The Adhesive Apparatus of the "Sucking-fish."

It is regarded in text-books¹ as a well-established fact that the adhesive organ of the "sucking-fish" (*Echeneis* and *Remora*, etc.), and a somewhat similar structure in *Pseudecheneis* and certain other freshwater fish, functions as a "sucker"; in other words, it enables the fish to adhere by the creation of a vacuum, or at any rate a partial vacuum, between the ridges and the rim of which it is constituted. Observations on *Pseudecheneis* and its allies in natural conditions led both Dr. Annandale and myself to doubt whether this belief is well founded.

It is very significant that, as several observers have noted, *Echeneis* can be detached from its hold quite easily by either thrusting it forwards or sideways,² while the so-called rim of its adhesive apparatus is entirely absent as a raised ridge in fresh material or well-preserved specimens. The whole structure,³ moreover, differs in almost every respect from the true sucking disc present on the lower surface of the fish *Garra*⁴ (*Discognathus*) and of the tadpoles⁵ of *Rana Formosa*.

I have recently had an opportunity of conducting experiments on the living *Pseudecheneis*; and have also had the great advantage of being able to consult Prof. C. V. Raman on the physics of adhesion both in this genus and the true *Echeneis*. We are convinced that the apparatus of these species, unlike that of *Garra* and the tadpoles mentioned above, is not a true sucker but essentially an elaborate device for producing the maximum amount of friction. It is correlated in a very interesting way with the shape of the fish. The upper surface of *Echeneis* and the under surface of *Pseudecheneis* are flattened to increase frictional area, while the lower surface of the former and the upper surface of the latter have adopted such a form that an advantage is taken of the swift current, which, instead of dislodging the animal, presses it against the substratum. The pressure exerted by the current increases friction, for friction is proportional to two factors—the coefficient of friction and pressure. The coefficient of friction is increased by the presence of a large number of strong spines, all of which are directed backwards on the lamellæ of the pad of *Echeneis*, and by innumerable microscopic epidermal spines⁶ found on the ridges of the adhesive discs of hill-stream fishes. The plates bearing the spines in *Echeneis* point posteriorly, with the result that the spines come into action against the opposing surface when the fish is pressed backwards by the current, but are released when the movement is in the opposite direction. The enormous difference in the frictional coefficient for forward and backward movement is easily noticed when a finger is passed over the pad of a preserved specimen of *Echeneis*. It is also possible that the ridges and grooves in these fishes assist in increasing friction much in the same way as the ridge- and groove-patterns to be found on the tyres of motor cars.

Echeneis can cling to smooth surfaces in the absence of currents.⁷ The strong spines on the lamellæ are quite sufficient to render this possible, and the phenomenon is not at first sight so remarkable

as the power of adhesion in opposition, as it seems, to a strong current.

This note is written chiefly with the object of bringing this new view of the mechanism of the so-called sucker to the notice of other workers, particularly of those who are in a position to make observations on living specimens of *Echeneis*, *Remora*, etc. I hope myself shortly to undertake fuller studies of the morphology and histology of the adhesive pad with the view of elucidating the subject further.

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Indian Museum, Calcutta, March 29.

Vertical Change of Wind and Tropical Cyclones.

In his article on the birth and death of cyclones (London Meteorological Office, Geophysical Memoirs, No. 19, 1922) Sir Napier Shaw makes the interesting suggestion that the shearing of the head of a tropical cyclone with reference to its foot, by difference of velocity at different levels in the air which carries it, might cause its dissolution. If the hypothesis that the movement of a cyclone is due to its being embedded in a flowing current of air is correct, it will of course be admitted that if there is a considerable gradient of wind upwards, positive or negative, then there must be a continual shearing of the cyclone and the shearing must either be continually countered by the cyclone, or it must die. But the question is, whether there are occasions when a cyclone has to face such a strong vertical gradient of wind, and if there are, what vertical gradient a cyclone can stand and continue to live? With regard to the first point, from an examination of the symmetry of temperature and pressure Sir Napier Shaw remarks:

"If isobaric surfaces are also isothermal surfaces there is no change of wind velocity with height. In any case one would have to assume approximate uniformity of direction and speed for a thickness of several kilometres, in order to get a definite connected body of air in stable motion. Perhaps for the levels between four and eight kilometres there are enough occasions of little change of wind velocity between those levels to furnish convenient circumstances for the persistence of a sufficient number of cyclones or cyclonic depressions."

The atmospheric conditions in the region surrounding a cyclonic depression are so different from those of normal weather, that it is perhaps quite incorrect to assume that the vertical gradient of wind, which a cyclone has to encounter, is roughly of the same order as the gradient derived from the observations of the motion of pilot balloons under normal conditions. As pointed out by Sir Napier Shaw, it is also a matter for careful consideration, what is actually presented to us by the motion of a pilot balloon in a cyclonic depression. The irregularities due to local turbulence or the changes incidental to an inclined axis will appear in the results with as much weight as the examples of fundamental structure. Perhaps the altered condition of the atmosphere in which a fully developed cyclone finds itself does not permit of too much change of wind velocity with height, and then all our conjectures regarding the supposed effect of a vertical gradient of wind on a cyclonic system will appear futile.

If a cyclone is to be considered a stable dynamical system consisting of a vortex with a ring of maximum velocity, as Sir Napier Shaw considers it to be, and "protected from the ordinary vicissitudes of weather by the enormous momentum of a vortex with a high rate of spin," then as a vortex will generally, except perhaps for the fact that air is not a perfect fluid,

¹ Günther, "An Introduction to the Study of Fishes," pp. 460 (Edinburgh: 1880); Dahlgren and Kepner, "Principles of Animal Histology," pp. 414 (New York: 1908).

² Holmwood, Proc. Zool. Soc. London, pp. 411 (1884); Gudgeon, Ann. Mag. Nat. Hist. (9), II, pp. 271-306 (1918).

³ Storms, Ann. Mag. Nat. Hist. (6), II, pp. 67-76 (1888).

⁴ Hora, Rec. Ind. Mus. XXIV, p. 47 (1922).

⁵ Annandale and Hora, Rec. Ind. Mus. XXIV, pp. 505-509 (1922).

⁶ Hora, Rec. Ind. Mus. XXIV, pp. 47-58 (1922).

⁷ Hornell, Madras Fisheries Bull., XIV, pp. 66 (1921).