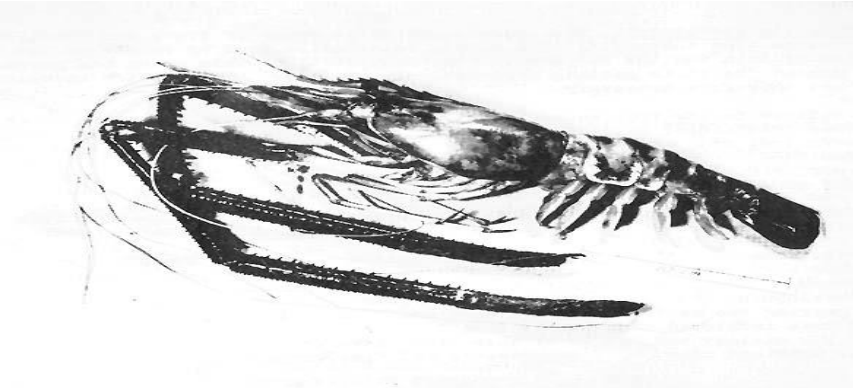
Sexual dimorphism

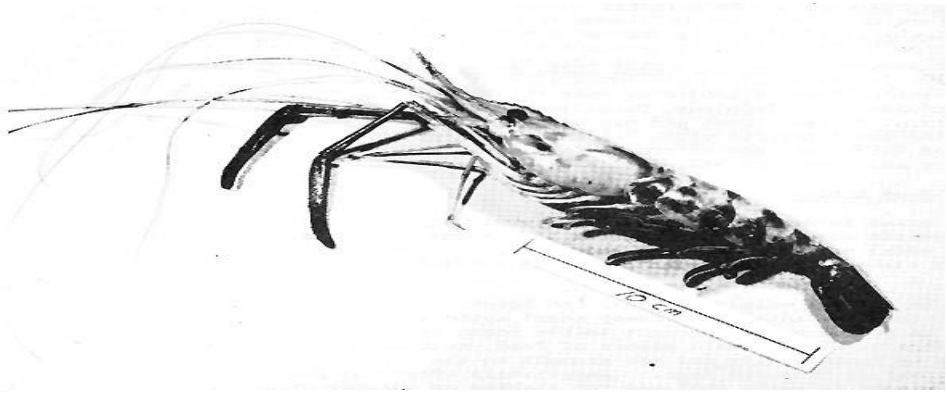
Male

- Pleura of abdomen is shorter.
- Reproductive setae are absent.
- Distance/gap between last pair walking leg is very less in male.

Female

- Pleura of 1st, 2nd, 3rd abdominal segment are longer and forms a brood chamber
- Reproductive setae present.
- Distance/gap between last pair walking leg is more in female





•Ventral side of the abdominal segment has a lump- a hard point- at the centre which can be felt with finger.

•Reproductive setae are absent on the ventral side of thorax and pleopods of mature male.

•No sperm receptacle in the thoracic sterna between last three pairs of pereopods.

•No lump or hard point at the ventral side of 1st abdominal segment.

•Reproductive setae appear on the ventral side of thorax and pleopods of mature females such as ovipositing and ovigarous setae.
Ovipositinng setae appears on coxa of last 3 pairs of pereopods and posteriors margin of sperm receptacle area and the pleopods. It helps in guiding and propelling eggs during spawning. Ovigarous setae serve to anchors the eggs to pleopods.

•There is an sperm receptacle on the thoracic sterna between last three pairs of pereopods.

Breeding seasons

Hoogly estuary – Dec to July(peak march to may)

Kerala backwater- July to Dec(peak in Oct and Nov)

Andhra Pradesh- through out year (peak in Aug to Oct)

Reproductive system

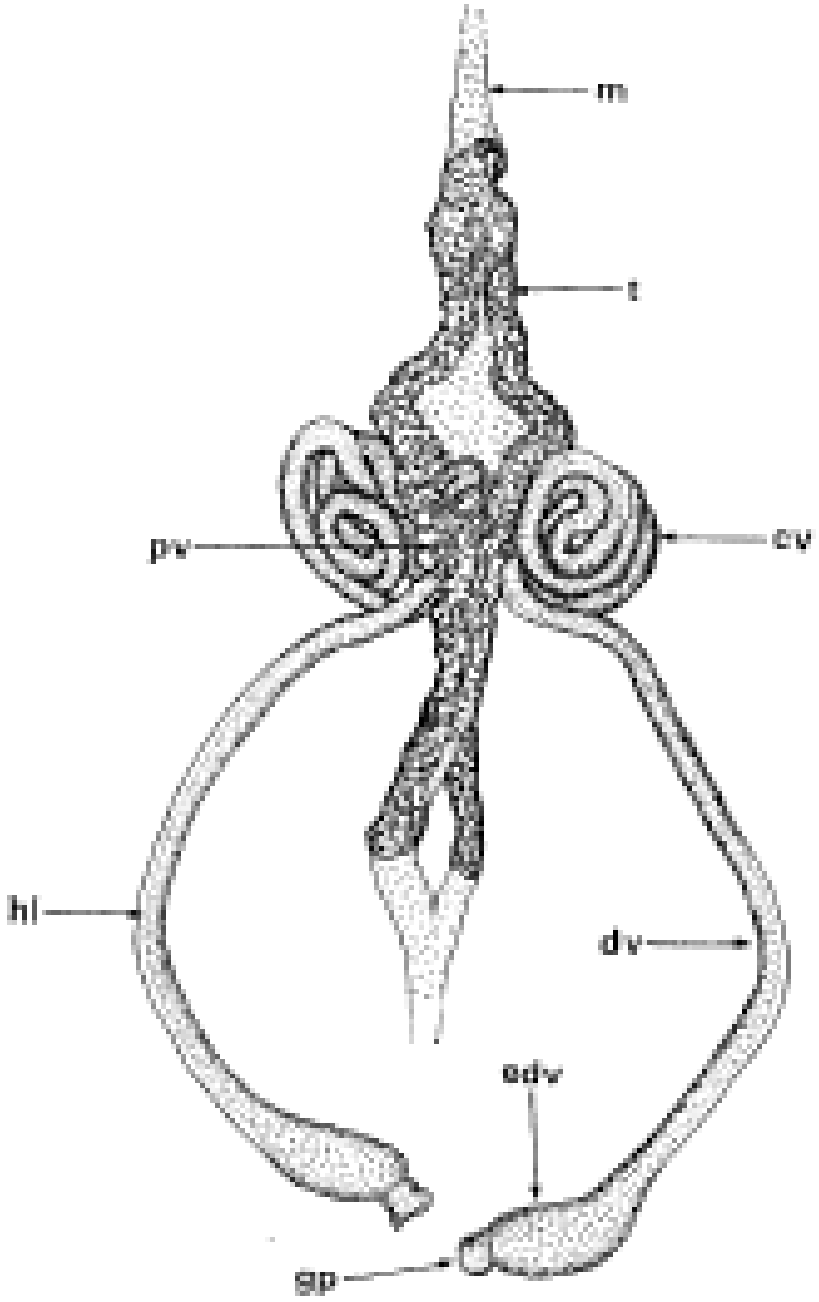
Male

It consists of the following—

A pair of fused testes located on mid dorsal side of cephalothorax below carapace.

