

The Morphology and Histology of Alimentary Tract of *Garra tibanica* Trewavas (Teleostei: Cyprinidae)

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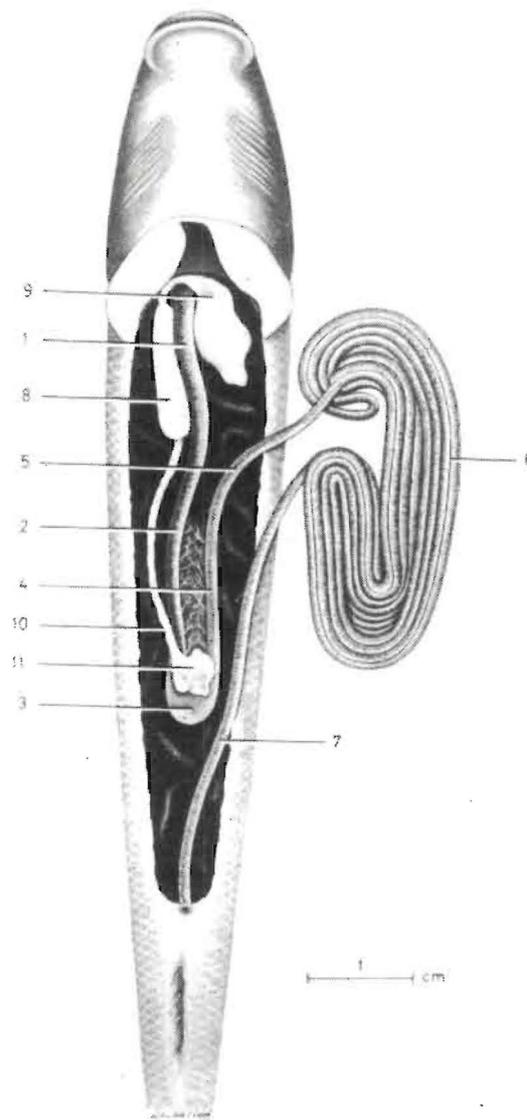
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ABSTRACT. The morphology and histology of the alimentary tract of *Garra tibanica* is described. Specializations in the form of the esophageo-intestinal sphincter, the intestinal swelling and the intestinal looping are reported. The histological features of the esophageal lining are characterized by ciliated columnar epithelium intermingled with goblet cells. Minor histological changes occur at the esophageo-intestinal sphincter, at the intestinal swelling and intestinal looping and at the distal intestine; otherwise, the intestinal lining is much the same throughout. The chief difference is in the degree of complexity and depth of folding. Neither a basement membrane nor a stratum compactum are evident.

The genus *Garra* is widespread from South China and Borneo in the east to the Congo in the West (Menon 1964), and in Saudi Arabia; the most widely distributed species in the Western region is *G. tibanica* Trewavas. It has been reported from various localities in the region by several workers (Trewavas 1941; Banister and Clark 1977, Al-Kahem 1980). The histology of the digestive system of this fish is yet to be investigated.

The studies on the histology of the alimentary canal of any fish are always accompanied with measuring the gut diameter and its total length; since the latter gives some indications to the food and feeding habit of the fish (Kafuku 1958, Harder 1975).

In the present study, the morphology and histology of the digestive tract of *G. tibanica* were investigated in detail, noting in particular its specializations. Compared with 'typical' vertebrates, this species is astonishingly distinctive in present contexts, although it conforms with the basic characteristics of other members of its family (Cyprinidae).



Pl.1 The alimentary tract of *G. tibonica* with the looped intestine placed aside. 1, Esophageo-intestinal sphincter; 2, caudally-running proximal intestine; 3, intestinal swelling; 4-5, cranially-running proximal intestine; 6, looped intestine; 7, caudally-running distal intestine; 8, gall bladder; 9, anterior lobe of liver; 10, liver isthmus; 11, posterior lobe of the liver.

