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Fish anatomy

ARCHITECTURAL PATTERN OF THE MUCOSAL EPITHELIUM OF THE ALIMENTARY CANAL OF *NOTOPTERUS NOTOPTERUS* (PALLAS) AND *OREOCHROMIS MOSSAMBICUS* (PETERS): A COMPARATIVE STUDY

STRUKTURA NABŁONKA BŁONY ŚLUZOWEJ PRZEWODU POKARMOWEGO *NOTOPTERUS NOTOPTERUS* (PALLAS) I *OREOCHROMIS MOSSAMBICUS* (PETERS): BADANIA PORÓWNAWCZE

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The stratified epithelial cells of the buccopharynx and oesophagus are provided with simple and unbranched microridges in *Notopterus notopterus*. On the contrary, highly complex microridges on the epithelial cells of buccopharynx and oesophagus are characteristic feature of *Oreochromis mossambicus*. In both the fishes the gastric mucosa is provided with various minor folds forming empty concavities. The concavities are comparatively deeper in *N. notopterus*. In the intestine of *N. notopterus* the mucosal folds are comparatively thinner and simpler than *O. mossambicus*. However, the presence of highly compact and slender microvilli of the columnar epithelial cells in the intestine of *N. notopterus* is the characteristic feature of a short gut. The complex arrangement of mucosal folds forming irregular pockets in the luminal wall of the rectum in *N. notopterus* permits the greater elasticity for accomodating the undigested food. On the other hand, in *O. mossambicus* the mucosal folds are comparatively thinner.

INTRODUCTION

In India, freshwater teleosts exhibit variations in their food habits and feeding specialization and the structure of the alimentary canal in different teleosts is also modified accordingly.

Though there is extensive information on the topological characteristics of the gut epithelium of different teleosts through scanning electron microscope (SEM) (Marsh and

Swift 1969; Sperry and Wassersug 1976; Sis et al. 1979; Ezeasor and Stokoe 1980; Chakrabarti and Sinha 1987; Chakrabarti and Ghosh 1990; Chakrabarti et al. 1992) but there is no information on the correlation and mucosal modifications of the alimentary canal with the food and feeding habits in carnivorous and stomach bearing herbivorous teleosts.

In view of the dearth knowledge of the topological structure and to compare of the fine anatomical structure of the alimentary canal of carnivorous species, *Notopterus notopterus*, with the stomach beraring herbivorous teleost, *Oreochromis mossambicus* the present topic has been explored.

MATERIAL AND METHODS

Adults of *Oreochromis mossambicus* and *Notopterus notopterus* were anaesthetized with tricaine methone-sulphonate (MS 222) and the representative portions of the alimentary canal viz. buccopharynx, oesophagus, stomach, intestine and rectum were removed. To expose the luminal surface of the oesophagus, stomach, intestine and rectum were incised longitudinally, spread out and pinned with luminal surface upper side on the cork sheets. The adhering mucus of the luminal surface was removed by repeated rinsing with Pleuronic F 68. After rinsing in 0.1 M cacodylate buffer, the tissues were infiltrated with 2.5% glutaraldehyde for 24 hours at 4°C, post fixed in 1% OsO_4 in 0.1 M cacodylate buffer for 2 hours, dehydrated through graded acetone and subsequaelntly acetone followed by amyl acetate and subjected to critical-point drying. After drying, the serosal surface of tissues were mounted on metal stubs, coated with gold and were scanned on HITACHI, S–530 SEM.

RESULTS

Buccopharynx

The mucosal surface of the buccopharynx in *O. mossambicus* exhibits prominent longitudinal mucosal folds. The mucosal folds are recognised into a series of pentagonal, rectangular and oval stratified epithelial cells. The apical plasma membrane of the stratified epithelium exhibits branched and highly convoluted microridges leaving deep concavities in between them (Fig. 1). The outermost microridges of a particular cell fused with the same of the neighbouring cell forming a thickened boundary (Fig. 1). In *N. notopterus* the mucosal surface exhibits irregular and narrow mucosal folds. The buccopharyngeal epithelium appeared in the form of oval, pentagonal, and hexagonal stratified epithelial cells, provided with unbranched and spin-silk pattern microridges (Fig. 2). Few oval depressions of mucous cells are located on cell junctions and encircled by stratified epithelial cells (Fig. 2).

