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A study morphology functional of air-breathing *Anabas testudineus* fishes

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Abstract

In this study an air-breathing fishes deals with morphology, histochemical analyses of respiratory membrane and muscles, morphometrics and development of respiratory organs, hematology and other blood parameters, oxygen uptake by gills and skin, physiological and behavioural aspects, ecology and effects of pollutants on the morphology and behaviour. The scientific significance and application of the studies of functional morphology and physiology in understanding the alteration caused by pollutants have also been elucidated.

Keywords: morphology functional, air-breathing, *Anabas testudineus*

1. Introduction

The air-breathing structures appeared in freshwater fish during the late Silurian or early Devonian period and are thought to have evolved as adaptation to hypoxic water conditions due to severe periodic droughts (Smith 1931; Johansen 1970) [1, 2]. Recent studies on air-breathing fish have demonstrated that various types of morphological and physiological adaptations have made it possible for fish to utilize aquatic and aerial respiration. The morphological and physiological adaptations in these fishes are designed in a manner so that they derive maximum advantage of their surrounding environment. There is an intimate relationship among the physico-chemical characters of habitat, nature of biota, food chain and finally the morpho-physiological adaptation of animals.

2. Morphology

The structures of the different types of respiratory organs have been studied for many years by several scientists. Munshi (1961) [3], and Burggren (1979) [4] found that certain air-breathing fishes such as *Clarias batrachus*, *Heteropneustes fossilis*, Blue gourami, *Trichogaster trichopterus*, Anabas, *Macropodus* and Betta possess labyrinthine air-breathing organs. These organs are derived from the epibranchial regions of the first and second branchial arches, and extend dorsally as plate-like organs to fill the suprabranchial chamber and the air-sacs which are the extensions of the opercular cavity or branchial chamber. The earlier hypothesis of Munshi (1962b) [3] that the "respiratory islets" of *H. fossilis* and C. batrachus are modified lamellar structures has been confirmed later by electron microscopic studies of Hughes and Munshi (1973a) [5].

According to them, the cells forming the vascular spaces in the dendritic organs and respiratory islets are typical pillar cells of the gills. Although the suprabranchial chambers in the Anabantidae group are extensions of branchial chambers and the labyrinthine organs which have developed on the epibranchials, the "respiratory islets" of the accessory respiratory organs have evolved in different fashion. The hypothesis that the labyrinthine organs and the respiratory islets of the suprabranchial chambers represent modified gill structure is now no longer tenable as the electron microscopic studies of Hughes and Munshi (1972a) revealed that in *Anabas testudineus* the pillar cells of the air-breathing organs do not have the same relationship as in gills, but are modified epithelial cells. Obviously we are dealing with analogous rather than homologous structures that are used to serve the same function, supporting the contiguous vascular units which make up these respiratory organs. Such a supporting function is clearly of importance. During evolution, different structural arrangements have been selected to provide surfaces with minimum diffusion barrier

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between blood and the respiratory medium (Hughes and Munshi 1962) [3]. Further, the blood capillaries of the respiratory islets of Anabas are unique structures, having a series of most characteristic type of unicellular valves ever discovered in any animal system so far. These valves control the movement of blood through the respiratory islets. In *Amphipnous cuchia* and *Channa* sp. the suprabranchial chambers are the extensions of the pharynx. The vascular mucosa of the air-sacs have evolved independently and not from the gill lamellae as it appears in the histological preparations under light microscope.

In Amphipnous (Monopterus) cuchia, the structure of the valve is very unique. It projects freely into the papilla lumen and appears to be involved in the regulation of blood flow through individual papilla (Hughes and Munshi 1973) [5]. These structures were discovered for the first time and are not only new contributions to knowledge, but open up new lines of further research.

In *Periophthalmus* vulgaris and *Boleophthalmus boddarti*, opercular chambers are modified for air-breathing purposes. The accessory respiratory organs of P. vulgaris provide an excellent example of adaptation by modification of opercular chambers (Singh and Munshi 1969) [6]. In this fish, the opercular chambers have enlarged and become vascularized for respiratory purposes. Intricate mechanisms for opening and closing of the inhalant and exhalent apertures have evolved and the branchiostegal apparatus has developed a special type of safety valve which is workable by stripes of muscles. Further, the studies on ultrastructure of gills of these air-breathing fishes have made new contributions to our knowledge. The earlier hypothesis of that the pillar cells are modified smooth muscle cells have been confirmed.

Some other forms of accessory gas exchange organs have evolved in numerous groups offish in order to obtain oxygen from air. These air-breathing organs may be in the form of modified swim bladders, pharyngeal cavities, stomach and intestine. Kramer and McClure (1980) [7] found that similar to other callichthyids, the posterior end of the intestine of *Corydoras aeneus* works as an accessory respiratory organ and its anterior end is provided with a muscular bulb. Generally, these organs are utilized for oxygen uptake and gills are used for the elimination of CO_2, and these processes seem to be similar to aquatic respiration.

It has been observed by Jordan (1976) that some air-breathing fishes are facultative air-breathers and can survive indefinitely on dissolved oxygen, while some such as *Protopterus*, *Lepidosiren* and Electrophorus are obligate air-breathers that will drown when access to air is denied. She also found that *Clarias batrachus* is a bi modally breathing teleost. C. batrachus possesses an air-breathing organ with highly branched dendritic organs or respiratory "trees" that develop as outgrowths of the second and fourth gill arches, and are located in the suprabranchial chamber.

The developmental studies of the pollutant-exposed fishes will give us the knowledge of the varied alterations in the structures and the functions in their different stages and pinpoint the stages which are most susceptible to the pollutants. The developmental study includes the fertilized eggs, larvae, juvenile and adult specimens.

Further, an indepth knowledge of their physiology, micro and macroecology, the development of the respiratory organs and general growth would be especially important in relation to any work envisaged in the culture of these fishes. Many of these species form an important food source in India. A knowledge of their mode of life and environmental conditions can improve methods for their successful culture and help to protect them from dangers of environmental pollution.

Conclusion

In the present study being a warm water tropical fish the air-breathers are not only widespread in India, but the Indian biologists have made significant contributions to the understanding of their functional morphology. Gross morphology and the behavioural aspects of the air breathing fishes have been researched more intensively than the applied aspects of physiology and effects of pollutants on morphology. With the use of more chemicals in our food and growing environmental pollution, the air-breathing fishes are likely to undergo varied changes in their functional morphology. Studies in this aspect, therefore, will have new openings of far reaching significance.

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