E-content for

B.sc. Part-I Zoology Honours

PaperI: Group B- Coelomate Non-chordata

Topic: Respiration in Arthropoda

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Respiration in Arthropods

The following points highlight the two main forms of respiration among arthropods. The forms are: 1. Aquatic Respiration 2. Aerial Respiration.

1. Aquatic Respiration:

The organs associated with aquatic respiration are:

1. Gills orBranchiae

2. Trachealgills

3. Bloodgills

4. Rectalgills

5. Bookgills

6. Branchiostegite or gillcover

7. Epipoditeand

8. Branchialbasket.

1. Gills or Branchiae:

(i) Occurrence:

The gills are the respiratory organs of aquatic arthropods. These are best developed in crustaceans. In other aquatic arthropods, special types of gills are often encountered.

(ii) Location:

Gills are situated within the gill chamber. The gill chamber is located on each lateral side of the cephalothorax and covered by the gill cover or branchiostegite.Origin of gills incrustacean:

Gills originate as out-pushings of the body wall. In Amphipoda, the gills are outgrowths of the thoracic limbs and in Isopods the endopodites of second and fifth pleapods are modified as gills.

(iii) Structure of gills inCrustacea:

A typical gill (Fig. 18.10) is crescent- shaped. It consists of a central axis or rod, on each side of which are arranged blade-like gill filaments, called lamellae. One end of each filament or lamella remains connected with the rod or central axis and the other end of

the filament is blind. Through the central axis of each gill runs an afferent and an efferent branchial channel.

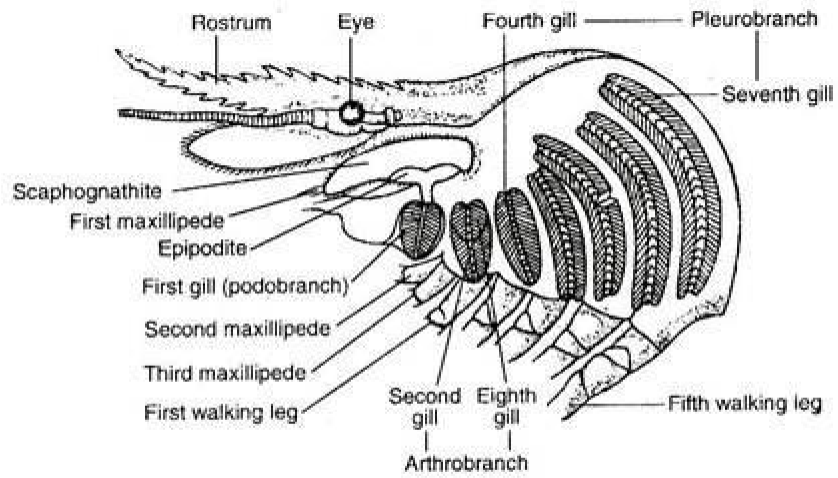

Fig. 18.10: Respiratory organs (Gills) of *Palaemon*. Note that the branchiostegite of one side has been removed to expose the gill-chamber.

(iv) Types of gills in Crustacea:

A. Based on the shape of the lamellae, the gills are of the followingtypes:

1. Phyllobranchiategill:

In this type of gills the lamellae are flat, broad leaf-like and are arranged in two rows. (Fig. 18.127A, B). It is found in crabs and prawns (Palaemon).

2. Trichobranchiategill:

In this type of gills, the gill filaments are tubular-shaped. It is found in crayfish (e.g., Astacus) and rock lobsters. It consists of a central axis with numerous lateral filaments, formed from the sides of the body or from an outgrowth of skin of the legs (Fig. 18.127C, D).

3. Dendrobranchiategill:

In this type of gills, the leaf-like lamellae are divided into fine branched filaments (Fig. 18.127E, F). It is found in Penaeus.