Vas deferens has 4 regions:-

- Proximal region
- Medial region
- Distal region and
- Terminal ampoule which open at the base of the coxa of 5th pereopod.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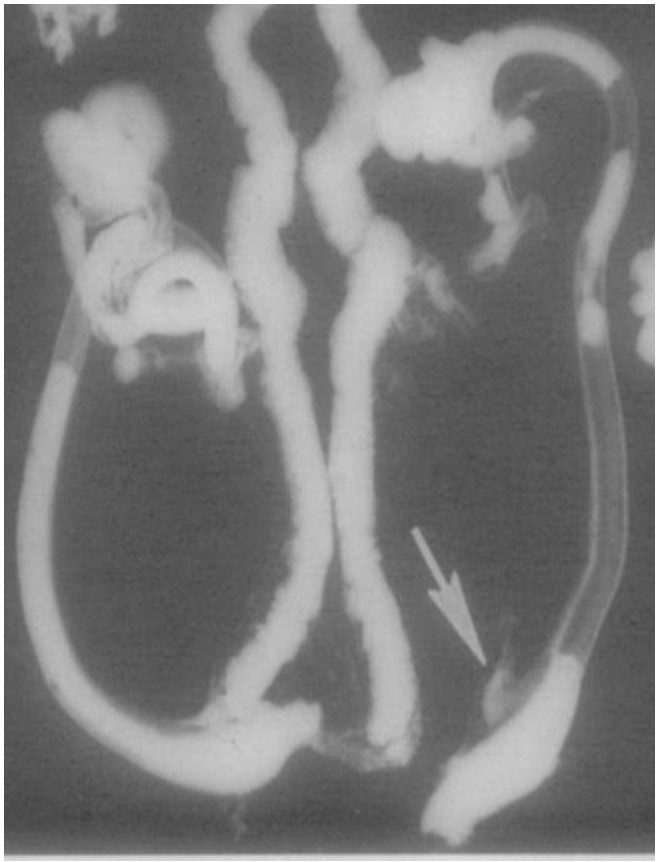


Each of the terminal ampulla contains half of the spermatophore. On ejection through the gonophore the spermatophore halves fuse along the median margin to form complete spermatophore. Each half of spermatophore contains a sperm mass in which nonmotile sperms are embedded in a dense fibrous matrix.

Reproductive System of Prawn:

The sexes are separate.

Male reproductive system:

1. The male reproductive system consist of a pair of testes, a pair of vasa deferentia, a pair of seminal vesicles and a pair of gonopores (Fig 25.15A).
2. The testes are soft, white, elongated bodies, fused at both the ends and are situated in the cephalothorax, below the heart and above the hepatopancreas.
3. From each testis arises a narrow tube, the vas deferens, which is much coiled at first and then descends down towards the base of the fifth walking leg of the side.
4. The terminal end of each vas deferens forms a club-shaped swelling, known as seminal vesicle, which opens to the exterior by the male gonopore on the inner side of the coxa of the 5th walking leg.

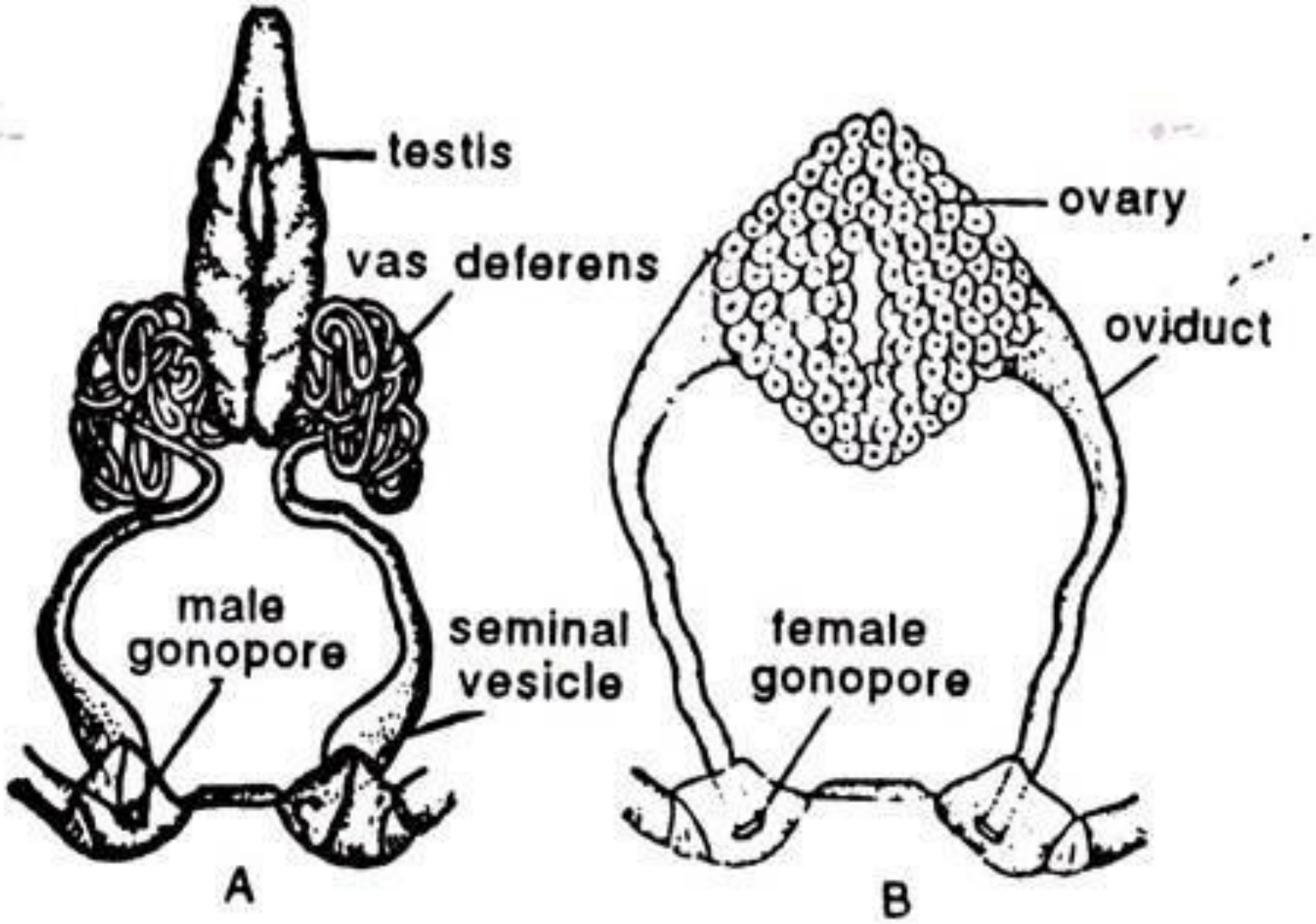


Fig. 25.15. Macrobrachium sp. Reproductive system. A. Male. B. Female

Female reproductive system:

1. The female reproductive system consist of a pair of ovaries, a pair of oviducts and a pair of female gonopores. (Fig 25.15B).
2. Ovaries are small and whitish in off-seasons but large and dark brown in the breeding season. They are fused at both the ends, larger in size than the testes and occupy same position as the testes in the male.
3. From the middle of the outer side of each ovary arises an oviduct, which narrows downwards to open in the gonopore on the inner side of the coxa of the 3rd walking leg of the side.

Fertilization and Development of Prawn:

1. Prawns breed in rainy season.
2. The eggs are round and yolk-filled.
3. Fertilization external and the fertilized eggs are carried in the abdominal basket, formed by the appendix internae of the second to fifth pleopods in females.

Development direct, the newly hatched young resembling the adult, leave the abdominal basket to lead a free life.