Material and Methods

A total of 30 specimens of *G. tibanica* measuring 8 to 10 cm in total length and weighing 7-11 g was obtained from Wadi Al Mahala, 7 Km East Abha, Western Region, Saudi Arabia. These were preserved in Bouin's solution before they were dissected for histological studies. From the dissected fish, the length and diameter of the alimentary tract were measured by using a calibrated stage micrometer under a stereoscopic microscope. Samples of the esophagus and intestine were then removed and fixed in either aqueous Bouin's fluid, neutral formalin, Carnoy's fixative or formal sublimate'. The tissues were then embedded in paraffin, thin sections (7 μ m) were cut and stained with Ehrlich's haematoxylin and eosin, Giemsa or Mallory's triple stain for histological investigations.

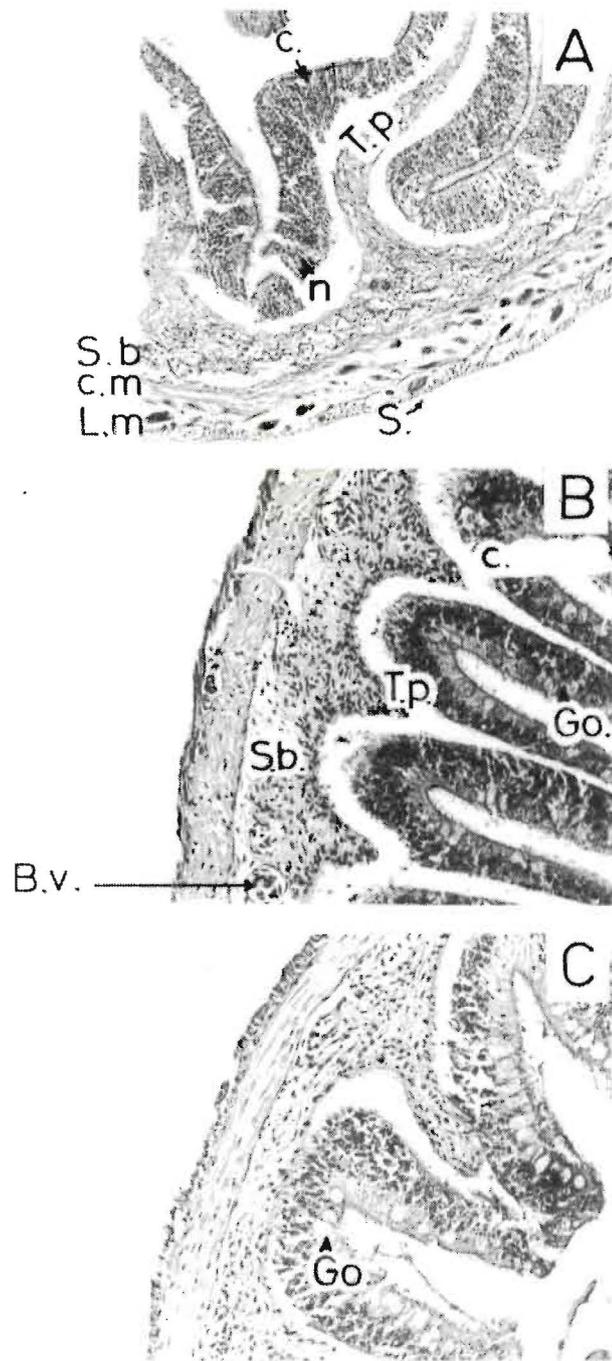
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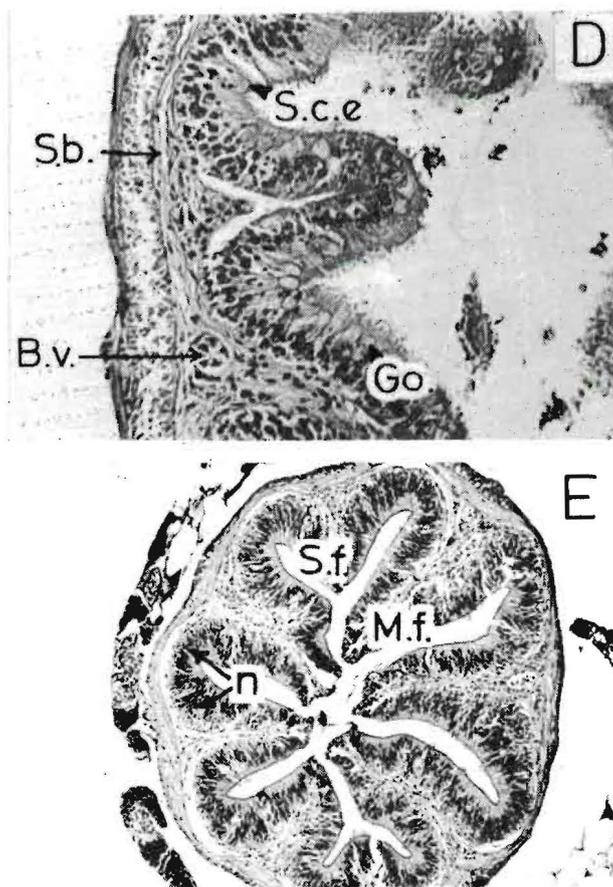
Gross Anatomy

