OBSERVATION
DIGESTIVE SYSTEM OF MYSTUS CAVASIUS

Morphology and Anatomy
Histology
Physiology
OBSERVATIONS

DIGESTIVE SYSTEM of Mystus cavasius

MORPHOLOGY AND ANATOMY

The alimentary canal:

The alimentary canal of Mystus cavasius comprises the lips, buccal cavity, pharynx, oesophagus stomach, intestine and rectum.

A. The mouth is fairly wide, non-protractile and bounded by thick upper and lower lips. Both the jaws are provided with strong, pointed teeth. The mouth proceeds into a spacious buccal cavity. The bucco-pharyngeal region is provided abundantly with strong teeth which are arranged in groups as follows:

   I. Teeth on the roof of the buccal cavity:
      a) Maxillary teeth
      b) Palatine teeth
      c) Pharyngeal teeth
Fig. I. Internal view of Bucco-pharyngeal region showing component parts - (M. uavasius).

1. Upper jaw  
2. Maxillary barbel  
3. Roof of the buccal cavity  
4. Opening of the oesophagus  
5. Floor of the buccal cavity  
6. Lower jaw  
7. Maxillary teeth  
8. Palatine teeth  
9. Pharyngeal teeth  
10. Branchial arch  
11. Gill rakers  
12. Mandibular teeth
a) **Maxillary teeth:**

The maxillary teeth are lodged on the upper jaw and are disposed in a semilunar band on the premaxillaries on each ramus. The anterior maxillary teeth are larger than the posterior ones. All these teeth are sharp, strong, pointed and are procumbent. The upper jaw is lined posteriorly by velar membrane. Fig. 1

b) **Palatine teeth:**

The palatine teeth are arranged in a semilunar band below the maxillary teeth. The former are strong and disposed in rows. The teeth on the proximal region are larger than those on the distal region. Fig. 1

c) **Pharyngeal teeth:**

The pharyngeal teeth are lodged on a pair of rounded and slightly elevated patches. They are not supported by the pharyngobranchials. They are larger than the maxillary teeth but slightly similar to the palatine teeth in size and shape. The teeth are recumbent and arranged in rows. Fig. 1
Fig. 2. Different retions A,B,C,D. of the alimentary canal longitudinally incised to show nature of the mucosal folds. (*M. cavasius*)

* Arrows indicates mucosal fold.

A = Oesophagus  
B = Stomach  
C = Intestine  
D = Rectum
II. Teeth on the floor of the buccal cavity:

a) Mandibular teeth

b) Horny pad teeth

a) Mandibular teeth:

The mandibular teeth are strong and pointed and are almost like the maxillary teeth in size and shape. The former are borne on the dentaries. They are procumbent and arranged in rows. The lower jaw is lined posteriorly by a velar membrane. Fig. 1

b) Horny pad teeth:

The horny pad teeth are lodged on a pair of rounded pads. They are almost similar to the pharyngeal teeth in shape and size. They are recumbent, strong and disposed in rows. Those present near the oesophageal opening are larger than the others.

In the posterior pharyngeal region teeth are absent. Fig. 1
Fig. 3. T.S. through dorsal lip of *M. cavasius* showing taste bud. HE X 450.
III. Gill-rakers:

Each gill arch is provided with a row of gill-rakers on each side. The latter bear laterally minute pointed teeth. Fig. 1

A mucosal thickening - the so called "tongue" is situated on the anterior region of the floor of the buccal cavity.

B. The Oesophagus:

The pharynx opens posteriorly into a broad, short and thick-walled oesophagus which, after penetrating the septum transversum, leads into the stomach. The mucosa of the oesophagus is provided with narrow longitudinal folds. Fig. 2

C. The stomach:

The stomach is a thick-walled, muscular, Sac-like structure. The mucosa of the stomach is provided with an outer thick longitudinal fold with thin longitudinal folds present inbetween. Fig. 2
Fig. 4. T.S. of Bucco-pharynx of *M. cavasiug*. HE × 450.
D. The intestine:

The intestine is weakly coiled in a clockwise manner and slightly thick-walled. It is not very long and the relative length of the gut (R.L.G.) is 0.77. The intestine has thin and closely set longitudinal folds. Fig. 2

E. The rectum:

The intestine opens into a short rectum posteriorly which can be identified by the nature of the mucosal folds and the presence of an ileo-rectal valve. The mucosa of the rectum is provided with narrow and prominent longitudinal folds. It opens externally through the anal opening.
Fig. 5 T.S. of Oesophagus of *M. cavagius*. HE X 100.
HISTOLOGY

