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Scanning Electron Microscopic Studies on the Mucosa of the Digestive Tract in *Mystus aor* (Hamilton)

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The buccopharyngeal mucosa was devoid of any longitudinal ridges but provided with many closely approximated oval or elongated luminal ends of the stratified epithelial cells. The latter cells, however, contained many unbranched and regularly arranged microridges. A large number of taste pores packed with pipillae-like projections (thought to be the terminal ends of the sensory neurons) were present in this region. Prominent longitudinal folds were detected in the oesophageal region. The mucosal surface of this region was also typified by the stratified epithelial cells provided with linearly arranged microridges. Scattered goblet cells located in between the stratified epithelial cells were enshrined in both the aforesaid regions. In the mucosal surface of the stomach, many discrete and irregular pockets were formed. Its inner surface was lined with the terminal ends of the epithelial cells where many short and stubby microvilli were discernible. Few gastric pits encircled by epithelial cells were detected in the stomach region. Highly complex and reticulate pattern of mucosal modifications were the characteristic features of the intestine. The internal mucosal surface of this region was closely packed with columnar cell apices containing stubby microvilli. The rectal folds were irregular and wavy in nature. In this region, most of the cell apices bearing short microvilli were covered over by secreted mucins.

Key Words: SEM, Digestive tract, *Mystus aor*

Introduction

Morphohistology of the gut of Indian freshwater teleosts has received considerable attention of many workers but data on topological characteristics, especially the surface ultrastructures as revealed under the scanning electron microscope (SEM) are still lacking except for some stray reports (Sinha 1979, 1981, 1983, Sinha & Chakrabarti 1985) and those too relating to herbivorous fishes alone.

The present study is an attempt to correlate the detailed mucosal modifications of the entire gut surface of a carnivorous fish, *M. aor*, to its diet.

Materials and Methods

Adult *M. aor* (wt. 400–500g) were killed in tricaine methone sulphonate (MS.222). Tissues were removed immediately after dissection. Gut tissues were incised longitudinally to expose the mucosal surface, spread out on thin cork sheets with the mucosal surface uppermost. Excess mucus of the mucosal surface was removed by repeated rinsing with heparinized physiological saline. The tissue blocks of 2–3 mm^3 prepared from different portions of the alimentary canal (viz. buccopharynx, oesophagus, stomach, intestine and rectum) were then fixed in 2.5% glutaraldehyde in 0.1M cacodylate buffer (*p*H 7.3) for 24 hr. After fixation, the tissues were removed, rinsed in buffer, trimmed properly, post-fixed for 2 hr in 1% osmium tetroxide in 0.1M cacodylate buffer (*p*H 7.3) and dehydrated in graded alcohols followed by absolute acetone. The tissues were then dried by critical point method with liquid carbon dioxide and cemented to standard aluminium stubs by plasticised microcellulose solutions, coated with gold to a thickness of approximately 20 nm. The tissues were examined under Philips PSEM 500.

