Accessory Respiratory Organs in Fishes | Phylum Chordata

Types of Accessory Respiratory Organs:

1. Suprabrachial Organ:

The supra-branchial organ is a specialised type of respiratory structure encountered in Clarias batrachus (Fig. 6.83A).

It has a complex structural organisation and consists of the following portions:

(a) An elaborate tree-like structure growing from the upper end of the second and fourth gill-arches of either side. This dendritic organ is composed of numerous terminal knobs, each has a core of cartilage covered by vascular membrane. Each exhibits eight folds which suggest that one such knob is formed by the coalescence of eight gill-filaments.

(b) There are a pair of highly vascularized supra- branchial chambers within which the tree-like structures are contained. The supra-branchial chambers are developed as the vascularized diverticula of the branchial chamber.

(c) The entrance of the supra-branchial chamber is guarded by 'fan'-like structures which are developed by the fusion of the adjacent gill- filaments of the dorsal side of the gill-arches.

The supra-branchial organs, like the gills, are lined by thin outer epithelial layers with intercellular spaces separated by the pilaster cells. The organs and the supra-branchial chambers are supplied by afferent and efferent blood vessels from the gill-arches.

The supra-branchial organs help to breathe in air. The supra-branchial chamber has inhalant and exhalant apertures. These fishes come to the surface of the water and gulp air into the supra-branchial organs. Atmospheric air from the pharyngeal cavity is taken into the supra-branchial chamber by an inhalant aperture located between the second and third gill- arches.

After gaseous exchange the air from the said chamber expels into the opercular cavity by the gill-slit lying between the third and fourth gill-arches. The fan-like structures present in the second and the third gill-arches help to intake the air while the expulsion of the air from the supra-branchial, chamber is caused by the contraction of its wall. Thus the supra-branchial chamber and its contained organs function as 'lung'.

2. Branchial Outgrowths:

In climbing perch (Anabas testudineus) there are two spacious sac-like outgrowths from the dorsal side of the branchial chambers (Fig. 6.83B). The epithelium lining these outgrowths is highly vascular and becomes folded to increase the respiratory area.

