*Palaemon malcolmsonii or Macrobrachium malcolmsonii

SYSTEMATIC POSITION

Phylum	Arthropoda
Subphylum	Mandibulata
Class	Crustacea
Subclass	Malacostraca
Order	Decapoda
Suborder	Natantia
Family	Palaemonidae
Genus	*Palaemon*
Species	*malcolmsonii*

HABITS AND HABITAT (ECOLOGY)

Palaemon inhabits freshwater streams, rivers, ponds and lakes. It is a **nocturnal** creature, hiding at the bottom during the day and coming to the surface at night in search of food. It is **omnivorous**, feeding on small organisms, like algae, mosses, minute insects, debris, etc. It walks slowly at the bottom with the help of its 10 walking legs and swims actively to the surface with the help of its 10 pleopods. When disturbed, it suddenly springs backwards with the help of a pair of uropods, attached to the last abdominal segment. In a desperate attempt to escape from the enemy's grasp, it can shed off one or more of its appendages. This phenomenon is known as **autotomy**. During the **breeding period** (May to July) the female is seen carrying a large number of eggs between its abdominal appendages.

EXTERNAL MORPHOLOGY

[I] Shape and Size

Body is elongated, more or less spindle-shaped and bilaterally symmetrical. It offers least resistance in swimming. Size of adult varies from species to species. *P. malcolmsonii,* now *Macrobrachium malcolmsonii,* found in Central India and Tamil Nadu, measures 25 to 40 cm in length. The giant prawn *P. carcinus* from Kerala is upto 90 cm long. While the dwarf prawn *P. lamarrei,* found almost throughout India, is 2.5 to 5 cm long.

[I] Colouration

Young stages are translucent and white, but the adults are differently tinted according to the species. Usual colour is dull pale-blue or greenish with brown orange-red patches. Preserved specimens become deep orange-red.

[III] Segmentation and Body Divisions

Body of adult prawn is distinctly divided into 19 segments or somites, all bearing jointed appendages. The segments are arranged into two main regions : an anterior **cephalothorax** (fused head-thorax) and a posterior abdomen.

1. Cephalothorax. Cephalothorax is large, rigid, unjointed and more or less cylindrical in shape. It consists of 13 segments. The joints between segments are obliterated. Cephalothorax is formed by the union of two regions : (i) **head** and (ii) **thorax**. Head consists of 5 segments, while thorax includes 8 segments, all bearing jointed appendages.

2 Abdomen. Well-developed abdomen is jointed, unlike cephalothorax. It is composed of 6 distinct movable segments, and a terminal conical piece, the **tail-plate** or **telson**, which is not considered a segment because of post-segmental

* Many species of *Palaemon,* including *P. malcolmsonii,* are now ascribed to the Genus *Macrobrachium.* But the generic name *Palaemon* is being retained here because of its familiarity and to avoid confusion at this stage.

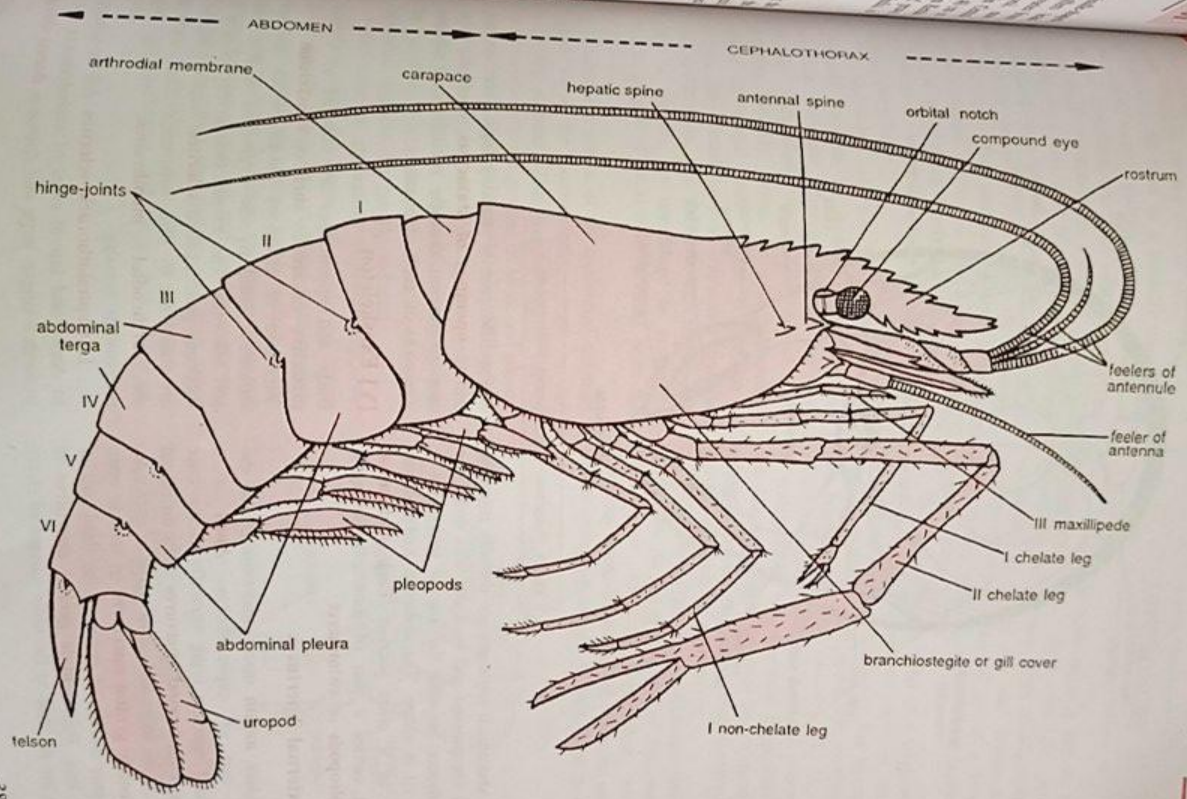


Fig. 1. *Palaemon.* External features of male in lateral view.

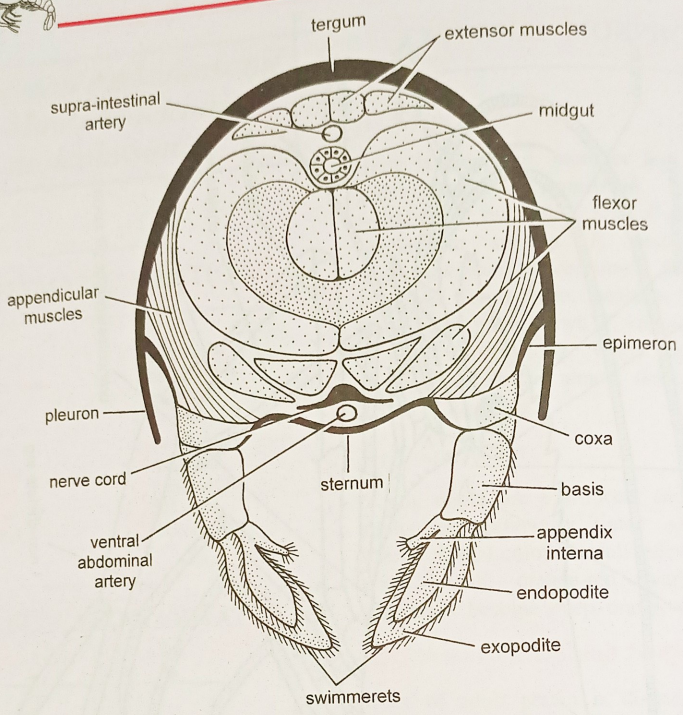


Fig. 2. *Palaemon.* T.S. abdomen (diagrammatic).

origin. Abdominal segments are dorsally rounded, laterally compressed and normally bent under the cephalothorax, so that the animal looks like a comma (,) in shape. The abdomen looks almost circular in a cross section. Each **abdominal** segment carries a pair of jointed appendages, called **pleopods** or **swimmeret**.

[IV] External Apertures

The slit-like **mouth** opens mid-ventrally at the anterior end of cephalothorax. **Anus** is a longitudinal aperture lying ventrally at the base of telson. Paired **renal apertures** open on raised papillae on the inner surface of coxae of antennae. Paired **female genital apertures** in female open on the inner surface of coxae of the third pair of walking legs. Paired **male genital apertures** in the male are situated on the inner surface of coxae of the fifth pair of walking legs. There are two minute **openings of statocysts**, one lying in a deep depression dorsally on the basal segment (precoxa) of each antennule.

[V] Exoskeleton

Body and appendages are covered by a hard protective calcareous **shell** or **exoskeleton**. It is composed of chitinous cuticle which becomes variously tinted by the deposition of lime salts and sclerotin. The exoskeleton comprises several hardened plates, called **sclerites**. Adjacent sclerites are connected by thin, soft, uncalcified cuticle or the **arthrodial membranes**, making the movements feasible.

1. Cephalothoracic sclerites. All the sclerites of dorsal and lateral sides of cephalothorax unite to form a single, large and coinuous **dorsal shield**.

The anterior and somewhat triangular region of dorsal shield is termed **dorsal plate**. It extends forward over the head as a laterally compressed and serrated vertical process, called **rostrum**. At the base of rostrum, on either side, is an **orbital notch**, which accommodates a stalked, jointed and movable **compound** eye. Just behind and below each orbital notch are two spine-like outgrowths, the anterior **antennal spine** and the posterior **hepatic spine**. The posterior region of dorsal shield is termed **carapace**. On either side of thorax, it hangs down freely as **branchiostegite** or **gill-cover** which encloses a gill-chamber housing the gills.

2. Abdominal sclerites. The sclerite of each abdominal segment is separate, ring-like and articulates with the adjacent sclerites by thin, flexible, uncalcified **arthrodial membranes** providing movable joints. In each abdominal sclerite, its dorsal broad plate is called as **tergum**, the ventral narrow transverse bar-like plate as **sternum**, and the two lateral flap-like plates as **pleura**. An appendage is connected with the pleuron of its side by a small plate the **epimeron**.

Tergum and pleura of an abdominal segment slightly cover the corresponding parts of the succeeding segment. This overlapping is known as the **imbricate arrangement** of terga and pleura. However, the pleura of second abdominal segment are much developed and overlap the pleura of both the first and third segments, thus disturbing the imbricate arrangement. Pleura of sixth abdominal segment are greatly reduced.

Two adjacent abdominal segments articulate with each other by means of a pair of **hinge joints**, one on either side. A hinge joint consists of a small round peg, fitting into a socket on the succeeding segment. However, the hinge joints are lacking between the third and fourth segments. Abdominal segments can move upon each other only in a vertical plane due to presence of arthrodial membranes and hinge joints between them.

APPENDAGES

Each segment of body bears a pair of jointed appendages. Thus, there are 19 pairs of appendages in *Palaemon*. They show considerable variations, depending on the functions they perform. However, they all are of a **biramous type**, as they are built on the same fundamental biramous plan.

Each appendage consists of a common base or **protopodite**, bearing two **ramii** or branches, an inner or median **endopodite** and an outer or lateral **exopodite**. Any appendage composed of two branches is called **biramous** (L. **bi**, two + **ramus**, branch). Typically, the basal **protopodite** is composed of two segments, a proximal **coxa** for attachment with the body and a distal **basis** which bears the two ramii, both comprising of several segments or **podomeres**.