Female

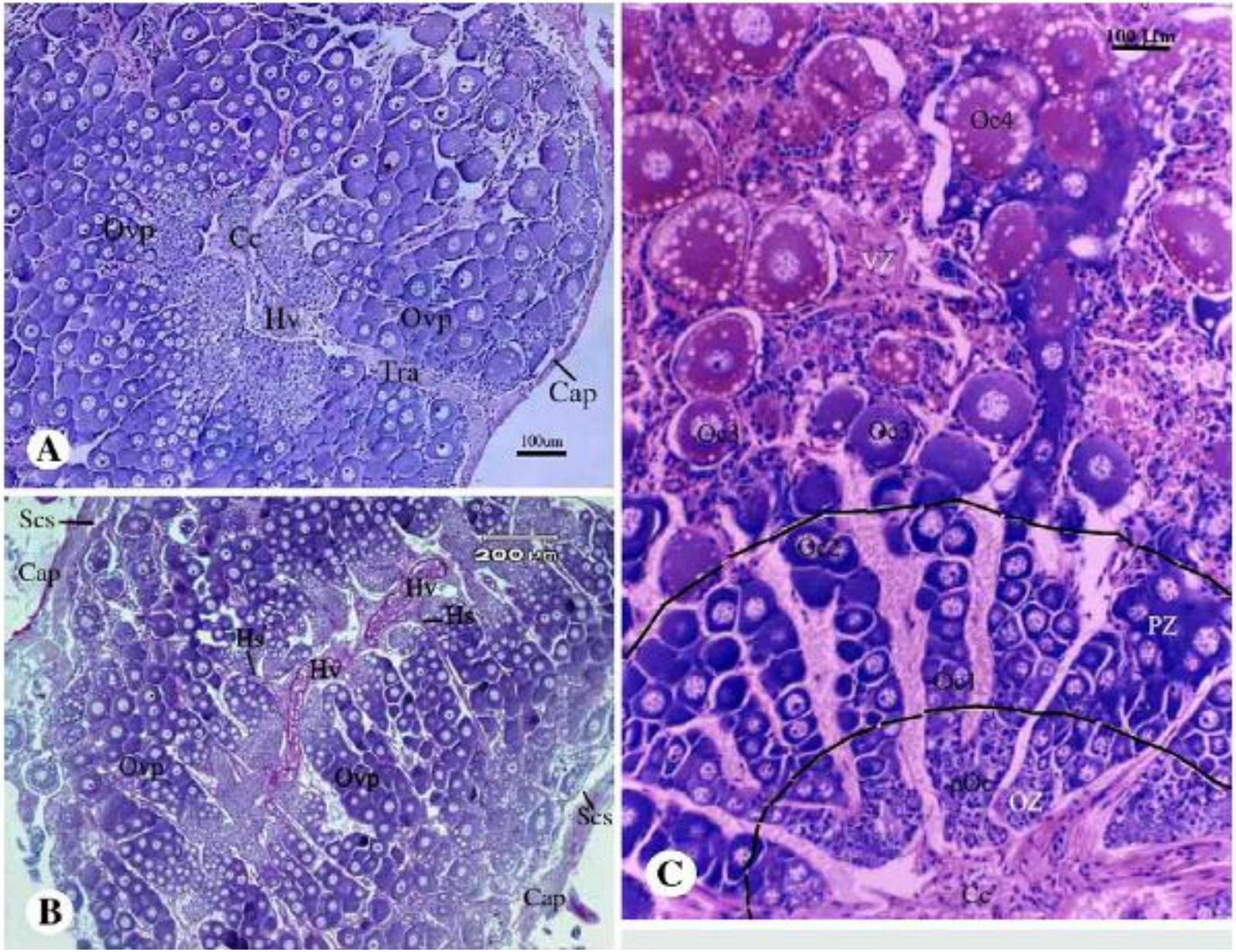
It consists of the following—

- A pair of ovaries located dorsal to the stomach and hepatopancreas in the cephalothorax cavity.
- Each ovary consist of —
  anterior lobe, lateral lobe and
  abdominal lobe.
- Oviduct which open at the base of the coxa of 3rd pereiopod.

➢ Four stages of ovary:

1. Immature
2. Early maturing
3. Maturing
4. Ripe

Development of ovary takes place within 15 to 20 days.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Oc1
nOc
OZ
Cc

Stage	colour	Oocytes size (mm)	Ovary size & position
Immature	transparent	0.064 to 0.128 Spherical	Vary and present in posterior most region of carapace cavity
Early maturing	Yellowish due to light deposition of yolk	0.191 to 0.447	Occupy ¼ to ½ of total carapace cavity
Maturing	Light orange in color due to heavier deposition of yolk	0.319 to 0.547	¾ of carapace cavity
Ripe	Dark orange Ova become opaque due to heavy yolk	0.4468 to 0.7761	Occupy entire carapace cavity

Mating

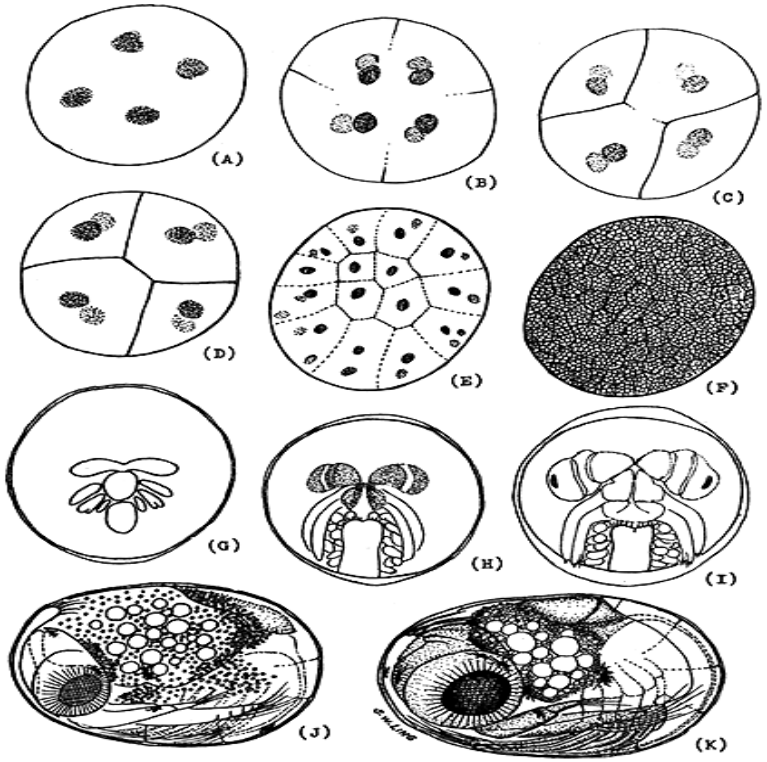
- Take place between hard shelled males and mature soft shelled females which have just completed their premating moult.
- Time between moulting and mating 1.2 to 21.8 hrs (avg. 9.1 hrs).
- Male gonopore is brought close to sperm receptacle of female on thoracic region and transfer the sperm to receptacle as spermatophore.
- After mating female may spend several hours in prespawning preening behaviour.

spawning

- Spawning occurs after few hour of mating.
- Eggs laid by female are fertilized by sperm attached to underside of thorax.
- The fertilized eggs are transferred to the ventral side of abdomen (brood chamber).
- Movements of pleopods helps in aerating the eggs.
- Fecundity varies from 80000-100000 eggs. However, their first broods, (i.e. those which are produced within their first year of life), are often not more than 5 000 to 20 000.

The average egg number/g total body weight for prawns having orange, yellow and grey eggs was 1132.7 ± 484.1, 766.4 ± 524.3 and 745.5 ± 487.2, respectively, a decrease of 32.3% when orange eggs became yellow and 34.3% when they turned grey. This decrease was probably due to unfertilized eggs dropping off and some eggs being eaten by the brooders during the incubation period.

- Females normally become mature when they reach 15-20 g but berried females have been observed as small as 6.5 g.
- Eggs are slightly elliptical (0.6-0.7 mm in long axis) Bright orange in colour.
- Incubation period avg. 19 days.
- Turns grey black 2-3 days before hatching.
- Freshly hatched larvae are called zoea.

