

The Digestive Tube of an Omnivorous Cyprinoid Fish, *Barbus stigma* (CUV. & VAL.)*

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The present study is a continuation of the author's previous reports (KAPOOR, '53 and in press) and has been conducted to increase the store of information on the digestive tube of teleosts. Contributions by AL-HUSSAINI ('49, '53) and GIRGIS ('52) have been relied upon heavily for information on this topic. WEINREB and BILSTAD ('55) have described the histology of the digestive tract, the liver and pancreas, and the detailed relationship of the swim bladder and its duct to the oesophagus in rainbow trout, *Salmo gairdneri irideus*. A study was also made to determine the sites of phagocytosis.

Several specimens of *Barbus stigma* were dissected to examine the gross anatomy. For histology, live fishes were dissected and the digestive tube in each case was immediately fixed in Bouin's fluid. Sections of the selected regions of the digestive tube were cut at 6 and 8 μ . Delafield's haematoxylin and eosin, Mallory's triple stain and mucicarmine were used for staining the sections.

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Gross anatomy : *Barbus stigma*, a column feeder, has a small gape of mouth and the lips are absent. Both the jaws are of equal size. Within the buccal cavity are present the maxillary valve (KAPOOR, '57) and the small rudimentary tongue (Fig. 1). The pharynx is divided into an anterior respiratory and gustatory part and a posterior into a masticatory one. The pharyngeal teeth are present in three rows in order of 2, 3, 5/5, 3, 2. They are homodont, polyphyodont and are of crushing type (Figs. 2, 3), and strike against the dorsal callous pad (KAPOOR, '57).

The oesophagus is the region of gut from the pharyngeal masticatory apparatus to the pyloric sphincter at the commencement of the intestinal bulb. The intestinal bulb is like that in *Catla catla* and its wall is very thin through which the internal folds are visible. The bile duct opens into anterior part of the bulb. The liver lobes cover the intestinal bulb and the gall bladder lies in juxtaposition to the anterior portion of the bulb. The coils of intestine which are few and less complicated surround the bulb. The rectum is not distinguishable (Fig. 4).

* *Barbus stigma* (CUV. & VAL.) or *Barbus (Puntius) sophore* (HAM.).

The folds of the different parts of the digestive tube are a little different from those of *Catla catla*. The buccal lining is disposed into mild folds. The floor near the tongue has folds in the form of papillae while the pharynx has thick longitudinal folds (Fig. 1). The folds of the oesophagus are longitudinal and those of the intestinal bulb as well as those of the intestine are in a zig-zag fashion and their complexity varies from one part to another (Figs. 5—10). The relative length of the gut is approximately 2.1.

Microscopic anatomy : *Buccal cavity* : The wall of the buccal cavity is composed of mucosa and submucosa (Fig. 11). The mucosa is of stratified nature with mucous cells and taste buds in it. The epithelial cells are of polygonal, fusiform and columnar types and between columnar cells lie the dome-shaped cells which are clearly distinguishable from the other epithelial cells. Mucous cells are limited to the border, vary in size and are of pyriform type. Taste bud consists of the usual neuroepithelial cells and the interposed supporting cells. The mucosa is supported by the basement membrane as well as by the stratum compactum. Underlying the mucosa is the submucosa of connective tissue fibres infiltrated with adipose tissue. Blood capillaries are present in the submucosa.

Pharynx : The pharyngeal wall consists of mucosa (epithelium, basement membrane and stratum compactum), submucosa and muscularis (Fig. 12). The epithelium is stratified and has the polygonal, elongated, columnar, mucous cells and the taste buds. The taste buds are present in the form of small clusters of cells.

The basement membrane and stratum compactum are also observed. The submucosa is made up of fibrous connective tissue and is heavily impregnated with adipose cells. The muscularis is embedded in submucosa and is of striated type. There are no definite circular and longitudinal layers of muscles. Blood capillaries extend up to the basement membrane. The structure of pharynx is similar to that of *Cirrhina mrigala* (ISLAM, '51).