With the exception of antennules which are uniramous, all the appendages of *Palaemon*, are **homologous structures**, regardless of their functions, because they are all biramous and have similar embryonic origin. As they occur in a serial

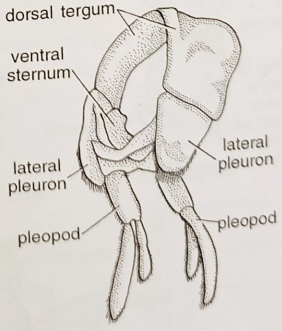


Fig. 3. *Palaemon*. Exoskeletal ring or sclerite of an abdominal segment, with appendages.

sequence on body, they also illustrate an example of **serial homology**.

In prawn, there are 19 pairs of appendages, 13 in cephalothorax and 6 in abdomen. Cephalothoracic appendages further include 5 pairs of anterior **cephalic appendages** and 8 pairs of posterior **thoracic appendages**.

1. Cephalic Appendages

There are 5 pairs of cephalic or head appendages. Beginning from the anterior end of head they are the **antennules**, **antennae**, **mandibles**, **maxillulae**, and **maxillae**. Antennules and antennae are **pre-oral**, while mandibles, maxillulae and maxillae are **post-oral**.

1. Antennules. The antennules are attached, one on either side, below the bases of eyes-stalks. The **protopodite** consists of three segments-a large proximal **precoxa**, middle **coxa** and distal **basis**. Precoxa bears a depression, containing the opening of **statocyst**, on its dorsal side. It also bears a basal spiny lobe called **stylocerite** and a distal spine on its outer margin. Coxa is short and cylindrical. Basis is elongated and without setae. It carries two long and many jointed, whip-like **feelers**, which are probably not homologous with the exopodite and endopodite. Outer feeler is further divided into an inner smaller branch and an outer larger branch. The feelers of antennules bear sensory setae and are **tactile** in function.

2. Antennae. The antennae lie, one on either side, just below the antennules. The **protopodite** is greatly swollen due to presence of excretory organ within, which opens by a minute **renal aperture** on the inner margin of **coxa**. Basis bears a **spine**. **Endopodite** is represented by a many-jointed sensory feeler, while **exopodite** is in the form of a broad and leaf-like plate, the **squama** or **scale**. It bears setae along its inner and distal

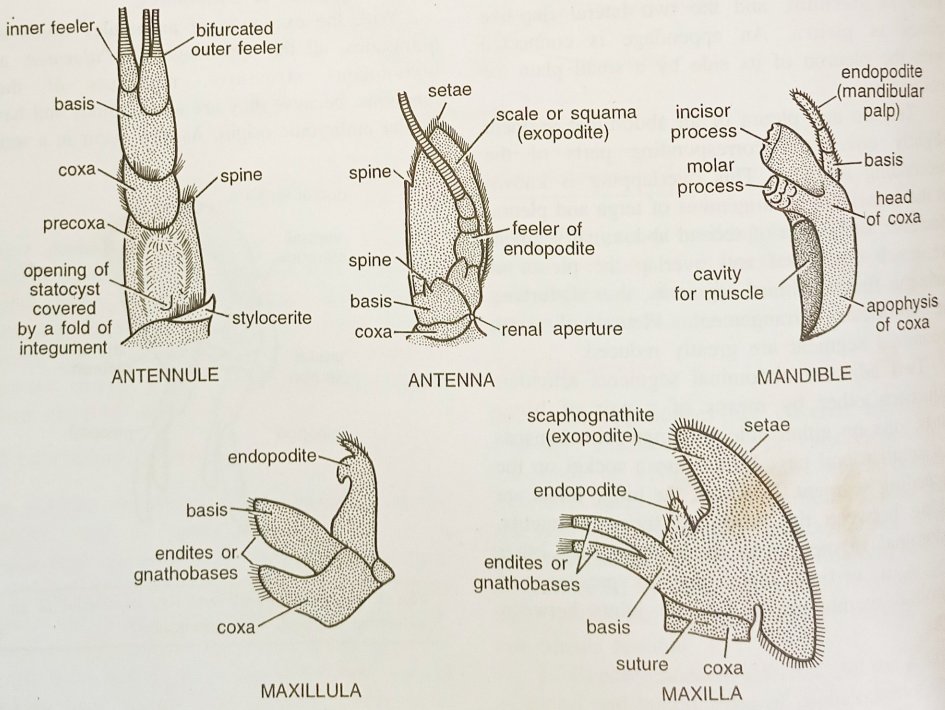


Fig. 4. *Palaemon.* Cephalic appendages.

margins, while the outer smooth margin bears a small spine. Squama probably serves as a balancer during swimming. Thus, the antennae are **sensory**, **excretory** and **balancing** in function.

3. **Mandibles.** The two mandibles are strong calcified bodies, lying one on either side of the mouth. Almost the entire mandible consists of **coxa**, which is differentiated into a proximal, triangular and hollow **apophysis**, and a distal solid **head**. The head forms two processes, a stout **molar process** bearing 5 to 6 dental plates, and a plate-like **incisor process** ending in 3 teeth. Outer margin of head carries a **mandibular palp** made of 3 segments. The proximal segment represents the **basis**, while two distal segments represent the **endopodite**. The **exopodite** is absent. Mandibles constitute the biting jaws and are **masticatory** in function.

4. **Maxillulae.** These are small, thin and leaf-like appendages. Free borders of **coxa** and **basis** are covered with pointed spines and project inwards as jaws or gnathobases (Gr., **gnathos**, jaw). **Endopodite** forms a curved process bifurcated at the apex. The **exopodite** is absent. Maxillulae help in the **manipulation** of food.

5. **Maxillae.** These are also thin and leaf-like mouth appendages. The small **coxa** is partially divided, while the large **basis** forms a bifurcated **gnathobase** internally. **Endopodite** is quite small, while **exopodite** forms a large expanded, fan-shaped **scaphognathite** or **baler**, the movements of which create a water current passing over the gills. The whole free margin of scaphognathite is beset with setae. Maxillae help in **respiration** and in the **manipulation** of food.

2. Thoracic Appendages

There are 8 pairs of thoracic appendages. These are differentiated into anterior 3 pairs of **maxillipedes** (Gr., **maxilla**, Jaw+**podos**, foot) or **foot-jaws**, and posterior 5 pairs of **paraeopods** or walking legs.

1. **First maxillipedes.** These are thin and leaf-like. Inner borders of coxa and basis form endites or **gnathobases**. Outer side of coxa bears a bilobed respiratory primitive gill or **epipodite**. **Endopodite** is smaller than **exopodite**, which gives out a plate-like process from its base. Margins of expodite and endopodite are fringed with setae.

2. **Second maxillipedes. Coxa** bears an **epipodite** and a **gill** (podobranch) on its outer margin. **Basis** carries a long, slender and unjointed **exopodite**, covered with setae along its distal half, and a 5- segmented **endopodite**. The segments or podomeres of endopodite are named from the base as **ischium**, **merus**, **carpus**, **propodus** and **dactylus**. The last two podomeres are bent backwards and inwards and possess cutting margins.

3. **Third maxillipedes.** These look leg-like in appearance and have the same parts as second maxillipedes. Outer border of **coxa** bears an **epipodite**. **Basis** supports a long, slender and

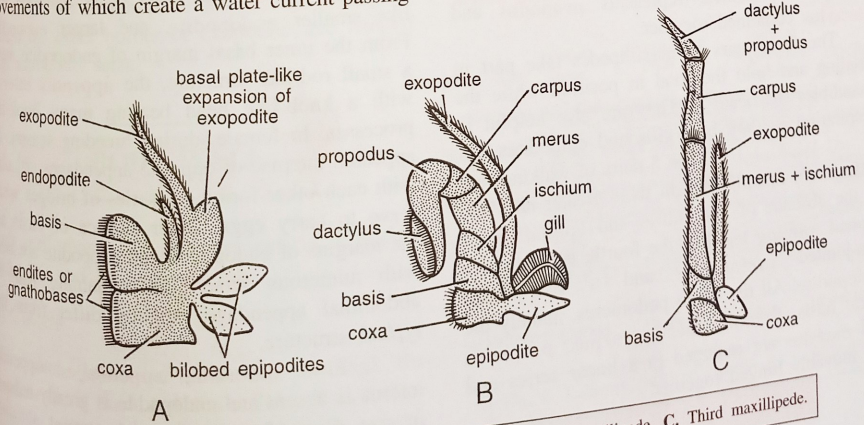


Fig. 5. *Palaemon.* Maxillipedes. **A.** First maxillipede. **B.** Second maxillipede. **C.** Third maxillipede.

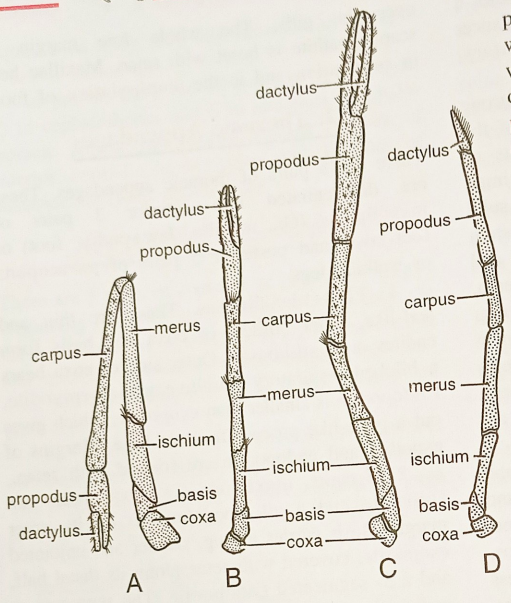


Fig. 6. *Palaemon.* Thoracic legs. **A.** First chelate leg. **B.** Second chelate leg of female. **C.** Second chelate leg of male. **D.** Typical or fourth non-chelate leg.

unsegmented **exopodite** covered with setae and a three-jointed **endopodite**. Proximal podomere of endopodite represents **ischium** and **merus** fused together, the middle podomere is the **carpus** and the distal podomere represents **propodus** and **dactylus** combined together.

The three pairs of maxillipedes take part in feeding and hold the food in position while the mandibles masticate it. They are also helpful in respiration as they bear gills and epipodites.

4. Walking legs. The 5 pairs of walking legs differ from maxillipedes in their greater size and in the absence of **exopodites** and **epipodites**. A **typical walking leg**, like the fourth, consists of a two-jointed **protopodite** and a five-jointed **endopodite**. All the seven podomeres, namely the **coxa, basis, ischium, merus, carpus, propodus** and **dactylus** are arranged in a linear series and are movably hinged together.

In the **first** and **second** pairs of legs, propodus is prolonged beyond its articulation with dactylus, so that the two podomeres work one against the other like the blades of a pair of forceps and form a **chela** or **pincer**. Such legs are termed **chelipeds** or **chelate legs**. They are used to grasp food and pass it on to the mouth. They also serve as organs of offence and defence. The second chelate legs in male are larger and more powerful than in female.

The **third, fourth** and **fifth** pairs of legs are **non-chelate** and typical. In female, each third leg bears a female reproductive aperture on the inner side of the coxa. While in male, each fifth leg bears a male genital aperture on the arthrodial membrane between the leg and thorax.

3. Abdominal Appendages

Abdomen bears 6 pairs of abdominal appendages, one pair in each of its segments. First 5 pairs, are the swimming **pleopods** or **swimmerets**, used as paddles, while the 6th pair are the **uropods** which, along with the post-segmental **telson**, form the tail fin. All these appendages are of simple biramous type.

1. Typical abdominal appendages. In a typical appendage, like the 3rd, 4th or 5th, the **protopodite** consists of a ring-like **coxa** and a cylindrical **basis**. The basis bears flattened leaf-like smaller **endopodite**, and larger **exopodite**. From the inner basal margin of endopodite arises a small rod-like structure, the **appendix interna**, with a knob-like head bearing many hook-like processes. In female, during breeding season, the appendix internae of opposite appendages articulate with each other forming a series of bridges which serve to carry eggs. Outer surface of basis and the margins of endopodite and exopodite are beset with numerous setae. The remaining pairs of abdominal appendages slightly differ from this typical structure.

