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A Study on the Intestinal Respiration of the Loach through Perfusion Method

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Introduction

The well-known habit called intestinal respiration has undergone many investigations, which are focused mainly upon the role as an accessory respiratory function. There is, however, no report about the way how it occurs. To get some information on this subject the headpart of the loach was perfused with physiological saline solution. The procedure and interesting phenomena observed are described in the present paper.

Method

The perfusion method devised by MASUGI (1922) was applied. The dody is sectioned traversely at the point of the one third of the whole length and divided into two parts. The anterior one third consists of the headpart and the anterior part of the trunk, which is opened along the median line and is pinned to the holder. The vena dorsalis as well as the viscera and the heart are removed, in order to expose the aorta dorsalis running just along the ventral side of the backbone. Into the aorta a small canule is inserted towards the head and supplied with saline solution led through a rubber-tube from the Mariott's bottle held 21 cm high (Fig. 1). The saline solution flows through aorta and perfuses the headpart of the preparation, while some of it flows through the gillfilaments and out of the sectioned opening of the aorta ventralis.

The saline solution designed by MASUGI was applied as the perfusate. The solution was shaken enough to equilibrate with air in partial pressure of gases contained. To the normal perfusate CO_2-rich solution was occasionally added through injection into the rubber-tube. The CO_2 richer saline water was obtained through bubbling for

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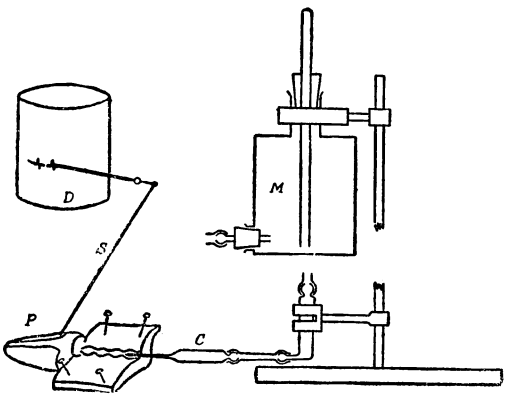

Fig. 1. Scheme of the method

C : canule D : smoked paper on the rotating drum M : Mariott's bottle P : preparation of the headpart of the loach S : string for the record of opercular movements

about 5 min. with CO_2 liberated from $NaHCO_3$ by addition of HCl. The aorta coeliaca is ligated or left open. The experiment was carried out in winter and the room-temperature was 8-12°C.

Reslts

The head-part operated as mentioned above and exposed to air moves just as that of normal specimen does in intestinal respiration (Fig. 2), and air flows through the pharynx, goes out of the open end of esophagus : that is, the normal intestinal respiratory movement occurs periodically for 2 to 12 hrs, although it does not serve to take O_2 any longer, since the intestine is beforehand removed. On the otherhand the gillrespiration can not be observed at all. It appears, however, when the preparation, especially the oral surface comes into contact with water. (Fig. 2).

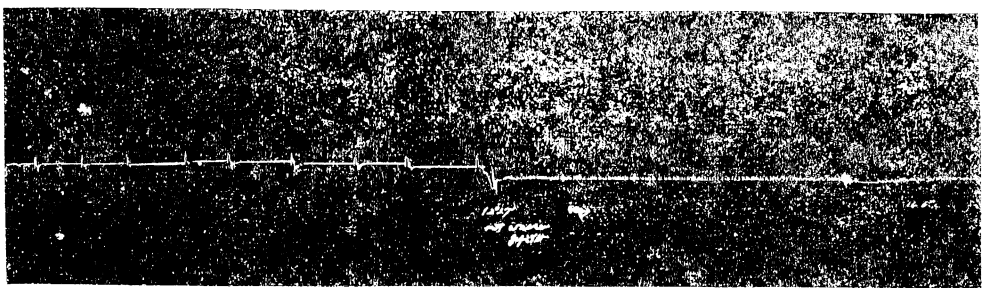

Fig. 2. The trace recorded by the head-part preparation perfused with the normal perfusate

In the left part of the trace the intestinal respiratory movement alone was registered by the preparation kept in air.

In the right part the preparation was sunk under the watersurface. The gillrespiration interrupted only through the so-called "cleaning motion" was recorded.

In the preparation kept in water the intestinal respiratory movement does not take place and gill-respiration alone is noticed to the sharp contrast with that kept in air. (Fig. 2). As soon as the preparation, especially the mouth of it contacts with air, occurs the intestinal respiratory movement and air-bubbles flow out through the esophagus. These were observed even in the preparations of which gillarches are beforehand removed and branches of the vagal nerve to the mucous membrane of the oral cavity are sectioned.

When a little volume of saline solution bubbled beforehand with CO_2-rich gas is added to the normal perfusate, it is observed in the preparation in air that the intestinal respiratory movement occurs more often and the gill-respiration, otherwise disappeared, also takes place. And moreover it is remarkable in the preperation fastened in water that the intestinal respiratory movement so long as the water surface is accessible or the movement for intestinal respiration, just as observed in the normal specimen fixed on water bottom, occurs periodically after the addition of CO_2-richer saline solution, that is, the gill-respiratory movement is often interrupted through intestinal respiratory movement. (Fig. 3). In this experiment however the actual concentration of CO_2 was not determined.

