Digestive system anatomy of the *Acipenser persicus*: New features

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Abstract

Sturgeon is one of the most important species of the Caspian Sea aquatics. Unfortunately, this species faces the threat of extinction today. This makes specific studies on any type of sturgeons more important than before. Studies like histological studies, radiology, and sonography, all require a complete understanding of the anatomy of this fish. Since pilot studies showed some misconceptions in description of the sturgeon digestive system, this study was conducted to evaluate more precise anatomical structure of the digestive system of *Acipenser persicus* as the most important sturgeon species of Iran.

A total of 40 adult *Acipenser persicus* were used in this experiment. They were autopsied primary to the study. All parts of the digestive system from buccal cavity toward rectum and anal orifice were evaluated. The anatomical structure and relations of the different parts of the digestive system including oral cavity, pharynx, esophagus, glandular stomach, muscular stomach, pyloric process, small intestine, spiral intestine, rectum, liver and pancreas were described.

The digestive tube is relatively short. The stomach has two parts. The first part, or the proventricle, is U-shaped. The second part or gizzard has thick muscles and is almost surrounded with liver lobes. Pyloric caecum is located on the left side bottom of the gizzard as a sponge like structure. The intestines are made of 3 parts: the small intestine, the spiral colon, and the rectum. The small intestine has two flexures that separate it to three parts named the descending, ascending, and the end part, respectively. The spiral colon is the longest part of the digestive tube. This part has mucosal spiral septum on the inner surface. The rectum is short and located in the middle of the abdominal cavity. However, in the present study the opening was shown to be located in the muscular stomach and the intestine junction, just close to the gall bladder duct opening.

Keywords: Digestive system, Anatomy, *Acipenser persicus*

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Introduction

Sturgeon is the common name used for some of the 25 fish species in Acipenseridae family, including the genera *Acipenser*, *Huso*, *Scaphirhynchus,* and *Pseudoscaphirhynchus*. The term includes over 20 species which commonly referred to sturgeon and several closely related species that have distinct common names, notably sterlet, kaluga, and beluga (Holcik and Mihlik, 1970). The Persian sturgeon has an elongated, bulky body with a bluish tint. This type of sturgeon is endemic in the Caspian Sea and Black Sea but primarily resides in the Caspian Sea. Populations may also occur in tributaries and rivers inbound to the Caspian Sea (Perevaryukha, 2001). Sturgeons are commercially important fish valued for their meat but mainly for their roe. Formerly omnipresent in the region, heavy fishing of the sturgeon for caviar has forced it to "endangered species" status. The Persian sturgeon (*Acipenser persicus*) is an endangered species of sturgeon. This makes specific studies on any type of sturgeons more important than before. Studies like histological studies, radiology, and ultrasonography, all require a complete understanding of the anatomy of this fish. Since pilot studies showed some misconceptions in description of the sturgeon digestive system, this study was performed to evaluate more precise the anatomical structure of the digestive system of *Acipenser persicus* as the most important sturgeon of Iran.

Materials and methods

A total of 40 adult *Acipenser persicus* (25 female and 15 male, Average weight: 21.4 kg; mean fork length: 139.2 m) were used in this experiment. They were randomly captured from the Caspian Sea with a 100 mm mesh size gillnet. To detect the normal location and details of the digestive system, they were autopsied primary to the study. All parts of the digestive system, from oral cavity toward rectum and anal orifice, were evaluated. The anatomical structure, morphological and relations of the different parts of the digestive system including buccal cavity, pharynx, esophagus, glandular stomach, muscular stomach, pyloric process, small intestine, spiral colon, rectum, and pancreas were described.

Results

The digestive tube is relatively short. Ther was not seen any differences between digestive tubes of male and female samples.

The stomach has two parts; the first part, or the proventricle (Fig.1), is U-shaped, and joins the esophagus on the left side. The second part or gizzard has thick muscles and is almost surrounded with liver lobes (Figure.2).