2. First abdominal appendages. Appendix interna is absent and endopodite is greatly reduced in size. Rest of the structure is typical.

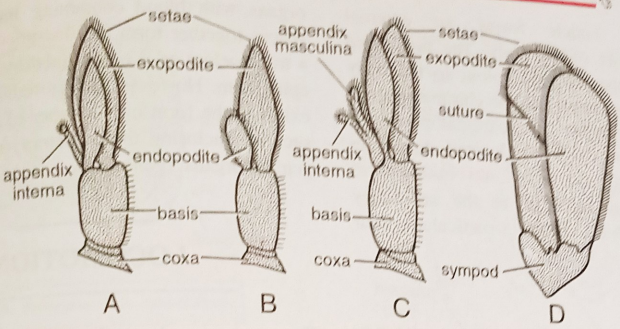


Fig. 7. *Palaemon.* Abdominal appendages. **A.** Typical. **B.** First. **C.** 2nd of male. **D.** Uropod.

3. Second abdomial appendages of male. Second pleopod of female is typical. But, in the second pleopod of male, there is an additional rod-like and setae-bearing process, the **appendix masculina,** lying in between the appendix interna and endopodite. The rest of the structure is typical.

4. Uropods. The 6th pair of abdominal appendages are called **uropods**. These are large and lie one on either side of the telson. Together with telson, they form **tail-fin** which enables the prawn to take backward spring in water. In each uropod, coxa and basis fuse together to form a triangular **sympod,** bearing the oar-shaped endopodite and exopodite. Exopodite is bigger than the endopodite and incompletely divided in the middle by a transverse-suture. Their margins, except the outer border of exopodite, are fringed with numerous setae.

BODY WALL

Body wall consists of an outer **cuticle**, a middle **epidermis** and an inner **dermis**.

[I] Cuticle

The outer layer of cuticle, forming the **exoskeleton,** is thick and non-cellular. It is further divisible into a thin, non-chitinous, outer **epicuticle,** and a **thick, chitinous, inner endocuticle**.

1. Epicuticle. It is made of an outer **lipoid layer** and an inner **protein layer**. Lipoid layer is permeable to gases but impermeable to water. Protein layer is relatively thick and hard, and is pigmented. Epicuticle is produced into spines of varying forms and bears, at places, fringes of setae. It is secreted by the tegumental glands lying in dermis.

2. Endocuticle. Endocuticle is elastic and permeable to gases and some solutes. It is secreted by epidermal cells. It is differentiated into three successive layers-a **pigmented layer,** a **calcified layer** and an **uncalcified layer**. All these three layers contain chitin.

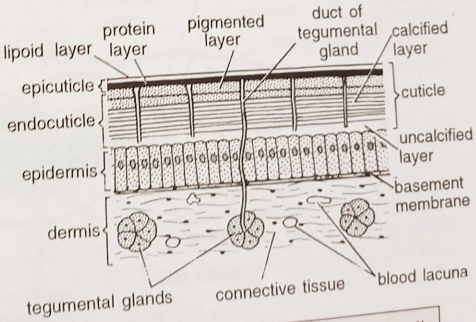


Fig. 8. *Palaemon.* V.S. of a portion of body wall.

The whole cuticle forms an external supporting structure of the body. The pigmented layer imparts a characteristic colour to the body due to the pigments present in the chromatophores. There are two types of chromatophores : (i) **primary chromatophores** located deeper in the body, and (ii) **secondary chromatophores** lying in chitinous layer. It is the secondary chromatophores which imparts a particular colour to the animal.

[I] Epidermis

It comprises a single layer of glandular columnar epithelium with centrally placed nuclei. It is lined by a thin basement membrane. This layer secretes the overlying endocuticle.

[II] Dermis

Dermis is made up of loose connective tissue beset with **blood lacunae**. It contains three types of **tegumental glands**, each of which opens to the outside through a fine duct.

BODY CAVITY

In contrast to annelids, the arthropods have a much reduced coelomic cavity. The space between gut and body wall is mostly occupied by muscles and organs with blood containing interspaces. These spaces together form the **haemocoel**, which is not a true coelom as it is not lined by the mesodermal epithelium. However, greatly reduced true coelom exists in the form of a number of separate spaces, such as enclosing the excretory (nephrocoel) and genital organs (gonocoel).

LOCOMOTION

The prawn crawls at the bottom of the river or pond by means of its walking legs. It can swim forward in a leisurely manner by beating its swimmerets or the abdominal appendages. It may take a quick backward spring by sudden contraction of the muscles which pulls the uropods and telson ventrally with a powerful stroke.

DIGESTIVE SYSTEM

1. Alimentary Canal

Alimentary canal consists of three distinct regions : (i) **Foregut**, comprising mouth, buccal cavity, oesophagus and stomach, (ii) **midgut** including intestine, and (iii) **hindgut** or rectum. Foregut and

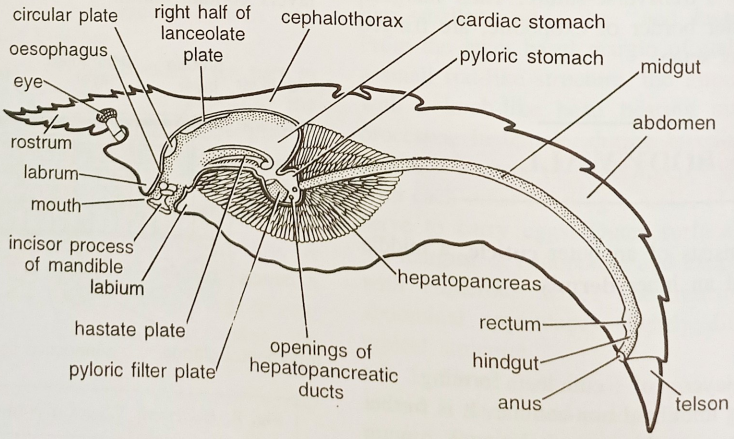


Fig. 9. *Palaemon.* Alimentary canal in lateral view.

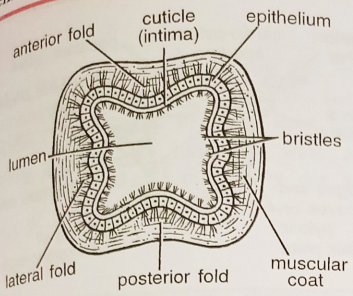


Fig. 10. *Palaemon.* T.S. oesophagus.

hindgut are lined internally by cuticle, called **intima**, which is shed with the exoskeleton when the animal moults. Midgut is lined internally by **endoderm**.

[I] Mouth

It is a large, slit-like aperture lying mid-ventrally below the anterior end of head. It is bounded in front by the shield-like fleshy **labrum**, laterally by the plate-like **incisor processes of mandibles** and behind by the bilobed **labium**.

[I] Buccal Cavity

Mouth leads into a short buccal cavity. It is antero-posteriorly compressed and has a thick cuticular lining which is irregularly folded. The **molar processes** of mandibles lie opposite each other in the buccal cavity to crush the food between them.

[III] Oesophagus

The short tubular oesophagus runs vertically upwards from the buccal cavity to the floor of cardiac stomach. Internally the thick muscular wall of oesophagus is thrown into four prominent longitudinal folds, one anterior, one posterior and two lateral.

[IV] Stomach

Stomach occupies most of the cephalothrac cavity. It remains buried laterally, ventrally and posteriorly in the hepatopancreas. Stomach of prawn is thin-walled and double-chambered, consisting of two parts : (i) a large anterior bag-like **cardiac stomach**, and (ii) a much smaller posterior **pyloric stomach**.

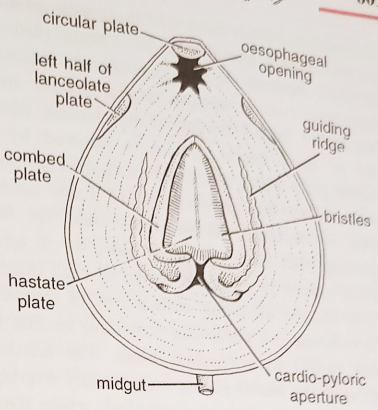


Fig. 11. *Palaemon.* Floor of cardiac stomach (dorsal view).

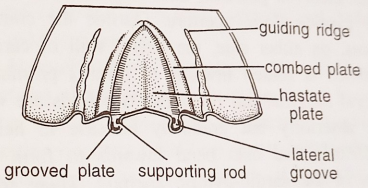


Fig. 12. *Palaemon.* Floor of cardiac stomach cut across, the hastate plate.

1. Cardiac stomach. The inner cuticular lining, or **intima**, of cardiac stomach presents numerous, inconspicuous, longitudinal folds covered by minute bristles. The wall of stomach is supported by some cuticular plates which remain embedded in it. Forming the anterior wall of the oesophageal opening is a **circular plate**. Behind it, on the roof of the stomach, is a **lanceolate plate**. A large triangular plate is embedded in the mid-ventral floor of cardiac stomach. It is called the **hastate plate**, because it looks like the head of a spear. Upper surface of hastate plate has a thick growth of delicate setae and carries a distinct **median ridge** with gradually sloping sides. The posterior triangular part of hastate plate is depressed and fringed with setae along its edge.

It forms the anterior border of the **cardio-pyloric aperture**. Each lateral side of hastate plate is supported beneath by a longitudinal cuticular **supporting rod**. A narrow **lateral groove** runs along either lateral border of the hastate plate. Floor of each lateral groove is covered by a cuticular plate which resembles an open drain pipe and is called the **grooved plate**. Each lateral groove is bounded on its inner side by the supporting rod and, on outer side, by a long cuticular **ridged plate**. Inner border of each ridged plate is fringed all along with a row of delicate bristles, forming a comb-like structure, so that it is also named as a **combed plate**. The bristles bridge over the lateral groove and partially overlap the lateral margin of the hastate plate, where they constantly keep moving in a living prawn. The two combed plates are united anteriorly, thus completely enclosing the hastate plate except that their incurved posterior ends remain separated by the cardio-pyloric aperture. Outside the combed plates, on either side, the lateral wall of cardiac stomach is folded inwards to form a prominent **lateral longitudinal fold**. The two folds are very low anteriorly but gradually increase in height posteriorly and also bend inwards to form the sides of the cardio-pyloric aperture. These folds are also known as the **guiding ridges** because they guide the food towards the cardio-pyloric aperture.

Cardio-pyloric aperture is narrow, X-shaped and leads into the pyloric stomach. It is guarded by four valves. **Anterior valve** is formed by the depressed posterior part of hastate plate; posterior **valve** by a semilunar fold of stomach wall, and two **lateral valves** by the large flap-like posterior ends of guiding ridges.

2. Pyloric stomach. Pyloric stomach is a small and narrow chamber lying below the posterior end of cardiac stomach. Its lateral walls are thick, muscular and prominently folded inwards, so that its cavity is imperfectly divided into a big **ventral chamber** and a small **dorsal chamber**, which are connected by a narrow vertical passage. Floor of ventral chamber is raised into a median longitudinal ridge, dividing it into two lateral compartments. Floor is covered by a **filter plate**. It is made of two rectangular surfaces

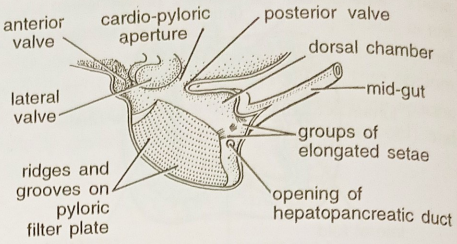


Fig. 13. *Palaemon.* Structure of the pyloric stomach (left wall removed).