Oesophagus : The oesophageal coats are : mucosa, submucosa, muscularis, and adventitia or serosa (Figs. 13, 14). The mucosa is composed of ordinary epithelial cells and has mucous cells and taste buds in it. The epithelial cells at places are squeezed in between the mucous cells which form a common element in the mucosa. The taste buds are present in abundance. The basement membrane is thin and separates mucosa from the submucosa. The tunica propria is histologically similar to submucosa.

The submucosa is a poorly developed layer and consists of very loosely arranged connective tissue fibres, scattered among which lie numerous longitudinal muscle bundles.

The muscularis is of striated variety and consists of a well-developed circular coat of muscles ; the longitudinal muscle layer forming a distinct outer coat being absent here. Numerous longitudinal muscle fibres, as mentioned earlier, are, however, present in the meshes of submucosa. The serosa is a very thin layer.

A notable feature of the oesophagus is the presence of taste buds in greater number than that in *Wallago attu* (KAPOOR, '53), *Cirrhina mrigala* (ISLAM, '51) and *Cyprinus carpio communis* (CURRY, '39). PICTET ('09) gave the impression that taste buds are numerous throughout the oesophagus.

Intestinal bulb : The intestinal bulb consists of the following tunics : mucosa (epithelium, tunica propria), submucosa, muscularis and serosa (Figs. 15—17). The epithelium of the bulbar mucosa is simple columnar ; the cells are very slender and tall and their nuclei are located in the centre or in the basal third of the cells. There is, however, some difference in the height of columnar cells which are lined by a top-plate. The mucous cells are sparsely present. Nowhere in the intestinal bulb the mucous cells are so plentiful as in the mouth, pharynx and the oesophagus. The part of each mucous cell filled with mucus is typically spherical ; the basal part is long, filamentous and has the oval nucleus. Small wandering cells are quite common in the epithelium. No multicellular glands of the gastric or intestinal types are found in the bulb.

In every fold the tunica propria is a thin sheet of very vascular fibrous connective tissue. In general it may be said that the submucosa does not form a thick layer in the bulb. The muscularis consists of an inner circular and the outer longitudinal layer of muscles. The circular layer of muscles is nearly equal or slightly thicker than the longitudinal muscle layer. The muscle fibres are smooth ; and the connective tissue between the muscle layers is usually small. Serosa is thin and is backed by the connective tissue.

The oeso-intestinal bulb region shows the mixed epithelia and also the pyloric valve (Figs. 18, 19).

PICTET ('09) gave a chain of evidences to show that the intestinal bulb is an enlargement of the anterior part of intestine.

Intestine : The four coats of intestine are mucosa, submucosa, muscularis and serosa (Figs. 20, 21). The epithelial lining consists of three common types of cells : the ordinary columnar, the mucous and the wandering cells. Each columnar cell is long and slender ; the nucleus is large, oval or slightly round and is situated in the central or basal portion of the cell. There is a top plate at the border of the columnar epithelial cells. The mucous cells are numerous and are modified epithelial cells of variable size. They are profusely present near the anal opening. Wandering cells occur between the true epithelial elements and are more common within the fluid-filled intercellular space around the bases of columnar cells and may migrate to the free border. There is no trace of intestinal glands, and there is neither the stratum compactum nor stratum granulosum as mentioned by GREENE ('12) in the intestine of salmon and by MAHADEVAN ('50) in the intestine of *Caranx djedaba*.

The tunica propria, an extension of the submucosa, runs into the folds throughout. The submucosa is a thin stratum of the connective tissue fibres within which run blood capillaries.

The muscularis consists of an inner circular and an outer longitudinal layer of muscles. Muscle fibres are smooth and are bound together by strands of connective tissue. The serosa is a thin outer covering.

At the anal aperture the columnar epithelium of the intestine changes over to the stratified epithelium of the skin.

