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A Study on the Mechanism of the Ingestion by Intestinal Respiration in the Loach

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Introduction

The ingestion and respiration in animals are complicated processes performed through intergrating functions of many organs and regions as a physiological whole. In higher vertebrates the materials for feeding pass through the mouth, oral cavity, pharyngus and esophagus in ingestion, and the air for breathing flows through the other passage consisting of the nostril, larynx, trachea and bronchea. On the other hand in fish both materials for feeding and water for breathing flow through the mouth opening into the oral cavity, then the former attains through pharyngeal cavity to the esophagus and the latter flows along gillfilaments from the pharyngeal cavity. In other words both of them pass obviously through same regions during the anterior part of passage. Moreover the tongue of fish is very primitive, though it contributes seemingly to control the ingestion of food (SUYEHIRO, 1941).

We have many reports about relationship between feeding-habit and morphological character of gillrakers. There is however no experimental report, how they act on feeding, on ingestion in fish. Research on the relationship above mentioned lacks therefore in experimental corroboration established from the viewpoint of functional correlation, that is, the base on which the relationship is discussed remains incomplete.

The research about the oral function of fish therefore is necessary and interesting.

It is however difficult to force fish to ingest any materials under experimental condition, as fish is small and lives in water.

Loach snap air even in restricted conditions more or less regularly in the so-called intestinal respiration; the air which has stayed beforehand in the digestive tracts is pushed out of the anus into the medium-water and noticed in bubble. Some

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study on the oral function in the so called intestinal respiration was performed, in order to get knowledge on mechanism of ingestion in fish.

Method and Results

In the course of this experiment effort was mainly paid to find out the functional defect resulting from section and removal of some parts or regions constructing the passage of materials for feeding and for breathing.

At first it was observed that ingestion took place in the normal way by the fish whose operculars of both sides were removed, though gill-filaments were exposed to the outermedium. Then a narrow stripe of the muscle layers and bones constructing the lateral side of the oral cavity were cut off in one side. The fish survived well afterwards and movement corresponding to that of the intestinal respiration by normal specimen often occurred. Ingestion however did not take place any longer. When the four gillarches in one side were respectively ligated just anterior to the point, where bones of gillarches, hypobranchial and ceratobranchial bones joined, the normal ingestion occurred. If ligated together, the air which had flowed into the oral cavity by the onset of the intestinal respiratory movement passed through the gillopening of the very side.

Moreover the gillarches in one side were removed after ligating at both the afferent and the efferent sides of the arteries. And it was observed, that the air did not flow into the digestive tracts but passed through the gillopening of the very side just as the result above. When the opercular of the operated side was sewed tightly to the abdominal muscle, air flowed partly into the digestive tracts and partly through the opposite side gillopening into the outermedium.

In mammals the second stage of ingestion and the peristaltic wave of the wall of the esophagus begins as part of the response to sensory stimulation of receptors in the back of the mouth and pharynx. The nerves concerned in this reflex are the sensory fibers to the mucous membrane of the pharynx and esophagus, including branches of the glosso-pharyngeal, trigeminal, vagal nerves. And the defect of the reflex, resulting from functional deficiency of these nerves entails that of ingestion. In the present experiment the glossopharyngeal to the mucous membrane of the anterior part of the oral cavity and the extrinsic vagal branches to the 5th gillarch as well as the gastric branches were respectively sectioned in both sides by the use of a needle with hooked tip. But in many cases air flowed normally into the digestive tracts. Administration of cocain on the pharyngeal mucosa however caused temporal deficiency of ingestion both in the normal fish and in those whose extrinsic branches of vagal nerve to the fifth gillarch in the both sides had been sectioned beforehand as above mentioned, while that on the other region of the cavity did not.

Moreover the normal ingestion was noticed in the fish, whose ligament of the mandibular abductor to the mandibular bone was sectioned.