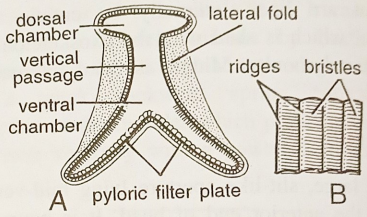


Fig. 14. *Palaemon.* **A.** T.S. of the pyloric stomach. **B.** Part of the pyloric filter.

and appears V-shaped in cross section. Each rectangular surface bears a series of alternating longitudinal ridges and grooves. The ridges bear rows of bristles forming a felt-like covering over the grooves. The side walls of ventral chamber are also covered with closely-set bristles which, together with the filter plate, form an efficient **strainer** or **filter**. This **pyloric filtering apparatus** allows only liquid food to pass through it. The paired **openings of the hepatopancreatic ducts** lie behind the filtering apparatus, just below the junction of the dorsal chamber of pyloric stomach and midgut. These openings are guarded by a group of **elongated setae** arising from the posterior end of the median ridge of filter plate.

Dorsal chamber gives out a small blind **caecum** dorsally and then leads behind into midgut. The junction of the two is guarded by one median dorsal and two lateral groups of **elongated setae** that project backwards into the midgut. These groups of setae strain the food entering the midgut and prevent its regurgitation into the dorsal chamber.

[V] Midgut

Midgut or intestine is a long, narrow and straight tube running back along the median line, between the extensor and flexor muscles, upto the 6th abdominal segment. Its lumen is wide at the anterior end but reduced posteriorly due to the presence of longitudinal folds.

[VI] Hindgut

It is the shortest portion of the alimentary canal, leading from midgut to anus. Its anterior swollen muscular part, called the **intestinal bulb** or **rectum**, bears many internal longitudinal folds. The terminal narrow, tubular part opens to the exterior through **anus**, which is a sphinctered mid-ventral longitudinal slit-like opening, situated on a raised papilla at the base of telson.

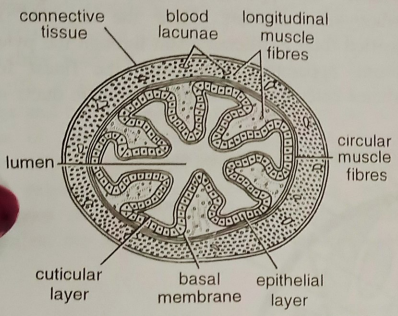


Fig. 15. *Palaemon.* T.S. of midgut.

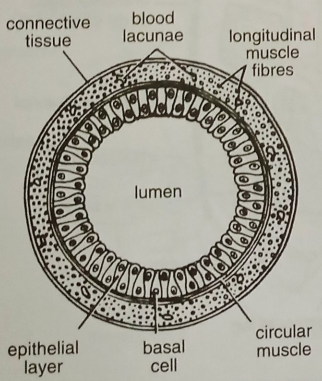


Fig. 16. *Palaemon.* T.S. of hindgut (rectum).

Hepatopancreas

It is a large, bilobed, dense and orange glandular mass, which lies below gonads and nearly fills up the cephalothoracic cavity. It surrounds stomach on its lateral, ventral and posterior sides. Hepatopancreas consists of numerous branching tubules completely held together by connective tissue. Wall of tubules consists of a single layer of columnar epithelium which is made up of : (i) granular cells, (ii) ferment cells, (iii) hepatic cells with globules of fat, and (iv) replacing or basal cells. The epithelium rests on a basement membrane. The tubules rejoin to form larger and larger canals, finally forming two large **hepatopancreatic** ducts, which open into the ventral chamber of pyloric stomach just behind the pyloric filter plate.

Hepatopancreas combines in itself the functions of pancreas, small intestine and liver of higher animals. Functioning as pancreas, it secretes digestive enzymes which can digest carbohydrates, proteins and fats. As midgut, it absorbs the digested food material, and as liver it serves as an important storage organ for glycogen, fat and calcium. Some intracellular digestion also seems to take place in hepatopancreas.

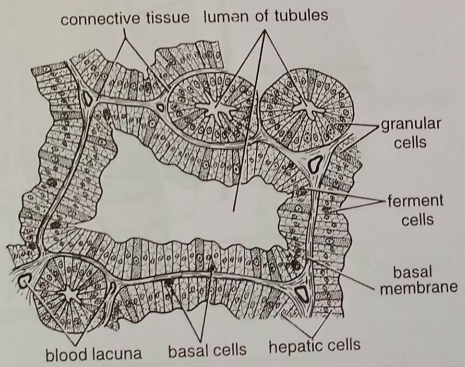


Fig. 17. *Palaemon.* A part of hepatopancreas in section.

Food and Feeding

Prawn feeds mainly on algae, moss and other aquatic weeds. It occasionally feeds on small aquatic animals such as insects, snails, tadpoles, fish, and debris of the bottom. It feeds at night, being more active at dawn and dusk than at any other time. Chelate legs, aided by the third maxillipedes, capture and convey food to the mouth. Coxae of second maxillipedes hold the food, while incisor processes of mandibles cut it into smaller pieces, which are swallowed with the help of maxillipedes, maxillulae and maxillae. Inside the buccal cavity, molar processes of mandibles masticate the food, which is then conveyed to the cardiac stomach through oesophagus. Passage of food through oesophagus is facilitated by the peristaltic activity of oesophagus and the sucking action of cardiac stomach.

Digestion and Absorption

The enzymatic digestive secretion of hepatopancreas flows through the two hepatopancreatic ducts into the ventral chamber of pyloric stomach, from where it reaches the cardiac stomach and mixes with food. Cardiac stomach expands and contracts to effect the churning of food and to facilitate its digestion by the action of digestive enzymes. As food passes over the hastate plate, the moving bristles of combed plates cut it into smaller particles. The semi-liquid and semi-digested food is filtered through the bristles of combed plates, into lateral grooves below, whence it is carried into the ventral chamber of pyloric stomach through the cardiopyloric aperture. Here the digested and liquefied food is filtered again through the pyloric filtering apparatus. Thus, only the finest food particles enter through hepatopancreatic ducts into

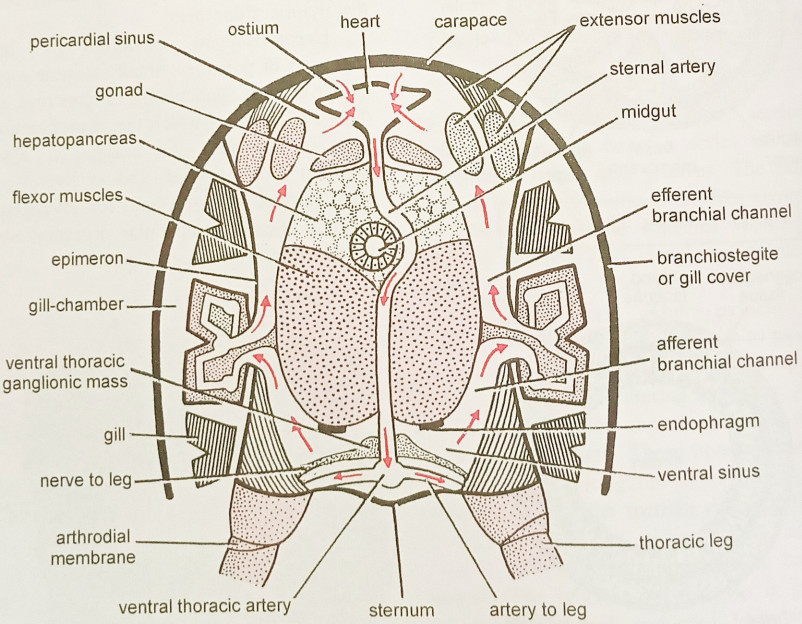


Fig. 18. *Palaemon.* A transverse hand section through the cephalothorax to show the two gill chambers.

the large digestive gland where they are hydrolysed and absorbed. The residual food, consisting of undigested and coarser particles, ascends up the dorsal pyloric chamber and from there enters the midgut for digestion and absorption. Undigested residual matter passes on to the hindgut. Here water is absorbed from it and the dry **faeces** thus formed is egested through the sphinctered anus.

RESPIRATORY SYSTEM

1. Respiratory Organs

Respiratory system is well developed and consists of : (i) **lining of branchiostegites** or gill covers, (ii) three pairs of **epipodites,** and (iii) eight pairs of **gills** or **branchiae**. These are sheltered in two large and compressed **gill-chambers,** one on either side of thorax. Each gill-chamber is bounded internally by **epimeron** or lateral wall of thorax, and externally by the curving pleural side of carapace or **branchiostegite**. The gill-chambers open on the anterior, ventral and posterior sides.

[I] Lining of Branchiostegites

Inner lining of branchiostegites or gill-covers is thin, membranous and highly vascular containing minute blood lacunae. These form large respiratory surfaces which absorb oxygen (O_2) dissolved in water and give out carbon dioxide (CO_2).

[II] Epipodites

These are 3 pairs of simple, foliaceous and highly vascular outgrowths of integument, given out from the coxal segments of 3 pairs of maxillipedes. They occupy the anterior part of gill-chambers beneath the scaphognathites of maxillae. Epipodites of 1st pair are bilobed and larger than others. Epipodites also serve as respiratory organs like primitive gills.

[III] Gills

There are 8 gills inside each gill-chamber. Only 7 of them are exposed on removing the gill-cover as the 8th gill lies concealed beneath the dorsal part of the 2nd gill.

1. Types of gills. Gills are of three kinds according to their place of origin and attachment.

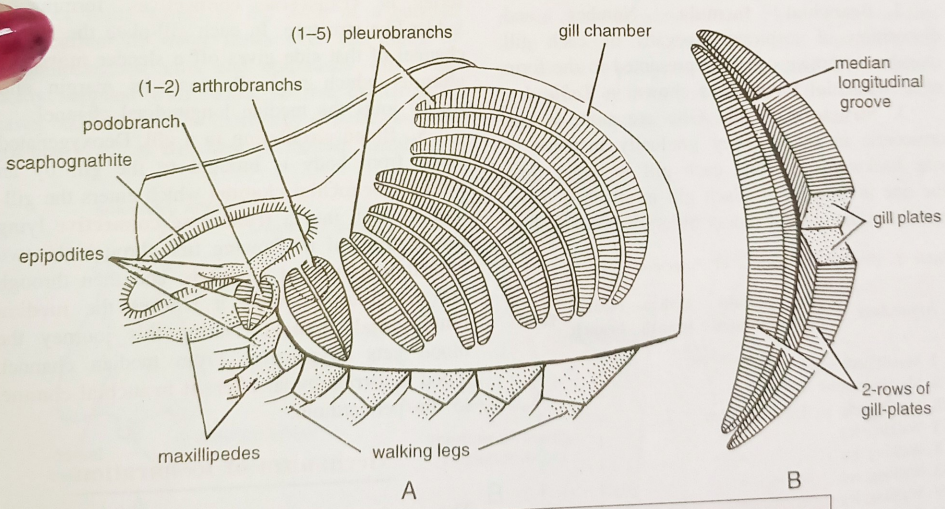


Fig. 19. *Palaemon.* **A.** Left gill-chamber exposed to show the gills. **B.** A phyllobranch.