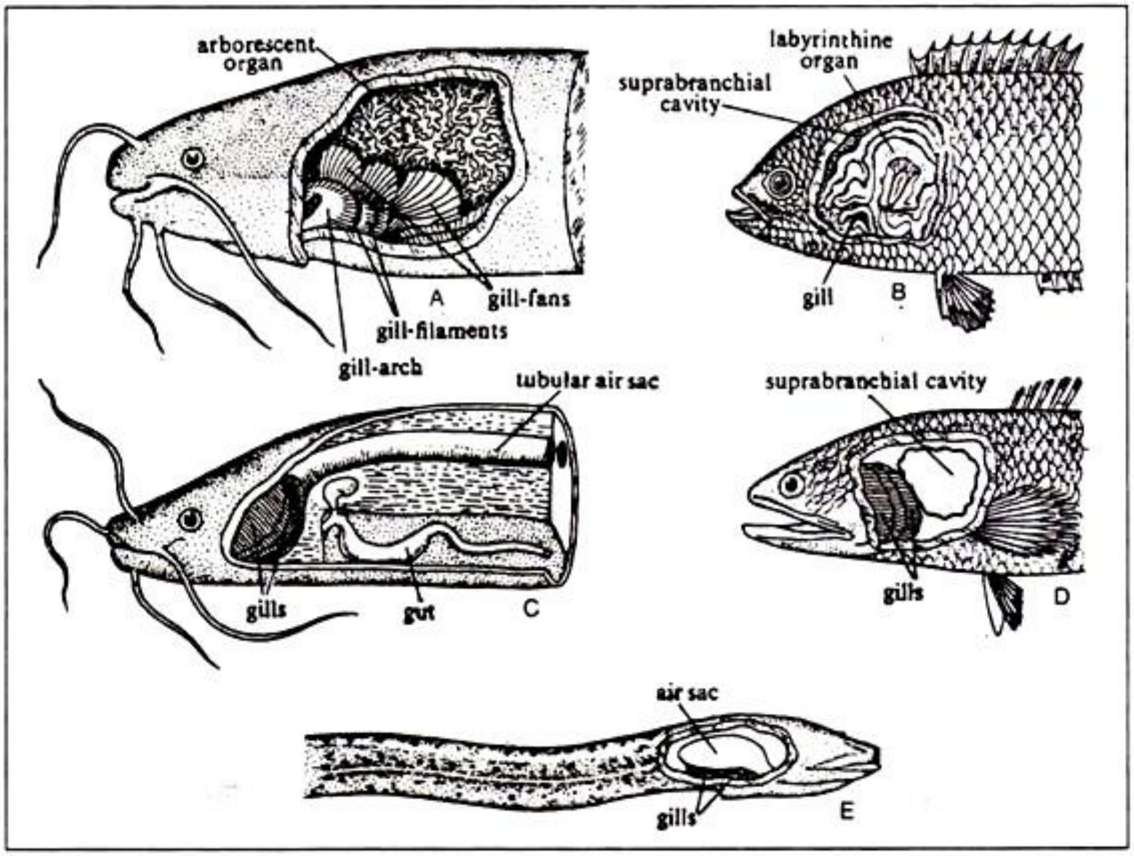

Fig. 6.83 : Accessory respiratory organs in air-breathing teleosts. A. *Clarias batrachus*. B. *Anabas testudineus*. C. *Heteropneustes fossils*. D. *Channa punctatus*. E. *Amphipnous cuchia*.

Each chamber contains a characteristic rosette-like labyrinthine organ. This organ develops from the first epibranchial bone and consists of a number of shell like concentric plates. The margins of the plates are wavy and the plates are covered with vascular gill-like epithelium.

Each branchial outgrowth communicates freely not only with the opercular cavity but also with the buccopharyngeal cavity. Air enters into the outgrowth by way of the buccopharyngeal opening and goes out through the external gill-slits. The entrance is controlled by valves.

During travelling the opercula alternately spread out and fix to the ground by the spines and get the forward push from the pectoral fins and the tail. The proverb that the fish can climb the trees seems to be erroneous. The climbing perches are found in the branches of palm or other trees which are possibly brought there by the kites or crows while these fishes migrate over the land.

In Trichogaster fasciatus the accessory respiratory organs are similar to that of Anabas and consist of supra-branchial chamber, labyrinthine organ and respiratory membrane (Fig. 6.84).

The labyrinthine organ is simpler in construction in comparison to that of Anabas. Each organ assumes a spiral configuration with two leaf-like expansions. Each of these two expansions is composed of loose connective tissue which is covered by highly vascular epithelium.

