

**STRUCTURE AND FUNCTION OF THE INTESTINAL EPITHELIUM
IN FRESHWATER TELEOSTS WITH DIFFERENT TYPES OF FEEDING**

Kuperman BI
I.D. Papanin Institute of Biology of Inland Waters RAS
152742 Borok, Yaroslavl, Russia
Phone: (085)225-38-45, FAX: (085)225-38-45, e-mail:
kuperman@ibiw.yaroslavl.su

Kuz'mina VV
I.D. Papanin Institute of Biology of Inland Waters RAS
152742 Borok, Yaroslavl, Russia
Phone: (085)225-38-45, FAX: (085)225-38-45, e-mail:
vkuzminav@ibiw.yaroslavl;.su

The mucosa of the intestine is of great importance in digestive, resorptive, and metabolic processes in different animals. The morphological organization of the digestive tract is related to their fishes type of feeding (Kapoor et. al., 1975). However, data on the fine structure of the intestinal epithelium in fish with various types of feeding are lacking. The aim of the present investigation was to examine the ultrastructure of the intestinal epithelium and gut functional organization in three species of fishes (the pike, the burbot and the bream) with different types of feeding.

In all fish species the epithelium of the intestine mainly consists of elongated columnar enterocytes and goblet cells. The apical part of the enterocyte plasmalemma bears numerous microvilli, forming the brush border. The length and number of the enterocyte microvilli in the different parts of fish intestine are given in Table 1.

Table 1. Dimensions of the microvilli of the enterocyte brush border in pike, burbot and bream, mean±S.E. (Kuperman & Kuz'mina, 1994)

Species		Height of microvilli (μm)	Diameter of microvilli (μm)	No, μm ⁻²
Pike	1	0.60±0.02	0.14±0.04	52.7±2.7
	2	0.79±0.04	0.11±0.003	62.3±7.0
	3	0.92±0.07	0.10±0.05	20.8±4.8
Burbot	1	0.50±0.02	0.12±0.01	32.4±7.1
	2	1.22±0.06	0.12±0.03	46.0±7.9
	3	1.08±0.04	0.13±0.005	35.2±7.1
Bream	1	1.88±0.05	0.09±0.01	47.9±4.2
	2	1.89±0.02	0.12±0.003	48.8±4.4
	3	0.94±0.07	0.13±0.01	45.7±5.8

1, Anterior; 2, middle; 3, posterior part of the intestine

Functional topography of the fish intestine was studied for pike and bream in detail. The analysis of the data obtained suggests that different enzymatic activities were distributed along both fish intestines in an irregular manner (Table 2). A significant decrease of enzyme activities was mostly observed in the distal intestinal segment in bream. In pike the variability of the proximo-distal gradients was revealed. In particular the total amylolytic activity was maximal in the distal segment; α -amylase, maltase, sucrase and all peptidases were maximal in the middle segment; and alkaline phosphatase was maximal in the proximal segment. These interspecies differences were probably caused by different gradients of the intestinal mucosa mass. Thus, mucosa mass of the middle and distal intestinal segments in both species was almost equal, while the mucosa mass of the proximal one in bream was 2-fold larger than that in pike.

In the same time it is important to know the standard values ($\mu\text{mol}\cdot\text{g}^{-1}\cdot\text{min}^{-1}$) of enzyme activity in each intestinal segment. In this case the character of proximo-distal gradients of the same enzymes is changed. In particular, the differences between enzyme activities in various intestinal segments are reduced in both species especially in bream. In some cases (peptidases) the maximum of enzyme activity is observed in the middle part of both fish intestines; in other cases it is revealed in the distal one (total amylolytic activity and sucrase). Maltase, α -amylase and alkaline phosphatase activities were maximal in the proximal part of intestine of bream, but only alkaline phosphatase was maximal in that of pike. Proximal-distal gradients of the activity of carbohydrases and alkaline phosphatase in burbot are similar to those in pike.

