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NOTES ON THE ALIMENTARY TRACT OF THE SWORDFISH (*XIPHIAS GLADIUS*)

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Through the generosity of Mr. Michael Lerner, The American Museum of Natural History was able to send some members of the Department of Fishes and the Department of Comparative Anatomy to Louisburg, Nova Scotia, where a laboratory was established for studies on the anatomy, food habits and other data relating to the marine fauna, particularly the swordfish.

It was thus our privilege to examine a number of fresh swordfish. We failed to find any recent literature on the visceral anatomy of this fish, but we did, however, find a very good account of its anatomy by R. E. Grant[1] published in 1828 and we here corroborate, in the main, his findings.

Louisburg, Cape Breton Island, at the northeastern extremity of Nova Scotia, is the principal Canadian swordfishing ground. The fish are harpooned at the surface of the sea from small motor and sail sloops, mostly during July and August, and shipped on ice from Louisburg to Boston and thence to the markets of the United States.

As most of the dissection was made on one specimen, we give below some of its measurements:

Total weight	225 lbs.		
Length to notch of caudal fin	106 1/2	ins.	= 270 cm.
Tip of sword to anterior edge of eye	39	"	= 101 cm.
Remainder of head	13	"	= 33 cm.
Diameter of eye	3	"	= 7.5 cm.
Greatest depth of body behind first dorsal	18	"	= 45 cm.
Greatest thickness of body behind first dorsal	11	"	= 29 cm.
Tip of lower jaw to angle of gape	9 1/2	"	= 24 cm.

The swordfish is a powerful, fast, predatory fish of the tropical and temperate open seas. It is a highly specialized relative of the mackerels. The food of the specimens we examined consisted chiefly of herring (*Clupea harengus*) but also of dogfish (*Squalus acanthias*) and the northern squid (*Ommastrephes illecibrossus*).

[1] 1828, Trans. Med.-Chir. Soc. Edinburgh, III, pp. 79–93.

