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## THE SWIMBLADDER AS A RESPIRATORY ORGAN IN *LEPIDOSTEUS*

GEORGE E. POTTER

In the past there have been many papers presented which have given evidence pointing to a probable origin of air-breathing vertebrates from certain physostomous fishes. The animals to which these papers have referred, apparently have some organ capable of supplementing respiration in times of need. Several of the Dipnoi and Ganoids have been credited with this adaptation and therefore have been responsible for the transition of a large number of vertebrates from water to land. Such a change gives rise to the need for organs capable of respiring atmospheric air.

Studies of anatomical data have led some workers to declare the swimbladder to be a respiratory organ in several genera of fish, including *Lepidosteus*. The existing hypothesis that the swimbladder has such a function is based upon the following facts: (a) that it has a cellular, spongy appearance internally; (b) that blood is distributed to a rich capillary network in its walls, then collected and carried directly to the heart; (c) it has a connection with the pharynx by the ductus pneumaticus and glottis, and (d) that apparently the animal gulps air into the mouth. It has been stated by some investigators that certain fish inhale air, but there has been no proof to show that the air was taken into the swimbladder.

This article is a report of experimental work which shows that *Lepidosteus* actually inhales atmospheric air into the swimbladder, where it serves in supplementing the respiration, both as the usual thing and to a much greater extent when the oxygen content of the water is low.

The method of procedure has been: (1) to carry on experiments with normal animals in deoxygenated water, allowing part of them to come to the surface for air, and confining others below the surface; (2) to inject melted paraffin through the glottis into the swimbladder of living animals and run them against controls in normal and deoxygenated water; (3) analysis of gas from the

swimbladders of the fish under various conditions, immediately following inhalation of air and again in the interval between inhalations, and (4) analysis of air from above deoxygenated water in an air-tight chamber where an animal is living.

Normal animals live for days in a small amount of deoxygenated water if allowed to come to the surface and gulp in air, but they are killed in five or six hours if confined below the surface. Control animals live for days with no apparent discomfort when confined below the surface by a screen, if a current of oxygenated water passes through the container. This seems to show that there is supplementary respiration. The average gram hour rate of oxygen consumption by the fish has been worked out, and shows that the volume of the swimbladder and the rate of inhalations is enough to supply sufficient air for the needs of the body.

Animals injected with the paraffin die in four to eight hours when placed in deoxygenated water, while control animals live for days in the same water and other injected controls will live in normal tank water for at least ten days. The rate of movement of the opercula in these animals is about one-third faster than in the normal. The injected fish were autopsied and all showed a good paraffin plug in the swimbladder, so that air could not be drawn in. This would indicate that the swimbladder is the organ used for supplementary respiration.

Gas was drawn from the swimbladder with a sampling tube, the canula of which was inserted through the glottis of the fish. The gas which was obtained was analyzed for oxygen and carbon dioxide with a Haldane apparatus. Analyses of gas from normal animals in normal tank water show: immediately following inhalation, on the average, 7.2% oxygen and 1.59% carbon dioxide; in interval between inhalation, 3.78% oxygen and 2.44% carbon dioxide. Analyses immediately following inhalation in animals which had been disturbed and were very active showed 8.03% and 2.39% carbon dioxide. Activity of the animal seems to cause the carbon dioxide to pile up. Active animals exposed to air for thirty minutes gave the following gas analysis: immediately following inhalation, 10.06% oxygen and 4.1% carbon dioxide, and in the interval 4.8% oxygen and 4.7% carbon dioxide. Analyses from animals kept in foul water showed: immediately following inhalation, 8.6% oxygen and 3% carbon dioxide; in the interval, 5.02% oxygen and 5.1% carbon dioxide.

The analyses of the air from above the water in which an ani-

mal is confined in an air-tight vessel also gave results which indicate that the fish uses the air in respiration.

(Preliminary report.)

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GASTRIC MOTILITY IN VITAMIN DEFICIENCY

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Guinea pigs in vitamin C deficiency and dogs in vitamin B deficiency were studied.

I. Guinea pigs:

The emptying time of the stomach after a standard barium meal was determined by means of the X-ray. The experiments were conducted upon four groups of twelve animals each as follows:

	CONTROLS	CHRONIC SCURVY	ACUTE SCURVY
NUMBER OF ANIMALS	16	12	16
Ration	Basal ration plus 4 to 5 cc. orange juice daily	Basal ration plus 0.5 cc. orange juice daily	Basal ration only
Total number of x-ray observations	84	58	50
Average emptying time in minutes	110	113	116

The observations show that the emptying time of the stomach in experimental scurvy is not significantly different from the emptying time in normal control animals.

II. Dogs:

Dogs were fed beri beri producing diets and after loss of appetite for the diet gastric peristalsis was studied by Carlson's balloon method. Graphic records from the stomach of animals before being placed upon the diet — compared to records from the same animals in a state of anorexia, after 100 days on the vitamin B deficient ration, demonstrate the same type of gastric peristalsis. Spastic paralysis develops after the period of pseudo-anorexia. When in this state a hunger balloon cannot be kept in the stomach long enough to obtain records.

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