The alimentary canal:

Lip:

In *M. cavasius*, the lip is made up of an outer layer of epidermis or mucosa and an inner layer of dermis or submucosa. The former is provided with many crypts, both in the upper and lower lips. It comprises simple, many layered, stratified epithelium. The latter cells are polygonal in shape, each with a spherical or oval, and deeply staining nucleus. Taste-buds and mucous secreting cells are scattered inbetween the epithelial cells. A few lymphocytes are also present at the basal region of the mucosa although club cells are absent. Lymphocytes stain deeply with haematoxylin. Taste-buds are tall flask-shaped and occur in groups in the lower lip. They are generally more numerous on the tips of the crypts. They are also provided with neuroepithelial cells and sustentacular cells which open to the outside through the gustatory pore. Taste-buds are usually provided with lamina propria. Those in the upper lip have extremely long neuroepithelial cells. Taste-buds are more abundant in the lower lip. Fig. 3
Fig. 6. T.S. of stomach of *M. cavasius* showing villi and muscle layer.
HE X 100.
Taste-buds decrease in numerical abundance considerably towards the posterior region. Mucous cells are oval or elongated in shape and their contents are reticulate in nature. Mucous cells are abundant in the upper lip. A clear homogeneous, non-cellular basement membrane is lies in between the mucosa and submucosa. The rounded cells of the former and the compact connective tissue fibres of the latter comprise the stratum Malpighii and stratum compactum above and below the basement membrane respectively. Both the strata are distinct in the upper lip but not so in the lower lip. The submucosa comprises the compact connective tissue. Blood vessels and nerve elements are also present in the submucosa. Chromatophores may be present in the submucosa of the lower lip.

Buccal cavity:

The roof of the buccal cavity comprises the mucosa, submucosa and muscularis. The mucosa of the buccal cavity does not form any crypt. It comprises 6 to 9 layers of stratified epithelial cells. The latter cells are polygonal in shape and contain darkly stained spherical or oval nuclei. A few taste-buds and many mucous cells are present in between the stratified cells. Club cells are absent in the buccal mucosa. Lymphocytes are very
Fig. 7. T.S. of stomach of *M. cavasius.*

showing gastric glands.

HE X 100.
few and are present in the deepest region of the mucosa. The taste-buds are typical in shape being provided with neuroepithelial and sustentacular cells. Taste-buds are provided with prominent sensory hairs which project outside the epithelial lining through the gustatory pores. Taste-buds are few in number and are not large. They vary in size. Most of the taste-buds are not provided with lamina propria. The latter when present, is very blunt and broad. Mucous cells are rounded or elliptical and are numerous in the buccal epithelium. Most of the mucous cells open to the outside. A few mucous mother cells however, are found in the rete mucosum of Malpighii. They are rounded, smaller in size than the mature mucous cells and are strongly PAS and mucicarmine positive. The strata Malpighii and compactum are situated above and below the basement membrane respectively. The former is thick and wavy being formed of homogeneous connective tissue fibres. The stratum compactum becomes folded in certain areas and participates in the formation of blunt, broad lamina propria of the taste-buds. The submucosa comprises the connective tissue fibres, blood capillaries and fat cells of the adipose tissue. The submucosa becomes suppressed due to the extensive development of fat cells of the adipose tissue. The muscular layer is formed of an
Fig. 8. T.S of stomach of *M. cavasius*, showing gastric glands. HE X 400.
inner circular and an outer longitudinal layer of muscle fibres. The former layer is striated while the latter layer is arranged in bands. Fig. 4.

**Tongue:**

The lining of the tongue is made up of two histological layers - mucosa or epidermis and submucosa or dermis. The former comprises a layer of stratified epithelium formed of 6 to 9 layers of polygonal cells. The mucosa is not provided with any folds. Taste-buds, mucous cells and lymphocytes are also present inbetween the stratified epithelium. Taste-buds are few in number but mucous cells are abundant in the epithelial layer. Lymphocytes are extremely few, being lodged at the deeper layers of the epithelial cells. Taste-buds are provided with short neuroepithelial cells and are typical in structure. They open to the outside through gustatory prores and are provided with gustatory hairs. The latter are present at the tip of the mucosa. The lamina propria of the taste-buds are extremely short and broad being formed of connective tissue fibres of the stratum compactum. The number of mucous cells increases in this region.
Fig. 9. T.S. of gastric glands of *M. cavasius*. HE X 400.
They are either rounded or flask-shaped and their contents are reticulate in nature. They are usually situated towards the apical region of the epithelial layer. A few mucous mother cells are present in the rete mucosum Malpighii. They are rounded, smaller than the matured mucous cells and show strong PAS and mucicarmine reactions. The deepest layer of the mucosa forms the stratum Malpighii and is supported by a distinct basement membrane. The connective tissue fibres of the submucosa constitutes the stratum compactum below the basement membrane which is very thick and wavy. It gets folded in certain zones and forms the lamina propria. The submucosa is areolar in nature being composed of loose connective tissue fibres, nerve elements, blood capillaries and fat cells.