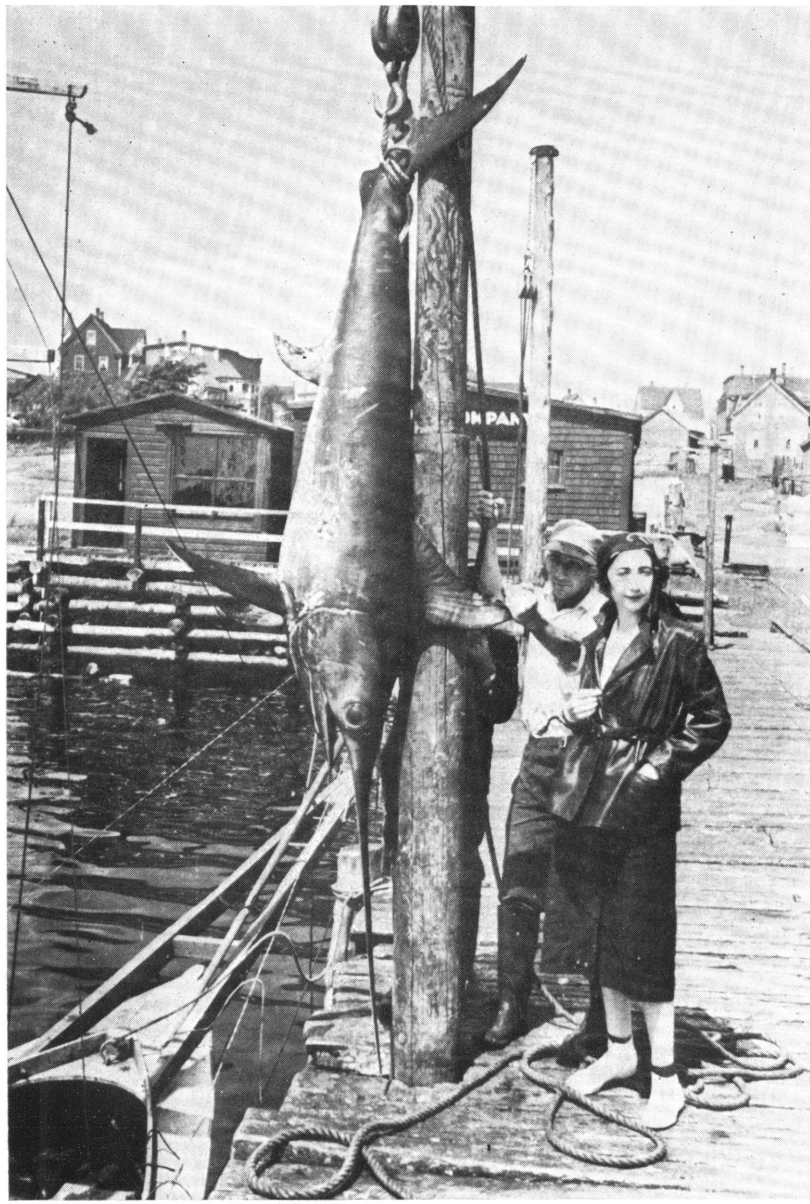

Fig. 1. Swordfish caught off Louisburg, Nova Scotia.

The swordfish is said to secure herring by swimming swiftly into a shoal of them and striking right and left with its sword, then darting about swallowing any that may have been disabled. During our examination of stomach contents of the swordfish the remains of a number

Fig. 2. Mouth of the swordfish, showing pointed mandible and jaws lacking teeth.

of herring which had apparently been mutilated before being swallowed were seen. The majority, however, showed no injury and had been engulfed whole, probably without having first been struck by the sword.

The swordfish has evolved beyond the mackerels in its digestive system, just as it is more specialized than the mackerels in its skeletal and other characters.

The mouth of the swordfish is relatively small and its bony framework delicate compared with the smaller mackerels. Its jaws are entirely devoid of teeth such as are found in mackerels, though the inside of the mouth and the oral surfaces of the gill arches are covered with fine, backwardly directed denticles which help in holding its prey, which

Fig. 3. The stomach, a long blind pouch, with a large oesophageal opening and a small pyloric opening close to it.

is of small size. The mouth and oesophagus of the swordfish are well supplied with mucous glands and much slime was always found there.

The mucous membrane of the very short oesophagus is smooth and arranged in a series of longitudinal folds when in its usual closed condition. The sphincter that surrounds the oesophagus is very strong, nearly a centimeter in thickness by 5 cm. caudo-rostrally, and composed of coarse red circular fibers externally. Beneath the circular fibers are longitudinal fibers, also coarse and red.

The stomach (Fig. 3), which had the shape of a long narrow flask, was widest at the middle and tapered toward the ends. It measured 25 ins. (= 63 cm.) in length and 8 1/2 ins. (= 21 cm.) in width, and hung free in the left side of the body cavity, being capable of extension when filled with food to a position nearly as far caudal as the vent. The proxi-