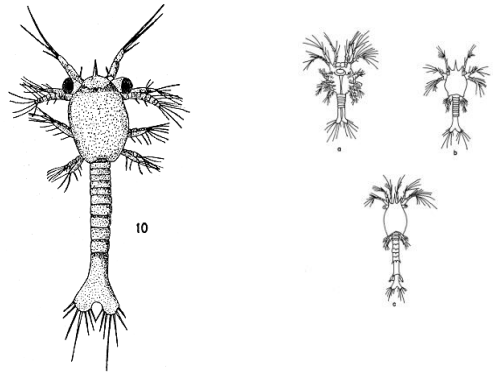


Macrobrachium rosenbergii, segmentation and embryonic development.

Times refer to period since fertilization.
(A) 7 h - completion of second nuclear division. (B) 8 h 45 min - third nuclear division nearly completed, appearance of 4 cleavage furrows. (C) 8 h 55 min - third nuclear division completed, tips of the 4 cleavage furrows have met at 2 points from which the median furrow is developing. (D) 9 h - complete formation of 4 quadrants (blastomeres). (E) 14 h - 32 nuclei. (F) 24 h - completion of segmentation. (G) 6 days - formation of caudal papilla. (H) 7 days - formation of optic vesicle. (I) 9 days - eye pigment developed. (J) 14 days - larva fully formed. (K) 19 days - larva ready to hatch.

Development of Larvae

- Newly hatched zoea about 1.92mm in length. It has the zoeal characteristics such as a body distinguishable into cephalothorax and abdomen. The cephalothorax is covered by a carapace having the dorsomedian rostrum. All cephalic and thoracic appendages are present. The segmented body is without pleopods.



- Larvae require salinity from 11-13 ppt for survival and growth.
- Larval passes through 11 zoeal stages within 23-32 days depending on temp., food, and water quality to become PL.

Identifying Characters of larval stages

Larval stage	Age (days)	Total length (mm)	Distinguishing features
I	1	1.92	Sessile eyes
II	2	1.99	Stalked eyes
III	3	2.14	Uropod present
IV	4-6	2.5	Two dorsal rostral teeth, uropod biramous with setae
V	5-8	2.8	Telson narrow, elongated
VI	7-10	3.75	Pleopod buds appear
VII	11-17	4.06	Pleopods biramous and bare
VIII	14-19	4.68	Pleopods with setae
IX	15-22	6.07	Endopods of pleopods with appendix interna
X	17-24	7.05	3-4 dorsal rostral teeth
XI	19-29	7.73	Teeth on half of upper dorsal margin
PL	23-27	7.69	Teeth on upper and lower margin of rostrum, adult behaviour

Macrobrachium rosenbergii go through eleven distinct larval stages (Figures 1-11) before metamorphosing to become postlarvae (Figure 12)

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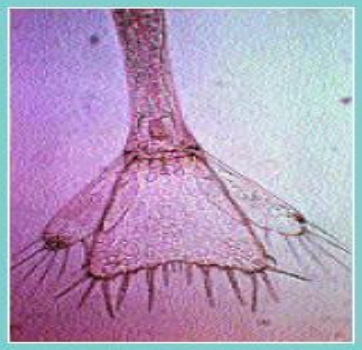

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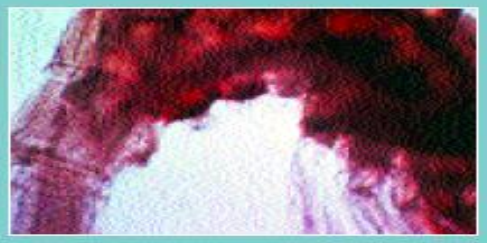

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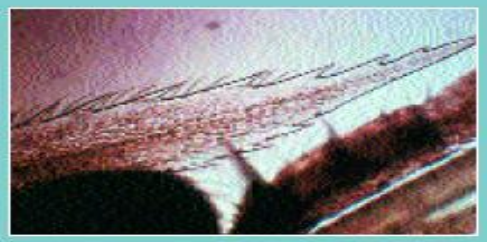

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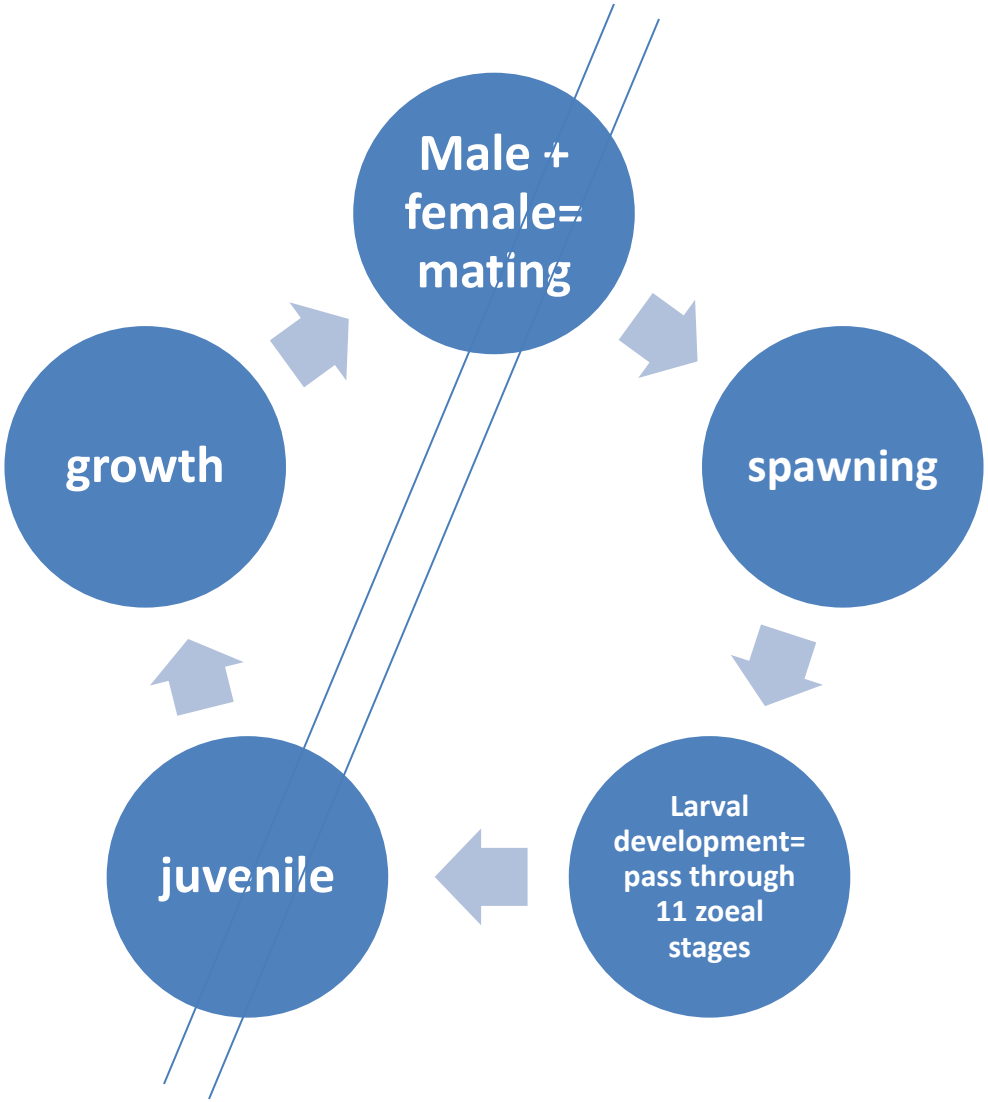
STAGES	CHARACTERISTICS						
	Eyes	Rostrum	Antennal flagellum	Uropod	Telson	Pleopods	Pereiopods
I	sessile						
II	stalked						
III		1 dorsal tooth		first appearance			
IV		2 dorsal teeth		biramous with setae			
V			2 or 3 segments		more elongated and narrower		
VI			4 segments		more narrow	first appearance of buds	
VII			5 segments			biramous and bare	
VIII			about 7 segments			biramous with setae	
IX			about 9 segments			endopods with appendices internae	
X		3 or 4 more dorsal teeth	about 12 segments				1st & 2nd fully chelated
XI		many dorsal teeth	about 15 segments				
PL	rostrum has dorsal and ventral teeth; behaviour predominantly benthic, as in adults						

Stage I larvae (zoeae) are just under 2 mm long (from the tip of the rostrum to the tip of the telson). Larvae swim upside down by using their thoracic appendages and are positively attracted to light. By stage XI they are about 7.7 mm long. Newly metamorphosed postlarvae (PL) are also about 7.7 mm long and are characterized by the fact that they move and swim in the same way as adult prawns. They are generally translucent and have a light orange pink head area.