The esophagus (Pl.1) is 4 ± 0.7 mm in length and 1.5 ± 0.3 mm in diameter and is located directly posterior to the gill-cavity or pharynx, preceded by the oral cavity. It is joined at its posteroventral end by the pneumatic duct. On entering the peritoneal cavity, the esophagus attains a 2.5 ± 0.2 mm diameter and continues 18-20 mm as the esophageo-intestinal sphincter, gradually narrowing posteriorly to a diameter of 1.5 ± 0.5 mm and suddenly dilating into a U-shaped intestinal swelling that replaces the stomach in this fish. This dilation averages 11 mm in length and 3-5 mm in diameter at its greatest curvature and is followed by a cranially directed straight tube 29 ± 2 mm in length and 1.5 ± 0.2 mm in diameter. The tract then describes a series of loops for about 445 mm and turns sharply towards the anus without any external demarcation for about 40 mm. The loop pattern is Acheilognathid (or plano-spiral) and consists of horizontal spirals in two parallel discs with coils situated on the same plane.

The liver consists of two lobes. The larger lobe lies in the anterior part of the left body cavity and is connected by a relatively long (28 ± 2 mm) and thin (1.5 ± 0.2 mm) isthmus to a smaller lobe that rests on the intestinal swelling ventrally. The gall bladder is on the anterior part of the right side of the body cavity and has a short choledochal duct that joins the intestine just posterior to the esophageo-intestinal sphincter.

The pancreas is a whitish grey organ suspended in the mesenteries between the arms of the U-shaped intestinal swelling and has a relatively long (16 ± 0.2 mm) pancreatic duct that runs forward and joins the intestine together with the choledochal duct. The spleen is a small reddish body that lies on the dorsal surface of the intestinal loop.





PI.2 Histology of various parts of the alimentary tract of *G. tibonica*. **A**, transverse section through anterior portion of esophagus (X200), showing ciliated stratified columnar epithelial cells (C.) of the mucosa; connective tissue cores of tunica propria (T.p.) and submucosa (S.b.); the muscularis with inner circular muscle layer (C.m.) and outer longitudinal (L.m.) muscle layer surrounded by a thin serosa (S) (Mallory triple stain). **B**, cross section of anterior part of the esophageo-intestinal pincher (X200), showing mucosal folds lined with ciliated simple columnar cells (C.) with basal nuclei, and slender goblet cells (Go.); tunica propria (T.p.) and submucosa (S.b.) with clear aeriolar connective tissue and blood vessels (B.v.) (haematoxylin and eosin). **C**, transverse section through intestinal swelling (X200), showing numerous distended goblet cells (Go) arranged at one plate (haematoxylin and eosin). **D**, transverse section of intestinal loop (X200), showing typical intestinal epithelium (Simple columnar epithelium, S.c.e.) with basal oval nuclei and numerous goblet cells (Go.) and relatively thin submucosa (S.b.) at the crypts of some mucosal folds (haematoxylin and eosin). **E**, Transverse section at the most distal part of the intestine (X78.75), showing the reduced number (6) of the major mucosal folds (M.f.); secondary folds (S.f.); the scattered nuclei (n.) of the epithelial cells; absence of goblet cells (haematoxylin and eosin).