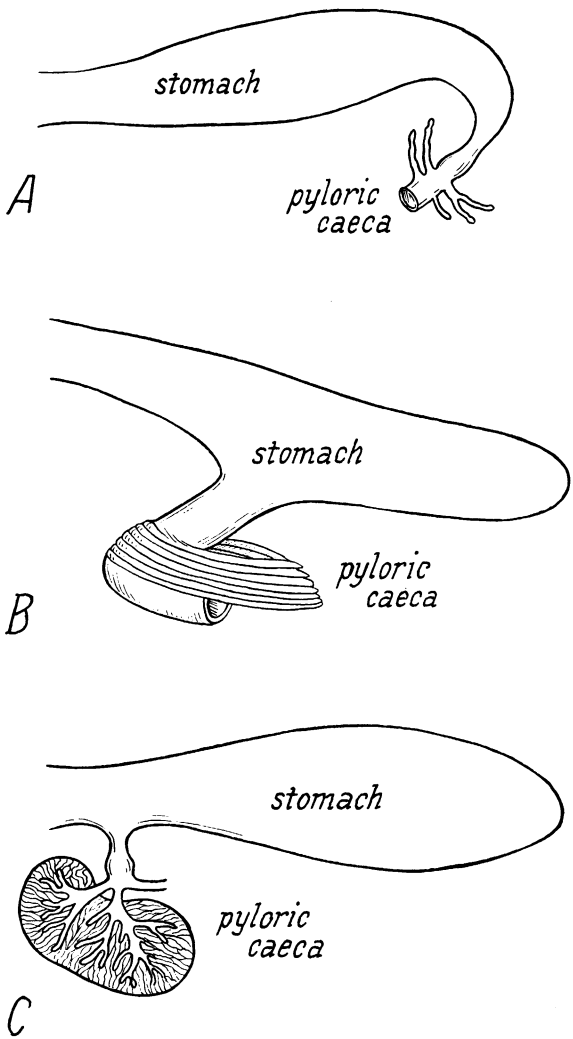

Fig. 4. Outline of the stomach and pyloric caeca in: A, less specialized bony fish; B, a mackerel; and C, the swordfish.

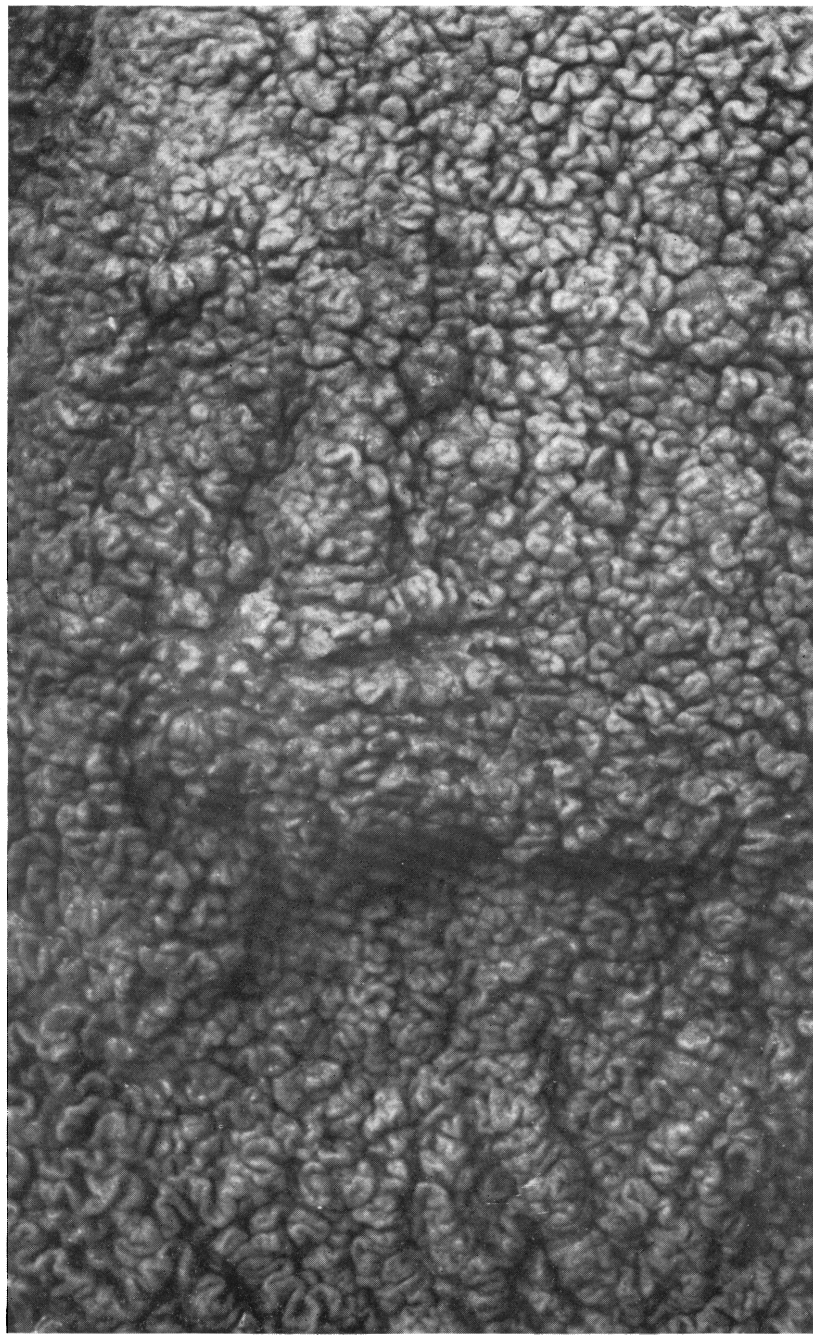

Fig. 5. The lining of the stomach in the swordfish.

mal half of the stomach occupied a sulcus formed by the liver rostrally and the pyloric caeca caudally.