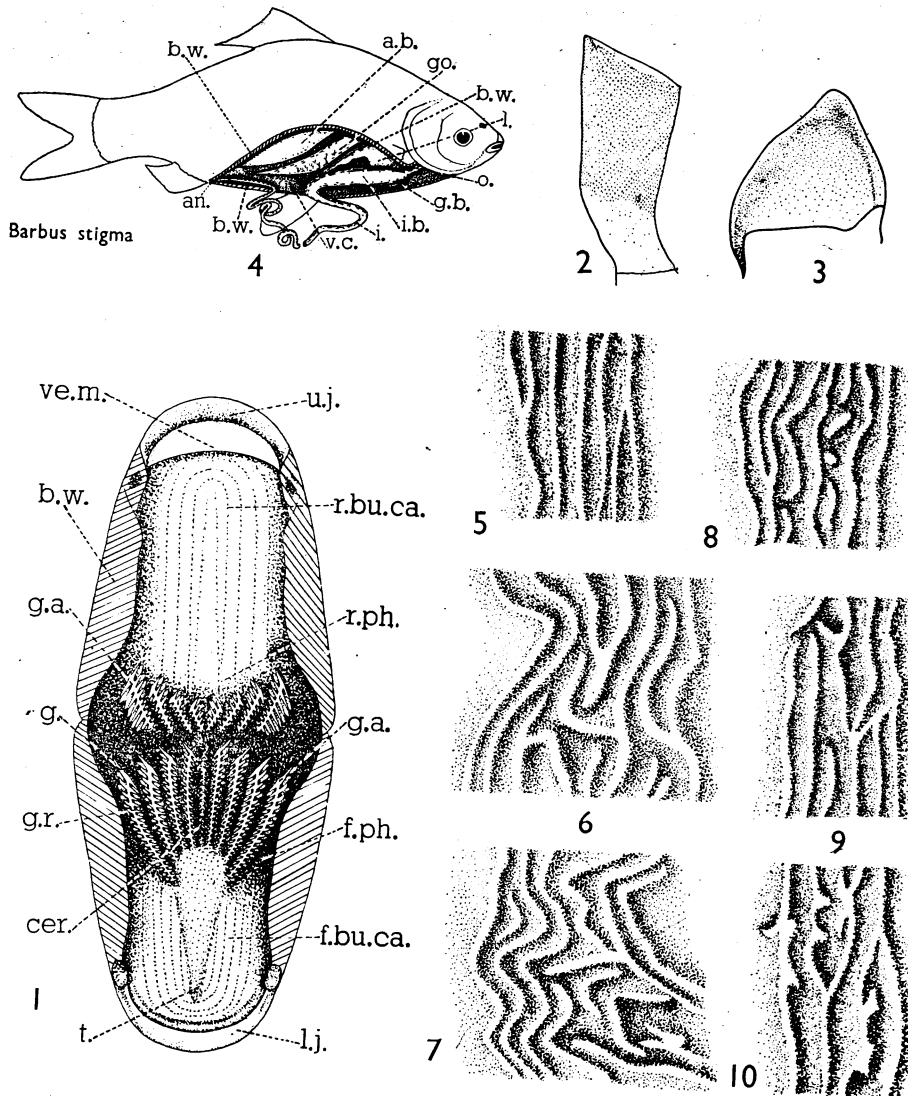
Summary : Points of anatomical and histological interest are : (1) The digestive

tube of *Barbus stigma* closely resembles to that of *Catla catla*. (2) The buccal cavity contains the maxillary valve and the rudimentary tongue; the anterior pharynx is respiratory and gustatory and the posterior is masticatory in function; the oesophagus opens directly into the intestinal bulb; a sphincter marks the boundary between the oesophagus and intestinal bulb; the intestine is not very much coiled and the rectum is not differentiated. (3) The buccal epithelium is characterised by the polygonal, fusiform and columnar cells. The basement membrane and stratum compactum are present. (4) The pharyngeal epithelium is packed with mucous cells and taste buds and is supported by a basement membrane and stratum compactum. The adipose tissue and striated muscle fibres in the submucosa are prominent. (5) The oesophageal lining is composed of differentiated stratified epithelium and abundant taste buds and mucous cells. The longitudinal muscle bundles are dispersed in the submucosa. The circular layer of striated muscles forms a thick coat. (6) The oeso-intestinal bulb region shows mixed epithelia. (7) The carp does not have a stomach as is shown by the absence of gastric glands and the point of entrance of the choledochal duct in the intestinal bulb. The structure of intestinal bulb is similar to that of intestine. At the anus the columnar epithelium of the intestine changes over to the stratified epithelium of the skin. (8) The multicellular glands are absent throughout the digestive tube.