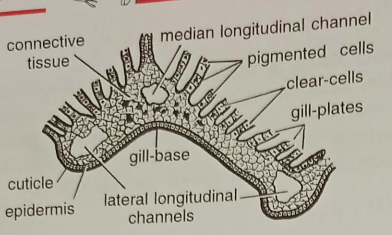


Fig. 20. *Palaemon.* Gill in oblique T.S.

(a) Podobranch or foot-gill. It is attached to the coxa of an appendage. In *Palaemon,* one podobranch is carried by the coxa of each second maxillipede.

(b) Arthrobranch or joint-gill. It is attached to the arthrodial membrane joining a limb with the body. Each third maxillipede bears two arthrobranchs. Second arthrobranch is the smallest and remains concealed beneath the first arthrobranch.

(c) Pleurobranch or side gill. It is attached to the lateral wall of segment bearing the limb. Last 5 gills on each side are pleurobranchs, attached to the lateral wall of thoracic segments bearing the 5 walking legs.

2. Branchial formula. Number and disposition of respiratory organs of each gill chamber in prawn can be represented in the form of a **branchial formula** as shown in *Table 1*.

3. Structure of gills. Gills are more or less crescentic in shape. They gradually increase in size backwards, so that each gill is larger than the one in front of it. Each gill is attached in its middle to the wall of thorax by a small connection called the **gill-root,** through which nerves and blood channels enter and leave the gill. All the gills of *Palaemon* are **phyllobranchs,** *i.e.,* each of them consists of two rows of leaf-like rhomboidal **gill-plates** arranged like leaves of a book, at right angles to the long narrow **axis** or **base** of gill. Gill-plates are largest in the middle but become gradually smaller towards the two ends. A deep median longitudinal **groove** runs between the two rows of diverging gill-plates.

Table 1. **Branchial Formula of *Palaemon*.**

Appendage	Epi-podite	Podo branch	Arthro-branch	Pleuro-branch	Total
I Maxillipede	1	–	–	–	1
II Maxillipede	1	1	–	–	2
III Maxillipede	1	–	2	–	3
I Walking leg	–	–	–	1	1
II Walking leg	–	–	–	1	1
III Walking leg	–	–	–	1	1
IV Walking leg	–	–	–	1	1
V Walking leg	–	–	–	1	1
Total	3	1	2	5	11

Histologically, a gill-plate is seen to be made of a single layer of cells with thin cuticle on both sides. The cells are of two types, **pigmented** and **transparent,** alternating with each other. Gill-base appears roughly triangular in a cross section, consisting of connective tissue bounded by an epidermis which is externally protected by a thin cuticle.

4. Blood supply in a gill. Three longitudinal **blood channels** run through the gill-base from one end of gill to the other. Two are **lateral longitudinal channels** running along the lateral margins, one on each side. The third is **median longitudinal channel** running through the apex of gill-base, beneath the outer median groove of gill. Lateral channels are connected together by a series of **transverse connectives,** forming a ladder-like structure. In each gill-plate the lateral channel of that side gives off a slender **marginal channel** which runs all along its margin and finally joins the median longitudinal channel.

5. Blood circulation in a gill. Deoxygenated blood from body is brought to the gill by an **afferent branchial channel** which enters the gill-root to open into a **transverse connective** lying just in front of it. Flowing first through the two **lateral longitudinal channels,** and then through the **marginal channels** it reaches the **median longitudinal channel.** During this journey the blood gets oxygenated. From median channel, blood is carried by an **efferent branchial channel** to the pericardium.

Mechanism of Respiration

The **scaphognathite** of each maxilla lies anteriorly inside the gill-chamber. By its constant vibrating movements, it bales out water from the anterior open end of gill chamber. Action of

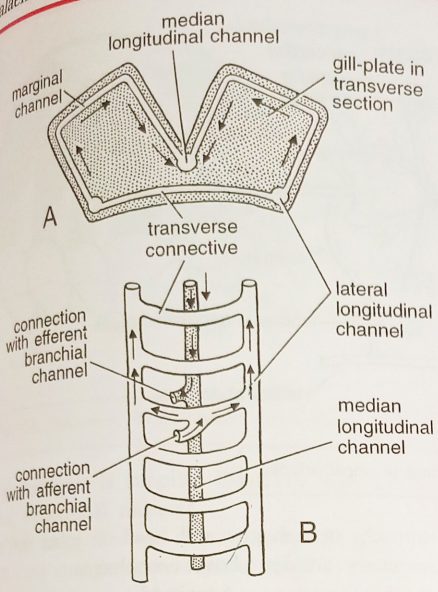


Fig. 21. *Palaemon.* **A.** Blood supply in gill plates. **B.** Diagrammatic representation of the ladder of blood channels in a gill.

scaphognathites is supplemented by the exopodites of maxillipedes. Fresh water enters the gill chamber from behind in the form of a current. This current of water flows over the lining of branchiostegites, gills and epipodites which are richly supplied with blood, so that exchange of gases takes place. The extremely delicate and thin gill-plates act as excellent permeable membranes for the passage of gases to and fro by diffusion. O_2, dissolved in water, is taken in by blood and CO_2 from blood diffuses out in the water.

BLOOD-VASCULAR SYSTEM

Blood Vascular Organs

Unlike annelids which have a 'closed type' of blood vascular system, prawn has an 'open type' or **lacunar type** of blood vascular system. Strictly speaking, it is partly closed and partly open. This type of blood vascular system is characterised by the absence of capillaries so that blood flows through open spaces, the **lacunae** or **sinuses**, in body. Blood vascular system of prawn includes : (i) **pericardium**, (ii) **heart**,. (iii) **arteries**, (iv) **blood lacunae** or **sinuses**, (v) **blood channels** and (vi) **blood**. There are no veins and capillaries as in vertebrates.

[I] Pericardium

Heart lies dorsally in the posterior part of thorax, enclosed in a spacious haemocoelic chamber, the **dorsal sinus** or **pericardium**. Floor of pericardium is in the form of a thin **horizontal septum**, lying just above hepatopancreas and gonad. This septum is attached in front and behind to the dorsal body wall and laterally to the thoracic wall.

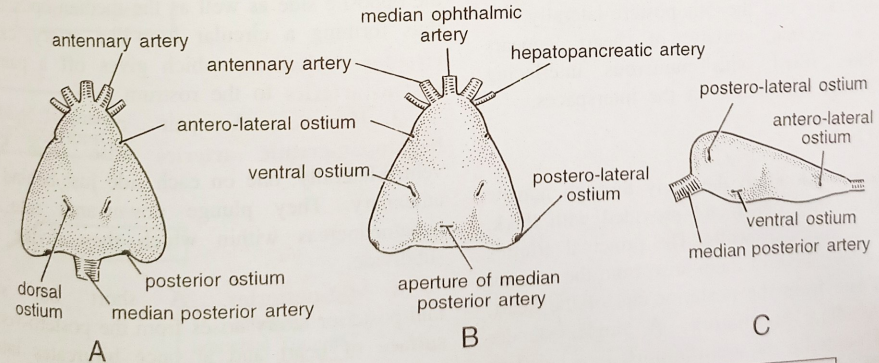


Fig. 22. *Palaemon.* Heart showing ostia. **A.** Dorsal view. **B.** Ventral view. **C.** Lateral view.

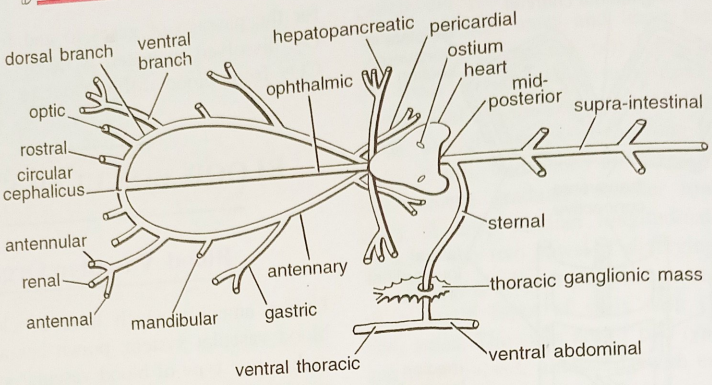


Fig. 23. *Palaemon.* Heart and principal arteries.

[II] Heart

Heart is a muscular and somewhat triangular organ with its **apex** directed anteriorly and the broad **base** posteriorly. A median longitudinal **cardio-pyloric strand** of fibrous tissue runs from its apex to the pyloric stomach. Two **lateral strands** extend from postero-lateral angles of heart to the body wall. The three strands keep the heart in position inside the pericardium. Thick and muscular wall of heart is perforated by five pairs of valvular, slit-like apertures, called **ostia** (L., **ostium**, a door). Blood from pericardial sinus enters the heart through ostia. Ostia are so distributed that the 1st pair lies dorsally, 2nd pair ventrally, 3rd pair posteriorly, 4th pair anterio-laterally and the 5th postero-laterally.

In a section, cavity of heart appears sponge-like, filled with numerous interlacing muscle fibres with blood in the interspaces.

[III] Arteries

Heart pumps blood to the body through narrow tube-like arteries which are provided with thick, strong and muscular walls. The principal arteries are as follows. Five of them arise from the anterior end and one from the posterior end of the heart.

1. Median ophthalmic. A single, slender **median cephalic** or **ophthalmic artery** arises from the apex of heart. It runs forward mid-dorsally along the renal sac to supply the cardiac stomach, oesophagus and head. It joins the two antennary arteries above oesophagus.

2. Antennary. A pair of **lateral cephalic** or **antennary arteries** also spring from heart's apex, one on either outer side of ophthalmic. Each antennary runs forward somewhat obliquely, passing along the outer border of mandibular muscle. It sends a **pericardial branch** to pericardium, a **gastric branch** to cardiac stomach and a **mandibular branch** to mandibular muscle. Then it bifurcates into a **dorsal** and a **ventral branch.** The **ventral branch** further divides to supply the antennule, antenna and renal organ. The **dorsal branch** sends an **optic artery** to the eye. Then it bends inwards to meet its fellow of the opposite side as well as the median opthalmic, thus forming a circular loop-like artery, called **circulus cephalicus,** which gives off a pair of **rostral arteries** to the rostrum.

3. Hepatic. A pair of **hepatic** or **hepatopan-creatic arteries** arise from heart ventro-laterally, one on each side just behind the antennary. They plunge downwards into the hepatopancreas within which they divide and subdivide.

4. Mid-posterior. A short but stout mid-posterior artery arises from the postero-ventral surface of heart and at once bifurcates into a **supra-intestinal** and a **sternal artery.**

Supra-intestinal or **dorsal abdominal artery** runs backwards along the dorsal surface of midgut

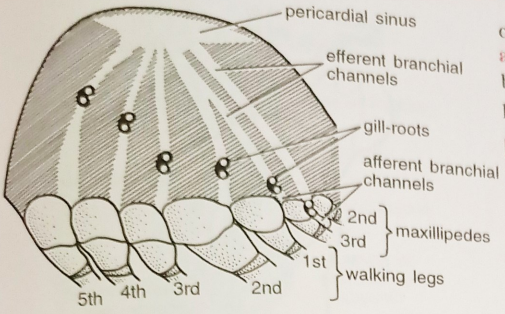


Fig. 24. *Palaemon.* Blood channels in cephalothorax.

up to hindgut. It supplies blood to midgut and dorsal abdominal muscles.

The large **sternal artery** is the stoutest of all. It runs straight downwards through the hepatopancreas. It passes through an aperture in the middle of the ventral thoracic ganglionic mass to reach the ventral side. Then it divides into two branches, (i) The **ventral thoracic** runs anteriorly up to mouth supplying the sternal region, first three pairs of walking legs, maxillae, maxillulae, oesophagus, gonads, etc. (ii) The **ventral abdominal** runs posteriorly upto anus and supplies blood to the ventral abdominal region, last two pairs of legs, pleopods, uropods, hindgut, etc.