Life cycle

Fresh water



Brackish water

morphotypes in M. rosenbergii

There are 4 morphotypes in *M. rosenbergii* altogether- bull males (blue clawed males), orange clawed males, small males and females.

The bull males are sexually matured individuals and possess large chelipedes. They are not necessarily large ,but are dominant in the community. The further growth of other members will occur only upon removal of these bull males from the community. Tying up of the chelipedes have also been found to be equally effective. However upon complete removal of bull males from the group, several of the orange clawed males convert into bull males. Bull males do not grow any further. The bull males are the sexually active members that fertilize the females.

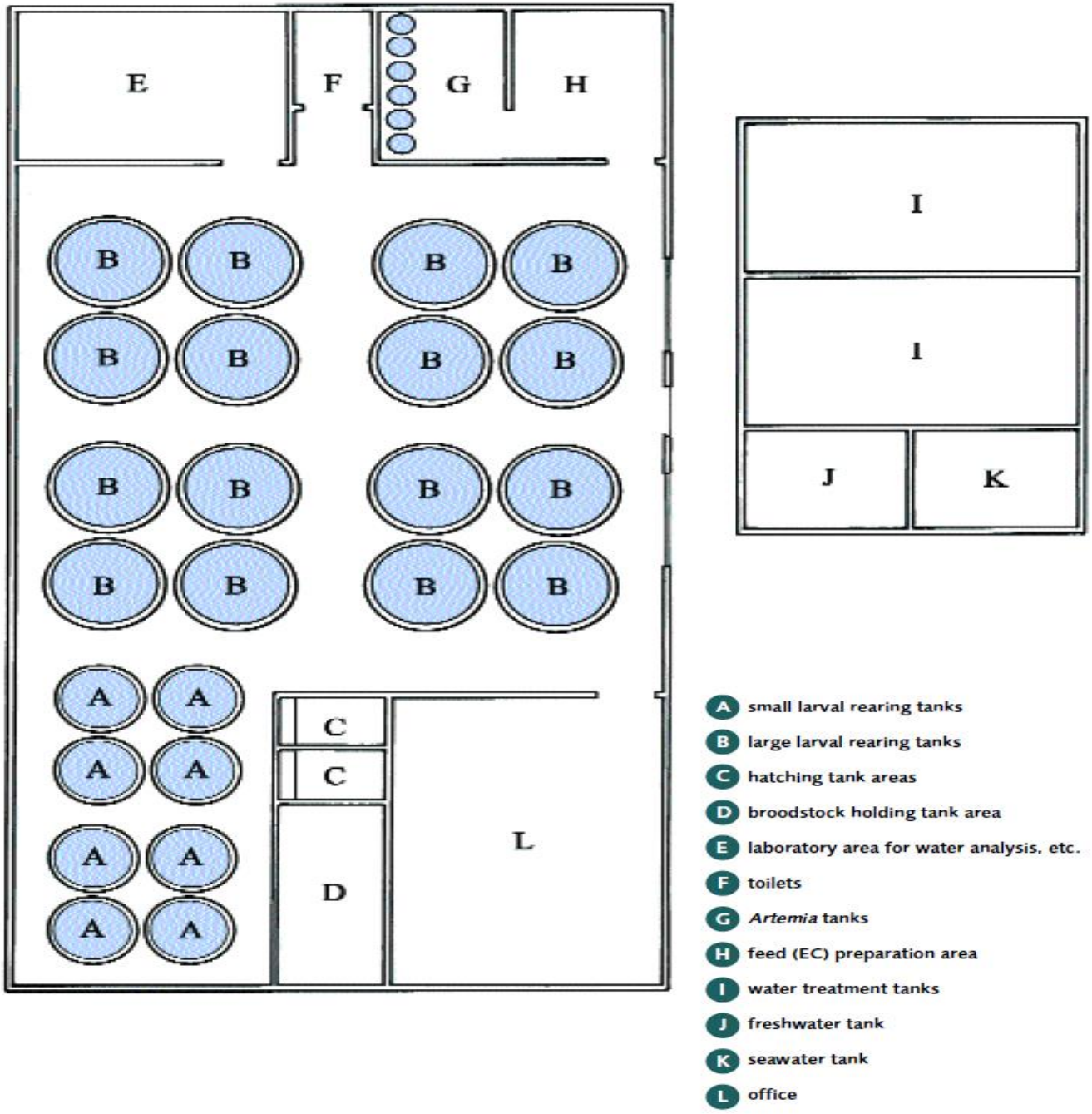
The orange clawed males grow further and gain weight. But this depends on the level of removal of the bull males from the community.

The small males are stunted individuals who also do not grow further. they are not dominant. They mate with females by sneaking in when the dominant bull males are not around. Small males are also sexually mature.

If the bull males are too many in a tank, and are not culled periodically, a large number of individuals exhibit retarded growth and become small males. The other morphotype is the female.

Hatchery Technology
(Seed Production)

a. Brood stock rearing unit,
b. spawning unit and Incubation unit,
c. Larval rearing unit,
d. Artemia unit,
e. Post larval holding unit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A small larval rearing tanks
B large larval rearing tanks
C hatching tank areas
D broodstock holding tank area
E laboratory area for water analysis, etc.
F toilets
G Artemia tanks
H feed (EC) preparation area
I water treatment tanks
J freshwater tank
K seawater tank
L office

Maintenance of brood stock

- Sex ratio for brood stock early juveniles are stocked in ponds @ 3-4/m^2 and adults @ 2 nos/m^2. Male(1) :Female(4) .
- Size of pond may very from 0.2-1.6 ha with avg. depth of 0.9 m
- Salinity: fresh water; although culture in salinity range 10 ppt-25 ppt is also possible.
- Hardness: 100 ppm CaCO3
- pH: 7- 8.5
- Opt. temp: 29-31˚C
- Feeding: pelleted feed with 35-40% protein at 3-4% total body wt. about 3 times per day.
- Others items-tapioca, trash fish, mollucs, prawn wastes etc.
- Prawn attain maturity in 4-7 months.

• Most farmers select larger females, which usually carry more eggs, but this may not be good practice. Selecting fast-growing, berried females from ponds three months after they were stocked, rather than choosing large females six months after stocking, has a positive genetic effect on weight at harvest.

• Collecting the faster growing females and rearing them in dedicated broodstock ponds would enable you to use selection to improve grow-out performance and also give you the ability to hold the animals until their clutch size becomes larger (after later mating moults).

Incubation and Hatching unit

- Berried females bearing dark grey eggs are used for incubation and hatching.

- Grey coloured eggs contain advanced stage embryo that will hatch out within 2-3 days, whereas orange coloured eggs will contain embryos at the early stages of development, hatching will be delayed.

- Catching, handling, and transportation of berried females have to be taken carefully to minimize egg loss/ damage.

- They are first disinfected in freshwater containing 0.3 ppm $CuSO_4$ or 15-20 ppm formalin and released into hatching/larval rearing tank having 5 ppt salinity @ 5 nos per m^2.
- Hatching takes place at night.
- Normally 500 larvae/ gm body wt. of brood prawn.
- Usually, berried females are not fed during 2-3 days of incubation to avoid deterioration of water quality.