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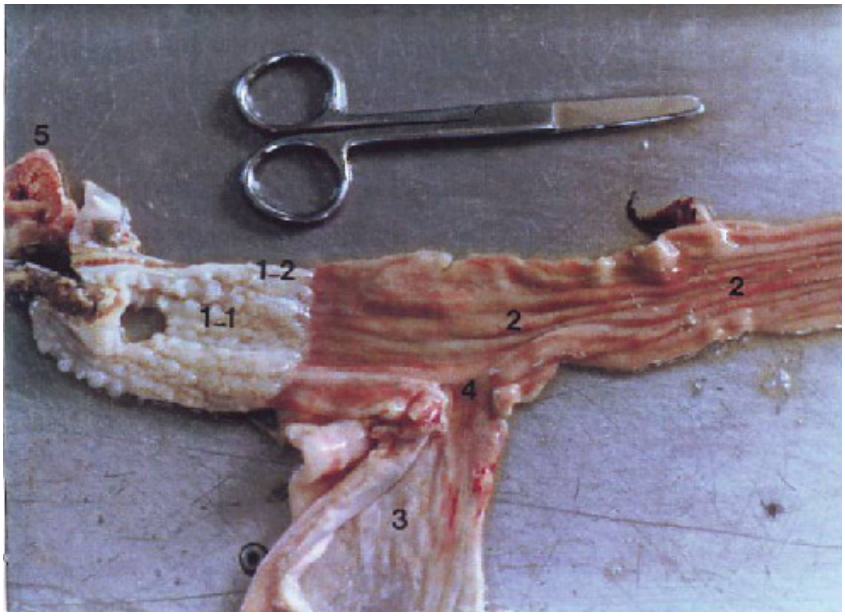

Figure.1: Longitudinal section of esophagus, proventricle and swim bladder in the mature male *A.persicus* 1-1: Cranial part of the esophagus; 1-2: Caudal part of the esophagus; 2: Proventricle; 3:Swim bladder; 4: Junction of the swim bladder and proventricle; 5: Heart.

Figure.2: Longitudinal section of the stomach and intestine in the mature male A. persicus 1: End of the proventricle; 2: First part of the gizzard; 3: Inner surface of the gizzard; 4: Pyloric sphincter; 5: Intestine.

The intestines are made of 3 parts: the small intestine, the spiral colon, and the rectum (Figure.3). The small intestine has two flexures that separate it to three parts named the

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descending, ascending, and the end part, respectively (Figure.4).

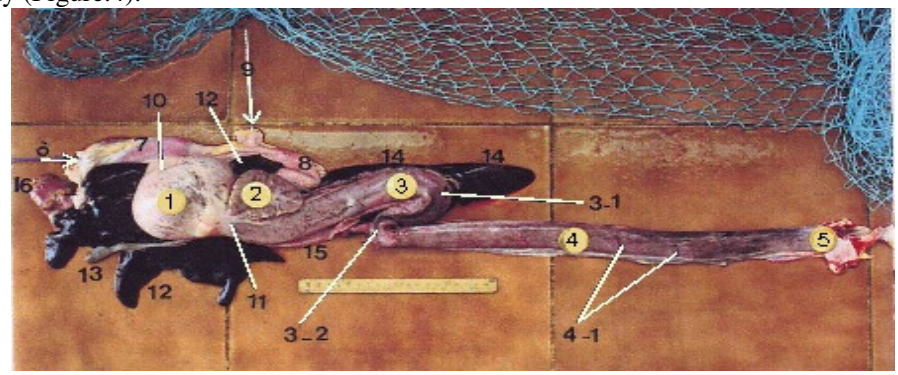

Figure 3: Digestive system of the mature male *A.persicus*

1: Gizzard; 2: Pyloric caecum; 3: Small intestine; 3-1: Primary flexure; 3-2: Secondary flexure; 4: Spiral colon; 4-1: Blood vessels; 5: Rectum; 6: Pharynx; 7: Esophagus; 8: Proventricle; 9: Junction of the swim bladder and proventricle; 10: Junction of the proventricle and gizzard; 11: Pylorus; 12: Liver; 13: Swim bladder; 14: Spleen; 15: Pancreas; 16: Heart