A comparison of the stomach of a more primitive bony fish, such as a salmon, with that of a mackerel and the swordfish indicates how the stomach of the latter evolved. In figure 4A the stomach is scarcely more than a slightly enlarged tube but in B, the mackerel, the fundus has elongated and the pylorus is relatively nearer the oesophageal opening; in C the same process has been carried still farther, so the stomach here appears mainly as a blind pouch.

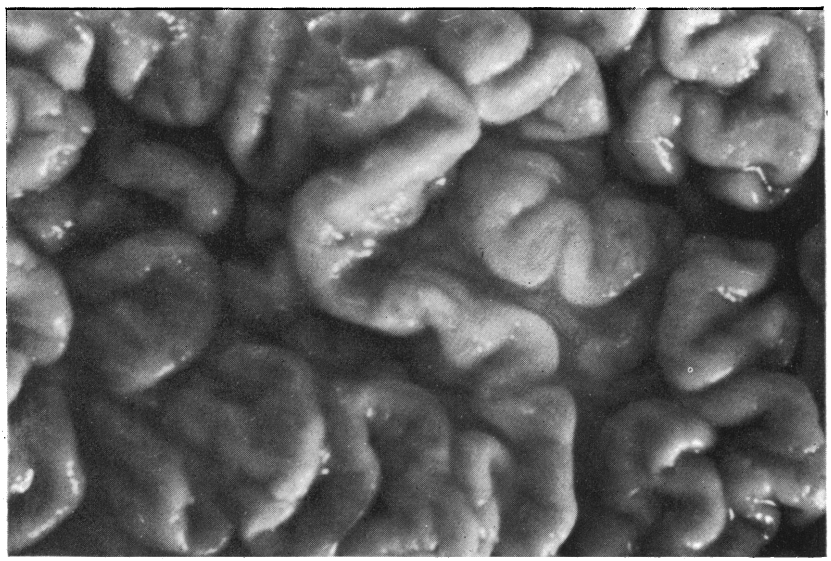

Fig. 6. Detail of the gastric mucosa.

The gastric mucosa is thick and much the same over the whole stomach, being highly convoluted. It is smooth in detail and rather soft to the touch.

Herring and dogfish ingested whole had their skin and scales completely digested off while their underlying tissues remained intact, indicating that the stomach secretes strong digestive enzymes and had not put this food under any considerable muscular stress. Food that had been in the stomach longer was very finely divided. No hard particles of food passed into the intestine.

