The Adhesive Apparatus of the "Sucking-fish."

EARLY in 1923 I published in NATURE a short summary of my views regarding the mechanism of the so-called suckers of certain hill-stream fishes and of the "Sucking-fish"—Echeneis.[1] My conclusions were based on an examination of the living specimens of two Indian genera of hill-stream fishes —Pseudecheneis and Glyptothorax, and on a study of preserved material of Echeneis. Later, at my request, Major R. B. Seymour Sewell, Surgeon-Naturalist to the Marine Survey of India, very kindly performed a series of experiments on living specimens of Echeneis. Quite recently (September 1924) I have been able to conduct a few experiments on the "Sucking-fish" in the Marine Aquarium at Madras. In carrying out these experiments I received great help from Dr. Sundara Raj, acting director of the Madras Fisheries, and Prof. H. Parameswaran, of the Presidency College.

The following experiments were carried out to test the sucker-theory of the disc of Echeneis:—

A smooth tin sheet perforated all over with minute holes was taken, and the fish was allowed to attach itself to it. It was observed that the animal was not able to stick to such a surface. This experiment was repeated with a piece of fine-meshed wire gauze in place of the tin sheet with similar results. A wooden plank with a large number of parallel grooves running across it at short distances was next used in place of the wire gauze. The fish could not adhere to such a surface.

In all these experiments it was observed that the fish did not like to have its sucker placed against either very rough or perforated surfaces. Moreover, on such surfaces it secreted large quantities of mucus from its disc. In all probability this secretion helps the fish in sticking to rough surfaces.

The fish was next allowed to adhere firmly to a smooth sheet of glass or a tin sheet. It was found that on such smooth surfaces the fish could be made to slide forwards and sideways without any difficulty, but a certain amount of force was needed to pull it backwards or vertically upwards. When pulled vertically upwards, the resistance against the pull is due to the sucker formed by the disc; while the force resisting the pull in the backward direction is due to the mechanical frictional device formed by the innumerable backwardly directed spines on the lamellæ of the disc. When lifting the fish vertically upwards it was observed that the entire outer rim of the disc formed a big sucker. In the next experiment the formation of the sucker by the entire rim of the disc was rendered impossible by introducing a number of match sticks under the rim. It was then discovered that a double series of secondary suckers were also formed between the transverse lamellæ on the two sides of the central axis of the disc. This was confirmed by gradually lifting the disc from behind, when it was noticed that each secondary sucker gave way with a hissing sound. It may also be noted that the secondary suckers produced between the lamellæ are not only independent of the outer large sucker, but are also independent of each other.

The disc of Echeneis, when in action, is therefore composed of an outer sucker formed by the rim, and of the two rows of secondary suckers formed in the grooves on either side of the central axis. At the same time, the spines on the lamellæ prevent the fish from slipping off whenever the animal is pushed backwards. The usefulness of the spines for attachment comes into play when the "Sucking-fish" is adhering to such fast-swimming animals as sharks and whales.

The case of the hill-stream fishes is somewhat different. They have only to contend against a rapid-running current constantly flowing in one direction. Suckers under such conditions are probably less useful than non-slipping frictional devices. This is beautifully illustrated by the various Indian species of the genus Garra.[2] In species of the genus which live in lakes and comparatively still water (*e.g. G. mullya, G. gravelyi*), the mental disc is large, and the adhesive pads on the under surface of the paired fins are feebly developed; while in species which inhabit rapid-running streams (*e.g. G. kempi, G. gotyla*) the disc on the under surface of the head is somewhat reduced and the non-slipping adhesive apparatus on the under surface of the paired fins is well developed. The frictional device in the case of these fishes is more useful than a vacuum sucker. The strength of a vacuum sucker is limited according to its area, while friction increases with pressure, and this in hill-streams increases with the rapidity of the current. The similarity in shape between the anterior dorsal profile of the hill-stream fishes and the anterior ventral profile of Echeneis shows similarity of purpose, which is to utilise the force of the current for increasing the pressure on the disc and thus to make it stick more firmly to the substratum.

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Indian Museum, Calcutta,
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IN order to test the action and mechanism of the disc in Echeneis and determine whether or not one function of the disc is to act as a sucker (in the strict sense of the word) a series of experiments were carried out.

Specimens were allowed to attach themselves to clean sheets of glass, and the disc was then examined and compared with the surface of the disc when unattached. In the unattached state the rim of the disc is soft and flexible, and around the anterior half of the disc the margin is distinctly raised while the posterior half is flat; the transverse ridges, on which are numerous posteriorly-directed spines, lie flat against each other and present a practically continuous surface. When the animal has attached itself by the disc, the smooth flexible margin can be seen to be closely pressed against the glass. The ridges running transversely are now separated from each other by narrow spaces, the two series, *i.e.* right and left, being separated by a median soft band that passes backwards in the middle line. At the posterior end this ridge stops short, so that the terminal posterior part of the sucker is occupied by a single large cavity the floor of which is depressed. Air bubbles can be seen between the ridges and in this posterior chamber, and such bubbles may be seen passing along each side of the median partition into the posterior chamber.

When thus attached, if the posterior rim of the sucker is separated from the glass, air immediately enters the posterior chamber, and by slowly pulling the sucker away, each pair of spaces between the transverse ridges can be opened separately, each giving way with a slight sucking noise; each compartment of the disc thus appears to act as a separate sucker.

When once the fish has attached itself by the disc it can be moved forwards or sideways easily, the disc sliding over the plate, but on attempting to pull the

[1] Hora, NATURE, 111, p. 668 (May 19, 1923). See also Rec. Ind. Mus. 25, pp. 587-591 (1923).

[2] Hora, Rec. Ind. Mus. 22, pp. 533-587, pls. xxiv.-xxvi. (1921).

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