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MECHANISM OF VACUUM FORMATION IN THE THORACIC DISC OF HILL-STREAM CATFISH, *PSEUDECHENEIS SALCATUS* (McCLELL.)

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ABSTRACT

The structure and function of thoracic disc of the hill-stream fish, *Pseudecheneis sulcatus*, have been described. The mechanism of vacuum formation in the disc has been explained by conducting an experiment with a model. The adaptive significance of the thoracic disc has been discussed.

INTRODUCTION

Pseudecheneis sulcatus (Sisoridae) occurs in the hill-streams of the Himalayas (Misra, 1976, Tilak and Hussain, 1977). It is known to live on stony bottom under the direct influence of fast current (Hora, 1923a, 1923b ; Shaw and Shebbeare, 1938) and adheres to rock surface by the help of a thoracic disc present on its ventral side (Hora, 1930). The thoracic disc consists of about 14 transverse, hollow ridges which are separated by narrow grooves. Since the ridges of the disc have no muscular arrangement for expanding or retracting the grooves it is believed that the fish is able to develop vacuum by some other mechanism. I have attempted in this paper to suggest the mechanism of vacuum formation inside grooves of the thoracic disc (Fig. 1).

OBSERVATIONS

In a resting *P. sulcatus*, the pectoral fins are fully expanded laterally in such a way that the anterior rays of the fins are adpressed to the substratum. Consequently, a narrow gap is formed between the pectoral and substratum. This gap permits water to enter the underside of the body and flow as a channel along the lateral borders of the disc.

As water would flow constantly along the lateral borders of the disc, the water from transverse grooves would be drawn towards lateral sides of the disc to join the water channel. This happens because the channel becomes narrower at points of termination of transverse grooves and a partial vacuum is formed at such points according to Bernoulli's theorem (see Singh *et al.* 1973). The water from transverse grooves, therefore, flows into the channel and thus a complete vacuum is formed in the grooves. The hollow ridges would in turn expand and cause considerable narrowing of the grooves. As a result, the disc would be further pressed against the substratum and help the fish adhere more effectively (Fig. 1).

EXPERIMENT WITH A MODEL

Fig. 2A shows the apparatus which represents the model of water channels in and around the thoracic disc of a resting *P. sulcatus*. It consists of a 'U' shaped glass tube with two out'ets and a common inlet at the curve of the 'U', and rubber tubes, arranged transversely between its arms, inserted through the holes (provided in the glass tube) in such a way that their ends