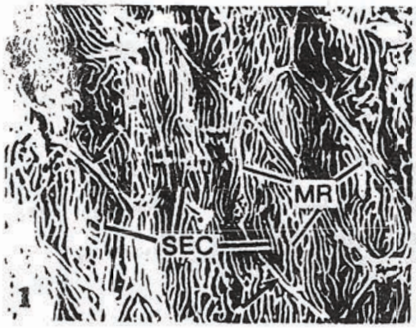

Fig. 1. Labirynth pattern microridges (MR) of stratified epithelial cells (SEC). Solid arrows indicate double ridges structures of two adjacent SEC. (*O. mossambicus* - buccopharynx) × 3200

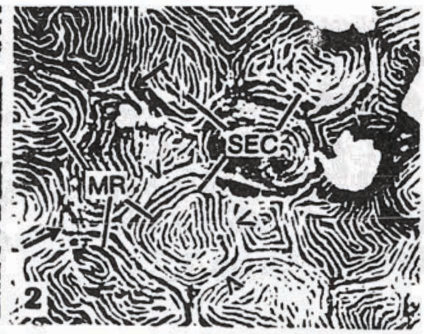

Fig. 2. Pentagonal or hexagonal SEC provided with MR and demarcated by double ridges (arrow heads). Note opening of MC (arrows) in between SEC. (*N. notopterus* - buccopharynx) × 1600

Oesophagus

The mucosal of the oesophagus of *O. mossambicus* exhibits compactly arranged pentagonal or hexagonal stratified epithelial cells. The luminal plasma membrane of these cells presented complex and/or linearly arranged microridges leaving narrow long and deep channels in between them (Fig 3). The mucosal surface of oesophagus in *N. notopterus* is typified into regularly spaced oval or rounded stratified epithelial cells provided with thick and linearly arranged microridges (Fig. 4). Discrete oval or circular openings of mucous cells are located in between the stratified epithelial cells (Fig. 4).

Fig. 3. Linearly arranged MR of SEC. Arrow heads indicate double ridges structures cell boundary. Note the presence of MC in between SEC (arrows) (*O. mossambicus* - oesopahagus) × 1600

Fig. 4. Oval or rounded SEC provided with thick and linearly arranged MR. Note channels (arrows) in between MR. Arrow head indicate double ridges of two adjacent cells. Note the presence of MC (*N. notopterus* - oesopahagus) × 1500

Stomach

The luminal surface of the gastric mucosa of *N. notopterus* and *O. mossambicus* is provided with numerous primary folds which amalgate with each other to form empty and round shaped concavitities. However, the concavities are comparatively deeper in *N. notopterus* (Fig. 5). The major mucosal folds at higher magnification exhibits densely packed oval or rounded columnar epithelial cells which are provided with short and stubby microvilli (Figs. 6, 7). Gastric pits remain impregnated in between epithelial cells have also been detected in this region (Figs. 6, 7).

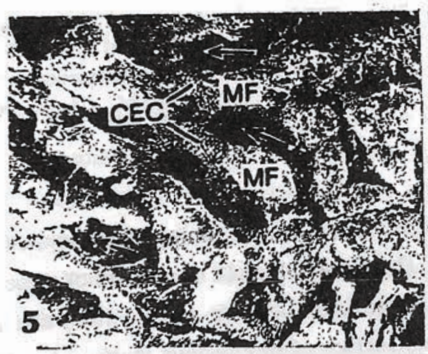

Fig. 5. Mucosal surface showing deep concavities (solid arrows) due to anastomosis of mucosal folds (MF). Note the presence of wart-like columnar epithelial cells (CEC). (*N. notopterus* - stomach) × 400

Fig. 6. Presence of gastric pit (GP) encircled by group of CEC provided with stubby microvilli (MV) (arrow heads). Note of retention of mucin (M) (arrows) over CEC. (*N. notopterus* - stomach) × 5000

Intestine

In *N. notopterus*, important feature of the intestinal mucosa is the presence of irregular wavy folds enclosing a zig-zag pattern of concavities in between them. On the contrary the luminal surface of the intestine of *O. mossambicus* exhibits chevron pattern of mucosal folds enclosing deep concavities in between them. The mucosal lining of the intestine of all the fish is supported by oval or rounded columnar cells intercalated with mucous cells (Fig. 8). SEM revealed that the apices of the epithelial cells of *O. mossambicus* are furnished with minute but prominent microvilli (Fig. 8) while in *N. notopterus* the cell apices are densely packed with slender and well developed microvilli (Fig. 9). The packing of the columnar cells is interrupted in certain areas by prominent mucous cells (Fig. 9) in both the fishes.