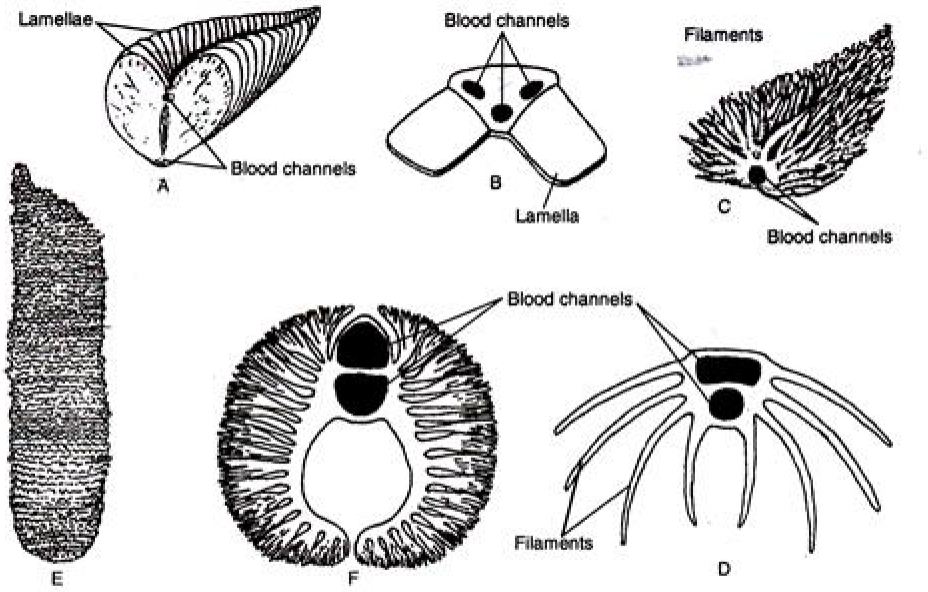

Fig. 18.127: Types of gills in decapod Crustacea. A. Lateral view of a phyllobranchiate gill with flat lamella, B. Transverse section of a phyllobranchiate gill. C. An entire view of a trichobranchiate gill. D. Transverse section of a trichobranchiate gill. E. An entire view of a dendrobranchiate gill. F. Transverse section of dendrobranchiate gill (from various sources).

B. Based on the mode of attachment, the gills may be of threetypes:

1. Podobranch:

Podobranch attached with the coxopodite of the thoracic appendage. In Macrobrachium (= Palaemon), Penaeus the podobranchs are one pair and remain attached to the second maxillipedes (Fig. 18.10).

2. Arthrobranch:

Arthrobranch the gills are attached with the arthroidal membrane which connect the appendages of the thorax. In Palaemon the arthrobranchs are two, attached to the arthroidal membrane of third maxillipede. In Penaeus there are eleven pairs of arthrobranchs, starting from second maxilliped to third walking leg, two in each appendage and fourth walking legs contain single arthrobranch.

3. Pleurobranch:

Pleurobranch—the gills are attached with the lateral wall of the thorax. In Palaemon there are five pleurobranchs, attached to the lateral side of the thorax. Is Penaeus there are six pairs of pleurobranchs attached to the last six pairs of thoracic appendages.

(v) Number of gills inCrustacea:

Number varies in different groups. The Decapods which contain all the types of gills

exhibit extreme variation—in the shrimp, Lucifer, gills are absent; penaeid shrimp has 24; Homarus has 20; Peacrab contains 6 gills. In Palaemon, there are 8 pairs of gills and the

anterior gills are small and the size increases towards the posterior end.

(vi) Modification of gills inArthropoda:

The gills are variously modified in Crustaceans and other Arthropods. In Phyllocarida, broad epipodites of the thoracic appendages work as gills. Similar gills are seen in Cumacea. Gills are plate-like in Amphipoda and flattened in a Decapod, Palinurus.

In Euphausiacea, the tufted podobranchs are not covered by carapace. The gills appear as a row of small branchial lamellae on each side of Cyprididae. In Phyllopoda, the leaf-like pleopods work as gills. Among the Crustaceans only Stomatopods and Isopods have abdominal gills.

2. Trachealgills:

In the aqualtic larvae of many insects a series of simple and divided external processes are attached to the abdominal segments. These are richly supplied with tracheae and are called the tracheal gills (Fig. 18.128A), help in respiration.

3. Bloodgills:

In certain aquatic insect larvae (mainly chironomidae) the tracheae are replaced by the branching tubular outgrowths containing blood vessels and are called the blood gills.

Remark:

These were formerly thought to be respiratory organs but recently it has found that the respiration of these animals takes place throughout the whole body surface.

4. Rectalgills:

In the nymphs of several insects the inner surface of the rectum bears gills. These gills are called the rectal gills.