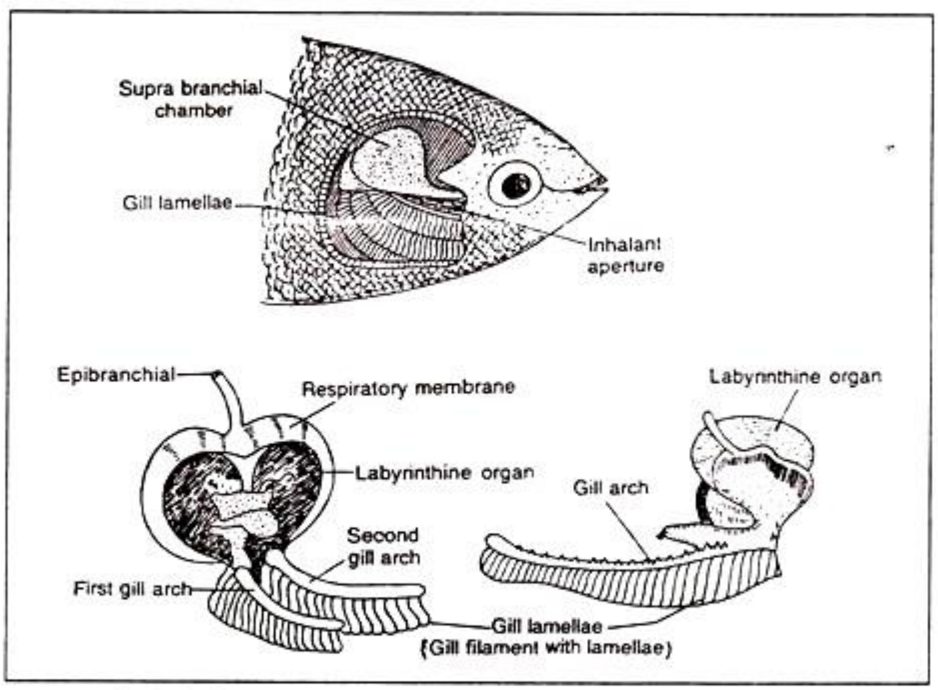

Fig. 6.84 : Gills and accessory respiratory organs of *Trichogaster fasciatus*.

3. Pharyngeal Diverticula:

Anabas can breathe in air by the help of these organs. These fishes have the habit of migration from one pond to the other. Their overland progression is peculiar and is assisted by the operculum and the fins. Each operculum bears sharp spines at the free edge.

In the Snake- headed fishes and Cuchia eels, the accessory respiratory organs are relatively simplified. These fishes can survive prolonged drought and their air breathing habit enables them to remain out of water for some time. In both the group of fishes, the pharynx gives a pair of saclike diverticula for gaseous exchange.

In Channa, the accessory respiratory organs are relatively simpler and consist of a pair of air-chambers (Fig. 6.83D). These are developed from the pharynx and not from the branchial chamber as seen in others.

The air-chambers are lined by thickened epithelium which is highly vascularized. The air-chambers are simple sac-like structures and do not contain any structure. These chambers function as the lung-like reservoirs. In Channa striatus the vascular epithelium lining the chambers becomes folded to form some alveoli. The gill-filaments are greatly reduced in size.

In Cuchia (Amphipnous cuchia) the accessory respiratory organs consist of a pair of vascular sac-like diverticula from the pharynx above the gills (Fig. 6.83E). These diverticula open anteriorly into the first gill-slit. These diverticula function physiologically as the lungs.

The gills are greatly reduced and a few rudimentary gill-filaments are present on the second of the three remaining gill- arches. The third gill-arch is found to bear fleshy vascular epithelium. In Periophthalmus, a pair of very small pharyngeal diverticula is present which are lined by vascular epithelium.

4. Pneumatic Sacs:
In Heteropneustes fossil is, a pair of tubular pneumatic sacs, one on each side of the body, act as the accessory respiratory organs.

These long tubular sacs arise as the outgrowths from the branchial chamber and extend almost up to the tail between the body musculature near the vertebral column (Fig. 6.83C). In Sacco-branchus, similar tubular lung-like outgrowths of the branchial chamber extend back into the body musculature.

5. Buccopharyngeal Epithelium:
The vascular membrane of buccopharyngeal region in almost all the fishes helps in absorbing oxygen from water. But in mudskippers (Periophthalmus and

Boleophthalmus) the highly vascularized buccopharyngeal epithelium helps in absorbing oxygen directly from the atmosphere.

These tropical fishes leave water and spend most of the time skipping or 'walking' about through dampy areas particularly round the roots of the mangrove trees. The old idea that the mud-skippers use the vascular tail as the respiratory organ is not supported by recent Icthyologists.

6. Integument:
Eels are recorded to make considerable journey through damp vegetation. The common eel, Anguilla Anguilla can respire through the integument both in air and in water. In Amphipnous cuchia and mud- skippers, the moist skin sub-serves respiration.

Many embryos and larvae of fishes respire through the skin before the emergence of the gills. The median fin fold of many larval fishes is supplied with numerous blood vessels and helps in breathing. The highly vascular opercular fold of Sturgeon and many Catfishes serves as the accessory respiratory structure.

7. Gut epithelium:
The inner epithelium of the gut essentially helps in digestive process. But in many fishes the gut becomes modified to sub-serve respiratory function. Cobitis (giant loach of Europe) comes above the water-level and swallows a certain volume of air which passes back along the stomach and intestine. In Misgurus fossilis, a bulge just behind the stomach is produced which is lined by fine blood vessels.