References*

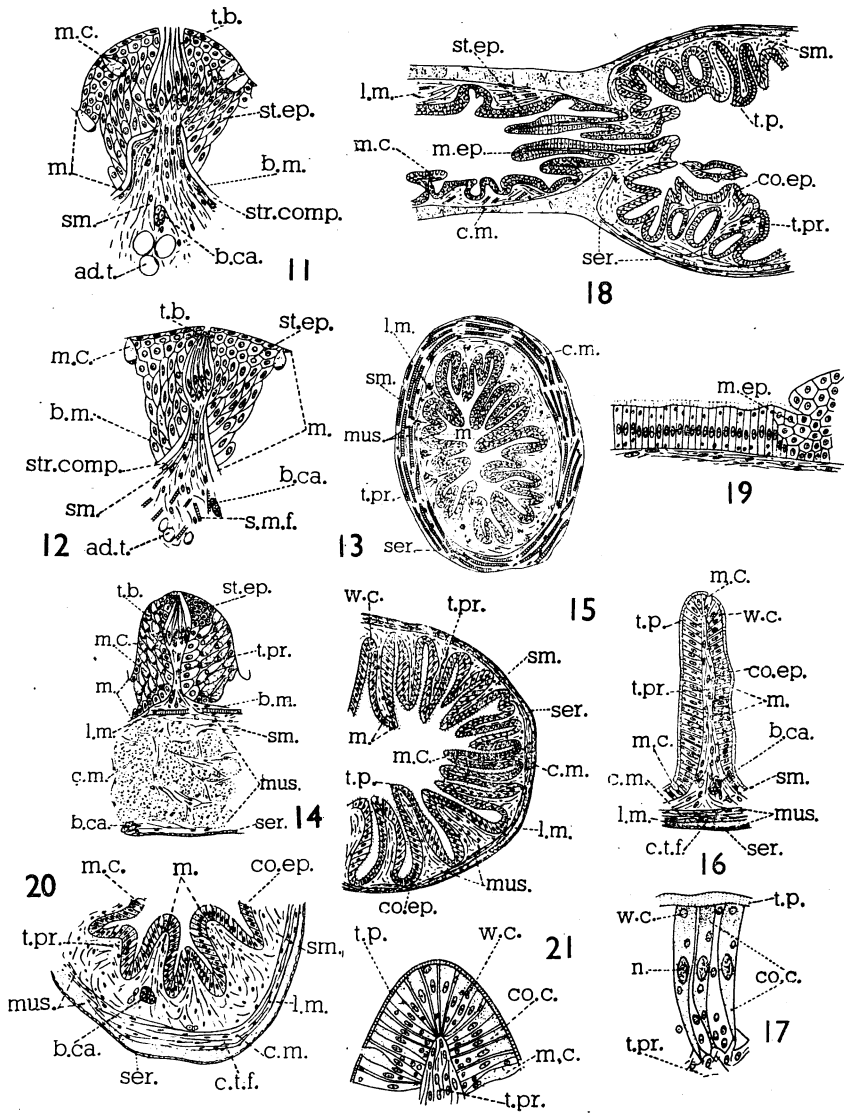
- AL-HUSSAINI, A.H. 1949 : On the functional morphology of the alimentary tract of some fish in relation to differences in their feeding habits : Anatomy and Histology. Quart. Journ. Micr. Sci., xc, 109—140.
- AL-HUSSAINI, A.H. and KHOLY, A.A. 1953 : On the functional morphology of the alimentary tract of some omnivorous teleost fish. Proc. Egyptian Academy of Sciences, ix, 17—39.
- CURRY, E. 1939 : The histology of the digestive tube of the carp (*Cyprinus carpio communis*). J. Morph., lxxv, 53—78.
- GIRGIS, S. 1952 : On the anatomy and histology of the alimentary tract of an herbivorous bottom-feeding cyprinoid fish, *Labeo horie* (CUVIER). J. Morph., xc, 317—362.
- GREENE, C.W. 1912 : Anatomy and histology of the alimentary tract of the king salmon. Bull. U.S. Bur. Fish., xxxii, 73—100.
- ISLAM, A.U. 1951 : The comparative histology of the alimentary canal of certain fresh water teleost fishes. Proc. Ind. Acad. Sci., xxxiii, 297—321.
- KAPOOR, B.G. 1953 : The anatomy and histology of the alimentary canal in relation to its feeding habits of a siluroid fish, *Wallago attu* (BL. & SOHN.). J. Zool. Soc. India., v, 191—210.
- 1957 : Oral valves of teleosts. Jap. Journ. Ichthyol., v (3/4/5/6), 127—131.
- 1957 : The callous pad of the pharyngeal masticatory apparatus in Indian carps. Jap. Journ. Ichthyol., vi (1/2), 26—30.
- 1957 : The anatomy and histology of the digestive tract of a cyprinoid fish, *Catla catla* (HAMILTON). Ann. Mus. Civ. Stor. Nat. Genova. (In Press).
- MAHADEVAN, S. 1950 : The digestive tube of *Caranx djedaba* (FORSK.) and *Trichiurus haumela* (FORSK.). J. Madras Univ., xxi, 25—48.
- PICTET, A. 1909 : Contribution à l'étude histologique du tube digestif des poissons cyprinoides. Revue Suisse de Zoologie, xvii, 1—78.
- WEINREB, E.L. and BILSTAD, N.M. 1955 : Histology of the digestive tract and adjacent structures of the rainbow trout, *Salmo gairdneri irideus*. Copeia, no. 3, 194—204.