5. Book gills:

The most specialised gills are seen in Xiphosurids, where the abdominal appendages bear plate- like book gills (Fig. 18.128E). These gills are formed by the evagination of the posterior borders of opisthosoma in segments from ninth to thirteenth. Each gill contains nearly 150 lamellae, which look like the delicate leaves of a book.

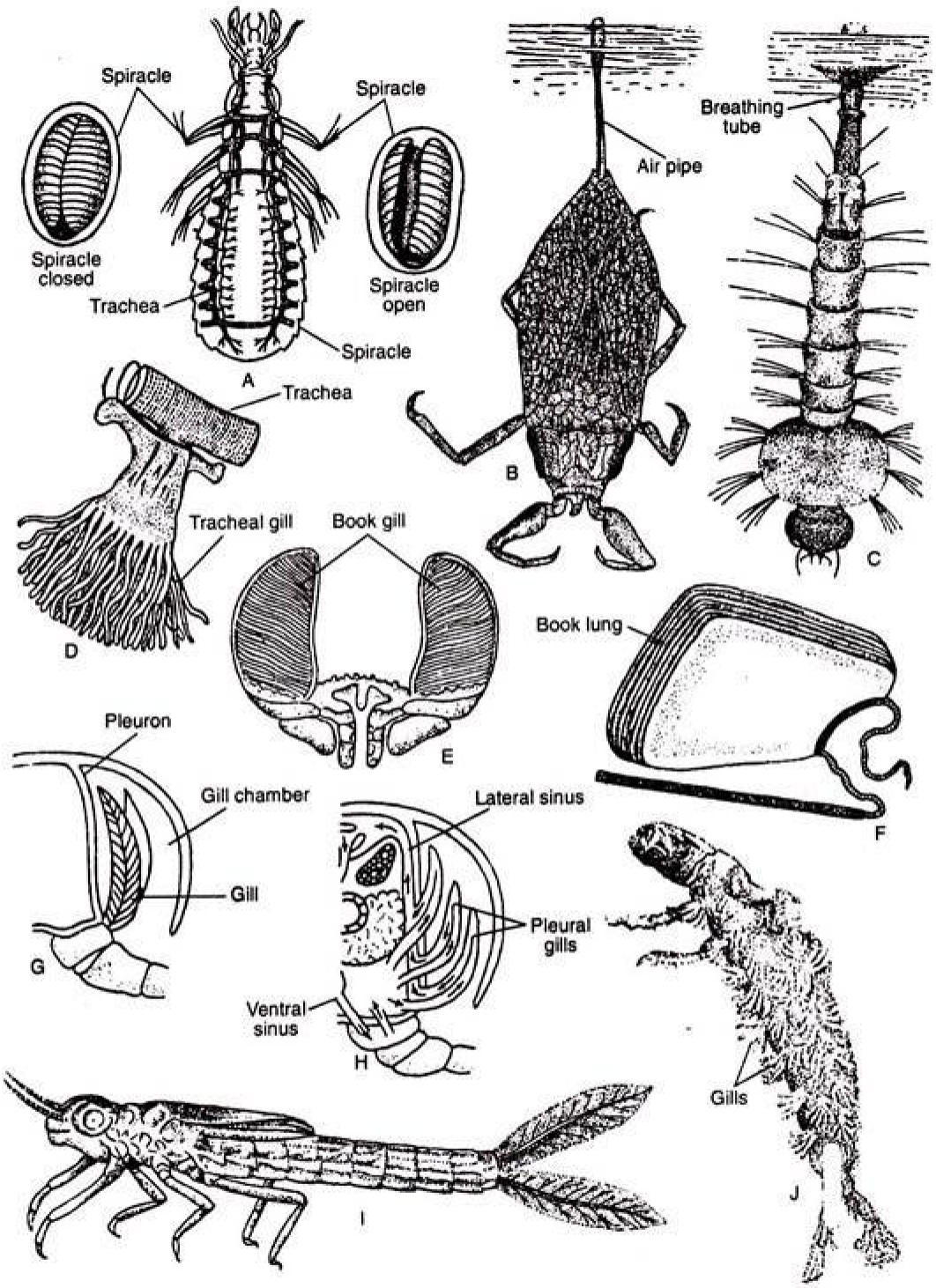

Fig. 18.128: Respiratory structures of a few arthropods. A. Tracheal system of a typical insect. B. Air pipe of water scorpion. C. Breathing tubes of a mosquito larva. D. Tracheal gill of an insect. E. Book gill of *Limulus*. F. Book-lung of spider. G. Podobranchial gill of crustacea. H. Pleural gills of crustacea. I. Leaf-like gill of a damsel-fly nymph. J. Mesh of gills in a caddisfly larva.