Histological Observations

The Esophagus (Pl. 2A)

The Mucosa. The entire length of the esophagus is characterized by the presence of 15-16 major short ($200 \pm 1.2 \mu\text{m}$) epithelial folds. The epithelium of these folds is ciliated stratified columnar cells interposed with goblet cells. The epithelial cells average $65 \mu\text{m}$ in height with basally located nuclei, whereas the goblet cells are $21 \mu\text{m}$ in height and decrease in number towards the intestine.

The Submucosa. The esophagus is devoid of a basement membrane and a stratum compactum. The tunica propria merges with the submucosa and extends between the mucosal folds, forming connective tissue cores with compact fibers and numerous oval nuclei. The submucosa consists of areolar connective tissues, large blood vessels and isolated bundles of striated muscles close to the muscularis.

The Muscularis. The muscle layer is uniform in thickness ($50\text{-}60 \mu\text{m}$) throughout the esophageal lining and consists of striated muscle fibers arranged in a thick ($40 \pm 0.5 \mu\text{m}$) circular inner layer and a thin ($12 \pm 0.3 \mu\text{m}$) longitudinal outer layer. The nuclei of the former are spindle shaped to oval, but the oval ones are more predominant.

The Serosa. This is a thin layer of flattened peritoneal cells interrupted at some places with connective tissue and blood vessels.

The Intestine (Pl. 2 B, C, D, E)

The Mucosa. The histological features of the esophageo-intestinal sphincter, intestinal swelling and the part just preceding the anus consist of simple columnar epithelial cells intermingled with goblet cells, although minor differences in the degree of complexity and depth of folding occur among these parts.

At the most anterior part of the esophageo-intestinal sphincter, 12 to 14 principal folds ($396 - 420 \mu\text{m}$ in height) occur. Posteriorly, the number of folds is reduced to 8-9. The folds in the intestinal swelling become more numerous, up to 16. The sides of the folds up to this region are parallel and their crypts are narrow. The folds decrease in number and height towards the intestinal loop (11-12 folds). Near the anus, occur only 6-7 short, thicker folds with secondary folds at the bases of their crypts. Goblet cells tend to be distended and numerous in the intestinal swelling and intestinal loop (Pl. 2C, D), but become slender and rare near the anus. The cilia on the outer surface of the epithelial cells also gradually disappear towards the anus. Throughout the intestinal lining a basement membrane and stratum compactum are lacking.

The Submucosa. Except for the region just preceding the anus, the lamina propria and the submucosa are clearly demarcated throughout the entire length of the intestinal lining. In the esophageo-intestinal sphincter (Pl. 2B), the lamina

propria runs deeply into the folds and is characterized by numerous rounded nuclei. Towards the anus (Pl. 2E), however, it is characterized by having clear smooth muscle fibers but few scattered nuclei and blood vessels.

The Muscularis. The striated esophageal muscle fibers continue for a short distance into the esophageo-intestinal sphincter before they are gradually replaced by smooth muscle fibers that constitute the entire musculature of the intestine. The circular muscle layer is always thicker than the longitudinal one; the latter follows the curvature of the intestinal swelling without undergoing much distortion. The circular muscle layer, however, is thinner on the greater curvature of the intestinal swelling. With the exception of this arrangement, the muscularis is maintained almost constant throughout the intestinal lining.

The Serosa. Similar to the esophagus, the intestinal serosa is made up of a single layer of peritoneal cells.