The ventral wall of the oral cavity consists of the dorsal side of the mandibular

abductor, the anterior part of the branchiostegals and mucous membrane on both of them. In addition there is the hyoid hinged to the gillarches under the mucous membrane, forming the primitive tongue. During the powerful contraction of the walls of the lateral sides of the cavity the tongue is passively elevated towards the inside of the oral cavity and the tissues forming the ventral wall of the cavity fold into it, obviously followed by the decrease in the volume of the cavity. This may serve to raise the preassure in the cavity, to force air into the esophagus and to prevent partly the flow back of the air towards the mouth opening in the contracted oral cavity. Expansion of the walls on the other hand forces the folded ventral wall to flatten towards both lateral directions, and the tongue to lower, causing apparently an increase in cross-sectional area of the oral cavity, into which air flows. In other words the change in the volume of the cavity is caused through the movement of the lateral walls and the passive extension and contraction of the ventral wall of the cavity. And the mandibular abductor may come into play only in seizure of prey but not in ingestion. The deficiency of the ingestion through the removal of gillarches also may partly be explained as follows. The supporter of the hyoid is destroyed, the passive movement of the hyoid becomes abnormal, followed by the insufficient volume change of the cavity.

Discussion

MOTT (1951) was successful in obtaining increased action potential of the branchial nerves by touch or jets of water on gills of eel. And it was concluded that there were two types of sensory endings in gills, one responsible to intravascular pressure, the other to external touch. In fact a touch by a needle or a bristle on gills causes the spitreflex named by BAGLIONI (1908). But stimulation on the gills ligated respectively as above descrived does not cause the reflex any longer. If the gillarches were supplied with fibers responsible reflexively to ingestion, the ligation of the arches would cause some abnormality in ingestion just as in spitreflex. Therefore it may be concluded that there is no special nerves concerned to air-ingestion on gillarches.

In specimens of which gillarches are removed in one side air does not flow into the digestive tracts, but passes through the gillopening of the operated side and when the opercular of the very side is sewed tightly to the abdominal muscle layer air flows partly into digestive tracts, partly through the opposite side opening into the outermedium. Gills therefore play an important, mechanical role, probably causing a rise in pressure in the oral cavity, to lead air into the esophagus.

On the other hand the operculars and the mandibular abductor are not so important; air passes into the tracts in a normal way by specimens whose operculars are removed, or the ligament of the abductor to the mandibular bone is sectioned.

It is possible that the cocain administered on the pharyngeal mucosa difuses into the serum of the blood and produces effect after being transported to brain. But the

effect observed in this experiment continued only for 5 to 10 min'. This may be interpreted, to be due to functional defect of sensory endings concerned to ingestion, and that, to be readily compensated for. The nerve responsible in this effet is not the extrinsic branches of vagal nerve to the fifth gillarch.

Conclusion

1. Normal ingestion took place in the fish whose operculars were removed.
2. Ingestion did not occur in the fish whose muscle layers and bones constructing the lateral wall of the oral cavity were cut off in a narrow stripe in one side, though movements corresponding to that of the intestinal respiration in normal specimens often took place.
3. Normal ingestion was noticed when gillarches ligated respectively just anterior to the point where bones of gillarches, hypo- and ceratobranchial bones joined. When they were ligated together ingestion did not take place; air passed through the gillopening of the very side.
4. After removal of the gillarches ingestion did not take place; air flowed out of the gillopening of the operated side, and when the gillopening of the operated side was closed as above described it was observed that air flowed partly into the digestive tracts through the esophagus, partly into the outermedium through the opposite side gillopening.
5. Ingestion was noticed in the fish whose extrinsic branches of the glossopharyngeal nerve to the mucous membrane of the anterior part of the oral cavity, and those of the vagal nerve to the fifth gillarch as well as the gastric branches were sectioned.
6. Temporal deficiency of ingestion was observed for 5 to 10 min. after administering cocain on pharyngeal mucosa both of the intact loach and of those whose extrinsic branches of the vagal nerve to the fifth gillarches beforehand sectioned as mentioned above.
7. Normal ingestion took place in the fish whose ligament of the mandibular abductor to the mandibular bone was sectioned.

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