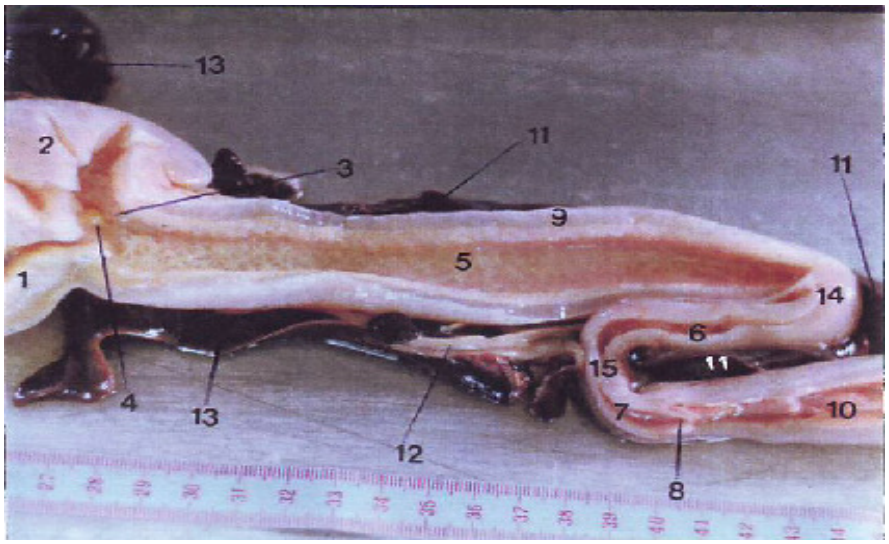

Figure 4: Small intestine, pyloric caecum and spleen in the mature mail *A. persicus*

1: Gizzard; 2: Pyloric caecum; 3: Duct of the pyloric caecum; 4: Duct of the gallbladder; 5: Prominent mucosal networks of the descending part of the small intestine; 6: Ascending part of the small intestine; 7: End part of the small intestine; 8: Valve between small intestine and spiral colon; 9: Muscles of the small intestine; 10: Spiral colon; 11: Spleen; 12: Pancreas; 13: Liver; 14: Primary flexure of the small intestine; 15: Secondary flexure of the small intestine.

The spiral colon is the longest part of the digestive tube. This part has mucosal spiral septum on the inner surface (Figure. 5).

The rectum is short and located in the middle of the abdominal cavity. Its muscles are thin and the mucosal surface is bright brown with

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long folds (Figure.5). The liver has two main lobes. The right lobe is much bigger than the left one (Figure. 3).

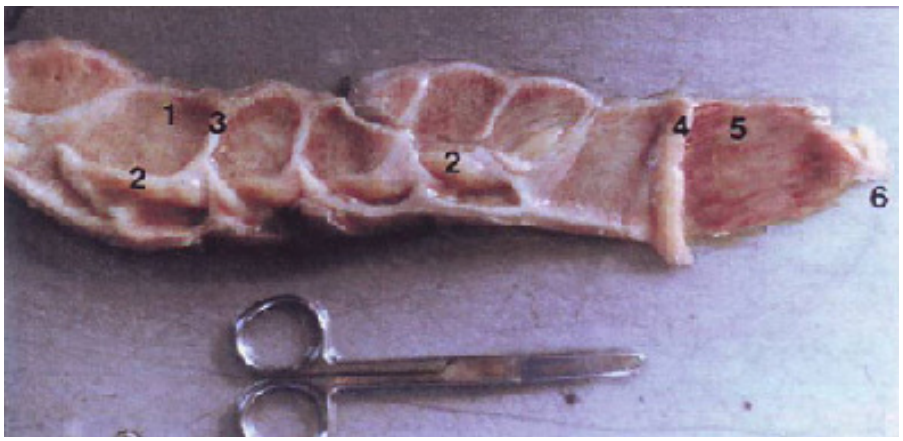

Figure.5: Longitudinal section of the spiral colon and rectum in the mature mail *A.persicus*
1: Spiral colon; 2: Typhosol; 3: Spiral septum; 4: Junction of the spiral colon and rectum; 5: Rectum; 6: Anus.

Discussion

The shape of the tube is not much different among different species (Cleveland and Hickman, 1998; Cataldi and Albano, 2002; North et al., 2002). The difference is mainly in length and volume (Randal and Buddington, 1985; Vajhi et al., 2009). The digestive tube is relatively short; this can be a consequence of the fish nutrition (Hildebrand and Goslow, 2001; Icardo and Colvee, 2002).

