Vol. VI, No. 10. Washington, D. C. Aug. 25, 1886.

49.—ON THE FOOD AND DIGESTION OF GERMAN FISH.*

By Dr. P. PANCRITIUS.

At the request of the Fishery Association of East and West Prussia I commenced a series of anatomical and physiological observations of the alimentary canal and the digestion of our fish, which will not be finished for some time, but concerning which I am able to make a preliminary report. Any experiments in feeding made on the basis of my results, will of course have to be made only in suitably arranged ponds, as in the narrow tanks at my disposal the fish live under too unnatural conditions to draw definite conclusions as to the influence of food on the increase of size and weight.

The alimentary canal of fish begins in the mouth, which is more or less furnished with teeth, to which is joined a wide throat with folds running lengthwise. The throat leads into a cylindrical tube, sometimes straight, and sometimes more or less twisted, which opens at the anus. In the lampreys the entire alimentary canal is of an even, cylindrical form, and entirely straight; in some fish it is somewhat twisted, but no distinction can be recognized between the stomach and the intestinal canal; while in other fish the stomach may easily be recognized as bag-like or at least as a considerably widened portion of that canal. A microscopic examination of the mucous membrane, which lines the entire alimentary canal, shows that in a large group of fish, to which among the rest the carp belong, the stomach is wanting, so that the intestinal canal commences at the throat. It is a characteristic feature of the stomach of fish, as well as of warm-blooded animals, that its mucous membrane possesses pepsin glands. These glands secrete a ferment (pepsin) which, together with a free acid produced by the glands of the mucous membrane, digests albuminous matter, that is to say, dissolves it and makes it fit to be received in the organism of fish. The pepsin of fish is distinguished from that of the mammals by the circumstance that even at a temperature far below 15° C. [59° Fahr.] it possesses an intensely digestive power, which is considerably increased by raising the temperature to 40° [104° F.], while it is entirely destroyed if the temperature is lowered to zero [32° F.]. In fish which possess a stomach the mucous membrane of the entire intestinal canal connected with it shows no digestive faculties, but serves only to absorb the albuminous matter dissolved by the gastric juice. The gall secreted from

* "*Ueber Nahrung und Verdauung unserer Fische.*" From *Berichte des Fischerei-Vereins der Provinzen Ost- und Westpreussen*; 1885-'86, No. 2; Königsberg, October, 1885. Translated from the German by HERMAN JACOBSON.

the liver, however, goes into the intestinal canal, as well as does a juice secreted by the pancreas and the appendages of the cæcum. Both the pancreas and the appendages of the cæcum are wanting in many fish. The appendages referred to, which in varying number are attached to the front part of the intestinal canal (3 in the perch, 19 to 150 in the salmonoids, and upwards of 200 in the mackerel), are often connected into a glandular mass by a loose tissue.

The gall-bladder does not digest albuminous matter, but contains a so-called "diastatic" ferment which transforms soaked starch to sugar, and thus renders it fit to be received in the organism. The liquids secreted by the pancreas and the appendages of the cæcum react in a neutral or alkalic manner, digest albumen, and to a limited extent possess the faculty of transforming soaked starch to sugar. Like the gall-bladder they also possess the faculty of changing fatty substances to an emulsion, and thus preparing them for absorption by the intestinal canal.

Matters are very different in those fish which have no stomach, for instance, in the carp and bleak. Here the entire intestinal canal, from the throat to the anus (though to a much greater extent in the front than in the back part), secretes a liquid, which in its effect resembles that secreted by the pancreas, and which therefore digests both albuminous matter and soaked starch, as well as fatty substances. These fish have no appendages to the cæcum, but the liver pours a considerable quantity of gall into the intestinal canal, immediately back of the throat. These fish, therefore, are capable of digesting albuminous matter, carbohydrates, and fatty substances.

It is well known that fish do not masticate their food, as the teeth of predatory fish serve only to take hold of and to retain food. Even in those fish which possess strong teeth, worms and the larvæ of insects are only squeezed somewhat. Nor do fish envelop their food in saliva while in the mouth, as is done by mammals, as fish have no salivary glands.

Although the food, therefore, reaches the alimentary canal without any preparation favoring digestion, the alimentary canal in the majority of our fish is comparatively short. While in the cat, for instance, it is 3 times the length of the body, in man 6 times, in the horse 12 times, and in the goat even 26 times, we find that, according to numerous measurements, the proportion of the length of the body and the length of the alimentary canal is in the pike, hake, whiting, and tench, as 1 : 1; in the bass, perch, and eel it is as 3 : 2; in the crucian carp as 2 : 3; and in the *wels*, as 11 : 8. Only in a few species of fish does the length of the alimentary canal exceed that of the body to any great extent. A notable example is the lump-fish (*Cyclopterus lumpus*) of the Baltic, whose alimentary canal is from 6 to 10 times as long as the body.

