Biospectra : ISSN: 0973-7057, Vol. 16(1), March, 2021, pp. 157-160
An International Biannual Refereed Journal of Life Sciences

32(AS).
Animal Science

ISSN : 0973-7057

Int. Database Index: 616 www.mjl.clarivate.com

Significance of aquatic/gill/branchial respiration in *Colisa fasciata* with concurrent exchange mechanism and role of some important factors

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Received : 15th January, 2021 ; Revised : 14th February, 2021

Abstract- Gills are the prime respiratory organs in fishes which enable them to remove dissolved oxygen from water. The gills of fishes receive venous blood or de-oxygenated blood through afferent blood vessels and get oxygenated by the absorption of oxygen from water through thin and much vascularised epithelial layers of secondary lamellae of gill filaments. Thus gill is the centre for oxygenation. The gill filaments along with its primary and secondary lamellae provide greater surface area for the exchange of gases. The water with dissolved oxygen passes over the surface of gill filaments consisting of primary and secondary lamellae, oxygen is absorbed through thin wall and carbon dioxide is released into water. The absorbed oxygen comes into blood and then to the different cells for the purpose of intracellular oxidation and liberation of energy for the maintenance of life process. In addition to the gill or branchial respiration, most of the tropical fishes including *Colisa fasciata* show aerial respiration supplementing the gill respiration and involves accessory respiratory organs developed in response to the exceptional environmental conditions which include life in polluted water or life out of water for short period or while taking excursion on land and enable the fish to tolerate oxygen depletion in water during summer season.

Key words: Gills, *Colisa fasciata,* respiratory organ, epithelial layers, secondary lamellae

INTRODUCTION

The gills of *Colisa fasciata* are located in gill/ branchial chamber covered by bony operculum. The respiratory water current enters through the mouth, flows over the surface of gill filaments and then goes out to the outside through the opercular slit or external branchial aperture. The dissolved oxygen of passing water current is absorbed by much vascularised gill filaments and carbon dioxide diffuses out of them into water.

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The aquatic/gill respiration and air breathing in fishes both have to carry the same function, the differences being that the former get the dissolved oxygen of water and later get oxygen of air and both are interdependent supplementing each other. Earlier published research report states that gill area in air breathing fishes is found to be half of the area of the fishes which have only aquatic respiration and has also shown that the gills area in two air breathing fishes *Heteropneustes fossilis* (Singhi) and *Clarias batrachus* (Mangur/Mangoor) is extremely low in comparison to the water breathing fishes. The

physiology of respiration in fishes is similar to that of other vertebrates but water consists of 1/17th amount of oxygen present in the air, so a aquatic breathers require a volume of oxygen containing medium 17 times greater than that required by air breathers. Notable contribution are those of Carter G.S. (1957)[1], Fry,F.E.J,(1957)[2], Beamish F W H (1964)[3], Day F. (1958)[4], Fry F E J and Hart J S (1948)[5], Weber M and De Beaufort L F (1911)[6], Mitra *et al.* (2007)[7], Talwar PK and Jhingran AG.(1991)[8].

MATERIALS & METHODS

The Banded gourami,*Colisa fasciata* was collected as samples from the different collecting sites of Hardia Chaur (Wetland) situated in Saran district Bihar in neat and clean plastic jars/polythenes filled with water taken from the sites. The collected samples fishes were brought to the laboratory of P.R. College, Sonpur for further study under certain conditions. In the present investigation the sample fishes were collected in summer seasons of a year of this wetland. The sample fishes were dissected with the help of required instruments like forceps, seasors and sharp knife in wax coated tray for anatomical details of gills of *Colisa fasciata*. Following anatomical details correlated with aquatic respiration were displayed:-

(a) Basic structural design of gills of *Colisa fasciata* as a bony fish:-

For efficient respiratory function structural design of primary respiratory organ (Gills) of *Colisa fasciata* is well suited according to its habitat and characterised by having

(i) A large surface area for diffusion
(ii) Short diffusion distance and low diffusion barriers i.e., provided with thin epithelium over the gill surface.
(iii) Effective structural support for renewal of the water.
(iv) Much vascularisation i.e., supplied with net work of capillaries.
(v) Effective structural support for continued passage of blood passing beneath the exchange surface.
(vi) A spatial arrangement of the water current and blood current in a counter streaming fashion.

(b) Typical structure of gill of *Colisa fasciata*:-

There are four pairs of gills situated in branchial chamber/gill chamber on either side of pharynx and covered with a bony covering , the operculum. Each gill is supported with gill arch bearing two rows of primary gill filaments. Each primary gill filament bears a pair of primary lamellae and are separated & supported by independent gill rays. Each primary lamella is provided with numerous flat leaf like secondary lamellae. The secondary lamellae are the actual site for the exchange of gases and provides ten times more surface area then a fish itself. The secondary lamella is made up of two epithelia which are continuous along with the distal margin of the lamella. The epithelia are held apart by pillar cells and the space between the two epithelia takes the form of a lacunar compartment, the blood spaces.

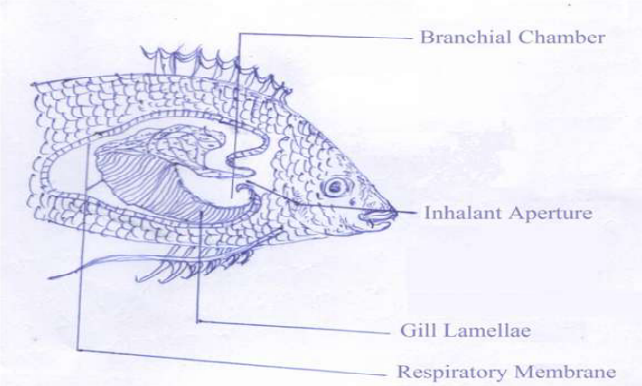

Fig. Location of gills in Colisa fasciata.