The pylorus (Figs. 7, 8) was directly on the ventral surface of the

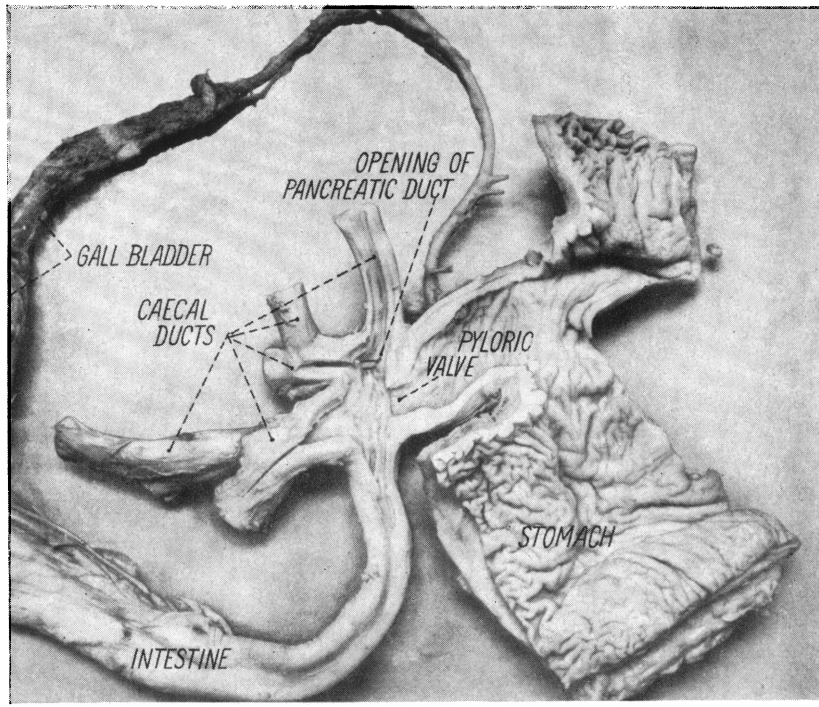

Fig. 7. Section of the pylorus and the pyloric caecal ducts; also the gall-bladder, its ducts and the intestinal openings of the bile and pancreatic ducts.

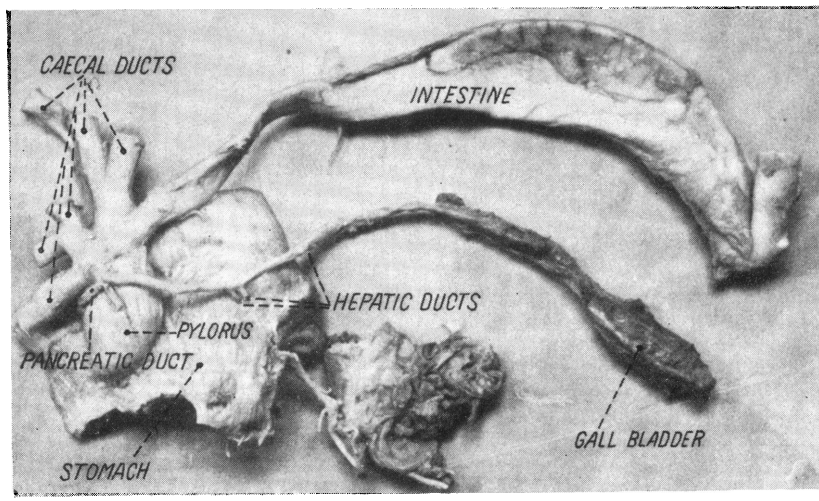

Fig. 8. Ventral view of the pylorus and ducts entering it.

stomach in the mid-line of our specimens. The pyloric opening was small. By inserting the forefinger it could be followed from within the stomach, first ventrally through an opening protected by a sphincter into

Fig. 9. Proximal part of the intestine.

a chamber 2 cm. in diameter by 3 cm. in length, in which the mucosa was arranged in longitudinal folds. At the extremity of this pyloric

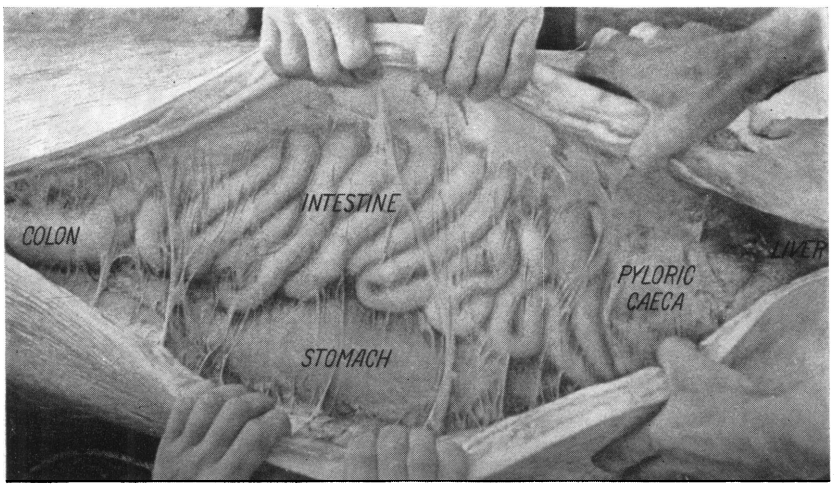

Fig. 10. Ventral view of the body cavity with viscera *in situ*.

chamber there was a small opening scarcely 1 cm. in diameter, with firm fibrous walls and a circular valve-like fold of the mucosa. At this point the intestine made almost a right-angled turn to the right and here

were the openings of the enormous pyloric caecal ducts, the bile duct and the pancreatic duct.

