

# DUODENAL PORTION OF THE HEPATO-PANCREATIC DUCT OF THE BOUTU, *INIA GEOFFRENSIS*

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## ABSTRACT

The duodenal portion of the hepato-pancreatic duct of the Boutu, *Inia geoffrensis* (body length 204 cm, female), was examined macroscopically and light microscopically. Passing through the muscle layer of the duodenum, the hepato-pancreatic duct ran intramurally, and formed the duodenal pouch, and opened into the lumen of the duodenum proper. The intramural cystic gland, mucous in nature, was located in the relatively thick submucosa of the duodenum, in which scattered bundles of muscle fibers were arranged in a layered appearance. A tentative comparison for some features of the duodenal portion of the hepato-pancreatic duct suggests that the fresh water dolphins may be a phylogenetically peculiar group in toothed whales.

## INTRODUCTION

The hepato-pancreatic duct of the cetacean bile-passage generally dilates and forms a well-developed glandular structure in the duodenal wall (Kamiya, 1962; Yablokov, Bel'kovich and Borisov, 1972). This glandular structure, termed as the intramural cystic gland, supposedly plays a role in the storage and excretion of the gall, compensating to some extent for the absence of the gallbladder (Kamiya, 1962). According to the above two works, the intramural cystic gland is located in the submucosa of the duodenum in whalebone whales and the sperm whale, and in the muscle layer of the duodenum in toothed whales except in the case of the sperm whale. It is, therefore, suggested that the location of the intramural cystic gland in the duodenal wall is an important character to consider the phylogeny of the cetaceans.

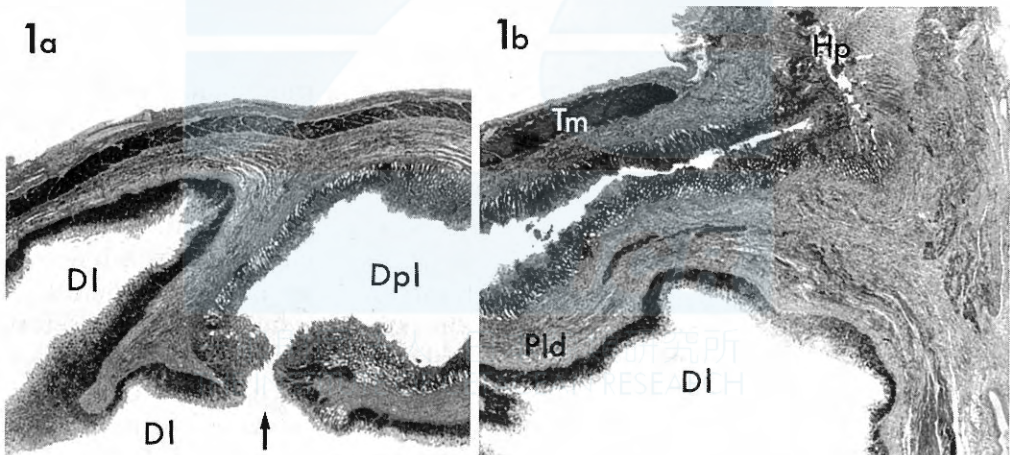
Some studies on the fresh water dolphins also have mentioned the hepato-pancreatic duct passing through the duodenal wall: Takahashi and Yamasaki (1972) and Yamasaki, Takahashi and Kamiya (1972) on *Platanista gangetica*; Yamasaki, Takahashi and Kamiya (1975) and Takahashi, Yamasaki and Kamiya (1976) on *Pontoporia blainvillei*; Zhou and Li (1981) on *Lipotes vexillifer*; Zhou, Li and Pilleri (1982) on *Inia boliviensis*; and Yamasaki and Kito (1984) on *Inia geoffrensis*. In order to discuss the fresh water dolphins, regarding the features of the bile-passage, it is necessary that these features of the

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*Inia* and *Lipotes* be described at least as detailedly as that of the *Platanista* and *Pontoporia*. The present paper, as the third report on the morphological study of the digestive tract of *Inia geoffrensis*, describes detailedly the hepato-pancreatic duct in the duodenum and provides some fundamental knowledge to consider the phylogenetic relationship of the fresh water dolphins in the cetaceans.

#### MATERIAL AND METHODS

A specimen of the *Boutu* (Amazonian dolphin), *Inia geoffrensis* (body length 204 cm, female) was provided for this study by Kamogawa Sea World, Chiba, Japan, after death from an unidentified disease. The duodenum with the hepato-pancreatic duct taken from the abdominal cavity was preserved in 10% formalin solution and transported to our laboratory. The bile-passage outside of the duodenum has been excluded from the material transported, so that the present observation is restricted to only the hepato-pancreatic duct located in the duodenum. After macroscopical observation, the material was embedded in celloidin, sectioned, and stained with hematoxylin-eosin for light microscopy.