[IV] Blood Sinuses

The heart and arteries comprise the closed portion of circulatory system. Arteries repeatedly branch in various organs of body. True **capillaries** and **veins** are absent. Minute arterial branches open freely into **blood sinuses** or **lacunae** of the haemocoel. All the sinuses of body eventually meet into a pair of elongated and ill-defined **ventral sinuses** lying below hepatopancreas on the floor of thorax. The two sinuses communicate with each other at various places.

[V] Blood Channels

The channels are lacunar tubes without proper walls. The sinuses and channels comprise the open portion of circulatory system. **Six afferent branchial channels** carry venous blood from each ventral sinus to the gills of that side, where it is aerated. As blood flows through gills, it gives off CO_2 and receives a fresh supply of O_2 from water

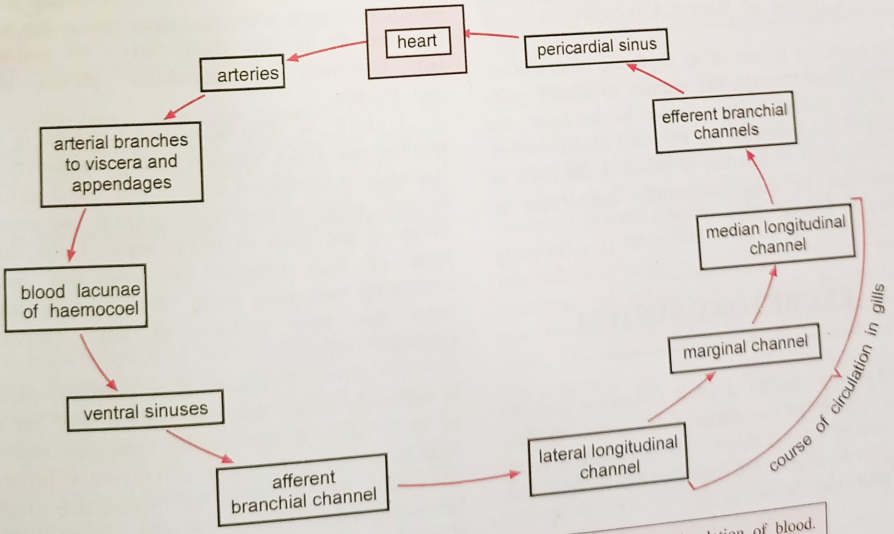


Fig. 25. *Palaemon.* A diagrammatic representation of the course of circulation of blood.

in the gill-chamber. Afferent channels run upwards along the inner side of the lateral thoracic wall and enter gills through their gill roots. First channel feeds the podobranch and two arthrobranchs. Of the remaining five channels, each supplies blood to a pleurobranch. Aerated blood from gills of each side is conveyed to the pericardium through another series of six **efferent branchial channels**, which also leave gills through their gill- roots.

[VI] Blood

Blood is colourless, thin and watery fluid, containing floating amoeboid white corpuscles or **leucocytes** which are phagocytic. There are no red blood cells. The respiratory pigment is **haemocyanin** which is dissolved in plasma. It has the same function as **haemoglobin** of other animals, but its metallic base is copper instead of iron. Haemocyanin becomes blue when combined with oxygen.

Blood of prawn has remarkable clotting properties. If an appendage is removed forcibly, there is hardly any noticeable loss of blood. The clot forms almost at once and fills the large wound opening.

Course of Blood Circulation

The heart, by means of its rhythmic contractions, forces blood through the arteries to all the parts of body. Before being returned to the heart, the blood is distributed to the gills and blood sinuses. The course of circulation of blood in the body of prawn can be diagrammatically represented as shown in Figure. 25.

EXCRETORY SYSTEM

The excretory system of adult *Palaemon* consists of (i) a pair of **antennary** or **green glands**, (ii) a pair of **lateral ducts**, (iii) an unpaired **renal** or **nephroperitoneal** sac, and (iv) the **integument**. True nephridia do not occur.

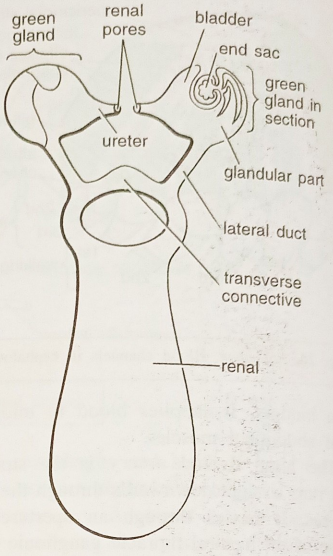


Fig. 26. *Palaemon.* Excretory organs in dorsal view.

[I] Antennary Glands

Coxa of each antenna encloses an antennary gland which is opaque white in colour and as big as a pea-seed. It includes three parts : (i) **end-sac**, (ii) **labyrinth** or **glandular plexus**, and (iii) **bladder**.

1. End sac. The bean-shaped end-sac is the smallest part lying between bladder and labyrinth. Internally, it contains a large central **blood-lacuna**. Its wall, made of two layers projects into central cavity in the form of radial **septa**. Outer thick layer of wall consists of connective tissue containing numerous small blood-lacunae, while inner thin layer consists of large excretory epithelial cells.

2. Labyrinth. Labyrinth or glandular plexus is relatively larger than the end-sac and lies on its outer side. It consists of numerous narrow, branching and greatly coiled **excretory tubules**, embedded in a mass of connective tissue containing blood lacunae. Tubules are lined by a single layer of large excretory epithelial cells. They

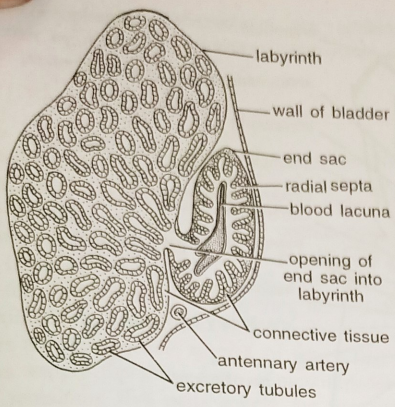


Fig. 27. *Palaemon.* Antennary gland in section.

open by a single aperture into end-sac and by many apertures into bladder.

3. **Bladder.** Bladder is the largest of all, lying on the inner side of end-sac. It is a thin-walled sac made of a single layer of excretory epithelial cells. Its inner wall is prolonged as a short excretory duct or **ureter,** which opens to outside through a small rounded **renal pore,** situated on a papilla on the inner surface of coxa of antenna.

[II] Lateral Ducts

A narrow lateral duct runs posteriorly from the bladder of each antennary gland. Lateral ducts of both sides are connected by a **transverse connective** just in front of the brain. The two ducts run backwards along the oesophagus to open into the **renal sac.**

[III] Renal-Sac

It is large thin-walled sac lying above the cardiac stomach, just beneath the carapace and extending posteriorly up to the gonads. Its wall is made of a single layer of flattened excretory epithelial cells.

Physiology of excretion. The complex, nephridia-like antennary glands extract nitrogenous wastes and excess water (osmoregulation) from blood in the same manner as the vertebrate kidneys. The end-sacs excrete mainly compounds of ammonia, but uric acid and other nitrogenous compounds are excreted by other parts. The excretory fluid from end sacs passes into labyrinths in which the useful materials are taken back by blood (selective resorption). The remaining fluid (urine) passes into bladders and finally expelled out through the renal apertures.

[IV] Integument

When the non-living chitinous covering or integument is cast off at each moult, the nitrogenous products secreted by body and deposited on the integument are also expelled. Thus, integument is believed to be an important excretory organ.

NERVOUS SYSTEM

The nervous system of prawn is of the **annelidan type.** However, it is somewhat larger and has more fusion of ganglia. It consists of : (i) the **central nervous system** including brain connected with a ventral ganglionated nerve cord through a pair of circum-oesophageal commissures, (ii) the **peripheral nervous system** including nerves, and (iii) the **sympathetic nervous system.**

[I] Brain or Supra-Oesophageal Ganglia

Brain lies at the base of rostrum, anterior to oesophagus and surrounded by a thick mass of fat. It is a bilobed structure derived from the fusion of several ganglia. On each side the brain gives off : (i) an **antennulary nerve** to antennule, into which it sends a **statocystic branch** to the statocyst, (ii) a stout **optic nerve** to compound eye, (iii) an ophthalmic nerve to muscles of eye-stalk, (iv) an **antennary nerve** to antenna and (v) a slender **tegumental nerve** to labrum.

[II] Circum-Oesophageal Commissures

Posteriorly, the Brain gives off a pair of stout nerves or the **circum-oesophageal commissures.**

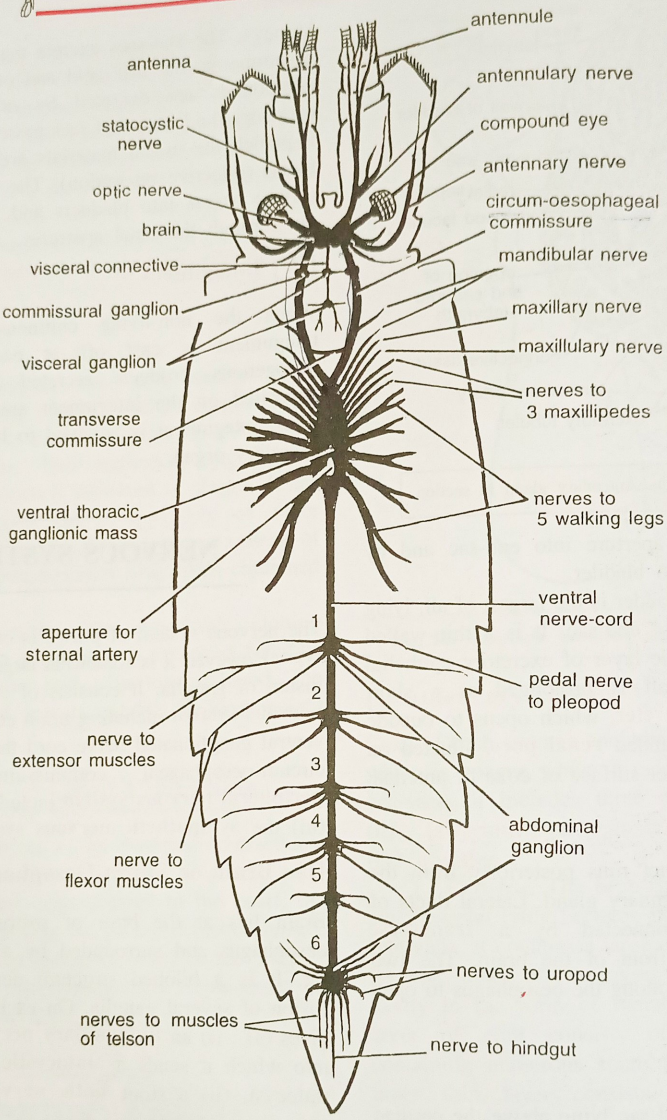


Fig. 28. *Palaemon.* Nervous system in dorsal view.

These run backwards and downwards, encircle the oesophagus and unite ventrally with the **sub-oesophageal ganglia**. The latter form an indistinguishable anterior part of the **ventral thoracic ganglionic mass**. The two commissures are crossed over, just behind oesophagus, by a double bridge of tough connective tissue, called **endosternite**. Each commissure bears a small **commissural ganglion** near its anterior end, sends a small **mandibular** nerve to mandible of its side.