Mechanism of gill respiration:

In most Crustaceans, the gills are not covered within a special gill chamber. But in Decapods, the carapace extends laterally over the gills to house them in a special chamber.

In such forms with chamber, current of water enters through one end and after bathing the gills, passes out through another direction. In Crustaceans and Xiphosurids, gaseous exchange takes place in the gills between the blood and the water. But in Insects, after diffusion the oxygen passes to the tracheal tubes.

Other devices of aquatic respiration:

6. Branchiostegites:

In Crustacea the gill-chamber is covered by the lateral extension of carapace, called gill cover or branchiostegite. The inner lining of the branchiostegite is thin, membranous and richly supplied with blood. It is in direct contact with water current and exchanges gases between the blood and the water.

7. Epipodites:

These are small highly vascularised leaf-like membranous outgrowths of integument on the outer side of coxa of the maxillipeds in first three thoracic segments. These epipodites being present in the anterior part of each gill-chamber (e.g., Crustacea) carry out respiratory functions.

8. Branchialbasket:

The immature Odonates (Insects) have their rectum modified into a branchial basket. Its wall is contractile and richly supplied with the branches of tracheae. This kind of respiration is often referred to as anal respiration.

2. Aerial Respiration:

The aerial respiration takes place in terrestrial arthropods.

The organs for respiration are the following:

1. Trachea

2. Lungs

3. Book-lungs

4. Pseudotracheae or airtubes

5. Analrespiration

6. Miscellaneousdevices

1. Trachea:

This is the most important organ for aerial respiration. This chitin-lined tube is seen in almost all land arthropods, such as insects, centipedes, millipedes and many

arachnids.

Two types of tracheae are seen:

(i) Ventilation trachea—oval in section and collapses after the exhalation of airand

(ii) Diffused trachea—rigid and does not collapse after theexhalation.

Origin:

The tracheae originate as the invagination of the body wall.

(a) Structures of trachea and associated parts:

(i) Each trachea is a tube with walls made up of polygonalcells.

(ii) The wall of trachea is composed of three layers—these are the internal layer, called intima, a middle layer of epithelium and an outer layer of basementmembrane.

(iii) The intima is lined by spiral cuticular ridges, called taenidea, that preventcollapse.

(iv) The tracheal cuticle contains the same layers as the surface cuticle except the cementlayer and waxlayer.

(v) The tracheae open externally by small openings, called spiracles orstigmata.

(vi) These spiracles are located along the sides of thebody.

(vii) Each spiracle opens into a chamber, called atrium and the spiracle is placed on aplate, calledpenetrene.

(viii) Each spiracle has two lids for opening andclosing.

(ix) Within the chamber foreign particles are eliminated by a filtering apparatus, containing either special bundles of setae or a kind of sieve-likemembrane.

(x) Some parts of tracheae are dilated to form air-sacs. They help as reservoirs ofair.

(xi) The finer branches of tracheae are called tracheoles which are without inner taerridialridges. A tracheole may be 1μ in diameter and reaches every cell of thebody.

(xii) The end of a finer tracheae is immersed in a fluid through which gaseous exchangetakes place.

(b) Classification oftracheae:

(i) In adult insects, the tracheal system is of onekind.

(ii) Two pairs thoracic and eight pairs abdominal spiracles are usually present in all adultinsects. There are 12 pairs in primitivecondition.

(iii) In certain forms some spiracles may be secondarily absent but they appear at least in some stages of development. For example, the queen termite has only six pairs abdominal spiracles instead of eight pairs. The metathoracic pair of spiracles is absent in Lepidoptera,Hymenoptera, Coleoptera and a fewothers.

(iv) In millipedes, a pair of spiracles is present in each thoracic segment and two pairsof spiracles in each abdominalsegment.

(v) During development, spiracles appear in varied ways in different in sects. Thus from the point of view of embryology the tracheal system is classified on the basis of the number of functional spiracles. This classification does not denote any special kind of tracheal system inthe adult.