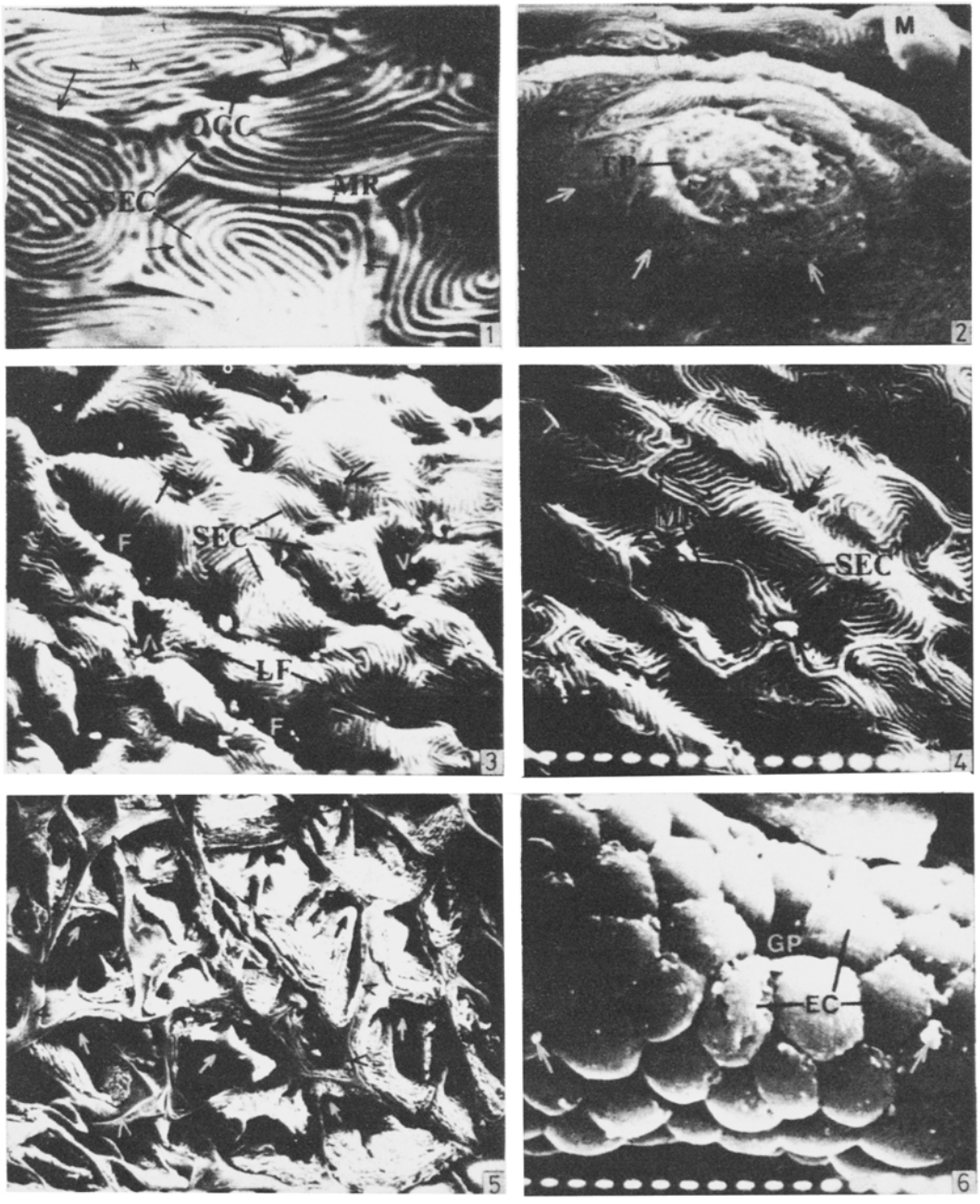
Results

Buccopharynx: The mucosal surface was devoid of any prominent folds but subdivided into a series of oval or elongated elevations which in fact, represent the apical surface of stratified epithelial cells (figure 1). These apical surfaces were provided with many microridges ranging from 1μ to 10μ in length. The latter structures were unbranched and appeared to be regularly arranged. The peripheral microridges were located in a concentric whorl while the central ones were arranged linearly. The outermost microridge of particular cell fused with the same of the neighbouring cell forming a thickend boundary. Few oval depressions were located at cell junctions (figure 1). Some discrete circular elevations surrounded by the stratified epithelial cells were also detected in the buccopharynx. These are the taste pores and measure about 4–6 μm and contain densely packed papillae-like projections. These probably represent the terminal ends of the sensory neurons (figure 2).