The proximal part of the intestine (Figs. 7, 8, 9) is of small diameter with indistinct longitudinal folds within, which, as the size of the lumen increases, break up into an irregular pattern. The spleen lies against this expanded part of the intestine. About 35 cm. from the pylorus the diameter again decreases to 15 mm. and the mucosa is thrown into a series of transverse folds characteristic of the small intestine. They resemble in appearance valvulae conniventes. The intestine then forms a series of loops, well shown in figure 10, and terminates with a strong valve at the short, thick, downwardly curved colon, 20 cm. in length.

Fig. 11. Pyloric caeca, showing system of ducts.

The colon is lined with soft, thread-like villi, three or four millimeters in length. The valve between the large and small intestines consisted of a sphincter at the middle of an S-shaped bend and protruding lips on both sides. It was impossible with a syringe to force water from the intestine into the colon or from the colon forward through this ileo-colic valve. The intestine measured 9 1/2 feet from pylorus to vent.

The liver was compact, not elongate, and occupied the ventral and lateral parts of the body cavity between the septum transversum and the pyloric caeca.

Mr. George Lewis of Louisburg gave us the following figures on the weights of swordfish livers compared with the dressed weight of the fish.

The livers are used for their vitamin-containing oil. Two hundred and sixty swordfish, weighing 73,083 lbs. (dressed), had livers weighing 1461

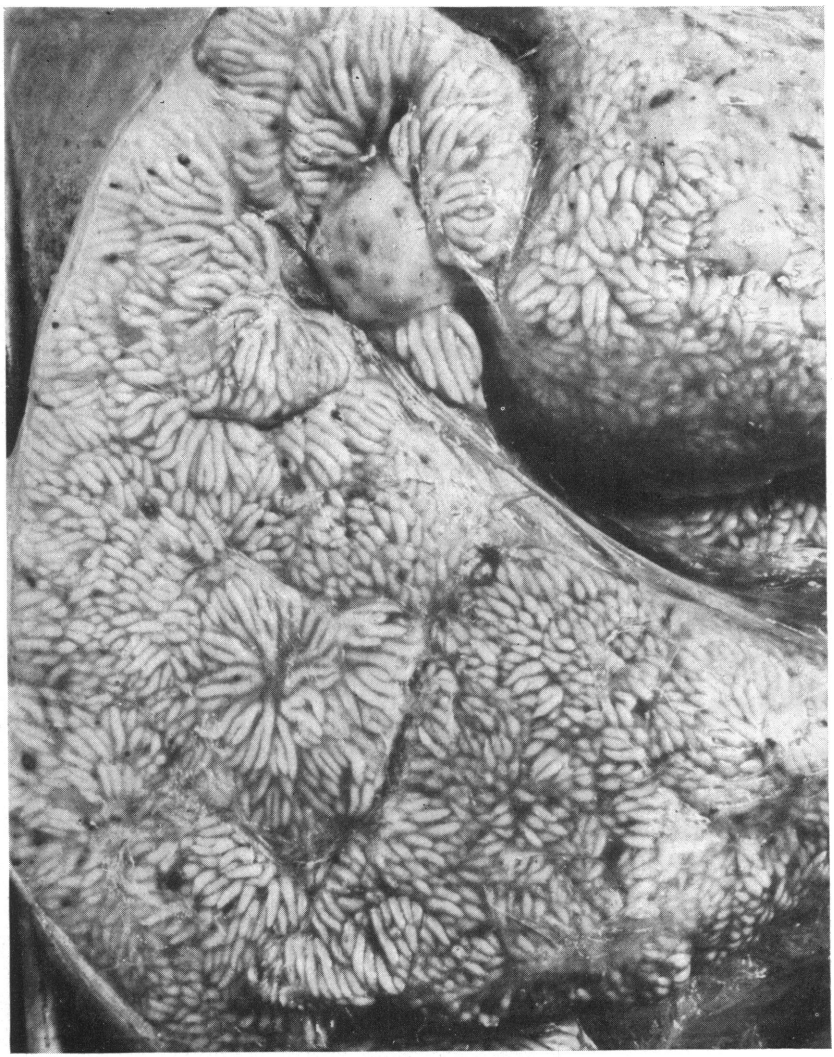

Fig. 12. Pyloric caeca, section of the gland.

lbs., which is very close to 2 per cent of the dressed weight of the fish.

