THE EFFICIENCY OF THE RESPIRATORY MECHANISM OF FUNDULUS MAJALIS

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Gills on the whole are rather poor structures for aerial respiration because of their softness as reported by Krogh (1941). In air they collapse completely and present only a greatly reduced surface area. Krogh does, however, mention that certain animals in the tidal zone have rigid gills and states further that some fish genera can breathe in air as well as in water.

The purpose of this project was to determine whether the drying of the gills of the killfish, *Fundulus majalis*, was the main factor which brought about death after it was removed from the water. These fish are used for bait in the Massachusetts area where they commonly are known as "chubs." They are caught in brackish water near Lynn, Massachusetts, and kept alive in fresh water by bait dealers.

Throughout the tests, tap water free of calcium and magnesium salts was used. Actively swimming specimens about 9 cm. long were tested and it was assumed that the general body condition of all was the same. A basement room was chosen for the work and a temperature between 18° and 19° C. was maintained both for the water and for the atmosphere. Therefore the fish needed to make no temperature adjustment when going from one to the other. The time of death was taken to be that time when no fin or body movement could be observed and when movement of the opercula, or gill covers, completely ceased.

For the first test, fish from the tub were lightly dried with a flannel cloth to remove excess moisture, gently wrapped with cotton muslin, the long ends of which were wrapped around small dry white pine boards so that the bare heads would protrude beyond the end of the wood. One half the specimens were wrapped with bands about 1 cm. wide so that their bodies would readily dry, and the rest were wrapped with cloths covering the entire body. Some of these latter were kept moist with water which had been boiled 20 minutes to remove all the dissolved gases. The narrow bands were changed several times because they took up moisture. Periodically, the fish, wrapped both ways, were reversed to lie on their other sides. The cloth as it clung to their bodies considerably restricted the movements of the fish; in no case did any fish wiggle out of the harness even though all were wrapped loosely.

From the 14 selected fish, 4 were wrapped with the broad muslin and left to dry, 6 wrapped with broad muslin and kept moist, and 4 held in place with narrow bands. One fish from the group of 4 wrapped with the narrow bands and one from those kept wet made a pair. The heads of

one pair were dipped every 15 minutes, another every 30 minutes, another every 45 minutes, and last, every hour. Into the oxygen-free water they were dipped head down and for several seconds were held with the branchiostegal valves at the posterior ends of the opercula under the water level. The time was long enough for the fish to make about 3 or 4 respiratory movements. In every case, water was allowed to enter the gill chamber even though mechanical pressure was sometimes necessary to get the branchiostegal valves open.

The results showed quite conclusively that moist gills are not the major factor determining the out-of-water life span and that a moist body is far more important. There was no apparent advantage for the fish dipped most frequently. Those dipped every 15 minutes lived 9.5 hours, every 30 minutes lived 11.25 hours, every 45 minutes lived 12 hours, and every hour lived 9.25 hours.

In the confirmatory test checking these results two fish were suspended from clamps head down into water which just covered the head and opercular area. The fish had been lightly dried with the flannel cloth, a small piece of muslin put around the tail, and the tail area secured in the clamp. In order to prevent water splashing up onto the fish, muslin with a small hole was put over the top of each glass and the fish was let through the hole. This test showed the effectiveness of the gills when they were under water even though the fishes' bodies became dry and stiff, for these lived almost three times as long as the wet gill, dry body specimens of the first test.

In a third test one fish was left to dry completely while 2 others were kept in a water-saturated atmosphere. Results, as far as they were carried out, confirmed the figures of tests one and two.

A practical application of this experiment might be the convenient packing of the "chubs" for mailing alive. It would be convenient for dealers and others if a light, easily wrapped package could be made up. As an experiment, 6 fish were wrapped in wet sterilized decayed leaves. The test was not a success, possibly because too much time elapsed between the packing and unwrapping. It is estimated that a similar wrapping could be successful up to at least 15 hours.

Summary

For lengthening the out-of-water longevity of *Fundulus majalis,* body moisture was proved to be the prepotent factor over gill moisture. The tests involved keeping either or both the body and gills wet and timing the life span. The results may be of value to those packing live fish for transportation.

REFERENCES

Krogh, August, 1941, The Comparative Physiology of Respiratory Mechanisms, University of Pennsylvania Press, Philadelphia, pp. 44-51.

See also LeConte, Joseph, 1900, Outlines of the Comparative Physiology and Morphology of Animals, D. Appleton and Co., New York, 370.