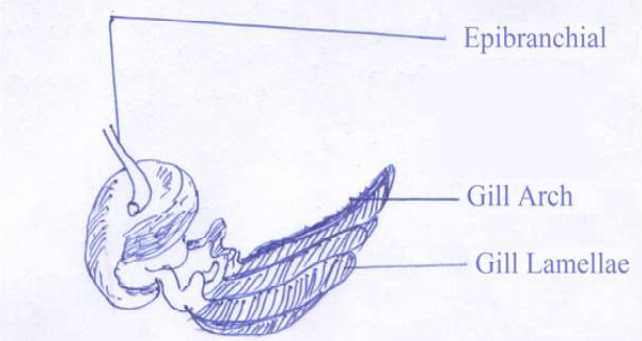

Fig. Anatomical details of gills of Colisa fasciata

(c) Blood supply to the gills:-

The gills of *Colisa fasciata* are much vascularised structure. It has got one afferent and two efferent brachial vessels in each gill arch. Each afferent branchial vessel gives off a series of primary afferent branches to the primary gill lamellae. Each primary afferent vessel divides laterally into a no. of secondary vessels which run across gill rays dividing into two-four tertiary branches to supply the secondary lamellae. In secondary lamellae each afferent vessel breaks up into a no. of minute capillaries which

finally join to form a short vessel carrying blood to the primary efferent vessel, thus it collects blood from the secondary lamellae of both sides and finally carries the oxygenated blood to the main efferent branchial vessel of the gill arch for the supply to the whole body directly without going to the heart.

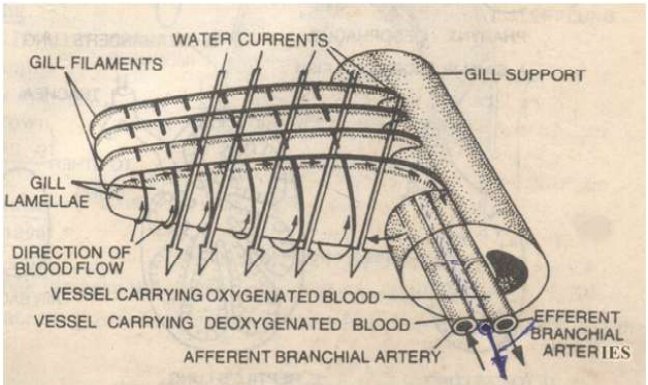

Fig. Direction of blood flow and water flow through the gill filaments in colisa.

(d) Mechanism of aquatic respiration:-

The *Colisa fasciata* pumps water over their gills by expanding and contracting the buccopharyngeal cavities in rhythmical manner like other teleosts with the help of muscle activities. During expansion mouth is opened & water enters into branchial chamber and the oxygenated water bathes the highly vascular gill lamellae for exchange of gases. The rhythmical water flow is created by suction of water into the buccopharyngeal cavity and its subsequent expulsion through the gill slits. The buccopharyngeal cavity, therefore, applies both suction and pressure to propel water through the gills. The blood becomes oxygenated by regular intake of oxygen from water by the process of diffusion.

RESULTS & DISCUSSION

Respiration is most important biological /vital/ metabolic activity of the living beings including *Colisa fasciata* in which biological energy is obtained by the breakdown of respiratory substrate for carrying out all metabolic activities of the body.

Counter Current Arrangement/Concurrent Exchange Mechanism.

In fishes including *Colisa fasciata* this mechanism greatly enhances the efficiency of gills as water flows across the gills, in the opposite direction of blood flow. In other way water has its unidirectional path and blood flows opposite to it as a maximum diffusion of gases occurs. About 80-90% of the oxygen is extracted from water by fishes due to this counter current arrangement. Fishes exchange gases by pulling the oxygen rich water content through their mouth and by pumping it across the gills. Once the oxygen has been absorbed by the gills the remaining water is thrown out through the gill slits or openings. The rate of diffusion of gases depends upon the distance (sometimes less than 1 micron) between water flowing outside the gills and blood flowing inside the gills. Less the distance rapid the exchange of gases.

The relative number and size of the gill lamellae determine the respiratory area and varies with the habit of

Table 1. Showing relative respiratory area of gills

Sl.No.	Name of fishes	Gill lamellae/mm of filament	Gill area/Gram of body weight(sq.mm)
1	*Colisa fasciata*	20	375
2	*Colisa lalia*	18	298
3	*Colisa sota*	15	312
4	*Heteropneustes fossilis*	21	359
5	*Clarias batrachus*	19	295
6	*Channa striatus*	15	318

Table 2. Showing effects of temperature, Dissolved Oxygen and pH of water on the opercular beats per minute in *Colisa fasciata*

Species	Normal condition	Increased temperature	Increased D.O.	pH	Average Range	
					Low	High
Colisa fasciata	80±5	6'7	13'5	10'0	80	120
Colisa lalia	70±5	6'0	11'6	8'6	70	105
Colisa sota	60±5	6'6	13'2	10'0	60	100

fishes. Generally fast swimming fishes have more gill area and a large number of gill lamellae per mm of gill filament than the sedentary species. The branchial movements are found to be dependent upon various physic chemical factors of water like concentration of oxygen & carbon dioxide, temperature and pH of water.

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