Artificial sea water(2000 L; 15 ppt)

Common salt (NaCl): 24 kg
MgCl2: 3.04 kg
Sodium sulphate: 2.428 kg
Calcium chloride: 0.704 kg
Potassium chloride: 0.376 kg
Sodium Bi-carbonate: 0.160 kg
Potassium Bromide: 0.08 kg
Boric acid: 0.4 gm
EDTA: 4.4gm
Cobalt sulphate: 40 mg
Potassium iodide: 80 mg

Larval rearing unit

Factor affecting larval rearing:

Salinity- 12 ppt ideal.

Quality of larval rearing tank- Cu & Zn, galvanized steel, bare concrete are toxic to larvae. So inner coating is required.

Temperature- ideal is 29-31ºC
temp below 25ºC and above 33ºC is detrimental for larval growth.

Dissolved oxygen- Should be maintained at saturation level by aeration.

Water exchange- 50% of water per day after cleaning the tank.

Exposure to sunlight- Helps in biological purification of water by algae but direct exposure is harmful to larvae.

Stocking density- 1st phase (larval stage I to V) stocked **@ 500-700 nos /Lit**

2nd phase (larval stage VI to XI) @ **50- 80 nos /Lit**

Larval behavior

- The newly hatched larvae(Zoea) are planktonic and they swim with tail first and ventral side upwards and head down at an oblique angle. They are attracted toward light, swim close to the water surface in group where as unhealthy larvae tend to accumulate at the pond/tank bottom.
- As larva grow to post larva, instead of free swimming they start crawl or cling to the tank surface.

Larval feeding

- Most commonly used is Artemia nauplii, others are such as Moina, cut pieces of Tubifex/ Acetes, Soya product, snail, marine bivalves, squilla, cut pieces of earthworm, fish flesh, egg custard etc.

- Feeding starts from 2nd day of hatching.

- Prepared feed given in day time and Artemia in the night time.

- Different stages require 50 to 150 µg prepared feed /larva /day and Artemia nauplii from 5 to 50 /larva /day.

- 25 to 40 PL / litre can be harvested within 35 days.

- Eight cycles of seed production is possible in one year.

Artemia hatching:

It is the most preferred live food in most of the hatcheries.

Artemia cyst is collected from salt pan/lake.

Main sources of artemia cyst is the Great Salt Lake in Utah, USA, and however it is also collceted from salt pan of Brazil, China, Iran, the former Soviet Republics, and VietNam.

Artemia hatching involves following steps:

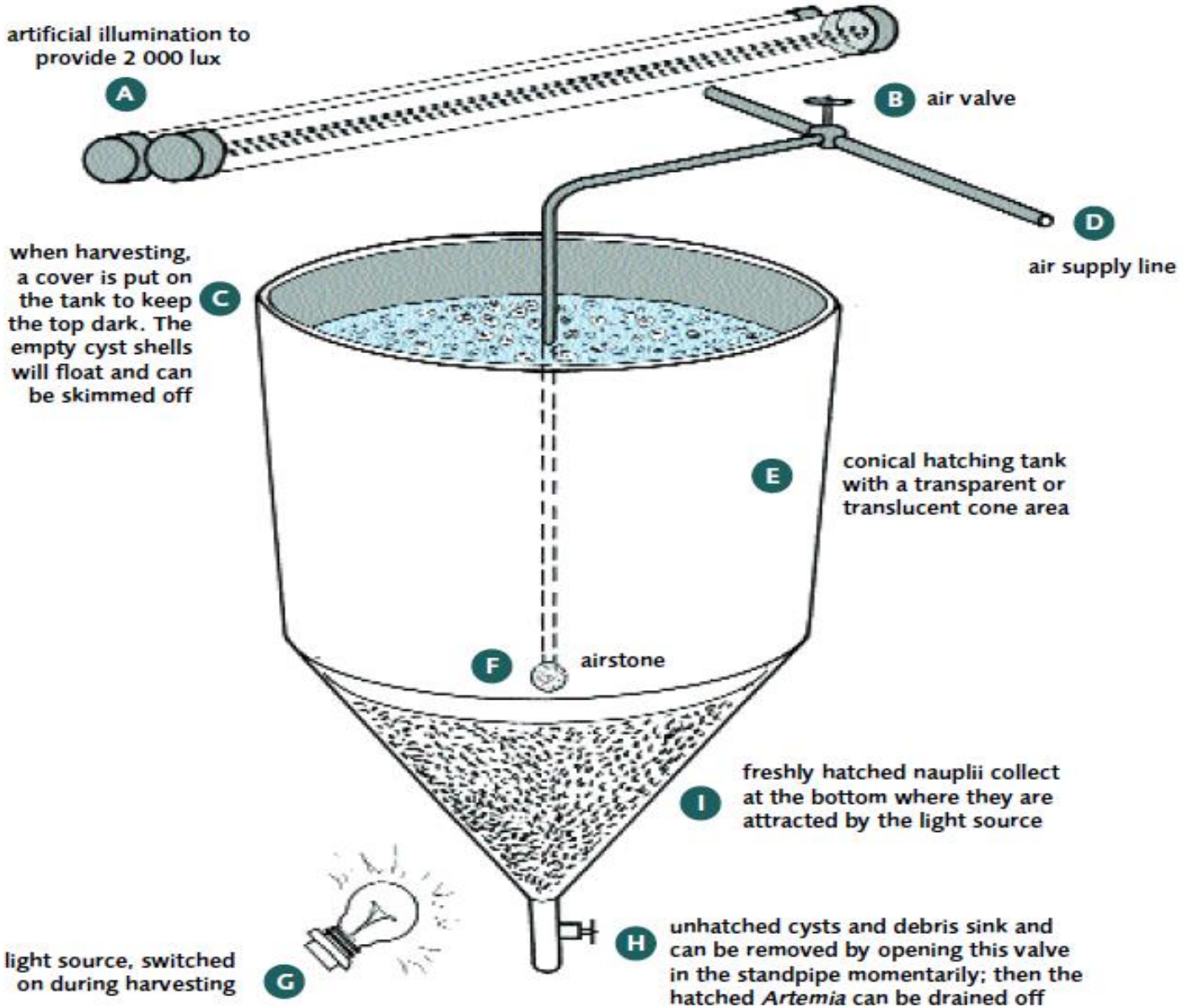
steps

Decapsulation : 200ppm chlorine

Stocking density : 0.25-1.00 g/L

salinity_: 15-35ppt

For collection of nauplii use 125-150 µm mess size net


artificial illumination to provide 2 000 lux
A
B air valve
D
air supply line
when harvesting, a cover is put on the tank to keep the top dark. The empty cyst shells will float and can be skimmed off
C
E
conical hatching tank with a transparent or translucent cone area
F
airstone
I
freshly hatched nauplii collect at the bottom where they are attracted by the light source
H
unhatched cysts and debris sink and can be removed by opening this valve in the standpipe momentarily; then the hatched *Artemia* can be drained off
light source, switched on during harvesting
G

Egg custard

Egg: 2 no.

Shrimp: 25 gm

Corn floor: 20 gm

Milk powder: 25 gm

Yeast: 2 gm

Cod liver oil: 3 ml

Vit mix: 2 gm

Post Larval holding unit

- Newly metamorphosed PL are gradually acclimatized to freshwater.
- Freshwater ponds of 400-500 m^2 water area and depth of 1 m are used as nursery tank.
- Ponds are treated with lime(200 kg / ha) and cow dung (2500-5000 kg /ha).
- Opt. temp. is 28-32°C.
- pH is 7-8.5
- Total hardness($CaCO_3$) 50-100 ppm
- DO is 4-6 ppm
- Larval fed at 10-20 % of body wt. daily for 2 months till 1^{st} reach 0.5-1.0 gm.
- Submerged artificial shelters are also provided.

