LETTERS TO THE EDITORS

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Pressure Changes during the Respiratory Movements of Teleostean Fishes

The nature of the changes of hydrostatic pressure produced in the buccal and opercular cavities by the breathing movements of teleost fishes has been discussed by several workers[1–3]. Pressure measurements were made by Woskoboinikoff and Balabai[4], but their results give no indication of the time-course of these changes. Using a capacitance manometer, we have been able to measure pressure changes in both buccal and opercular cavities throughout the complete respiratory cycle in three species of freshwater fish. Ciné films taken simultaneously made it possible to plot the movements of the mouth and operculum without loading these structures in any way. The action of the mouth and opercular valves was also studied from the films.

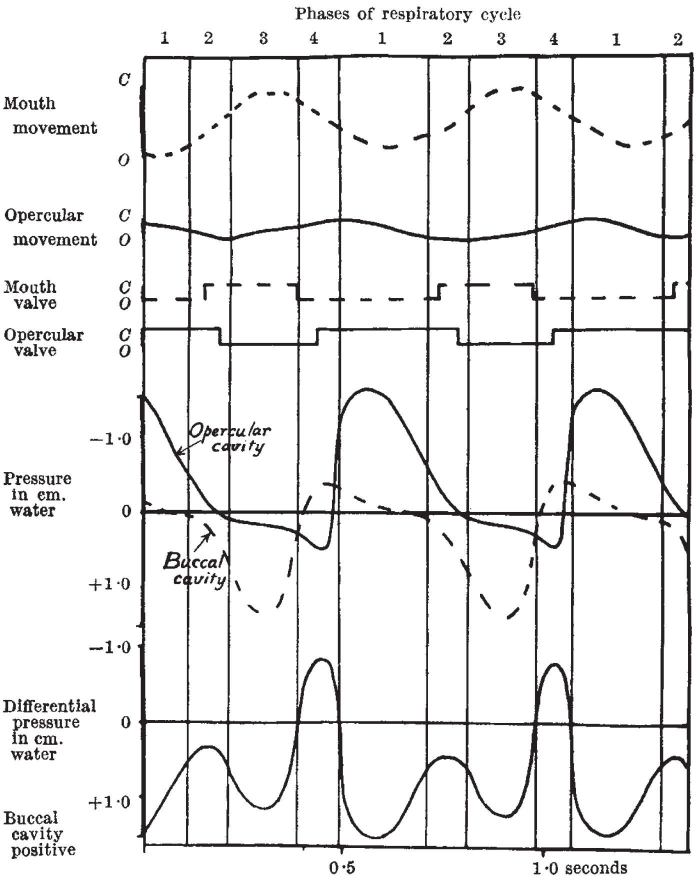

Fig. 1. Movements of the mouth and operculum with associated pressure changes in the buccal and opercular cavities during breathing in a trout (70 gm.) at 17° C. Dashed lines relate to the mouth and buccal cavity. The differential pressure between the two cavities is shown below. *C* and *O* indicate 'closed' and 'open' respectively

The events during a typical respiratory cycle of the trout (*Salmo trutta* sp.) are shown in Fig. 1. The buccal cavity begins to expand about a quarter of a cycle before abduction of the operculum starts, and begins to contract about one-fifth of a cycle before abduction of the operculum. During a single respiratory cycle, the pressure in both cavities is first negative and then positive with respect to the surrounding water, but the relative amplitude of these two parts of the pressure curves is different in the two cavities. In the buccal cavity the positive pressure, associated with mouth closing (phases 2 and 3 of Fig. 1), is the most marked; whereas the negative pressure is greater in the opercular cavity (phases 1 and 2). During these three phases water will pass across the gills as the pressure in the buccal cavity exceeds that in the opercular cavity. In phase 3 water is forced through the gills by a buccal pump; in phase 1 it is drawn through by the action of an opercular suction pump; and phase 2 is a transition during which both pumps are operating to some extent. However, between phases 3 and 1 we have invariably observed a brief period (phase 4) during which the opercular pressure is positive with respect to the pressure in the buccal cavity. This will tend to cause a reversal in the direction of flow of water across the gills and is probably of importance in bringing about closure of the opercular valve. Thus, with this exception, we have been able to confirm van Dam's suggestion that flow of water across the gills is continuous, in spite of its discontinuous inflow to the buccal cavity and outflow from the opercular cavities.

Results obtained with the roach (*Leuciscus rutilus*) and tench (*Tinca tinca*) were in general agreement with those described above, although the negative pressure in the buccal cavity was larger in amplitude. Variations of this and other types were most common in the tench, where the negative pressure in the buccal and opercular cavities were sometimes equal.

Measurements of the volume of water flowing across the gills, together with simultaneous determinations of the mean pressure-difference, have made possible the calculation of values for the resistance of the gills. An increase in minute-volume, caused by raising the carbon dioxide tension in the water breathed, is largely achieved by a greater stroke-volume and is accompanied by a fall in gill resistance.

Further details of this work will be published shortly.

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[3] Woskoboinikoff, M. M., *Zool. Jahrb., Abt. Anat.*, **55**, 315 (1932).
[4] Woskoboinikoff, M. M., and Balabai, P. P., *Acad. Sci. RSS. d'Ukraine, Trav. Inst. Zool. et Biol.*, **16**, 77 (1937).

Purkinje Shift and Retinal Noise

The Purkinje shift is the displacement of the maximum sensitivity of the eye towards the blue end of the spectrum at low levels of ambient illumination. It occurs in a wide variety of vertebrates, including some which possess the porphyropsin