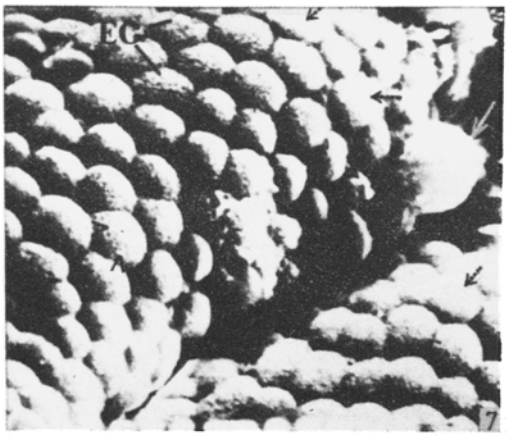
Anterior oesophagus: The mucosal surface was provided with many prominent longitudinal folds leaving long furrows in between them (figure 3). The characteristic feature of this region was the division of its surface into a series of irregular well-circumscribed areas. These are the so-called stratified epithelial cells which contain many well-defined wavy microridges (figure 3). Some "pock" marks representing the luminal surface of goblet cells were found in between the cell junctions (figure 4). A few circular openings of empty goblet cells were also detected in this region (figure 4).

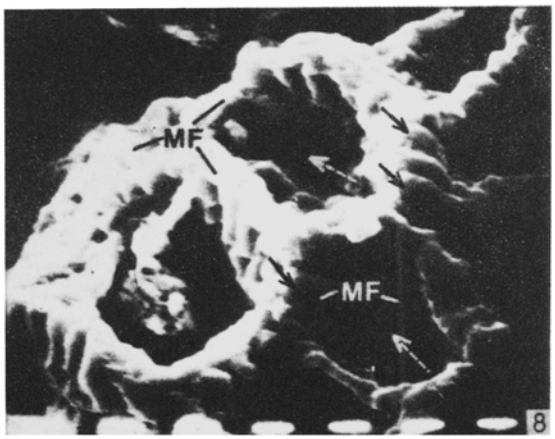
Stomach: Under low magnifications of SEM, the mucosal surface was seen to form various folds forming many discrete but irregular pockets (figure 5). Under higher magnifications, however, it was found to be divided into pentagons and hexagons (figure 6). These correspond to the luminal surface of the epithelial cells. Occasional presence of prominent gastric pits surrounded by the epithelial cells was detected in this region. The epithelial cell surface was provided with short but stubby microvilli (figure 7).

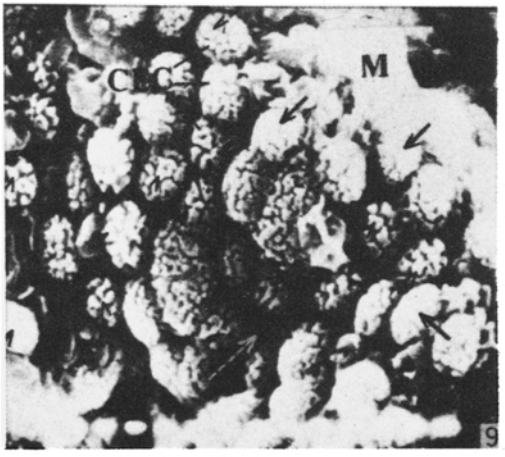
Intestine: The internal mucosa exhibited various types of infoldings. These folds anastomosed with each other to form a complex reticulate pattern leaving cup-shaped cavities in between (figure 8). The internal surface of the intestine was provided with short and blunt projections representing the so-called villi (figure 8). The outlines of the luminal surface of the columnar epithelial cells detected at higher magnifications were clearly seen (figure 9). Such cell apices varied in shape and size but contained densely-packed stubby microridges, the so-called microvilli (figure 9).