The larval rearing of Macrobrachium was first completed in Malaysia by Ling in 1969; but the mass production was perfected by Fujimura and Okomoto in 1972. Two main systems are followed now viz:

GREEN WATER CULTURE

This system has been successfully used in Hawai to control blooms of organisms harmful to freshwater larvae and has been claimed to act as buffer against ammonia build up.

Green water is a mixed phytoplankton culture in which Chlorella species dominate.

The cell density is 750 000- 1500000 cells/ml. The 12 ppt saline water prepared by mixing sea water with freshwater in which a mixture of 4 parts of urea and 1 part of N P K (15:15:15) garden fertilizer applied at the rate of 185 g/m3 of water.

Male tilapia are introduced to the tank @1: 400 litre to graze and control filamentous algae.

CuSO4 @ 0.6ppm is added to the green water once in a week to control rotifers.

10 ppm of the sodium salt of EDTA is sometimes included in the culture.

This green water is used as replacement water during exchange process instead of plain brackish water.

CLEAR WATER CULTURE

Clearwater is prepared by treating both freshwater and seawater.

Seawater is pumped into an aerated storage and 25 ppm formalin is added. Aeration is provided over a 6 day period to precipitate, and precipitate is allowed to settle down without aeration for one day. Supernatant water is pumped to the mixing tank.

Freshwater is pumped into another aerated storage tank and 6ppm bleaching powder (or 5.25% sodium hypochlorite) is added. A contact time of 6 days is allowed and is followed by one day of vigorous aeration to remove the chlorine. The precipitate is allowed to settle down without aeration for one day before pumping supernatant into mixing tank.

Hatcheries need a reliable power supply, because continuous operation of the aeration system is essential. Even where public power supplies are reliable, you need a backup.

water supplies - freshwater, seawater, brine, or made from artificial sea-salts - must have excellent quality.

Artificial brackishwater (12 ppt) for *M. rosenbergii hatcheries*

SALT	QUANTITY (G/M^3)
Sodium chloride (NaCl)	9 200
Magnesium sulphate ($MgSO_4.7H_2O$)	2 300
Magnesium chloride ($MgCl_2.6H_2O$)	1 800
Calcium chloride ($CaCl_2.H_2O$)	467
Potassium chloride (KCl)	200
Sodium bicarbonate ($NaHCO_3$)	67
Potassium bromide (KBr)	9

Iron and manganese problem of water

VIRUS DISEASES	BACTERIAL AND RICKETTSIAL DISEASES	FUNGAL DISEASES
***Macrobrachium* hepatopancreatic parvo-like virus (MHPV):** none; not associated with significant morbidity or mortality.	**Black spot (sometimes called brown spot or shell disease):** one or many melanized lesions on the cuticle; often caused by opportunistic bacteria which enter following physical damage; problem may disappear at the following moult but sometimes develops into deep spreading lesions; reduces marketable value of harvested prawns.	***Lagenidium* infection:** affects larvae: an extensive mycelial network can be seen through the exoskeleton; can decimate hatchery populations within 24 hours.
***Macrobrachium* muscle virus (MMV):** muscle tissues become opaque, followed by necrosis; occurs within 10 days of stocking PL and may cause up to 50% mortality.	**Appendage necrosis:** larval appendages become necrotic and melanized; affected larvae do not eat and may become bluish in colour; may be associated with a heavy surface burden of the filamentous bacterium *Leucothrix*.	**Infections by *Fusarium* and *Saprolegnia*:** cause necrosis and melanization; follow physical damage.
White spot syndrome baculovirus (WSBV): targets the cuticular epidermis, stomach, gills and hepatopancreas; important disease in marine shrimp; *Macrobrachium* is known to be a carrier but it is not yet certain whether WSBV causes mortalities in freshwater prawns.	**Internal infections:** caused by a variety of Gram negative bacteria such as *Vibrio* spp. and *Aeromonas* spp.; feeding discontinues; discolouration of the body (usually pale and white) occurs; animals listless; infections by luminous vibrios are usually serious.	**Yeast infections:** muscles appear yellowish, bluish or grey; causes heavy mortalities in grow-out ponds; particularly prevalent when temperatures are lower than optimal and organic matter is allowed to accumulate and eutrophication occurs.
Nodavirus (*MrNV*): opaque whitish appearance of the abdomen, followed by severe mortalities.	**Bacterial infection caused by *Enterococcus*:** necrosis in muscles and hepatopancreas; begins in the head portion and proceeds to the tail; animal appears opaque; exacerbated in high temperature (33-34°C) and high pH (8.8-9.5) conditions.	
	Rickettsial disease: larvae become white throughout their bodies and generally inactive before death; infected populations experience significant mortalities.	

DISEASE	PREVENTION AND TREATMENTS* REPORTED IN THE LITERATURE ON PRAWN DISEASES
***Macrobrachium* hepatopancreatic parvo-like virus (MHPV)**	Obtain and maintain disease-free stock; good management. No treatment reported.
***Macrobrachium* muscle virus (MMV)**	Obtain and maintain disease-free stock; good management. No treatment reported.
White spot syndrome baculovirus (WSBV)	Obtain and maintain disease-free stock; good management. No treatment reported.
Nodavirus (*MR*NV)	Obtain and maintain disease-free stock; good management. No treatment reported.
Black spot (sometimes called brown spot or shell disease)	Good management, especially maintaining good water quality and avoiding physical damage by handling (by transfer, sampling) or by other prawns (may be caused by over-stocking, poor feeding, etc.). Treatment by immersion in 10 ppm oxolinic acid for 1 hour, or 2 ppm nifurpirinol for 96 hours reported.
Appendage necrosis	Good management, especially maintaining good water quality and avoiding physical damage by handling (by transfer, sampling) or by other prawns (may be caused by over-stocking, poor feeding, etc.). Treatment by 0.65-1.0 ppm erythromycin or 2 ppm of a penicillin-streptomycin mixture, or 1.5 ppm chloramphenicol reported.
Internal infections	Good management, especially good filtration and/or treatment of incoming hatchery water. Treatment by 2 ppm chloramphenicol combined with 2 ppm furazolidone for 5-7 days reported.
Bacterial infection caused by *Enterococcus*	Good management, especially by avoiding constructing farms in areas where (or operating farms at times when) temperature and pH are too high. No treatment reported.
Rickettsial disease	Obtain and maintain disease-free stock; good management; treatment of tanks and equipment with lime (CaO) before stocking. Treatment by application of 10 ppm oxytetracycline combined with 10 ppm furazolidone reported.
***Lagenidium* infection**	Good management. Treatment by maintaining 10-100 ppb trifluralin in hatchery tanks, or treatment with 20 ppm of Merthiolate® has been reported.
Infections by *Fusarium* and *Saprolegnia*	Good management, especially maintaining good water quality and avoiding physical damage by handling (by transfer, sampling) or by other prawns (may be caused by over-stocking, poor feeding, etc.). No treatment reported.
Yeast infections	Good management, especially the avoidance of lower than optimal water temperatures and the accumulation of organic matter and eutrophication; use better water exchange, aeration and circulation and lower feeding rates. No treatment reported.

An important disease in *M. rosenbergii hatcheries, whose exact cause is unknown, is* referred to as the 'mid-cycle disease' (MCD).

As its names indicates, it is most noticeable in the middle of the larval rearing period (days 15-22 when the larvae are at stage VI-VII), when heavy daily mortalities may occur.

Mortalities may even start to become obvious as early as day 10. The disease is recognisable by the larvae becoming bluish-grey and swimming slowly in a spiralling pattern, as well as by a reduced rate of consumption of *Artemia* and poor growth rate.

You can reduce the incidence of this disease by cleaning, disinfecting and drying out hatchery equipment between cycles and taking special care in general hygiene throughout the larval cycle.

A possible cause may be the bacterium *Enterobacter aerogenes* (Johnson, 1978; Brock, 1988).