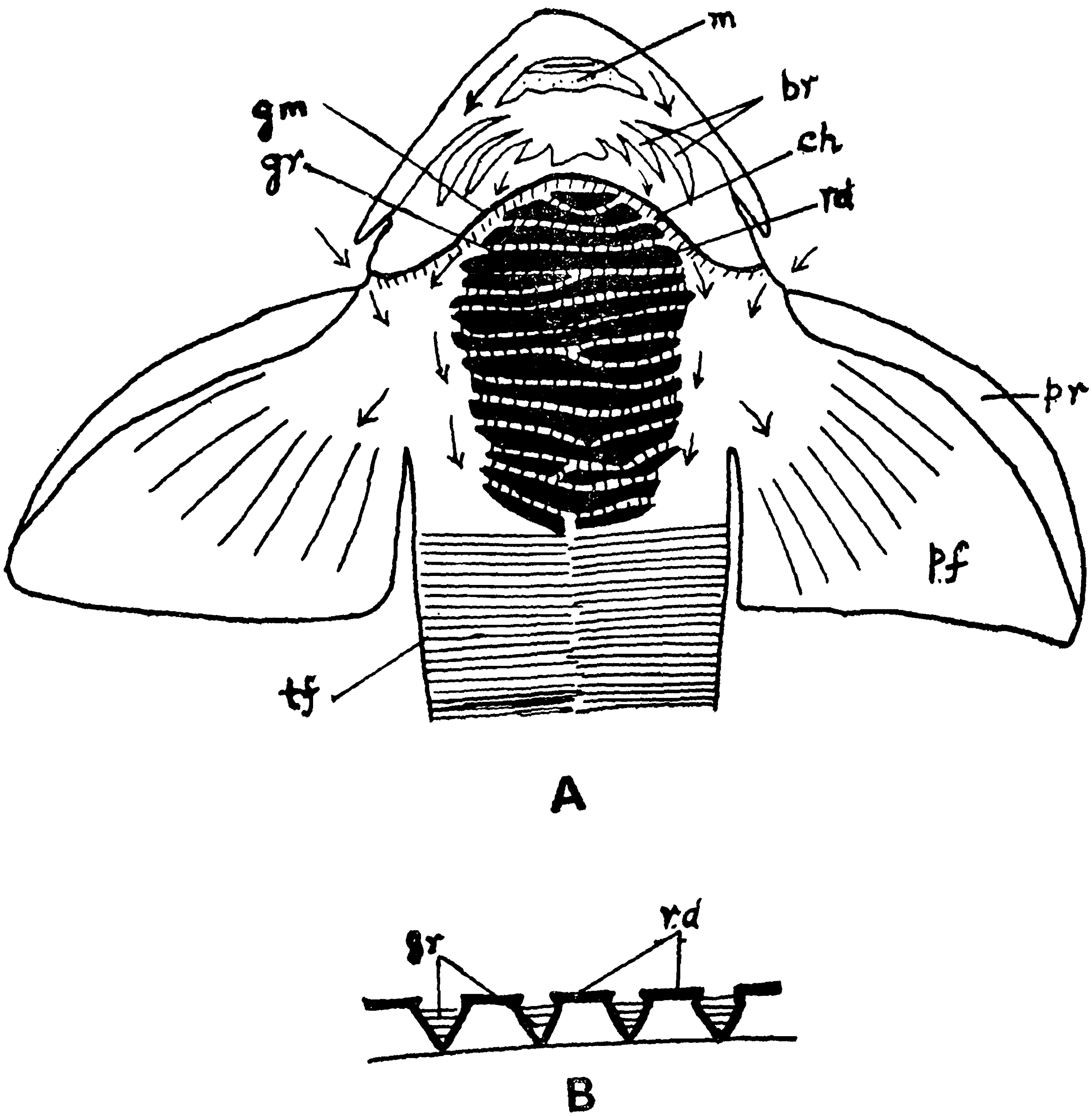

Fig. 1. A, Ventral view (semidiagrammatic) of anterior part of *P. sulcatus* showing the thoracic disc (arrows show the direction of water current), B, cross section of some ridges and grooves; br, barbel; ch, channel between the disc and gill-membrane; gm, gill-membrane; gr, groove; m, mouth; pf, pectoral fin; pr, first ray of pectoral; rd, ridge; tf, transverse folds.

extend a little inside. As a result, the space inside glass tube becomes narrower at points where rubber tubes are inserted (Fig. 2A). The arms of the 'U' and the rubber tubes, respectively, represent the water channel (along the lateral borders of the disc) and the transverse grooves of the disc. Each rubber tube is further connected to an uninflated rubber baloon through a glass tube piece and all its connections are properly