*The references cited above may be consulted for earlier work.



Explanation of figures :

—Fig. 1—Buccal cavity and pharynx. Fig. 2—Fully developed pharyngeal tooth. Fig. 3—Developing tooth. Fig. 4—Digestive tube with uncoiled intestine. Figs. 5-10—Mucosal folds. (5) Oesophagus, (6) intestinal bulb, (7) anterior part of the intestine, (8) middle part of the intestine, (9) posterior part of the intestine, (10) last part of the intestine. Fig. 11—T. S. Buccal wall. Fig. 12—T. S. Pharyngeal wall. Fig. 13—T. S. Oesophagus. Fig. 14—L. S. Oesophagus (magnified). Fig. 15—T. S. Intestinal bulb. Fig. 16—T. S. Intestinal bulb. Fig. 17—Mucosa of the intestinal bulb (magnified). Fig. 18—L. S. Oeso-intestinal bulb region. Fig. 19—Mixed epithelia in the oeso-intestinal bulb region (magnified). Fig. 20—T. S. Intestine. Fig. 21—Mucosa of intestine (magnified).



Key to lettering : *a. b.*, air bladder ; *ad. t.*, adipose tissue ; *an.*, anus ; *b. ca.*, blood capillary ; *b. m.*, basement membrane ; *b. w.*, body wall ; *c. m.*, circular layer of muscles ; *c. t. f.*, connective tissue fibres ; *cer.*, ceratobranchial (5th) ; *co. c.*, columnar cell ; *co. ep.*, columnar epithelium ; *f. bu. ca.*, floor of the buccal cavity ; *f. ph.*, floor of the pharynx ; *g.*, gill filaments ; *g. a.*, gill arch ; *g. b.*, gall bladder ; *g. r.*, gill raker ; *go.*, gonad ; *i.*, intestine ; *i. b.*, intestinal bulb ; *l.*, liver ; *l. j.*, lower jaw ; *l. m.*, longitudinal layer of muscles ; *m.*, mucosa ; *m. c.*, mucous cell ; *m. ep.*, mixed epithelia ; *mus.*, muscularis ; *n.*, nucleus ; *o.*, oesophagus ; *r. bu. ca.*, roof of the buccal cavity ; *r. ph.*, roof of the pharynx ; *s. m. f.*, striated muscle fibres ; *ser.*, serosa ; *sm.*, submucosa ; *st. ep.*, stratified epithelium ; *str. comp.*, stratum compactum ; *t.*, tongue ; *t. b.*, taste bud ; *t. p.*, top-plate ; *t. pr.*, tunica propria ; *u. j.*, upper jaw ; *v. c.*, visceral cavity ; *ve. m.*, velar membrane (maxillary oral valve) ; *w. c.*, wandering cell.