Another disease which has mainly been noted to affect larvae is known sometimes as the 'exuvia entrapment disease' (EED) or as the 'moult-death syndrome' (MDS) or as the 'metamorphosis moult mortality syndrome'.

The characteristic of this disease is that the larvae get trapped in the old exoskeleton (exuvia) during moulting.

It is mostly noticed towards the end of the larval rearing cycle, especially at the moult which occurs when stage XI metamorphoses into the PL stage.

The mortality rate at this point can be very high. The cause of EED is not known; it may have multiple causes. It may imply that the diet is nutritionally inadequate and requires enrichment.

Difficulties in shedding the old exoskeleton during moulting have also been observed in juvenile and adult prawns.

The moulting process is stressful and may be difficult for weakened animals, and it is at this time that hidden problems become noticeable.

Idiopathic Muscle Necrosis (IMN)

This disease is known by various names, white muscle disease, muscle necrosis, spontaneous muscle necrosis, muscle opacity or milky prawn disease. It causes massive larval mortalities in hatcheries.

Nash *et al.* (1987) reported that IMN caused sudden mortality of up to 60% of 28 day old post larvae in intensive rearing systems in Thailand. The disease appears as multifocal diffuse opacity of striated muscle. (Akiyama *et al.* 1982; Nash, *et al.* 1987; Brock, 1988).

IMN of *M. rosenbergii* is considered to be associated with environmental stressors including salinity and temperature fluctuation, hypoxia, hyperactivity and overcrowding. (Nash, 1987; Brock, 1988).

Mortalities are associated with extensive necrosis of muscle fibres. It has been observed in various hatcheries that if necrosis has not progressed extensively, the disease process is reversible once the water is changed.

IMN may occur within one or two day following stocking in production ponds. This is considered to be associated with stressful pond conditions. Stocking postlarvae into nursery ponds before release into grow-out pond may reduce this problem.

Reversibility of the disease in early affected larvae has been observed in some hatcheries.

However, the disease progresses very rapidly from onset. Sarver et al. (1982) suggested that the prevalence of IMN in a population of postlarvae serves as a useful indicator of their general health.

There is no effective treatment for this disease except minimising the environmental stressors.

Luminescence Disease

Early Macrobrachium larval stages are susceptible to vibriosis caused by *Vibrio harveyi*. This disease is very common in hatcheries of both freshwater and marine shrimps.

The unique clinical sign of this disease is the luminescence of infected larvae which can be observed at night. Infected larvae also show fouling, opacity, swim slowly, aggregration and they ultimately die.

Mortalities may reach 100%. In Thailand, luminescent bacteria are often observed in the sea or salt water farms. When this appears, there is almost complete failure of postlarval production at the hatchery.

Treating the salt water with chlorine or formalin before use does not seem to be effective during such an incident.

The bacterium was sensitive to chloramphenicol and novobiocin but resistant to streptromycin.

They also found that the bacteria were completely killed by treating with Ca(HOCl)2 at 20-30 ppm or formalin at 50 ppm.

Diseases caused by protozoa

Protozoa that cause diseases of prawns are *Zoothamnium* sp., *Epistylis* sp., *Vorticella* sp. and *Acineta* sp.

Larvae with protozoa infestation are slightly opaque. With mild infestations the protozoa are removed with moulting, but with heavy infestations they can obstruct moulting, suppressing the growth and causing death.

Larvae are more susceptible to infestation with protozoa than adults.

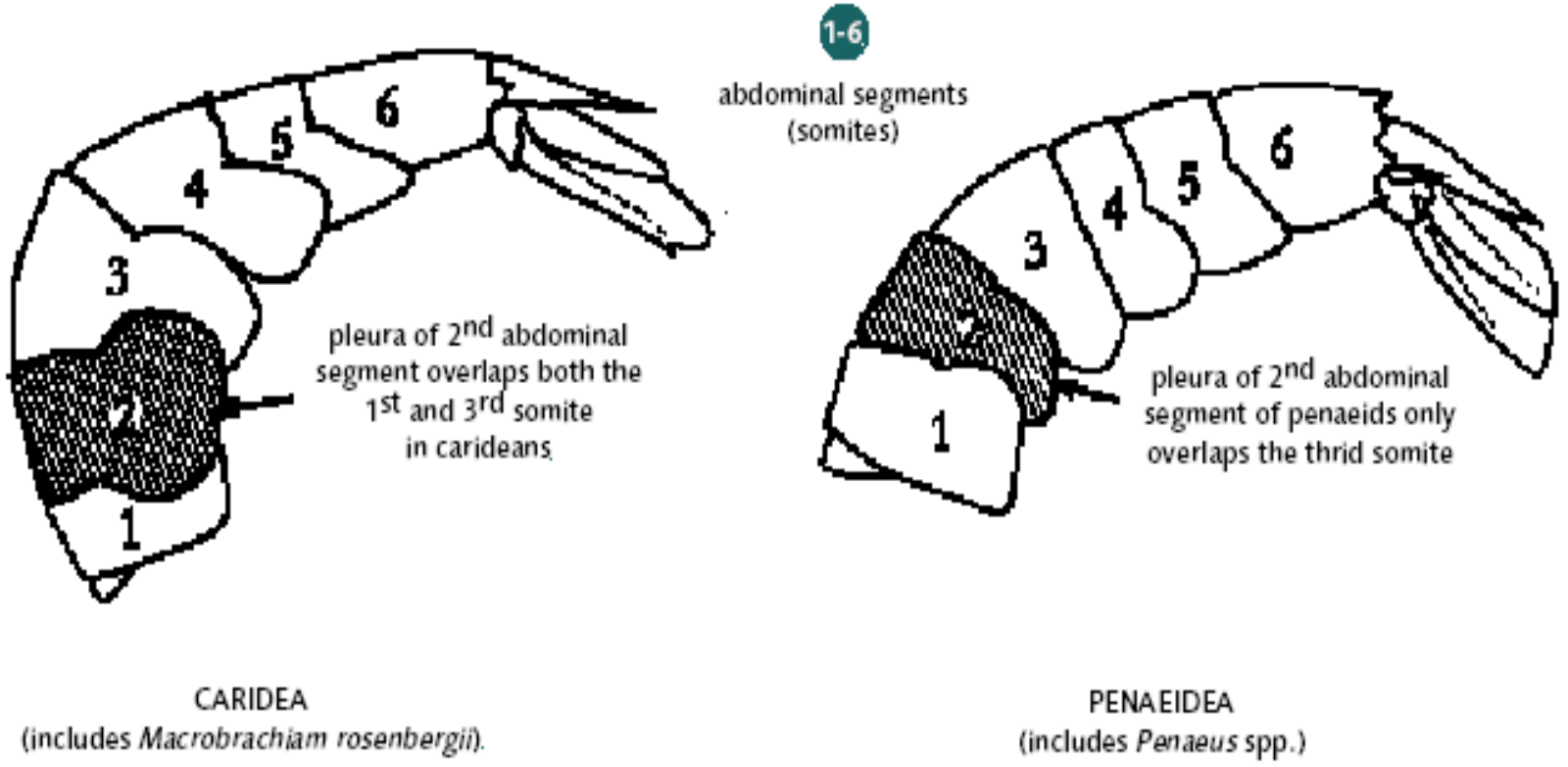
When protozoa are observed on the larvae, the water quality must be improved.

Treatment with formalin at 20-30 ppm as a 24 hour static bath is effective and safe in controlling larval *Zoothamnium* infestation (Roegge *et al.*, 1979).

Acetic acid at 2.0 ppt as a one minute dip with repeat treatment is recommended for *Epistylis* sp. on larvae (Sindermann, 1977).

FIGURE 7

Freshwater (caridean) prawns can also be distinguished from penaeid shrimp by looking at the second pleura on the abdomen (see arrow)



SOURCE: EMANUELA D'ANTONI, AFTER FINCHAM AND WICKINS (1976)