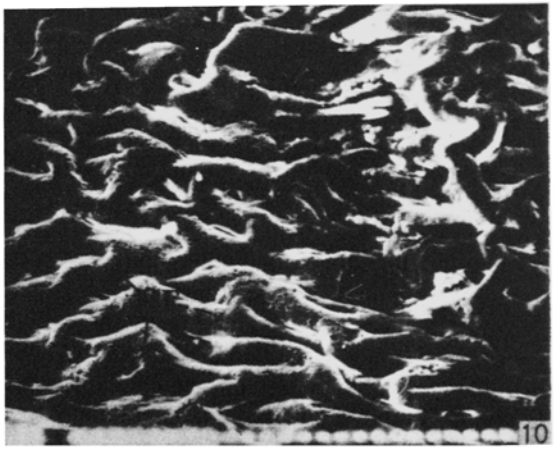


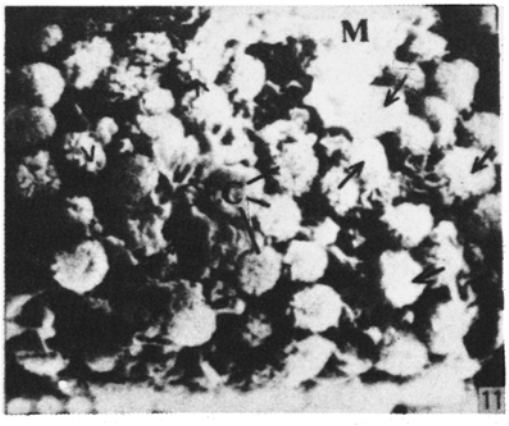
Figures 1–11 Scanning electron micrographs of mucosa of digestive tract in *M. aor* (Ham.); **1,** Oval or elongated stratified epithelial cells (SEC) provided with prominent microridges (MR). Solid arrows indicate thickened boundary of two adjacent cells. Note arrangements of peripheral MR (broken arrows) and central MR (arrow heads). Note also the opening of goblet cell (OGC) at the cell junction (Buc.) (×6400); **2,** Taste pore (TP) located in between SEC (solid arrows). Note the presence of densely-packed papillae-like projections (arrow heads). Note also the occurrence of an oval mass of extruded mucin mass (M) (Buc.) (×3200); **3,** Prominent long furrows (F) situated in between the longitudinal folds (LF). Note the presence of irregular-shaped SEC provided with weavy MR (solid arrows). Note also the presence of opening of GC (arrow heads) (Oeso.) (×2300); **4,** Oval elevation in between SEC (solid arrow) represented luminal surface of goblet cell (GC). Note the presence of opening of empty GC in between SEC (broken arrow) (Oeso.) (×3200); **5,** Formation of many irregular discrete pockets (solid arrows) due to anastomosis of mucosal folds (MF) (arrow heads) (Sto.) (×50); **6,** Luminal surface of epithelial cells (EC) represented by pentagonal and hexagonal elevations. Note the presence of gastric pit (GP) encircled by rosette of EC. Overlying mucin droplets are arrowed; (Sto.) (×6400); **7,** Apical surface of EC provided with stubby microvilli (arrow heads). Note the retention of mucin mass on the surface of EC (broken arrows). Solid arrow indicates exfoliation of GC (Sto.) (×3200)











8, Formation of cup-shaped concavities (broken arrows) due to the anastomosis of MF. Note the presence of prominent villi (solid arrows) (Int.) (×400); **9,** Oval or elongated elevations provided with stubby MR (arrow heads) representing the apical surface of CEC. Note extruded mucin (M) deposition on apical surface of CEC (solid arrows). Broken arrows indicate GC in between CEC (Int.) (×3200); **10,** Showing shallow discrete depression (arrow heads) formed by anastomosis of irregular and wavy MF (Rec.) (×200); **11,** Apical surface of CEC provided with prominent microvilli (arrow heads). Note heavy deposition of mucin mass (M) on the surface of CEC (solid arrows). Note the presence of a circular orifice (broken arrow) representing the apical surface of a discharging GC (Rec.) (×3200).

Abbreviations used: **Buc., Buccopharynx; Int., Intestine; Oeso., Oesophagus; Rec., Rectum; Sto., Stomach;**

However, some of the cell apices were completely covered over by secreted mucins as a result of which the microvilli of the same cells could not be seen. Few goblet cells were also detected in between the columnar epithelial cells (figure 9).

Important feature of the rectal mucosa was the presence of irregular wavy folds. Often they united with neighbouring ones and formed shallow irregular depressions (figure 10). The apices of the columnar cells containing prominent microvilli were detected at higher magnifications. Profuse mucins layer was seen on majority of the cell surfaces. The apices of discharging goblet cells appeared as shallow depressions (figure 11).