Both oesophageal commissures are connected together by a slender transverse commissure near their posterior ends.

[III] Ventral Thoracic Ganglionic Mass

Like segments, the segmental nerve ganglia of cephalothorax also become fused to form an elongated **ventral thoracic ganglionic mass,** lying mid-ventrally on the floor of cephalothorax. It represents fusion of 11 pairs of ganglia and gives off laterally 11 pairs of nerves. First three pairs are the **cephalic nerves,** supplying the mandibles, maxillulae and maxillae, respectively. Last eight pairs are the **thoracic nerves,** of which first three pairs supply the three pairs of maxillipedes, and the remaining five pairs supply the five pairs of walking legs. Each nerve to a leg becomes bifurcated before entering the legs.

[IV] Ventral Nerve Cord

Ventral thoracic ganglionic mass gives off from its hind end a stout **ventral** or **abdominal nerve cord.** It runs along the mid-ventral line of abdomen. In each abdominal segment, it enlarges to form an **abdominal ganglion.** Each of the first five abdominal ganglia gives off three pairs of nerves : (i) one pair of **pedal nerves** to pleopods, (ii) one pair of nerves to extensor muscles, and (iii) one pair of nerves to flexor muscles of succeeding segment. The last, **stellate** or **sixth abdominal ganglion** is the largest composed of several fused ganglia. It supplies two pairs of nerves to flexor muscles, two pairs to uropods, two pairs to telson and a single median nerve to hindgut.

[V] Sympathetic Nervous System

Sympathetic, visceral or **autonomic nervous system** comprises a few ganglia and nerves. A small nerve, arising mid-posteriorly from brain, bears two **visceral ganglia** lying one behind the other. First ganglion is joined with the two **commissural ganglia** by connectives. Second ganglion gives off two pairs of nerves to the walls of oesophagus and cardiac stomach.

SENSE ORGANS

The most conspicuous sense organs are the eyes, antennules and antennae.

Compound Eyes

1. Structure. Prawn has one pair of black and hemispherical eyes. Each eye is mounted on a short, movable and two-jointed **stalk,** which is lodged in an **orbital notch** at the base of rostrum. Each eye is made of a large number of independent visual elements or units, called **ommatidia** (Gr., **ommation,** little eye). Such eyes are called the **compound eyes.** These are characteristic of Arthropoda and do not occur

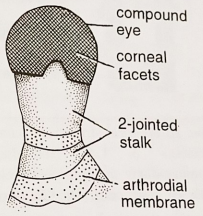


Fig. 29. *Palaemon.* Compound eye.

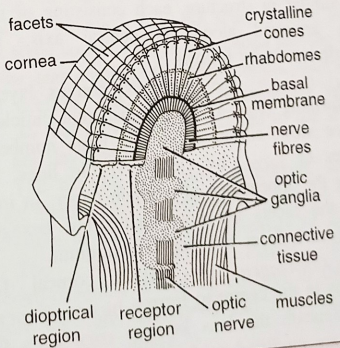


Fig. 30. *Palaemon.* L.s. of compound eye showing arrangement of ommatidia.

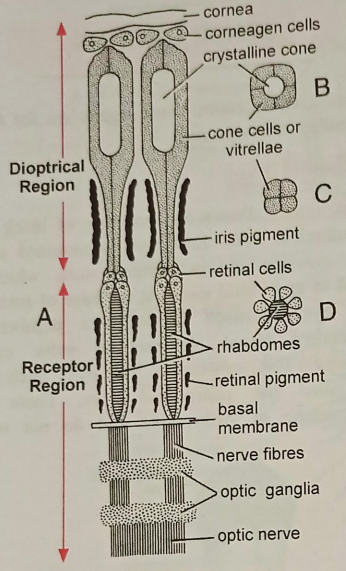


Fig. 31. *Palaemon.* Histological structure of compound eye. **A.** Two ommatidia in L.S. (semi-diagrammatic). **B.** T.S. of an ommatidium through cone cells. **C.** T.S. through basal ends of cone cells. **D.** T.S. through retinal cells.

elsewhere in the animal kingdom. All the ommatidia (about 2,500) are arranged radially and are similar in structure, each consisting of many cells arranged along its central axis. Their description is as follows :

(a) Cornea. The outermost convex layer of eye forming **cornea** is the transparent cuticle. In surface view, cornea exhibits a large number of squares or **facets** by clearly visible lines, thus giving the appearance of a graph paper. In insect eyes, the facets are not squares but hexagons. Below each facet lies one ommatidium.

(b) Corneagen cells. Each corneal facet thickens in the centre to form a **biconvex corneal lens**. Beneath the lens lie two **corneagen** cells which are modified epidermal cells and secrete a new cornea as soon as the old one is cast off in moulting.

(c) Cone cells. Beneath the corneagen cells lie four elongated **cone cells** or **vitrellae** which constitute a transparent, homogeneous **crystalline cone**. Inner ends of cone cells are long and tapering.

The part of eye, from cornea up to extreme ends of cone cells, is known as the **dioptrical region,** which focusses light upon the inner sensitive part or **receptor region** of eye.

(d) Rhabdome and retinal cells. Inner ends of cone cells lie upon an elongated, spindle-shaped rod, the **rhabdome**. It has a transversely striated appearance. Rhabdome is secreted and surrounded by a group of seven elongated **retinal cells.** Rhabdome and retinal cells together form the **receptor region** of eye. Inner ends of retinal cells rest upon a **basal membrane** beyond which they are continuous with sensory nerve fibres of **optic ganglia** which are connected with brain by the **optic nerve**.

(e) Chromatophores. Each ommatidium is cut off from its neighbours by a sheath of movable, amoeboid, dark **pigment cells** or **chromatophores** which are arranged in two series. Outer series lying along the cone cells is called **iris pigment,** and inner series separating the rhabdomes is called **retinal pigment**. Amoeboid pigment cells take up different positions according to the variations in the intensity of light.

2. Mosaic vision. Working of compound eye is very complex. It is deficient in focussing ability and clarity of image. But, such an eye is efficient for picking up motion and for **peripheral vision.** It functions as a very efficient organ for photo-reception. Mounted on a movable stalk, it can move on the head in much the same manner as the antenna of radar, and gives the animal almost 360-degree vision. Each ommatidium is capable of producing a separate image of a small part of the object seen. Therefore, in prawns and other arthropods possessing compound eyes, the image of the object viewed consists of several dark and light tiny pieces or spots, so that the total image of an object formed is a sort of a flat **mosaic.** Moving objects can thus be detected. The vision effected is said to be **mosasic vision** because of its similarity to mosaic art work.

The nature of composite image formed varies according to different intensities of light. Thus two types of images are formed. This is made possible by the movement of pigment cells.

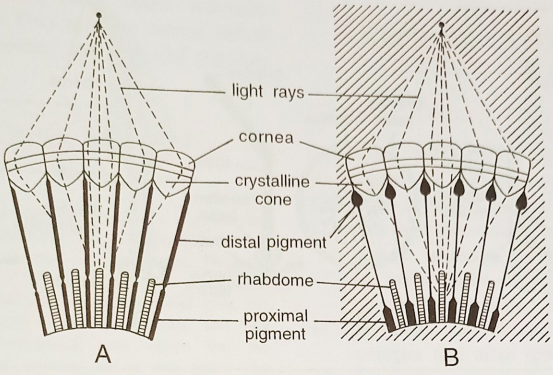


Fig. 32. *Palaemon.* Diagrammatic representation of image formation by a compound eye. **A.** Apposition image in bright light (day vision). **B.** Superposition image in dim light (night vision).

(a) Apposition image. In **bright light** (during daytime), the pigment cells spread in such a way that they completely isolate optically the adjacent ommatidia. No light can pass through from one visual unit to the other. In this condition the rays of light, which strike the cornea obliquely, are absorbed by the pigment cells without producing a visual effect. Only those rays of light which fall perpendicularly upon the cornea, can travel through the ommatidium and reach the rhabdome to form a point of image. As a result, the complete image formed is a mosaic of several components placed in juxtaposition in which the slightest movement is readily detected. In other words, each ommatidium responds to a fragment of the total field of vision and then these fragmentary images are fitted together into a single general picture. It is known as a mosaic or **apposition image**. Its sharpness depends upon the number of ommatidia involved and the degree of their isolation from one another. In butterflies, which are night-blind, the eyes are permanently set in this condition and are suited to see only in bright light. The image formed by this type of eye is never very good. It functions best at short distances only. Thus, most arthropods are always short-sighted.

(b) Superposition image. In **dim light** (during night), the pigment cells migrate and become separated into distal and proximal pigments, so that the neighbouring ommatidia no longer remain optically isolated but work in unison. In this condition even oblique rays of light are capable of forming a point of image after passing through a number of ommatidia in their way. As a result, an overlapping of the adjacent points of image occurs so that a continuous or **superposition image** is obtained. It is not sharp but the animal gets some sort of idea of the objects moving about in the surrounding. In some insects, like moths and fireflies, the eyes are permanently set like this, so that they are well adapted to see at night but are day-blind.

The prawns, like most arthropods, seem to adjust their eyes to form both types of images according to the prevailing intensity of light.

The **optic nerve** carries impulses (electro-chemical waves of energy) to the brain, where they are interpreted and registered as an upright **mental** image.

[II] Statocysts

1. Structure of statocyst. Statocysts are a pair of small, white, bead-like cuticular and hollow

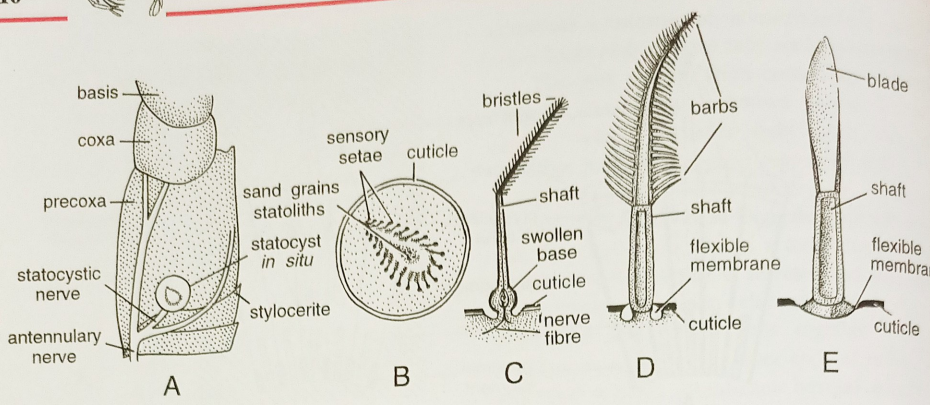


Fig. 33. *Palaemon.* **A.** Precoxa of antennule showing statocyst *in situ*. **B.** T.S. of statocyst. **C.** A single receptor seta (highly magnified).' **D.** A tactile seta (tangoreceptor). **E.** An olfactory seta (chemoreceptor).

spherical sacs. A statocyst lies inside the basal segment or precoxa of each antennule, attached to its dorsal wall. It opens dorsally on the concave surface or depression of precoxa through a minute **statocystic aperture**, which remains covered by a small fold of integument. A small **statocystic branch** of antennular nerve supplies the statocyst. Cavity of statocyst is oval, filled with minute sand particles, and lined by a number of elongated delicate sensory hairs or **receptor setae**. Each receptor seta is innervated by a small branch of the statocystic nerve. It consists of a swollen **base** and a long tapering **shaft**, which points towards the centre. The shaft is bent in the middle and bears fine bristles beyond the bend.