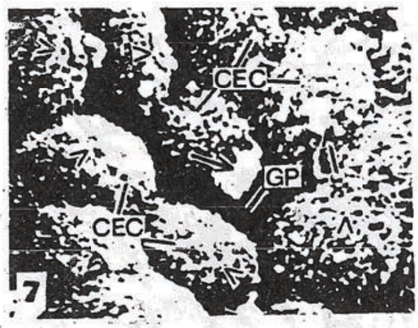

Fig. 7. Luminal surface provided with rounded or oval CEC with stubby MV (arrow heads). Note the presence GP encircled by rosette of CEC. Overlying M are arrowed (*O. mossambicus* - stomach) × 6400

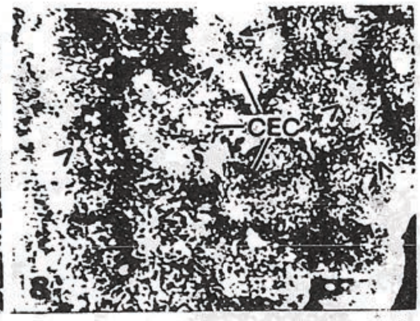

Fig. 8. Oval or rounded elevations provided with broad and stubby MV (arrow heads) representing the apical surface of CEC. Note the opening of MC and deposition of extruded MD (broken arrows) on CEC (*O. mossambicus* - intestinum) × 6400

Fig. 9. Mucosal surface showing densely packed CEC provided with prominent and slender MV (arrow heads). Note tehe retention of mucin droplets (MD) over CEC (arrows) (*N. notopterus* - intestinum) × 6400

Fig. 10. Mucosal surface showing irregular pockets (solid arrows) formed by amalgation of various types of MF. (*N. notopterus* - rectum) × 100

Rectum

In the rectum of *N. notopterus* irregular mucosal fold enclose deep pocket (Fig. 10) while in *O. mossambicus* the thin mucosal folds forming shallow concavities. The mucosal surface of the rectum is demarcated into round or oval structures representing the luminal surface of columnar epithelial cells (Figs. 11, 12). In *O. mossambicus* the apices of columnar epithelial cells are provided with prominent microvilli (Fig. 11) whereas in N. *notopterus* the microvilli of the epithelial cells are stubby and inconspicuous (Fig. 12). The secretion from the circular opening of mucous cells partially cover up the luminal end of the epithelial cells in certain areas (Figs. 10, 11).

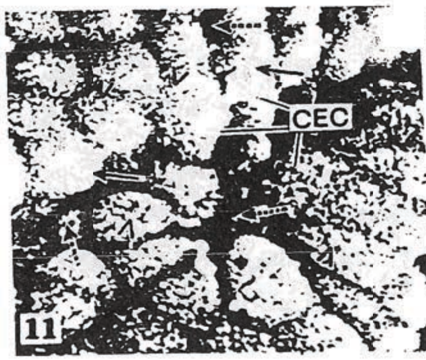

Fig. 11. Apical surface of CEC provided with MV (arrow heads). Note deposition of M on the surface of CEC (solid arrows), circular orfice representing the apical surface of MC (broken arrows) (*O. mossambicus* - rectum) × 3200

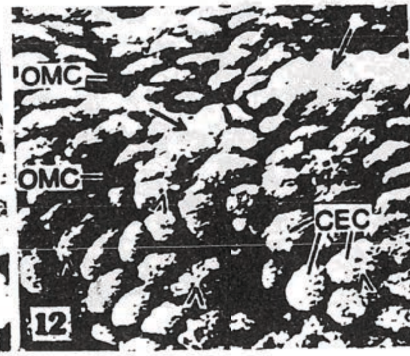

Fig. 12. Showing stubby and inconspicuous MV (arrow heads) on the apical surface of CEC. Note the presence of opening of empty MC (OMC) and deposition of secreted M (arrows) over CEC (*N. notopterus* - rectum) × 1600

DISCUSSION

It is well konwn fact that the stomach bearing carnivorous fishes have a relatively shorter gut than the herbivorous one (Islam 1951; Das and Moitra 1956; Kapoor 1957). However, the possession of a short gut as a feature characteristic of a carnivorous teleost would not seem to be valid in stomach bearing *O. mossambicus* in which a relatively longer and coiled intestine is the main feature associated with the herbivorous mode of feeding.

In the present SEM study, the longitudinal mucosal folds in buccopharynx of *O. mossambicus* is the main feature associated with the herbivorous mode of feeding. On the other hand, in *N. notopterus* the mucosal folds in the buccopharynx is low. This is an adaptive feature for carnivorous fishes which feeds on prey of comparatively larger size and normally requires more space for easy transmittion of the food. Further in *N. notopterus* the mucosa of buccopharynx is made up of intimately associated stratified epithelial cells, provided with unbranched and concentrically arranged microridges leaving comparatively narrower concavities to hold small amount of mucin for glueing of ingested food. On the contrary the presence of complex nature of microridges and deep channels in between them on the stratified epithelial cells in *O. mossambicus* play a major role for anchorage of mucus film which serves as a lubricant for easy transmitting the coarse plant food materials. Such type of microridges on the stratified epithelial cells has also been reported in the buccopharynx of *Catla catla* (Sinha and Chakrabarti 1985).