Figs 1a and 1b. Photomicrographs of the longitudinal section of the duodenal portion of the hepato-pancreatic duct which is located in the duodenal wall of the *Inia geoffrensis*. The midpart of the duct was sectioned transversely and shown in Fig. 2. Figs 1a and 1b show the final one-fourth and the initial part of the duodenal pouch, respectively. The pouch exists submucosally in the duodenal wall. DI-duodenal lumen; Dpl-lumen of duodenal pouch; Tm-tunica muscularis of the duodenum; Hp-hepato-pancreatic duct; Pld-plica longitudinalis duodeni; an arrow shows the orifice of the duodenal pouch. H-E stain.  $\times 8$ .

## OBSERVATION

The hepato-pancreatic duct entered the wall of the duodenum proper at a rather steep angle and ran analwards intramurally (Figs 1a and 1b). The distal three-fourths of the duct in the duodenal wall enlarged its lumen and formed the so-called duodenal pouch; the plica longitudinalis duodeni, which could be distinctly seen, is about 1.5 cm long and 0.6 cm wide, on the inner surface of the duodenum proper. The hepato-pancreatic duct opened into the



Fig. 2. A photomicrograph of the transverse section of the midpart of the duodenal pouch. The muscle layer of the duodenum consists of the thick inner and thin outer ones. The duodenal pouch is located in the thick tela submucosa in which some smooth muscle fibers can be seen (arrow). The mucosa of the pouch is thicker than that of the duodenal lumen and glands of the former are mucous and the latter's are serous in nature. DI-duodenal lumen; Dpl-lumen of duodenal pouch; Tm-tunica muscularis of the duodenum; Ts-tela submucosa; \*-artificial structure. H-E stain.  $\times 16$ .



duodenal lumen through the slit-like orifice with 2 mm in length (Fig. 1a), which was located about 9 cm away from the commencement of the duodenum proper. The duodenal papilla was indistinct and no peculiar structure was found around the orifice.

Microscopically, the hepato-pancreatic duct ran in the submucosa of the duodenum after passing through the muscle layer of the duodenum (Fig. 1b). There were no longitudinal or transverse folds and also no villi on the inner surface of the duodenal pouch; luminal epithelium was seen to be worn-off. As shown in Figs 1 and 2, the lamina propria mucosae of the hepato-pancreatic duct was 0.3-1.2 mm thick, and was occupied with well-developed tubulo-alveolar glands. This glandular structure, the intramural cystic gland, was mucous in nature and apparently differed from that of the duodenum proper, mostly consisting of serous glands. Goblet cells were not found among the epithelial cells of the intramural cystic glands and lymphatic nodules were also absent in the lamina propria mucosae of the hepato-pancreatic duct. No sphincteric smooth muscles could be seen either at the proximal or distal portion of the duodenal pouch, though the outer longitudinal muscles of the duodenal wall irregularly and intermittently extended to the submucosa around the proximal portion of the intramural cystic gland. Scattered bundles of smooth muscle fibers gave a layered appearance near the middle of the submucosa between both the mucosa of the duodenum and the hepato-pancreatic duct.

#### DISCUSSION

Table 1 summarizes the macro- and microscopical features on the duodenal portion of the hepato-pancreatic duct of the fresh water dolphins, based upon the following studies, Takahashi and Yamasaki (1972) and Yamasaki *et al.* (1972) on *Platanista gangetica*; Yamasaki *et al.* (1975) and Takahashi *et al.* (1976) on *Pontoporia blainvillei*; Zhou and Li (1981) on *Lipotes vexillifer*; and Zhou *et al.* (1982) on *Inia boliviensis*; Yamasaki and Kito (1984) and the present study on *Inia geoffrensis*. This table is unfortunately incomplete because all information on the features are not given from the above studies. Therefore, it is presently possible to compare the fresh water dolphins in only a few characters which are clearly described.

The hepato-pancreatic duct of *Inia* is similar to that of *Pontoporia* and *Platanista* in running analwards within the submucosa of the duodenum and in entering the lumen of the duodenum proper through the orifice not surrounded by any peculiar prominences. While, the hepato-pancreatic duct of *Lipotes* runs within the circular muscle layer of the duodenum and enters the lumen of the duodenal ampulla through the orifice surrounded by a lip-like prominence (Zhou and Li, 1981). The intramural cystic gland of *I. geoffrensis* is mucous in nature as that of *Pontoporia*, and it also clearly forms the duodenal pouch as that of *Platanista*. The duodenal pouch of *Platanista* is