**Pharynx:**

The pharyngial wall is made up of three histological layers viz., mucosa, submucosa and muscularis. The mucosa is simple and is without any folds. It consists of a few layers of stratified epithelial cells. These cells are usually polygonal in shape. Taste-buds, mucous cells and lymphocytes are present inbetween the stratified
Fig. 10. T.S. of anterior intestine of *M. cavasius*, showing villi and muscle layer HE X 100.
epithelial cells. Club cells are absent in the epithelium. Taste-buds are relatively few although mucous cells may be abundant in the pharyngeal epithelium. The former are oval in shape and bear neuroepithelial and sustentacular cells. They usually open to the outside through the gustatory pores. The epithelial layer, where the taste-buds are located protrudes slightly. All the taste-buds may not be provided with distinct lamina propria. The latter, when present, are broad and short. Their numbers remains almost constant throughout the pharynx.

The mucous cells may be spherical, oval or elongated structures, present in several rows in the epithelial layer. Their contents are reticulate in nature. Mucous cells are abundant in the pharyngeal region. In some regions the mucous cells occur in groups. They vary in size. Lymphocytes are very few and occur in the basal region of the stratified epithelium. The rete mucosum of Malpighii is not conspicuous although the stratum compactum is distinct and well developed, lying below a distinct basement membrane. The stratum compactum is thick and is formed by a homogeneous layer of connective tissue fibres. The folds of the stratum compactum constitute the lamina propria of the taste-buds. The submucosa is thin and
Fig. 11. T.S. of anterior intestine of *M. cavagius*, showing villi. HE × 400.
Fig. 12. T.S. of anterior intestine of *M. cavasius*, showing muscle layers. HE X 400.
provided with connective tissue fibres, blood vessels and nerve elements. Fat cells of the adipose tissue are abundant below the submucosa, thus the entire submucosa becomes suppressed. The muscular layer is formed of an inner layer of striated circular and an outer layer of longitudinal muscle layers.

**Oesophagus:**

The wall of the oesophagus comprises four histological layers viz., mucosa, submucosa, muscularis and serosa. The mucosa of the oesophagus are thrown into folds which form distinct longitudinal villi. The epithelial cells are polygonal in shape and are arranged in layers in the oesophagus. Taste-buds, mucous cells and lymphocytes are present in between the epithelial cells. Taste-buds are flask-shaped being provided with sustentacular and neuroepithelial cells. Most of them contain distinct gustatory pores. They are situated either at the tips or sides of the villi. The size of the taste-buds varies. Mucous cells are numerous in the oesophagus. They are elliptical, spherical or oval in shape and are strongly PAS and mucicarmine positive in reaction. The mucous cells, from which mucin has been discharged, show weak PAS and
Fig. 13. T.S. of posterior intestine of *M. cavasius*. HE X 100.
mucicarmine reaction. The contents of the mucous cells are reticulate in nature. Some deeply stained mucous mother cells are present in the deeper region of the mucosa. Mucous cells are abundant at the base of the villi and at certain sites, they form a two to three cell thick layer. The size of the mucous cells vary. Lymphocytes may be present at the base of the epithelial cells. Atop plate is not distinct in the oesophagus. The stratum Malpighii and stratum compactum are present above and below the thin basement membrane respectively. The stratum Malpighii is not well defined in the posterior oesophagus. The lamina propria is well developed but the submucosa is thin. The submucosa is made up of loose connective tissue fibres and is highly vascular. Some granular cells are also present in the submucosa. Fat cells of the adipose tissue may be present in the submucosa. They are also present inbetween the longitudinal muscle bands. The muscular layer is thick and is composed of an inner longitudinal and an outer circular layer of muscle fibres. The former layer is well developed and is arranged in thick bundles. They are also present in the submucosa and in certain regions may even extend into the lamina propria. A thick coat of striated circular muscle fibres lies external to this layer. The serosa is formed of a thin layer of cells and supplied with blood vessels. Fig. 5
Fig. 14. T.S. of posterior intestine of *M. cavasius*. showing villi
HE X 400.
Fig. 15. T.S. of posterior intestine of *H. cavasius*. showing muscle layers. HE X 400.
Stomach:

The wall of the stomach constitutes four histological layers viz., mucosa, submucosa, muscularis and serosa. The mucosa forms thick longitudinal folds the surfaces of which are provided with minute depressions, the gastric pits or gastric crypts. The mucosa of the stomach is made up of two types of epithelium - the outer superficial and the inner glandular epithelium. The superficial epithelium contains simple columnar epithelial cells. These cells are cylindrical in shape and almost uniform in size. Each epithelial cell contains a large, oval basal nucleus. The nuclei stain lightly with haematoxylin. The free borders of the epithelial cells are provided with deep, cup-shaped zones filled with mucous due to which they show strong PAS and mucicarmine positive reaction. The mucous-secreting cells of the stomach epithelium are uniform in size. Fig. 6

The glandular epithelium is provided with a few gastric glands. Fig. 7, 8

The gastric glands are present in abundance throughout the stomach so much so that they occupy the entire mucosal layer below the superficial epithelium. They are simple glands and are either rounded or elongated in shape.
Fig. 16. T.S. of rectum of *M. cavusius*. HE X 100.
The gastric glands in the basal region are generally rounded in shape. The cells of these glands are rhomboidal and provided with centrally located spherical nuclei. The cells are closely arranged around a lumen. They are neither differentiated into oxyntic nor peptic cells. The gastric glands are held firmly by the thin lamina propria. The latter consists of delicate interwoven connective tissue fibres. In certain regions it is in the form of extremely thin strands. The stratum compactum is distinct but the stratum Malpighii is not so. The submucosa is thin being formed of loose connective tissue. It is also provided with blood capillaries and nerve elements. A muscularis mucosa is absent. The muscularies layer comprises an inner circular and an outer longitudinal layer of muscle fibres. It is thinner than in the pyloric stomach. The circular is thicker than the longitudinal layer. These layers are unstriated. The serosa is thin and penetrated by blood capillaries. Fig. 9

**Intestine:**

The wall of the intestine comprises four histological layers viz., mucosa, submucosa, muscularis and serosa. The epithelial cells of the mucosa are typically columnar in shape. The epithelial cells are elongated, cylindrical and are provided with distinct rounded nuclei. The inner ends of
Fig. 17. T.S. of rectum of *N. cavasius* showing villi HE  X 400.
the columnar cells are broad. Mucous cells and lymphocytes are also present in the mucosa of the intestine. The mucous cells vary in shape and size. The number of mucous cells are numerically more abundant in the posterior region than in the anterior and middle regions of the intestine. Deeply staining lymphocytes are present in the basal region of the absorptive cells throughout the intestine. The villi of the anterior intestine are short due to the wider lumen. In the middle intestine they become slightly long and lie very close to each other. A thin top plate covers the epithelial cells except in those areas where mucous cells are present. The submucosa is very thin and made up of compact connective tissue. A few blood vessels and nerve elements may be present in the submucosa. The lamina propria is extremely thin except in the posterior region where it becomes slightly thick. A few eosinophilic granular cells may be present in the submucosa and the lamina propria. The muscular layer is very thin the anterior intestine but becomes thicker posteriorly. It is formed of an inner circular and an outer longitudinal layer of muscle fibres. The circular layer is thicker than the longitudinal layer. The serosa is very thin and forms the outer boundary of the intestine. Fig.10-1
Fig. 18. T.S. of rectum of *M. cavasius*, showing muscle layers. HE X 400.
Fig. 19. T.S. of hepatopancreas of *M. cavasius* HE X 400.
Rectum:

The rectum is almost similar to the intestine histologically, but for some minor differences. The mucosa is thrown into short, shallow and broad longitudinal folds. The number of the villi gets progressively reduced and in some regions, become more or less flat. The mucosa formed of typical columnar epithelial cells with oval nuclei situated at the bases. The mucous cells increase in numbers considerably in the rectal mucosa. The epithelial cells get reduced due to excessive development of the mucous secreting cells. They are either oval or cylindrical in shape. They may vary in size. A large number of deeply stained lymphocytes are present at the basal region of the epithelial cells. A thin top plate covers most of the mucosa except in regions where mucous cells are present. The submucosa is well developed and is made up of connective tissue fibres and is highly vascular. Granular cells of eosinophilic type are present in the submucosa. The latter gives rise to short and broad lamina propria. The basement membrane is distinct but the strata Malpighii and compactum are not clearly defined. The muscularis is extremely thick consisting of the usual inner circular and outer longitudinal layer of muscle fibres. The former layer is thicker than the longitudinal one. The serosa is the outermost layer and is traversed by the blood capillaries. Fig.16-18
Fig. 20. T.S. of hepatopancreas of *M. cavasius*, showing pancreatic acini HE X 400.
Digestive gland and associated structures:

A. Hepatopancreas:

Pancreatic acini are located within the hepatic tissue so as to form a composite gland known as the hepatopancreas. Neither the liver nor the pancreas is a discrete separate gland - a peculiarity met with in many teleosts. The pancreatic tissue which is formed of acini are, scattered within the lobes of the hepatic tissue, but may also be present in the mesentaries, sides of the alimentary canal and the gall bladder.

The hepatopancreas is made up of numerous hexagonal or polygonal cells, which contain granular cytoplasm and rounded nuclei. A few cells, however, may contain more than one nucleus. The hepatic tissue is provided with a close network of hepatic capillaries. The latter unite to form hepatic ducts. The pancreatic acini or exocrine cells are present within this hepatic tissue. The former are arranged in one to many layers, encircling the blood capillaries. Islets of Langerhans could not be identified in the hepatopancreas during the present studies. The pancreatic acini occur in the form of numerous clusters.
Fig. 21. T.S. of pancreas of M. cavasius, showing pancreatic duct HE X 400.
scattered throughout the hepatic tissue. They are small in size. The acini which lie in intimate association with the blood capillaries, on the other hand, are columnar but the rest are either pyramidal or cuboidal.

A typical exocrine cell or acinus comprises a basal homogenous area, lying in intimate proximity of a blood capillary, and an apical part containing zymogen granules, believed to be secretory in function. In the former area is present a large spherical nucleus. The zymogen granules are small in size and few in numbers. Exocrine cells, present in the lining of the alimentary canal and mesenteries, are almost identical in nature. They may or may not surround the blood capillaries. Fig. 19-22

B. Gall bladder:

The wall of the gall bladder in M. cavasius is extremely thin. Histologically, it is made up of three layers viz., (a) the columnar epithelium (b) the fibromuscular tissue layer and (c) the serosa. The epithelial or mucosal layer of the gall bladder is not thrown into many folds. These folds or mucosal folds are extremely short and blunt. The mucosa comprises tall, simple columnar epithelial cells. Each cell contains a basally situated oval nucleus.
The columnar epithelium is supported by a thin layer of fibro-muscular tissue layer.

The serosa is thin and formed up of connective tissue fibres. It is penetrated by blood capillaries which supply blood to the gall bladder.
PHYSIOLOGY

A. Determination of pH in the different regions of the alimentary canal and hepatopancreas of M. cavasius

The extent of hydrogen ion concentration (pH) in the different regions of the digestive system plays a significant role in the physiology of digestion. Besides, it is well known, that different digestive enzymes operate optimally under different pH conditions.

In M. cavasius the pH in the stomach was found to be moderately acidic (5.0 to 6.0). The hepatopancreas was found to be moderately alkaline (8.0 to 9.0) while the gall-bladder showed a neutral to weak alkaline condition (7.0 to 8.0). The intestine maintained relatively higher alkaline medium (7.0 to 8.0).

B. Qualitative estimation of the digestive enzymes:

During the present investigations, protease, lipase, amylase, maltase, invertase, and lactase activities have been identified in the stomach, intestine and hepatopancreas and the gall-bladder.
Proteolytic activity was found to be quite pronounced in the hepatopancreas. A strong proteolytic activity, however, has also been determined in the intestine. The stomach maintains a weak proteolytic activity (Table I).

The lipolytic activity is relatively stronger in the intestine and hepatopancreas than in the other regions of the alimentary canal.

Amylase is more or less active in all the regions of the digestive system. A strong amylase activity is present in the hepatopancreas and the intestine. The activity of this enzyme is weak in the stomach.

Maltase activity is weakly positive in the stomach and intestine but strong in the hepatopancreas.
different regions of *mysus cavasius*.

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<th>Enzyme</th>
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<th>Stomach</th>
<th>Intestine</th>
<th>Hepatopancreas</th>
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+++ = Strongly present
++ = Moderately present
+ = Weakly present
± = Activity doubtful
- = No activity