The bulge acts as the reservoir of air and functions as the accessory respiratory organ. After the gaseous exchange, the gas is voided through the anus. In certain other fishes, Callichthyes, Hypostomus and Doras the highly vascular rectum acts as the respiratory organ by sucking in and giving out water through the anus alternately.

In these fishes the wall of the gut becomes modified. The wall becomes thin due to the reduction of the muscular layers.

8. Swim-Bladder acts as Lung:
Swim-bladder is essentially a hydrostatic organ but in some fishes it functions as the 'lung'. In Amia and Lepisosteus, the wall of the swim-bladder is sacculated and

resembles lung. In Polypterus the swim-bladder is more lung-like and gets a pair of pulmonary arteries arising from the last pair of epibranchial arteries.

The swim-bladder in dipnoans resembles strikingly the tetra- pod lung in structure as well as in function. In Neoceratodus, it is single, but in Protopterus and Lepidosiren it is bilobed. The inner surface of the 'lung' is increased by spongy alveolar structures.

In these fishes, the 'lung' is mainly respiratory in function during aestivation because the gills become useless during this period. Like that of Polypterus, the 'lung' in dipnoans gets the pulmonary arteries from the last epibranchial arteries.

In Notopterus, the swim-bladder becomes more complex and acts as a lung. Except the hydrostatic, sound production and hearing, a new function like respiration was innovated in Notopterus. In Notopterus chitala the posterior tip of swim-bladder is enlarged which is called caudal extension and the ventral part gives off several finger-like projections, the dorsal side of the gas bladder possesses a specialised striated muscle.

The anterior part extends into a projection to the ear. An artery arising from the dorsal aorta forms a network of blood capillaries that spread the entire inner surface of the abdominal and caecal parts of the swim bladder.

The blood capillaries that cover a single epithelial layer helps in the gaseous exchange between the blood and the air of the swim-bladder. This air breathing habit is considered as a secondary adaptation in these fishes.

Functions of Accessory Respiratory Organs:

The accessory respiratory organs contain a high percentage of oxygen. The fishes possessing such respiratory organs are capable of living in water where oxygen concentration is very low. Under this condition these fishes come to the surface of water to gulp in air for transmission to the accessory respiratory organs.

If these fishes are prevented from coming to the surface, they will die due to asphyxiation for want of oxygen. So the acquisition of accessory respiratory organs in fishes is an adaptive feature.

Further it has been observed that the rate of absorption of oxygen in such organs is much higher than the rate of elimination of carbon-dioxide. Hence, it is natural that the gills excrete most of the carbon-dioxide. Absorption of oxygen appears to be the primary function of the accessory respiratory organs.

Significance of Accessory Respiratory Organs:

The cause of emergence of the accessory respiratory structures in fishes in addition to the primary respiratory organ is very difficult to interpret. There are two contrasting views regarding the origin of the aerial accessory respiratory structures. First view: some fishes have the natural instinct to make short excursion to the land from the primal aquatic home.

To remain out of water, the development of certain devices to breathe in air becomes necessary. Second view holds that the fishes are forced to ascend the land when the oxygen content of water falls to a considerable extent. The fishes in that particular condition of life gulp in atmospheric air from the land and pass it into the accessory respiratory structures.

If they are prevented by mechanical barriers to come to surface, the fishes will die of suffocation. This habit of swallowing bubbles of air is observed in many bony fishes, especially living in shallow water which dries up periodically or becomes foul by the decomposition of aquatic vegetation.

As a consequence of the air-breathing habit for a considerable span of time, the fishes have developed specialised accessory respiratory organs in addition to the gills.

Most of such structures encountered in the fishes assume the shape of reservoir of air and originate either from the pharyngeal or branchial cavities. In extreme cases the reservoir may house special structure for gaseous exchange.

However, the development of such accessory respiratory organs is essentially adaptive in nature to meet the respiratory need and thus enables the fishes to tolerate oxygen depletion in water or to live on land over a varying period of time. The development of the accessory respiratory organs depends directly on the ability to remain out of the water.