The smaller the swordfish, the greater its proportional liver weight; thus the fish dissected, which was one of the smallest obtained, had a

total weight of 225 lbs. and a liver of 6 1/2 lbs., or 2.8 per cent of its total weight.

There were five hepatic ducts is uing from the liver to join the cystic duct along 55 mm. of its length. The ductus choledochus passes through the intestinal wall at an acute angle and opens into the intestine from the apex of a papilla close to the pylorus (Figs. 7, 8).

The gall-bladder occupies a position on the right side, between coils of the intestine, far caudad to the liver, and the total length of its duct

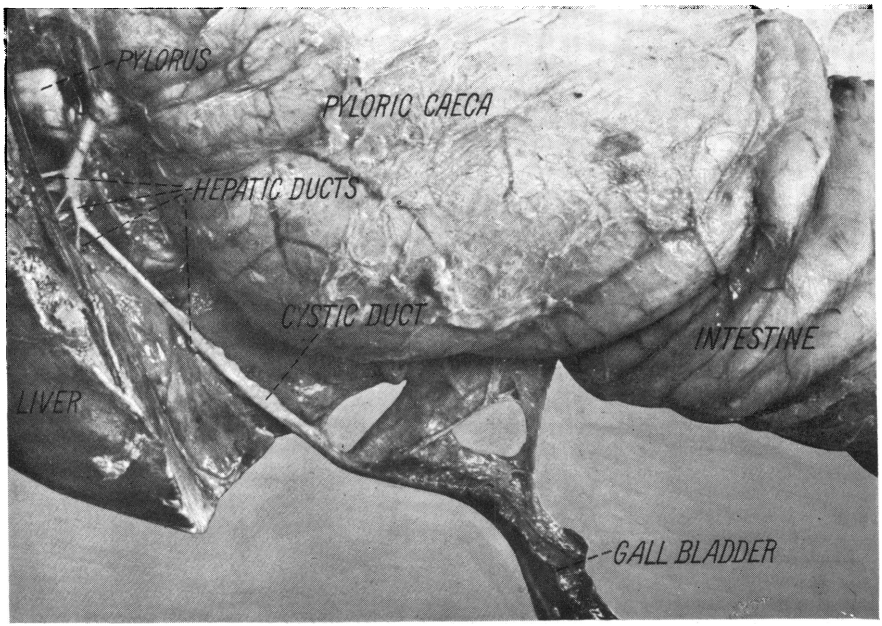

Fig. 13. Liver, gall-bladder and pyloric caeca.

was lined by longitudinal lamelliform ridges, most pronounced within the gall-bladder and near the terminus of the ductus choledochus.

The pancreatic duct had its opening on the same papilla as the bile duct (Fig. 7), though the two ducts were separate. The pancreatic duct could be distinguished from the bile duct by its thin walls and smooth lining that lacked lamelliform ridges.

By injecting the pancreatic duct it could be followed to the mesentery, where the diffuse and ill-defined pancreas was located.

In the less specialized bony fishes, such as the salmon, the pyloric

caeca (Fig. 4) consist of a few separate finger-like processes, the function of which has been thought to be to increase the surface of the intestinal lining for either absorption or secretion. Mackerels (Fig. 4B) are cited in the literature as having the greatest number of pyloric caeca (up to 191) and as having them not as separate processes, as in the salmon, but formed in a mass bound together by connective tissue and supplied with blood vessels. The swordfish in its pyloric caeca (Fig. 4C) has gone far beyond the stage seen in the mackerels. In a swordfish with a total weight of 225 lbs. the pyloric caeca weighed 10 3/4 lbs. and forms, in fact, an enormous gland, pouring quantities of secretion into the intestine (Figs. 11, 12, 13). In the fishes possessing any considerable number of pyloric caeca two or more caeca unite and have a single intestinal opening. In the swordfish hundreds of caeca open into ducts, which in turn open into the intestine.