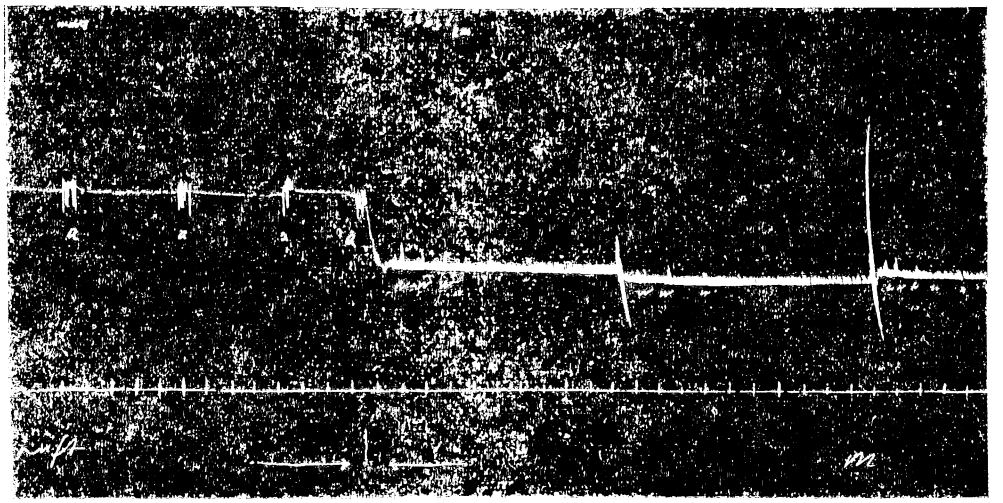

Fig. 3. The trace recorded by the head-part preparation perfused with CO_2-richer perfusate

The left part was registered in air; intestinal respiratory movements, and slow, irregular gillrespiration took place together.

The right part was registered in water ; normal gillrespiration was interrupted through the movement for intestinal respiration. (Time interval 30 sec.)

When lactic acid (10^{-6}—10^{-10} 1 cc) is added instead of CO_2 both of the respiratory movement cease and sudden deflections of the headpart take place.

Discussion

In the normal loach kept in air the gill- and intestinal-respiratory movements go together, just as the headpart-preparation in air perfused with CO_2-richer saline solution. On the other hand it is observed in the preparation kept in air and perfused with saline solution equilibrated with air that the intestinal respiratory movement takes place periodically, while the gill-respiratory movement is ceased.

In the preparation kept in water the inverse phenomena are observed. In the normal specimen kept in air the CO_2-concentration e.g. the partial pressure of it in arterial blood rises and that of O_2 lowers as already known in other species (KOYAMA). On the contrary the gas-content of the perfusate remains seemingly constant in the headpart-preparation. And if the total volume of O_2 contained in the perfusate, equilibrated with air in partial pressure of gases contained, is consumed in the head part and converted to CO_2, the partial pressure of it will be 4.5 mmHg at most. This is much smaller than that measured in the arterial blood of normal other species. (13 mmHg in carp). Therefore the following may be concluded. The intestinal respiration appears mainly in air and the gill-respiration appears in water, but it is modified through the change in the concentration or partial pressure of CO_2 or O_2 in the arterial blood.

Moreover there must be some system accelerating one of the two types of respiration and suppressing the other reflexively in air or in water. In order to find nerves concerning to this suggested system, branches of vagal nerve on the mucous membrane of oral cavity were sectioned and gillarches removed, but positive result was not obtained. Therefore the sensory endings of these branches are not indispensable for the alternation in the two types of respiration.

The CO_2-richer saline solution was obtained as above described through bubbling with CO_2-rich gas, but not determined in O_2 content. Consequently it is possible that the rise in the CO_2-concentration is followed by the decrease in the O_2-concentration, and that the effect of the addition of CO_2-richer saline solution is partially due to the decrease in the O_2-concentration. This point will be further investigated. Anyway the rise in the concentration or partial pressure of CO_2 and the decrease in that of O_2 resulted in acceleration of both types of the respiration. There must be therefore some chemoreceptor or sensitive portion in the headpart. And probably the effect observed is not due to lowered pH, as no acceleration in respiration was noticed after addition of dilute lactic acid.

The intestinal respiratory movement occurs even by the specimen, of which viscera are beforehand removed, and it is neither modified through section of branches of vagal nerve to stomach nor through artifically caused change in pressure inside of the digestive tracts as ever observed. Therefore the gill- and the intestinal respiration are presumably not arrayed through afferent impulses from viscera, even if regulated, not so effectively.

Summary

The headpart of the loach was perfused with physiological saline solution. The intestinal respiration was observed so long as preparations were kept in air. When they came into contact with water, the frequency of the intestinal respiration decreased and the gill respiration started. On the other hand, in the preparations held in water only the gill respiration occurred. Adding of a little volume of CO_2-rich solution to

perfusate caused the gill-respiration even in the preparations exposed to air. Meanwhile, fastened on the waterbottom, movements for intestinal respiration could be observed. Addition of lactic acid instead of CO_2 did not accelerate anv forms of respiration, and sudden deflections of headpart were noticed.

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