Esophagus: The esophagus is relatively short, and makes up to just 5% of the tube. Most of its length is located prior to the thick septum of the diaphragm-like connective tissue which separates the pericardial cavity from the abdominal cavity. The esophagus has prominent muscles on its outer surface, producing a pink color. On the inner surface, there are white muscles, longitudinal folds and many mucosal papillae. The cranial part of the esophagus has numerous long pyramidal papillae which are faced the caudal part of the body. Larger species have relatively longer papillae. There can be found fine short papillae on the caudal part (Fig.1). This part has relatively less length. The esophagus is long and thin in *A. stellatus* which is shorter and thicker in *A. gueldenstaedti*, and voluminous and just shorter in *Huso huso* (Vajhi et al., 2009).

Stomach: The stomach has two parts, and makes up to 35 to 40 % of the digestive tube. The first part or the proventricle is U-shaped and joins the esophagus on the left side. This part has a thin muscular septum, and joins the muscular stomach or the gizzard on the left side of the body. Next to the U-shaped part there is one of the lobes of the liver. The U-shaped stomach tissue is easily differentiated from the esophagus macroscopically. The

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stomach has longitudinal folds and the mucosal surface is bright brown. It is roughly equal in diameter to the esophagus. The opening of the pneumatic duct to the stomach is prominent in this region. Gizzard has thick muscles and has the same size as the clinched fist (Fig. 2). It is almost surrounded with liver lobes. The inner surface has no folds and has a velvet surface. The pyloric sphincter is located at the end of the gizzard (Vajhi et al., 2009).

Pyloric caecum: At the region of the opening of the gizzard to the small intestine, a sponge like structure named pyloric caecum is located on the left side bottom of the gizzard (Mohr, 1952). Its secretions enter the small intestine through a duct at the beginning of the small intestine. A duct corresponding to the gall bladder is also located in this region. This structure has several lobes that are separated by connective tissue and muscles. In each lobe there is a big saclike folded gland, similar to that of the intestine (Fig. 4). Stoskof (1992) has stated that the opening of the pyloric process duct was in the junction of the muscular stomach with U-shaped stomach. However, in the present study the opening was shown to be located in the muscular stomach and the intestine junction, just close to the gall bladder duct opening.

Intestines: The intestines are made of 3 parts: the small intestine, the spiral colon, and the rectum. The small intestine and the spiral colon make up to 45 to 50 percent of the digestive tube's overall length (Fig. 3).

Small Intestine: It has two flexures that separate it to three parts (Stephan and John, 1999) named the descending, ascending, and the end part, respectively. The spleen is located behind and under the first flexure. A part of the spleen is located close to the descending part and another between the ascending and the spiral colon on its dorsal surface. A liver lobe is also located on the right of the descending part. The descending part has the spleen on the left side and the liver on its right. Pancreas is located between the descending and ascending parts. Immediately after the second flexure, the end part of the small intestine starts. Small intestine and the spiral colon are separated by a valve in this region. The inner surface of the small intestine is made up of prominent mucosal networks (Fig. 4). The first and second flexures are located near the fourth and third ventral scutes, respectively. The first flexure is thin and is located approximately in the middle. All in all, the small intestine is very short and is a bended sac spanning form the pylorus to the spiral colon (Fig. 4).

Spiral Colon: The spiral colon is the longest part of the digestive tube located in the middle of the abdominal cavity under the swim bladder. This part has mucosal spiral septum on the inner surface, these mucosal septum have collapsed on them, shaping a longitudinal central rope called Typhosol. The tip of this septum bends over itself and forms a spiral shape (Fig.5). This shape is well apparent in longitudinal and transverse sections, as well as in ultrasonography pictures (Vajhi et al., 2002).

Rectum: The rectum is the end part of the intestine, and is rather short. It is located in the middle of the abdominal cavity. Its muscles are thin, and the mucosal surface is bright brown

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with long folds. The anus does not have cloacae and is located on the ventral surface between the pelvic fins in the anterior part of the urogenital opening. This region is cartilaginous and hard in palpation which is also observable in section with scalpel (Fig.5).