In the oesophagus of *N. notopterus* comparatively broader and deeper, channels in between the microridges on the stratified epithelial cells, help in retention of mucus for the lubrication of food and also provides mechanical support to the mucosal villi while swallowing large morsels of animal prey. Similar function of microridges is also recorded in the oesophageal region of the trout (Sperry and Wessersug 1976) and in channel catfish (Sis et al. 1979). On the contrary, in herbivorous teleost, *O. mossambicus* the concavities in between microridges are comparatively deeper and narrower than *N. notopterus*. Such arrangement of microridges hold considerable amount of mucus serving as a lubricant while the plant foods are being manipulated through this narrow region.

In *O. mossambicus* the concavities formed by the anastomosis of the major mucosal folds, serve for the temporary retention of ingested food for effective break down of algal wall by secretion of hydrochloric acids. The complicated arrangement of mucosal folds in the stomach of *N. notopterus* would probably allow great distension to accommodate the ingested food for digestive activity. In both the fishes, the minute and stubby microvilli of the columnar cells probably hold considerable amount of mucus and protects the subsurface cells from gastric acidity and mechanical injury. *N. notopterus* being a carnivore, may require rapid secretion of digestive enzymes for the effective digestion of protein food, therefore, gastric pits appear to be more numerous than *O. mossambicus*.

Al-Hussaini (1949) opined that the shortness of the gut in a fish may be compensated by the increase in the complexity of the mucosal folds. In *N. notopterus* shallow and zig-zag depressions in the wall of the intestine would probably allow for partial retention of semidigested food for effective digestion and absorption. However, the deep and large concavities in the intestinal wall of *O. mossambicus* may serve for the retention of ingested food for longer periods – a feature generally encountered in typical herbivores and/or omnivores (Sinha 1983; Sinha and Chakrabarti 1985). The compact nature of microvilli on the columnar epithelial cells in the intestine of *O. mossambicus* is mainly associated with the absorption function. On the contrary, delicate and compactly arranged microvilli on the columnar epithelial cells in the intestine of *N. notopterus* is suggestive of their active participation in absorption by increase their surface area.

In the present study, the unique reticulated arrangement of mucosal folds in rectal mucosa of *N. notopterus* increase the surface area for accommodating the undigested food. Similar type of arrangement of mucosal folds has also been reported in the rectum of *Mystus aor* (Sinha and Chakrabarti 1986), *Mystus vittatus* (Chakrabarti and Sinha 1987) and *Heteropneustes fossilis* (Chakrabarti and Ghosh 1990). However, comparatively shallow concavities developed by the infoldings of the luminal wall of the rectal region of *O. mossambicus* permit rectal coil easy defecation. The short and stubby microridges in the apical surface of the columnar epithelial cells elucidate their negative role in the proces of absorption. However, the presence of abundant mucous cells and retention of secreted mucin between the microridges of the epithelial cells probably would help in expulsion of the faecal matter.

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STRESZCZENIE

Uwarstwione komórki nabłonkowe gębo-gardzieli i przełyku *Notopterus notopterus* są wyposażone w proste i nie.rozgałęzione mikrogrzbiety. Dla odmiany, bardzo złożone mikrogrzbiety komórek nabłonkowych gębo-gardzieli i przełyku są cechą charakterystyczną *Oreochromis mossambicus*. U obydwu gatunków ryb błona śluzowa żołądka jest wyposażona w różne drobne fałdy, tworzące puste zagłębienia. Zagłębienia te są stosunkowo głębsze u *N. notopterus*. W jelicie *N. notopterus* fałdy błony śluzowej są porównywalnie cieńsze i prostsze jak u *O. mossambicus*. Obecność bardzo zwartych i wysmukłych mikrokosmków komórek nabłonka kolumnowego w jelicie *N. notopterus* jest cechą charakterystyczną krótkiego jelita. Złożony układ fałd błony śluzowej, tworzącej nieregularne kieszenie w ścianie jelita końcowego *N. notopterus* pozwala na większą elastyczność w przyjmowaniu nie.strawionego pokarmu. Z drugiej jednak strony, u *O. mossambicus* fałdy błony śluzowej są porównywalnie cieńsze.

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