Table 2. Distribution of enzyme activities along the intestine in pike (upper values) and bream (bottom values) $\mu\text{mol}/\text{min}$, N=5

Enzyme	Intestinal segments		
	Proximal	Middle	Distal
Total amylolytic activity (Starch)	<u>0.28±0.01</u>	<u>0.23 ±0.01</u>	<u>0.42±0.01</u>
α -amylase* (Starch)	<u>1.70±0.02</u>	<u>0.86 ±0.02</u>	<u>0.65±0.02</u>
Maltase (Maltose)	<u>0.95±0.01</u>	<u>1.15±0.03</u>	<u>0.88±0.02</u>
Sucrase (Saccharose)	<u>12.00±0.46</u>	<u>5.07±0.12</u>	<u>3.29±0.07</u>
Alkaline phosphatase Sodium p-nitrophenyl phosphate	<u>0.56±0.01</u>	<u>0.69±0.01</u>	<u>0.46±0.01</u>
Peptidases** (Triglycyl-glycine)	<u>3.40±0.04</u>	<u>1.53±0.02</u>	<u>0.96±0.02</u>
(Diglycyl-glycine)	<u>0.01±0.001</u>	<u>0.04±0.001</u>	<u>0.03±0.001</u>
(Glycyl-glycine)	<u>0.40±0.001</u>	<u>0.14±0.004</u>	<u>0.27±0.001</u>
(Glycyl-L-valine)	<u>0.13±0.002</u>	<u>0.07±0.001</u>	<u>0.04±0.001</u>
	<u>0.27±0.004</u>	<u>0.07±0.001</u>	<u>0.03 ±0.001</u>
(Triglycyl-glycine)	<u>1.34±0.04</u>	<u>2.39±0.05</u>	<u>1.68±0.06</u>
(Diglycyl-glycine)	<u>2.30±0.04</u>	<u>0.86±0.01</u>	<u>0.37±0.004</u>
(Glycyl-glycine)	<u>2.29±0.01</u>	<u>4.60±0.12</u>	<u>2.45±0.07</u>
(Glycyl-L-valine)	<u>3.50±0.14</u>	<u>1.49±0.02</u>	<u>0.44±0.01</u>
	<u>7.00±0.21</u>	<u>8.09±0.34</u>	<u>5.04±0.28</u>
	<u>11.00±0.23</u>	<u>3.06±0.03</u>	<u>2.24±0.02</u>
	<u>5.88±0.08</u>	<u>9.20±0.27</u>	<u>4.55±0.08</u>
	<u>280.00±5.70</u>	<u>90.00±1.00</u>	<u>60.79±1.10</u>

* mg/min ** The assays by L.F.Smirnova. In the branches is a substrate.

In spite of the similarities between the basic structural organization of the intestinal epithelium of the three species of freshwater teleost fishes, there are a number of

peculiarities in their ultrastructure. The most substantial differences were discovered in the exterior structure of the enterocyte brush border. Thus, the height of microvilli of the same part of the intestine in the three species of fish differed considerably. The height of microvilli of the anterior part of burbot intestine was significantly smaller ($P < 0.001$) than of pike and bream. The length of microvilli in the middle section of the pike intestine was much smaller, than in the burbot ($P < 0.001$) and especially in the bream ($P < 0.001$). The differences between the values of these parameters were significant only in the posterior parts of all fish species.

In previous work it has been shown that the anatomical structure of the intestine depends on feeding habits of the fish, in particular the relative length of the intestine depends upon the nature of the food (Kapoor et. al., 1975). There is probably a link between feeding habits and the structure of the enterocyte brush border.

It was also demonstrated that the quantitative characteristic of the brush border is certainly dependent on the localization of the enterocytes in different parts of the fish intestine. The maximal height of microvilli in the pike and the burbot is observed in the anterior section, while in the bream it is in the posterior part. In the bream, which starves in the winter degenerative changes have been recorded in the intestinal epithelium. During the period of starvation the number of cellular organelles and their electron density decreased. These data are evidence of the marked influence of feeding intensity on the ultrastructure of the intestinal mucosa in fish.

Thus, there have been revealed differences in morphology, ultrastructure and the activity of enzymes in the intestine of bream burbot and pike. However, these differences are more prominent between the typical bentophag-bream and the predators-burbot and pike than between the latter two species. The differences observed are probably connected with the larger length of the intestine in bream and can be considered as the structural and functional adaptation to the type of feeding.

References

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