Discussion

Specializations in the form of esophageo-intestinal sphincter, intestinal swelling and intestinal looping characterize the alimentary tract of *G. tibanica*. Esophageo-intestinal sphincters separating intestinal swellings from esophagi have been observed in *Notemigonus chrysoleucus*, *Pimephalus promelas*, *Labeo horie* and other cyprinid fishes (Girgis 1952, Reifel and Travill 1979); although previously misnamed pyloric sphincters (Al-Hussaini 1945, Kapoor 1958). The absence of the stomach, however, is supported by the absence of gastric glands in the intestine and the hind entrance of the choledochal duct into the lower portion of the esophagus (Szarski 1956, Harder 1975), a feature of the family Cyprinidae (Pernkopf 1930, Rauther 1937, Kafuku 1966, Harder 1975, Rombout 1977).

The Acheilognathid type of the intestinal looping reported in the present study conforms with the basic cyprinid pattern (Kafuku 1958). A similar type of looping has been observed in *Labeo horie* (Girgis 1952).

The structure of the esophageal epithelium in *G. tibanica* is consistent with the general pattern in teleost fishes. Features distinctive of the posterior part of the intestine are the reduction in the epithelial height, and complexity of folding together with the scarcity of goblet cells without a noticeable increase of the musculature. In the anterior part of the tract (esophageo-intestinal sphincter, intestinal swelling and intestinal looping), the epithelial cells are higher, goblet cells are numerous and the folds are complex. Such a reduction in height and depth of folding is a common histological feature of teleost fishes (Blake 1930, Al-Hussaini 1945, Kapoor 1958, Harder 1975). Moreover, a scarcity of goblet cells in the posterior part of the intestine has been reported in some of the cyprinid fishes (Sarbah 1940, Girgis 1952). An abundance of goblet cells in the posterior part of the intestine has been considered essential for fecal lubrication (Curry 1939, Das

and Moitra 1956, Girgis 1952, Reifel and Travill 1979).

The absence of a basement membrane, with or without stratum compactum, is common in teleosts (Kafuku 1966, Harder 1975, Rombout 1977), and could be attributed to the type of food ingested by these fishes. The type of food for *G. tibanica* could be a simple one (microscopic organisms and algae) needing no lubrication, as indicated by the absence of both stratum compactum and basement membrane. A relationship between these two layers and the type of food has been suggested by several authors (Girgis 1952, Kafuku 1966, Harder 1975, Reifel and Travill 1977).

The musculature in *G. tibanica* is developed to the same degree throughout the length of the intestine, perhaps reflecting the simple type of food eaten by this fish. A more complex food (aquatic vegetation, insects, benthos or fish) needs lubrication, especially during the passage through the rectum. Similar observations have been noticed in several other fishes (Girgis 1952, Kafuku 1958, Reifel and Travill 1979).

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الشكل الخارجي وأنسجة القناة الهضمية
 لسمكة
 «الغاراتيانكا تريوفاس (تيلوستاي:
 سايريندي)»

ناصر الأصقة

قسم علم الحيوان - كلية العلوم - جامعة الملك سعود الرياض -
 المملكة العربية السعودية

يدرس هذا البحث الشكل العام والتركيب الهستولوجي للقناة الهضمية في سمكة الغاراتيانكا . من خصائص الشكل العام للقناة الهضمية وجود الصمام المريئي - المعوى ، الانتفاخ المعوى ، والالتفاف المعوى . ومن مميزات التركيب الهستولوجي للجزء المبطن من المريء وجود خلايا طلائية عمودية مهدبة بينها خلايا كأسية . فيما عدا بعض التغيرات الهستولوجية الطفيفة في الصمام المريئي - المعوى ، الانتفاخ المعوى ، والالتفاف المعوى ، فإن التركيب الهستولوجي للقناة الهضمية متساوٍ بشكل عام . يلاحظ تغير واضح في درجة تعقيد وعمق الشيايات المبطنة للقناة الهضمية ، كما لم يلاحظ وجود غشاء قاعدي ولا طبقة ماكنة على طول القناة الهضمية .