On the basis of functional spiracles the tracheal system in larvae may be classified as:

(i) Polypneustic:

Tracheal system openings to the exterior by 8 or more pairs of functional spiracles.

It may again be subdivided into:

(a) Holopneustic:

When 2 pairs of thoracic and 8 pairs of abdominal spiracles are functional. The term is used when 10 pairs of functional spiracles are present.

(b) Peripneustic:

A respiratory system with 1 thoracic and 8 abdominal spiracles are present on each side of the body. The term is denoted when the abdominal spiracles occur on all the segments of the abdomen.

(c) Hemipneustic:

A respiratory system with 1 thoracic and 7 abdominal spiracles are present on each side of the body. The term is used when one or more pairs of spiracles are nonfunctional.

(ii) Oligoneustic:

Here, either one or two pairs of spiracles are functional.

It includes divisions like:

(a) Amphipneustic:

When one pair of thoracic and one pair of post-abdominal spiracles are present. Such condition is found in the larva of the common house fly.

(b) Metapneustic:

Only one pair of post abdominal spiracles is functional. This condition is seen in the mosquito larva.

(c) Propneustic:

Only one pair of thoracic spiracles is functional. This condition is seen in the pupae of certain Diptera.

(iii) Apneustic:

No spiracle is present in functional state. Gaseous exchange takes place through the integument, seen among aquatic insect larvae.

(c) Mechanism of trachealrespiration:

The trachea ramifies into a number of fine networks of tracheoles which terminate into tissues where exchange of gases takes place by diffusion. Air is drawn in and forced out through the spiracles by the alternate contraction and expansion of the body. The spiracles remain closed most of the time and exchange of gases is probably due to diffusion and ventilation.

Recent studies indicate that the spiracles open very briefly but not all at a time due to reduction of haemocoelomic pressure. The spiracles are closed by valves, thus control the water loss, and opening of the spiracles is related to the high CO_2 concentration.

Gaseous exchange through the tracheae takes place by diffusion primarily and tracheoles are permeable to water and remain fluid-filled. This fluid is believed to be involved in the final O_2 transport to the tissues.

Again it is reported that the movement of trachea is facilitated by the alternate contraction and relaxation of the body sclerites. In the bed bugs, rigid and convex sternum does not take part in the respiratory movement, which is done only by the elastic tergum. In cockroaches the tergum and sternum of the segments are separated by intersegmental membrane which bulges out during respiration.

(d) Modifications of thetracheae:

In most Collembola, the tracheae are absent and the respiration is largely cutaneous. In Machiles, segmental tracheae originate from spiracles but do not have trunks. In the larva of Musca, dorsal longitudinal trunk is provided with one pair of anterior and one pair of posterior apertures.

In the larvae of mosquito, a single spiracle is connected to the dorsal trunk. In the Myriapods, stigmata open within air chamber from where large numbers of tracheae are given off. The other peculiar features of this group are that in Diplopoda the tracheae are branched and in Symphyla only two tracheae are present on the head.

Other devices of aerial respiration:

1. Book-lungs:

The book-lungs are best seen in Scorpionids and spiders (Fig. 18.128F). These are blind sacs which originate from the evaginations of opisthosoma. These are regarded as the modified abdominal appendages.

Within the sac the inner lining is raised into numerous delicate folds, like the leaves of a book. These folds are richly vascularised and thus respiration in Scorpionids is circulation dependent. Each book-lung communicates to the exterior by a stigma.

2. Pseudotracheae or airtubes:

The only land living Crustacea, Oniscus (wood lice), possess numerous minute tube-like structures in the abdominal appendages, called Pseudotracheae, help in respiration.

3. Analrespiration:

Many crustaceans perform rhythmical contractions of intestine—taking in and expelling out water. Such anal respiration is common in lower crustaceans and is especially noticeable in Cyclops.

4. Miscellaneousdevices:

A combination of book-lung with trachea is seen in spiders. Some aquatic members of Colleoptera and Hemiptera (e.g., Nepa, Ranatra) carry respiratory tubes, located at the posterior end of the body which is formed by two cerci. While they dive inside the water, they cany air with them for respiration. In mosquito larvae, a long siphon draws air from the surface of the water.