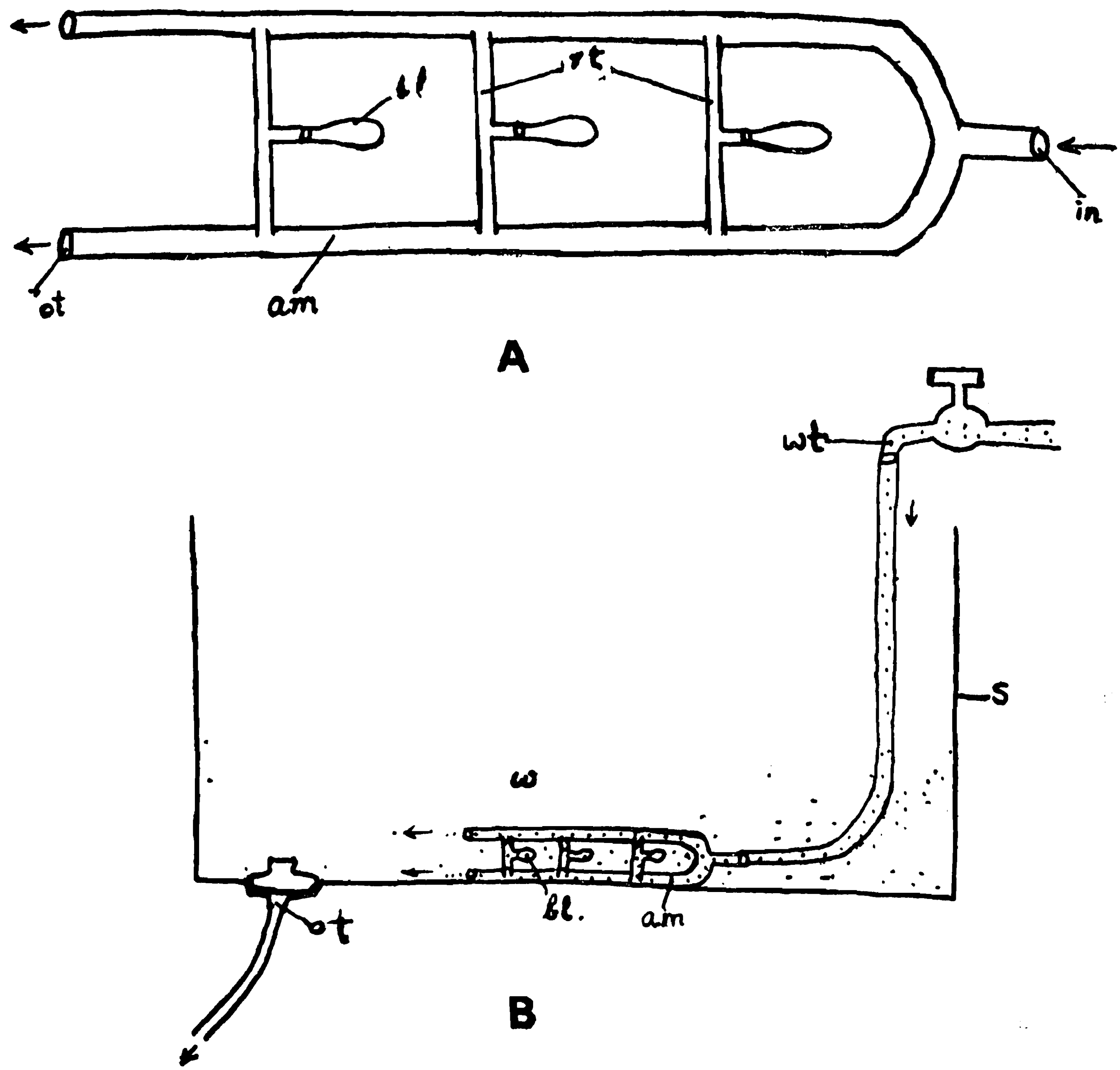

Fig. 2. A, Glass apparatus ; B, experiment with the apparatus described in the text : a, apparatus am, arm of the U-tube ; bl, baloon ; in, common inlet ; ot, outlet ; rt, rubber tube ; s, sink w, water ; wt, tap.

sealed with a suitable adhesive. The baloon is used to notice any difference of pressure inside the rubber tubes during the experiment.

The common inlet of the apparatus is connected to a water tap through a rubber tube and the whole apparatus is then placed horizontally at the bottom of the sink (Fig. 2B). The outlet of the sink is plugged in order to store sufficient quantity of water for keeping the apparatus fully submerged. The tap is opened slowly and the whole apparatus, including the baloons, is filled with water. This is done first by allowing the water to pass out of the apparatus and then filling it fully with water by closing the outlets temporarily. Adequate care is taken to ensure that no air bubble is left anywhere inside the apparatus. The tap is further opened and the water is allowed to flow at a fast speed. It is observed that as soon as the water flows out, the baloons start collapsing thereby suggesting that water from the rubber tubes is drawn towards the arms. This happens because a partial vacuum is formed inside arms at points of termination of rubber tubes and consequently the water from the rubber tubes (and baloons) is drawn towards the arms. Thus a vacuum is formed in the rubber tubes since no water supply towards them is possible from any side.

Discussion

Unlike those of stationary or slow running waters, the fishes inhabiting hill-streams and mountain ranges have to live constantly against the pressure of fast current. Consequently, many of them have evolved mechanical devices to resist the force of current for adhering firmly to the substratum. In *P. sulcatus*, the thoracic disc appears to serve dual purpose *viz.*, it acts as a frictional device owing to the presence of transverse ridges which are so arranged that they would prevent backward sliding and it also functions as an automatic sucker without involving any special effort by the fish. It would be reasonable to believe that as soon as *P. sulcatus* settles down at the bottom of a fast stream the frictional device immediately provides a hold on the rock surface and thereafter vacuum is formed in the grooves to provide further adhesion between the disc and the substratum. In fishes of the genus *Garra* (Cyprinidae) the vacuum is believed to be produced by raising the central part of the sucker (Hora, 1930) which can resist pressure from all sides. But in *P. sulcatus*, where vacuum is formed in the grooves by utilising the strength of current, the disc can successfully oppose pressure from only front side. Hora (1930) suggested that the grooves on the thoracic disc of sisorid fishes serve as channels for the constant exit of water current from underneath and as a result a partial vacuum is created in the grooves which helps the fish to adhere firmly. He (op. cit.) explained with the aid of hydraulic principle that if water is allowed to flow through a pipe of varying diameter a partial vacuum would be formed in its narrower portion. Since the grooves on the thoracic disc of *P. sulcatus* are transverse in position it appears quite unlikely that water would constantly flow through them. Therefore, Hora's suggestion about the mechanism of vacuum formation in the thoracic disc of *P. sulcatus* does not hold good.

Among sisorid fishes only two species, *P. sulcatus* from India and *Parapseudecheneis* *paviei* (Vaiilant) from Tonkin in the far east possess thoracic disc with transverse ridges and grooves (Hora and Chabanaud, 1930). Some members of *Glyptothorax* (Sisoridae) also possess thoracic disc but in them the ridges and grooves are arranged obliquely in a logitudinal direction (Misra, 1976). It seems probable that the disc in other sisorid fishes also serves the same dual function of friction and adhesion.

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