Liver: The liver has two main lobes. The right lobe is much bigger than the left lobe, and spans to the pyloric area on the right of the gizzard. The left lobe is on the left side of the gizzard. Another part of the liver is on the left of the descending part of the small intestine and the other lobes are on the dorsal surface of the bend of the U-shaped stomach. The Gall bladder is a bubble shaped sac on the cranioventral part of the liver right lobe. It has a prominent duct which enters the papilla near the pyloric sphincter (at the same place as the opening of the pyloric caecum in adults (Fig. 3).

Pancreas: The pancreas is a diffused organ. It can be found between the ascending and descending parts of the small intestine as well as in the intestinal serosa in some cases. The secretions of this diffused structure are moved with a duct connected to the bile duct (Fig. 3) .

Swim Bladder: The sturgeons have the simplest type of swim bladder; a single cavity ellipsoid with rather thick opaque septum. It enters the papilla inside the stomach, through the pneumatic duct (Fig.1). It is mostly located in the right, starting from the first third of the abdominal cavity, continuing to the last third on the dorsal part of the spiral colon just near the vertebral columen (Masoudifard et al., 2009; Vajhi et al., 2009).

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جنبه‌های تازه‌ای از دستگاه گوارش ماهی قره برون *Acipenser persicus*

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چکیده

ماهیان خاویاری یکی از مهمترین آبزیان دریای خزر می‌باشند. متاسفانه امروزه این گونه‌ها در معرض خطر انقراض قرار دارند. انجام مطالعات اختصاصی بر روی ماهیان خاویاری می‌تواند در شناخت بیشتر و کمک به حفظ نسل این ماهی‌ها بسیار اهمیت داشته باشد. مطالعاتی همچون مطالعات بافت شناسی، رادیولوژی و سونوگرافی همگی نیازمند فهمی درست از کالبدشناسی این ماهیان است. از آنجایی که مطالعات اولیه نشان دهنده اشتباهاتی در توصیف دستگاه گوارش ماهیان خاویاری بود، این مطالعه با هدف مشخص کردن کالبدشناسی دقیق دستگاه گوارش قره برون *Acipenser persicus* به عنوان مهمترین ماهی خاویاری ایران انجام شد.

در این مطالعه ۴۰ عدد قره برون بالغ مورد بررسی کالبدگشایی قرار گرفتند. تمام بخش‌های دستگاه گوارش از دهان تا رکتوم و سوراخ مخرج ارزیابی شدند. ساختار آناتومیک و ارتباط بخش‌های مختلف دستگاه گوارش شامل حفره دهان، حلق، مری، معده غده‌ای، معده عضلانی، زائده پیلوریک، روده باریک، روده مارپیچ، رکتوم، کبد و پانکراس بررسی شد.

لوله گوارش نسبتا کوتاه است. معده دارای دو بخش است. بخش اول یا پیش معده یو شکل بود (u). بخش دوم یا سنگدان دارای دیواره عضلانی ضخیمی بود و تقریبا با لوب‌های کبد پوشانده می‌شد. سکوم پیلوری به صورت ساختار اسفنج مانندی در زیر سنگدان در سمت چپ قرار گرفته بود. روده از سه بخش تشکیل شده بود: روده باریک، روده مارپیچ و رکتوم. روده باریک دارای دو خم بود که آن را به سه بخش پایین رو، بالارو و بخش انتهایی تقسیم می‌کردند. روده مارپیچ طویل‌ترین بخش لوله گوارش بود، این بخش در سطح داخلی خود دارای دیواره مخاطی مارپیچ بود. رکتوم کوتاه بود و در بخش میانی حفره شکمی قرار گرفته بود. محققین قبلی سوراخ مربوط به مجرای زوائد پیلوریک را در محل اتصال معده عضلانی و معده u شکل نمایش داده اند، در حالی که در این مطالعه مشخص شد این سوراخ در محل اتصال معده عضلانی و روده باریک نزدیک به مجرای کیسه صفرا قرارگرفته است.

لغات کلیدی: دستگاه گوارش، کالبدشناسی، *Acipenser persicus*

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