TABLE 1. COMPARISON OF THE DUODENAL PORTION OF THE HEPATO-PANCREATIC DUCT IN THE FRESH WATER DOLPHINS

Character	<i>Inia geoffrensis</i> <sup>1)</sup>	<i>Inia boliviensis</i> <sup>2)</sup>	<i>Lipotes vexillifer</i> <sup>3)</sup>	<i>Pontoporia blainvilliei</i> <sup>4)</sup>	<i>Platanista gangetica</i> <sup>5)</sup>
Location of the hepato-pancreatic duct in the duodenal wall	submucosa	submucosa*	muscle layer	submucosa	submucosa
Duodenal pouch	present	absent*	absent*	absent	present
Nature of the intramural cystic gland	mucous	mucous*	mucous*	mucous	serous, partially mucous
Thickness of the mucosa	0.3-1.2 mm	0.4-0.6 mm	1.3 mm	0.6-1.3 mm	0.5-2.4 mm
Lymphatic nodules	not found	—	abundant	present	abundant
Musculature around the hepato-pancreatic duct	scattered bundles of muscle fibers	—	circular muscle layer of the duodenal wall	well-developed longitudinal muscle layer	thin circular layer, many muscle fibers scattered
Location of opening of the hepato-pancreatic duct	duodenum proper	duodenum proper	duodenal ampulla	duodenum proper	duodenum proper
Duodenal papilla	indistinct	indistinct	lip-like prominence around the orifice	indistinct	indistinct
Size of plica longitudinalis duodeni**	1.5 × 0.6 cm	—	2.0 × 1.0 cm	1.5 × 0.9 cm	1.5 × 0.7 cm

References: 1) Yamasaki and Kito (1984) and the present study, 2) Zhou *et al.* (1982), 3) Zhou and Li (1981), 4) Yamasaki *et al.* (1975) and Takahashi *et al.* (1976), 5) Takahashi and Yamasaki (1972) and Yamasaki *et al.* (1972).

— Data not given. \* Data suggested from photomicrographs of the hepato-pancreatic duct. \*\* Length × width.

more developed than that of *I. geoffrensis* and is especially characterized by the presence of many circular folds on its inner surface and the presence of villi of the mucosa; *Pontoporia* has no pouch in the duodenal wall\*. There is no mention of the nature of the intramural cystic gland in *Lipotes* and *I. boliviensis*, though the photomicrographs of the hepato-pancreatic duct in the duodenal wall in *Lipotes* (Fig. 2-2, Zhou and Li, 1981) and *I. boliviensis* (Plate 4A, Zhou *et al.*, 1982) suggest that both their glandular structures are mucous in nature and they have no distinct duodenal pouch. If the duodenal pouch is really missing in the bile-passage of *I. boliviensis* but present in that of *I. geoffrensis*, the feature of the duodenal pouch appears to be one of the important characters in which to classify these two closely related dolphins of the genus *Inia*.

According to Kamiya (1962), the intramural cystic gland is located in the submucosa of the duodenum in whalebone whales and it is located in the circular muscle layer of the duodenum in toothed whales except in the case of the sperm whale, whose gland is located in the submucosa, the same as in whalebone whales. Yablokov *et al.* (1972) added to Kamiya's view, based upon their investigation on the duodenum of the white whale, *Delphinapterus*, that the intramural cystic gland has its own musculature in toothed whales (except the sperm whale) and is not found in whalebone whales and the sperm whale. Among the fresh water dolphins, *Lipotes* has the intramural cystic gland in the muscle layer of the duodenum as do most toothed whales, though it is not mentioned whether the gland of *Lipotes* has its own musculature or not. The *Pontoporia*, *Platanista*, and *Inia* have the intramural cystic gland in the submucosa as do whalebone whales and the sperm whale. The three differ, however, from whalebone whales and the sperm whale in regards to the distributional feature of the musculature in the submucosa. The intramural cystic gland of *Pontoporia* is surrounded by a very thin submucosa and a remarkably developed muscle layer, mainly consisting of longitudinal muscles, of the hepato-pancreatic duct; so that it appears to be located in the muscle layer of the duodenum. The intramural cystic gland of *Platanista* is also surrounded by a thin submucosa and a relatively thin muscle layer, and many muscle fibers are distributed within the submucosa and lamina propria of the duct. The intramural cystic gland of *Inia* is characterized by the scattered bundles of muscle fibers intermittently running near the middle of the thick submucosa between both the mucosa of the duodenum and the hepato-pancreatic duct. Thus, in toothed whales, the fresh water dolphins seem to be a peculiar group consisting of dolphins having the intramural cystic gland with its own musculature in the submucosa of the duodenum and those dolphins having the intramural cystic gland in the muscle layer of the duodenum.

The duodenal portion of the hepato-pancreatic duct of the fresh water

\* The glandular structure of the hepato-pancreatic duct having no distinct duodenal pouch is thought to be a kind of the intramural cystic gland.

dolphins have some important and useful characters as do other structures, such as the skelton, brain, the other digestive and respiratory organs, in order to clarify the phylogenetic relationship among the fresh water dolphins and cetaceans. For example, the location of the opening of the hepato-pancreatic duct into the duodenal lumen is already considered as a plesiomorphous character (located at duodenum proper) or an apomorphous character (located at duodenal ampulla) in discussing the phylogeny of the fresh water dolphins (Zhou, 1982). We will continue the discussion about the fresh water dolphins when more details and new findings are gathered in the future which will be sufficient to consider their phylogenetic relationship.

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