Modification of Swim-Bladder in Certain Air-Breathing Fishes of India.*

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IN a general sense, the swim-bladder of fishes performs a hydrostatic function, but there are many structural anomalies which have neither been explained nor correlated with any variations in the habits of their possessors. In 1830, Taylor† directed attention to the modifications of the bladder in certain air-breathing fishes of India, but, so far as I am aware, these modifications have not been correlated with the habits of the fishes. For carrying out certain physiological experiments, several kinds of air-breathing fishes were kept in aquaria and it was observed that different species behaved differently when at rest. For instance, *Heteropneustes* (=*Saccobranchus*) floated in any position with its dorsal surface directed upwards; *Clarias* and *Amphipnous* floated vertically so long as their air-chambers were full of air; while *Ophicephalus* and *Anabas* did not float at all even after taking a fresh supply of air in their respiratory chambers; they lay quietly at the bottom for most of the time. For an explanation of their behaviour, I studied the form of their swim-bladder with the following results.

With the development of additional receptacles for the storage of air for respiration, it is evident that some adjustment of the hydrostatic organs had to take place. In *Clarias* and *Amphipnous*, the air-chambers are at the anterior end, and as the habit of these fishes is to lie suspended vertically for most of the time, they can keep the anterior end buoyant with the help of the air-chambers. A bladder in the abdominal cavity would have been a disturbing factor under the circumstances and is, therefore, either greatly reduced or lost altogether. *Ophicephalus* and *Anabas*, in spite of the extensive air-cavities in the head, are enabled to lie at the bottom by the extension of the swim-bladder in their caudal region. Thus the development of the buoyant chambers at the anterior end is balanced by the portion of the air-bladder enclosed in the caudal region. The long, dorsal tubes of *Heteropneustes* replace the ventral swim-bladder which becomes greatly reduced and enclosed in bone. The fish is enabled by the tubes to float or lie at the bottom, as the buoyant area is thus uniformly distributed all over the surface of the fish.

The study of the estuarine Gobioid fishes,‡ all of which are capable of aerial respiration under adverse circumstances, also leads to the conclusion that definite correlation exists between the form and position of the bladder and the mode of life of the different species. *Glossogobius giurus*, *Eleotris fusca*, *Bulis bulis* and *Stigmatogobius sadanundio* swim about freely and, though capable of living out of water for some time, are in the main water-breathing fishes and do not show any marked development of the gill-chambers. Consequently, the swim-bladder is extensive and of the normal type. *Pseudapocryptes lanceolatus*, *Apocryptes bato* and *Tæniodes rubicundus* live in deep burrows, usually under water, and have developed large gill-chambers for aerial respiration under adverse circumstances. These eel-like fishes do not swim about and when the water is foul, they hang from the surface by distending their air-cavities (gill-chambers) with air. Under the circumstances, the bladder is of little use and, in consequence, it is greatly reduced. *Periophthalmodon*, *Periophthalmus* and *Boleophthalmus* are almost terrestrial in their habits and possess well-developed cheek-pouches for the storage of air. The air-bladder is absent in these genera.

From the above it is clear that the size and position of the swim-bladder in fishes are definitely correlated with their mode of life, and the structural modifications, referred to above, especially in the case of the fresh-water air-breathing fishes, are, no doubt, induced by the presence of air-chambers. These observations lend considerable weight to the view that the present chief function of the swim-bladder is to act as a hydrostatic organ, for where other structures have appeared to interfere with this