2. Function of statocysts. Statocysts perceive the direction of the force of gravity and function as the organs of **orientation** and **equilibrium**. The sand particles function as **statoliths**. Any change in the position of the swimming prawn causes a corresponding displacement of sand particles, which press against some of the sensory setae and stimulate them. Stimulated setae convey the information to brain through nerves, so that the animal corrects its position. At each moulting (ecdysis), statoliths are also shed along with the chitinous lining of statocysts, so that freshly-moulted individuals lose much of the power of orientation. However, the animal acquires new sand particles through the dorsal pore when the statocyst lining is renewed.

[III] Other Sense Organs

1. Tangoreceptors. The prawn is without a sense of hearing. However, the animal is sensitive to touch by means of tactile organs or tangoreceptors. These are in the form of **plumose setae** fringing the flattened portions of appendages, like the ramii of pleopods. Each tactile seta is a hollow cuticular outgrowth supplied with a nerve fibre. It consists of two segments. Basal segment or **shaft** is slightly swollen and attached to the integument by a membrane. Distal segment or **blade** gradually tapers and bears two rows of small barbs.

The elongated feelers of both **antennae** are also said to be tactile in function.

2. Chemoreceptors. Chemoreceptors or olfactory organs respond to chemical stimuli. They occur on **mouthparts, flagella of antennules** and inner wall of **gill chambers**. Inner smaller branch of outer feeler of each antennule bears a longitudinal groove containing numerous **olfactory setae**. Each seta consists of a basal segment or **shaft** which is attached to the integument by a flexible membrane, and a distal segment or **blade** which is bluntly rounded. A small nerve fibre from the olfactory branch of antennulary nerve innervates each seta.

3. **Proprioceptors.** These occur internally throughout the body. They perceive internal stimuli such as related to posture and muscular function.

ENDOCRINE SYSTEM

Palaemon, like other crustaceans, produces a large number of hormones. It is believed that the **sinus gland**, located at the base of eyestalk, secretes many hormones. They are believed to regulate : (i) the spread of pigment in chromotophores of epidermis and in compound eyes, (ii) deposition of lime salts in the exoskeleton, and (iii) moulting. Recent investigations have shown that the hormones that regulate moulting are of two types. The moulting-inhibiting hormones are secreted by **X organ** in the eyestalk and moulting- accelerating hormone by the **Y organ** beneath the adductor muscle of mandible. The latter hormone also induces metamorphosis.

Secretion of male sex hormones (androgens) has been reported by **H. Chariaux-Cotton** (1954) from androgenic glands located between, muscles of coxal segments of the last pair of walking legs. These hormones control the male sex characters.

REPRODUCTIVE SYSTEM

[I] Sexual Dimorphism

The **sexes** are separate (dioecious) and **sexual dimorphism** is well marked :

(1) Male is bigger in size than female.
(2) The male possesses a narrower abdomen than female.
(3) In male, bases of thoracic legs are more closely approximated than in female.
(4) In male, second chelate legs are longer, stronger and more spiny than in female.
(5) In male, each second pleopod bears an additional process, the **appendix masculina**, in between endopodite and appendix interna.
(6) In male, epimera of abdominal segments are smaller than in female.
(7) In male, paired genital openings lie on the coxae of 5th pair of legs, while they lie on the coxae of 3rd pair of legs in female.

A pair of **gonads** are similar in position, shape, size and general disposition in both the sexes. They lie in the posterior region of thorax, dorsally above the hepatopancreas and below pericardium. They extend anteriorly up to the renal sac and posteriorly up to the first abdominal segment.

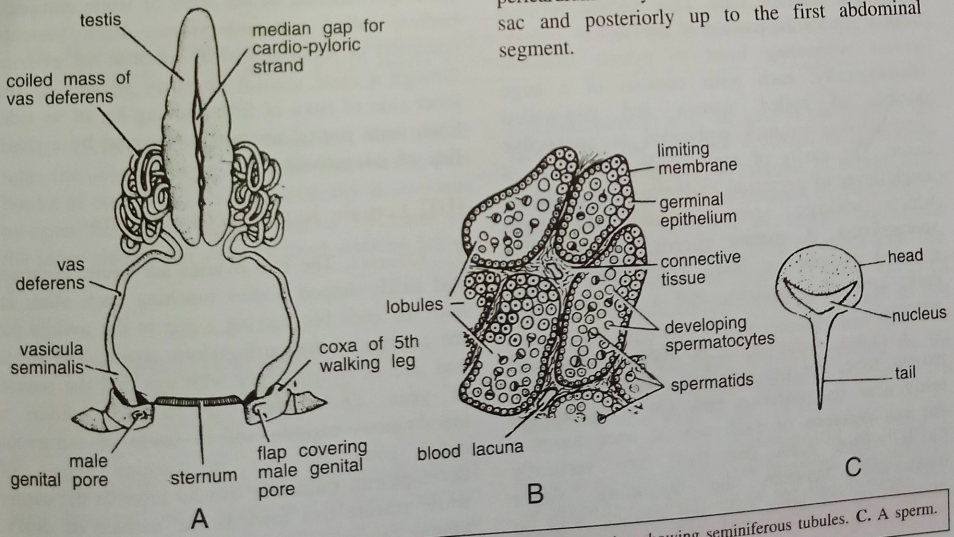
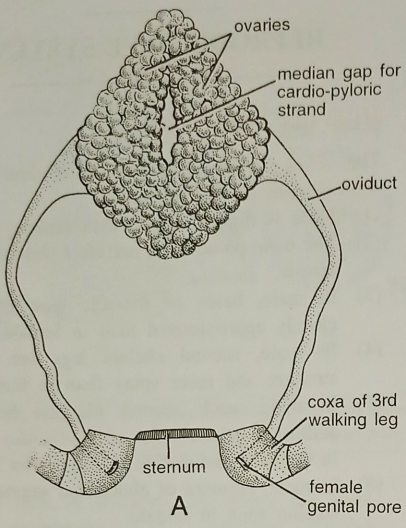


Fig. 34. *Palaemon*. **A.** Male reproductive organs. **B.** A portion of testis in section showing seminiferous tubules. **C.** A sperm.



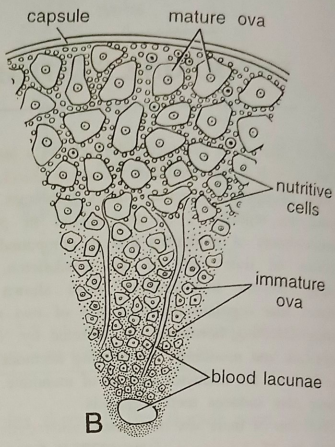


Fig. 35. *Palaemon.* **A.** Female reproductive organs. **B.** A portion of ovary in section (magnified).

[II] Male Reproductive System

1. Testes. The two testes are soft, white and elongated bodies which fuse at their anterior ends to form a common lobe. They enclose between them a gap for the passage of the **cardio - pyloric strand** connecting heart to pyloric stomach. Histologically, each testis consists of a large number of coiled, narrow and thin-walled **seminiferous tubules** embedded in connective tissue. The cavity of each tubule is lined by a single layer of **germinal epithelium,** the cells of which undergo **spermatogenesis** to form spermatozoa. A mature **sperm** consists of a rounded cytoplasmic body, containing a large, dark, crescentic nucleus, and a tail-like blunt process.

2. Vasa deferentia. A long, coiled and narrow tube, the **vas deferens,** arises from each testis near its posterior end. On emerging out the vas deferens of each side at once forms a much coiled mass and then runs vertically downwards between the abdominal flexor muscles on the inner side and thoracic wall on the outer side.

3. Vesicula seminalis. Each vas deferens reaching ventrally near the base of fifth leg, swells to form a club-shaped **vesicula seminalis**. These store spermatozoa in the form of white compact, bodies, called **spermatophores**. Each vesicula seminalis or seminal vesicle opens to the exterior through a **male genital aperture** situated on the inner side of coxa of fifth walking leg of its side. Each male genital aperture is covered by a small flap of integument.

[III] Female Reproductive System

1. Ovaries. The two ovaries are white, compact and sickle-shaped bodies touching each other at both the ends but leaving a gap in the middle for the passage of the cardiopyloric strand. The shape and size of ovaries vary with age and the season of year. Each ovary is enclosed within a membranous capsule and is made of numerous radial rows of **ova** in various stages of development. Immature ova lie towards the centre while mature ova towards the surface of ovary. Mature ova or **eggs** are large nucleated cells with plenty of yolk material (centrolecithal).

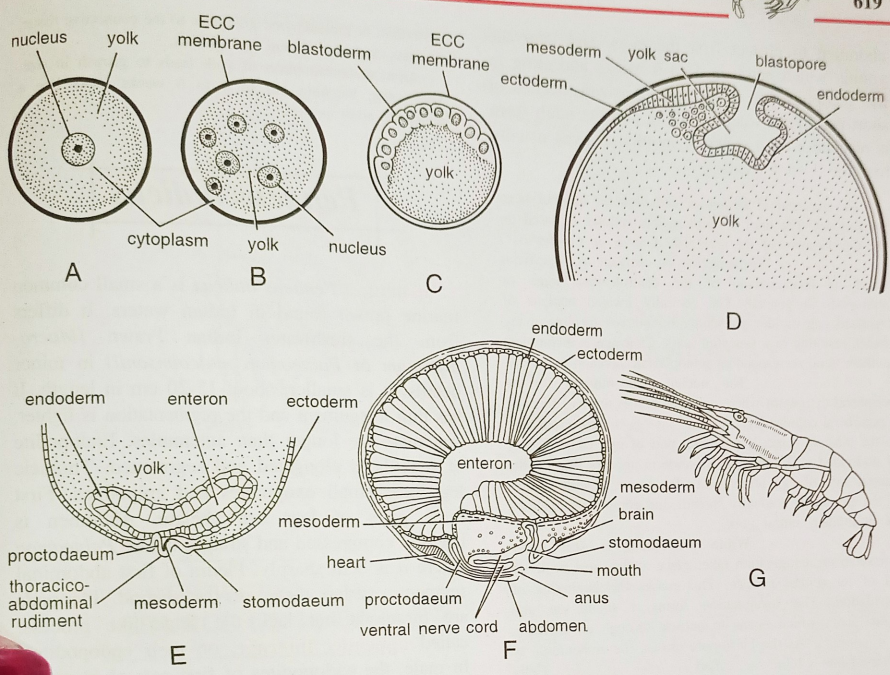


Fig. 36. *Palaemon.* Stages of development (diagrammatic) in sections. **A.** Zygote. **B.** Early cleavage. **C.** Early blastula. **D.** Early gastrula. **E.** Early embryo. **F.** Late embryo. **G.** Young prawn.

2. Oviducts. A short, wide and thin walled tube, the **oviduct**, originates from the outer middle border of each ovary. It runs vertically downwards to open through a **female genital aperture** on the inner side of the coxa of third walking leg of its side.

LIFE HISTORY AND DEVELOPMENT

1. Fertilization. *P. malcolmsonii* breeds during May, June and July. About two to three hundred mature eggs are laid by the female at one time in slimy strings. The male deposits sperms (spermatophores) near the genital openings of the female and the eggs are fertilized as they come out. Thus, **fertilization** is external, or *in situ*. After fertilization, the eggs are fastened to the pleopods by the sticky secretion of certain tegumental glands. The eggs hanging from pleopods look like berries or bunches of grapes. During breeding season, a female carries hundreds of eggs in this way, until they hatch. She carries them wherever she goes and the eggs are kept aerated by the slow back and forth movements of pleopods. The female is now said to be 'in berry'.

2. Development. Development is direct as there is no free larval form involved. The offspring or juvenile hatching out of the egg resembles the adult except in size. The female bends down her