Discussion

Electron microscopical studies on teleostean gut have been done by various authors abroad during the last two decades (Yamamoto 1966, Krementz & Chapman 1975, Sperry & Wassersug 1976, Giraud et al. 1978, Noaillac-Depeyre & Gas 1978, Sis et al. 1979, Takanashi 1980, Clarke & Witcomb 1980, Ezeasor & Stokoe 1980a,b) but few published records are available on Indian freshwater teleosts (Sinha 1979, 1981, 1983, Sinha & Chakravarti 1985). These authors, however, correlated the fine anatomical structures of the teleostean gut as revealed by the electron microscope with the diet of the fish concerned. Consequently, earlier histological findings on the various fish gut have been supplemented with the data obtained recently by ultrastructural studies of different authors.

M. aor is a carnivorous freshwater teleost. The possession of a short gut as a feature characteristic of carnivorous teleosts would seem to be valid in this fish also. The value of the relative length of the gut in *M. aor* varies from 1.0 to 1.5—a feature which has almost invariably been observed in all carnivorous fishes studied thus far.

The main feature of the buccopharynx is the sculping of the luminal surface of the stratified epithelium into microridges. However, the presence of complex nature of microridges on the superficial cells of buccopharynx has been reported in an Indian freshwater teleost, *C. catla* (Sinha & Chakrabarti 1985). But the occurrence of simple and unbranched microridges in the buccopharyngeal region is a unique feature which has been noticed in the present study. Microridges by virtue of their nature would seem to spread and hold mucus film secreted by the adjacent goblet cells. Another important feature of the buccopharynx is the presence of taste buds whose apices contain a tuft of finger-like projections. These are the apical ends of the sensory neurons which probably play a critical role in food selection.

Similar type of microridges, like those of buccopharynx, have also been detected in the oesophageal region of the fish studied. Such microridges in the oesophageal region of many teleosts have been reported by different authors (Ezeasor & Stokoe 1980a, Sis et al. 1979, Clarke & Witcomb 1980). However, these appeared as striations in rainbow trout under light microscope (Weinreb & Bilstad 1955). On the other hand, Linns (1969) reported them to be microvilli in pike. The microridges of the present study, however, bear a close similarity to those observed in the skin of Salmonids (Hawkes 1974, Harris & Hunt 1975). Similar microridges have also been reported to be present on various epithelial surfaces, such as skin (Hawkes 1974), gills (Hughes & Wright 1970, Mattey et al. 1980), etc., which are subject to mechanical stress. This would appear to be an advantage in having a sculped surface for absorbing impacts.

The complex nature of foldings in stomach wall in the fish under study would probably allow for stretching during food consumption and also increase surface area for digestive activity. However, the most striking feature of the luminal surface of the epithelial cells of the stomach is the presence of short and

stubby microvilli justifying its meagre or no role in absorption process.

The intestinal mucosa of *M. aor* is typified by the formation of cup-shaped shallow depressions. However, this type of modifications in the mucosal folds of intestine in *M. aor* differs greatly from those found in *C. catla* (Sinha & Chakrabarti 1985). In the latter fish species, deep and large concavities are formed by the anastomosis of the primary mucosal folds of the intestine for the retention of ingested food for longer periods—a feature generally encountered in herbivores. Other feature of the intestine in *M. aor* is the sculping of the luminal plasma membrane into microvilli. However, relatively short microvilli were found in the present study in contrast to those of *C. catla*, as reported by Sinha and Chakrabarti (1985). This may be related to the differences in their food habits. On the other hand, a few goblet cells has been observed in the intestine of *M. aor*. As carnivorous fish do not require much mucins for glueing the ingested food, therefore, the occurrence of goblet cells is few and far between.

The increase in the surface area of the rectal mucosa is effected by the unique arrangement of mucosal folds as revealed by the present SEM study. The microvilli located on the luminal aspects of the columnar epithelial cells are relatively shorter than those found in any other regions justifying inappreciable or no absorption process is being effected in this region. In the rectal region, profuse mucus secretion is another characteristic feature which has been confirmed by the present study.

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