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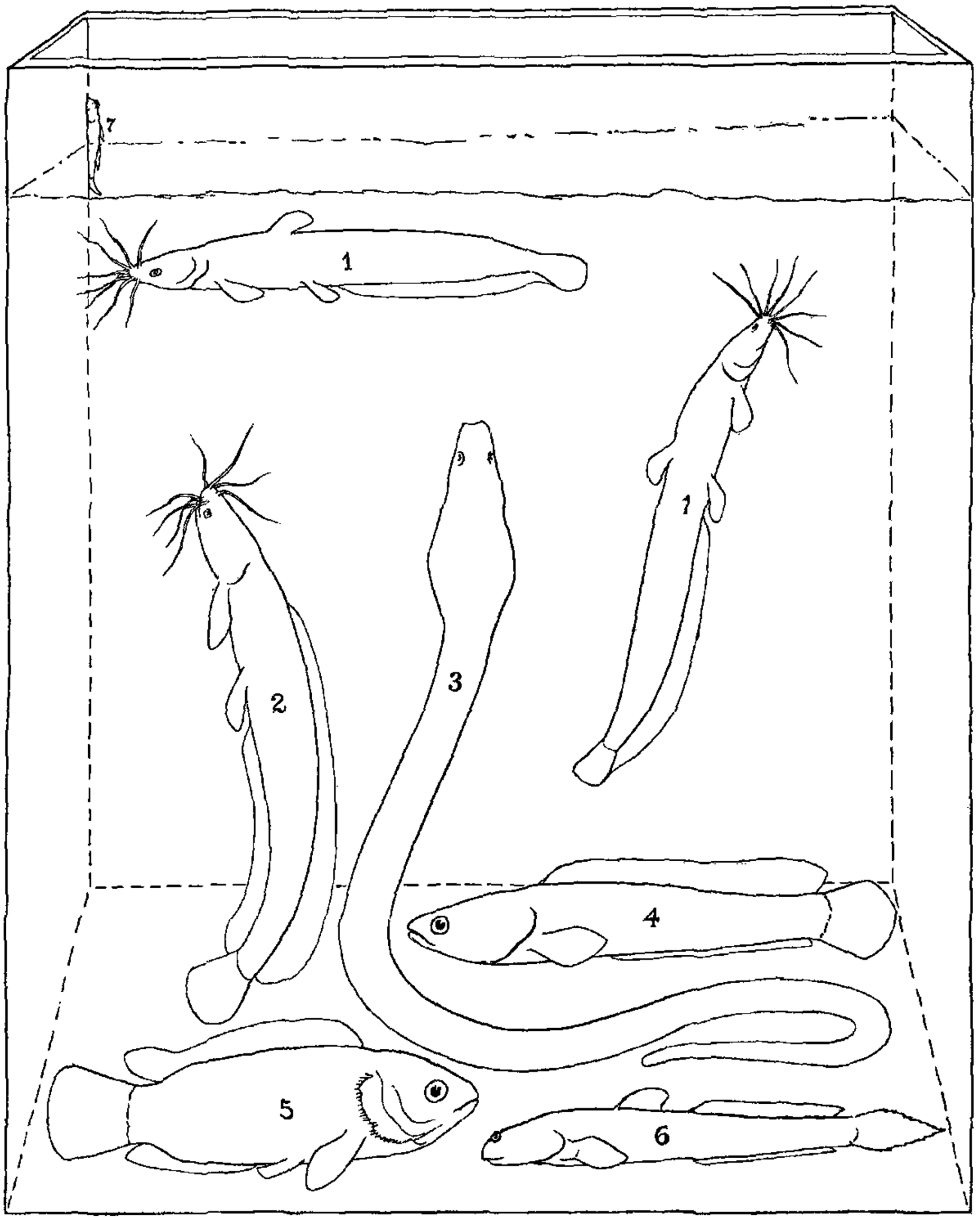
† Taylor, J., "On the Respiratory Organs and Air-Bladder of Certain Fishes of the Ganges," *Gleanings in Science*, 1830, **2**, 169-176.

‡ Mr. Dev Dev Mukerji of the Zoological Survey of India is at present engaged in investigating the correlation between the structure of the air-bladder and the ecological factors in the case of Gobioid fishes in the Gangetic delta.



Position at Rest of Certain Air-Breathing Fishes of India.
(Diagrammatic.)