The rapidity of digestion depends very much on the quantity of food taken at one time. Small quantities are, of course, digested quicker than large ones. If a pike swallows a fish half its own size, so that in

the beginning the tail protrudes from the mouth, the head is, of course, digested very soon; but gradually there is some delay, as the digestive liquids are only secreted in limited quantity, and the dissolved substances can be absorbed only gradually. Pike are not suitable for making observations relative to the time occupied by digestion, as they are in the habit of throwing up very soon some of the prey which they have swallowed; but I have made experiments with perch and hake which were fed on worms.

A number of perch, measuring each about 15 centimeters [about 6 inches] in length, which had been kept on very short rations for some time previous, were fed on worms, which they swallowed so greedily that their bag-like stomachs were filled to their utmost capacity. In a perch killed two hours later the food was found only in the stomach, the gastric juices reacting in a strongly acid manner. After eight or ten hours a portion of the worms had reached the front part of the intestinal canal; but even after twenty or twenty-four hours the stomach was still very full, while at the end of the intestinal canal balls of feces were already forming; after sixty or seventy hours the stomach was empty; and after one hundred and ten hours the front and middle parts of the intestinal canal had likewise become empty, and only at the end of the canal were there feces, and digestion might therefore be considered as finished.

In hake which had been well fed with worms, they evenly filled the entire intestinal canal from the throat to the anus after twelve or fifteen hours; but owing to the stronger secretion of gastric juice in the front part of the intestinal canal, they had been better digested there than in the lower part. This explains the observation that half-digested particles of food frequently protrude from the anus of fish, and from it the conclusion may be drawn that if fish are to be fed with the view to fatten them it is better to give them moderate quantities of food at frequent intervals, than to give them large quantities at longer intervals.

The carp-like fish are frequently termed herbivorous fish, in contradistinction to predaceous fish. This term, as I have been taught by numerous investigations, is entirely erroneous. While young fish of all kinds, examined by me, were found to have eaten small crustaceans and infusorians, the intestinal canal of all fish of the carp kind, measuring more than a finger's length, always contained at all seasons larvæ of gnats, dragon-flies, day-flies, beetles, &c.

Large quantities of plants (green algæ) I found regularly only in the intestinal canal of *Chondrostoma nasus;* but it remains to be examined whether the algæ or the large quantities of infusorians and other diminutive animals adhering to them, form the principal food of this fish.

Uncooked starch flour was not digested by any of the fish which I examined. Even when, after being stirred with water, it was injected into the intestinal canal and remained there for days, the extracts of

the digestive liquids produced in different ways did not in the slightest change it; but when it was boiled or roasted it was easily changed to sugar and thus rendered soluble. It is, therefore, evident that of the seeds of some grasses growing in the water and the young shoots of some aquatic plants, which are occasionally found in the intestinal canal of carp, and of the grains of wheat, &c., which I discovered in some fish, and which Professor Fric found in large quantities in the stomach of young salmon, it was not the starch which was digested, but the small quantity of albumen, fat, and sugar contained in them.

50.—POISONOUS FISH.*

By Dr. OSCAR TYBRING.

It is well known that in many places, especially in the tropics, there is a risk of eating fish which are injurious to health and which may even endanger life. Some fish seem to be poisonous at certain seasons of the year, while at others they are perfectly harmless. The spawning season seems to be the one in which they are particularly dangerous. Some fish are poisonous when caught in certain localities, while in others they may be eaten without any bad result. In most fish of this kind it is not the meat which is poisonous, but the entrails, especially the liver, the roe, and the milt; sometimes the skin also is poisonous; and finally there are some fish whose meat is poisonous. Certain kinds furnish a perfectly harmless food if eaten as soon as they are taken out of the water, but if they are allowed to lie only an hour their flesh spoils.

One cannot judge by the appearance of the fish, for those that look finest and most appetizing are frequently the ones that are poisonous; while there are fish which have a revolting appearance, but which are harmless and good to eat.

In the East Indian and Australian waters the poisonous *Meletta* is found in large numbers. It greatly resembles a herring, to which family it belongs; it is 5 or 6 inches long, with a sharp, serrated belly, silvery scales, and a bluish-green back. Foussagrive states as its principal characteristic that it has no teeth, with the exception of a few very small ones on the tongue. This fish is found especially near the Seychelles and near New Caledonia. It is always poisonous; and when eaten, causes vomiting, violent diarrhea, chills, a languid feeling, and invariably pain and cramps, particularly in the legs; the symptoms, therefore, resemble those of cholera. It is often caught with another kind of *Meletta* which is not strictly poisonous, and which may be distinguished from the poisonous one by having larger scales. The poisonous *Meletta* has a black snout and a black spot on the dorsal fin. Other-

* "*Giftige Fiske.*" From the *Norsk Fiskeritidende*, Bergen, October, 1885. Translated from the Danish by HERMAN JACOBSON.