1. *Heteropneustes fossilis.*
2. *Clarias batrachus.*
3. *Amphipnous cuchia.*
4. *Ophicephalus punctatus.*
5. *Anabas testudineus.*
6. *Pseudapocryptes lanceolatus.*
7. *Periophthalmodon schlosseri.*

function, the bladder has either disappeared functionally§ or has become greatly modified to meet the new requirements. The probable mode of origin of the type of air-bladder found in *Anabas* and *Ophicephalus* is discussed below.

The extension of the air-bladder in the caudal region among the Anabantidæ and the Ophicephalidæ is a remarkable morphological feature of these fishes. It has been indicated above that they are provided with extensive chambers in the head region for storing air for respiration and, in spite of these buoyant structures at the anterior end, they spend most of their time lying horizontally at the bottom. To reconcile these two facts, one has to imagine a type of fish before the development of the air-chambers. In an ordinary fish, the air-bladder is situated in the abdominal cavity and the fish is enabled to move up and down or lie at the bottom without feeling inconvenienced. The ancestors of the Anabantidæ and the Ophicephalidæ were probably bottom fishes. When they developed the habit of breathing air and storing it in cavities in the head, the anterior end became buoyant, so, for bottom life, they had to spend a great deal of energy to keep the front end down. Thus, such a fish had to swim almost constantly with the head directed downwards and the body inclined at an angle. Under these circumstances, the air in the air-bladder began to exert some pressure on the neighbouring ventral muscles of the caudal region which gave way and enabled the extension of the bladder backwards. This process must have continued for some time, till the buoyant tendencies of the anterior part of the fish were balanced by the extension of the bladder right up to the base of the caudal fin and it could lie at the bottom without any exertion.

The origin of the air tubes of *Heteropneustes* and of the air-bladder in fishes has to be traced to a similar habit. In the beginning, these structures probably developed as small pouches for storing air in the head region and when the anterior end became buoyant and the fish had to struggle for lying at the bottom, the backward extension of these pouches resulted in the setting up of the proper equilibrium. These observations lend support to the view that air-bladder probably developed as an organ of aerial respiration and that its present hydrostatic function is only a secondary acquisition.

§ *Clarias* and *Heteropneustes* (=*Saccobranchus*) are generally regarded as mud-inhabiting fishes of India. Though capable of living in mud when the water dries up, they are by no means mud-fishes, for they keep floating in water, usually near the bottom. It was under a misapprehension, therefore, that I (*Proc. 17th Ind. Sci. Cong.*, 1930, 229-243) attributed the reduction of the air-bladder in these fishes to a ground habit of life. The most plausible reason for the reduction of the bladder is to be found in the development of air-chambers and the floating habit of these fishes.

These observations show how identical modifications sometimes result from widely different causes, and, in consequence, the great need of field observations in the study of adaptations—correlation of form and habits. Cases are known of divergent modifications under similar environmental conditions (Hora, *Phil. Trans. Roy. Soc. London* (B), 1930 *a*, **218**, 266), and in the case of the reduction of air-bladder in fishes similar modifications have resulted from different causes. The result in all cases is the adjustment of an organism to the external conditions of its existence.

Institute of Oil Technology, Nagpur.

THE Committee appointed by the Nagpur University in April 1933 to investigate the economic potentialities of the development of Oil Technology in Central Provinces and Berar, have recently issued their Report. The Committee recommend the establishment of an Institute at a capital cost of 3·5 lakhs of Rupees and an annual recurring expenditure of 51,000 Rupees. The Institute will provide a three-year course leading to the B.Sc. Degree in Technology and a one-year course leading to the M.Sc. Degree. Provision is made for 36 under-graduate and 12 post-graduate students. The course of study includes Chemical Technology and Engineering, Physics and Mathematics bearing on engineering problems, commercial economics, accountancy and industrial administration. Plants for the manufacture of soaps, candles, paints and varnishes will be erected so as to afford training of a semi-commercial character to students. If run on commercial basis, the plant is expected to pay its own way. It is hoped that with the help of the Lakshminarayan Bequest, the University will soon be able to establish the Institute.