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ABSTRACT

The digestive tract of the amur is like that of other vertebrates in that it is composed of four layers: mucosa, submucosa, muscularis externa and serosa. The mucosa is composed of pseudostratified epithelial tissue and an extremely thin lamina propria and muscularis mucosa. Goblet cells are found throughout this layer of the gut, being most numerous in the posterior part. The submucosa is composed of dense irregular connective tissue. The muscularis externa consists of an inner and an outer layer of smooth muscle fibers. However, in the esophageal region this layer also contains some striated muscle. The serosa is composed of a thin layer of dense irregular connective tissue and a single layer of simple squamous mesothelium.

INTRODUCTION

The white amur or grass carp (*Ctenopharyngodon idella* Val.) is a large cyprinid fish, attaining weights of up to 100 lb, having an elongate, moderately compressed body with large scales. The head is broad and rounded with a wide, toothless mouth. In the pharynx are two rows of comblike pharyngeal teeth preceeding the digestive tract. Midway along the back is the short dorsal fin. The caudal fin is broad and powerful, pectoral fins are near the ventral surface and the pelvic fins originate just posterior to the dorsal fin. There are no barbels on the amur and the short dorsal fin has no serrated osseous spines as are present in the common carp, *Cyprinus carpio* (Bailey and Boyd, 1971).

The herbivorousness of the adult fish has created, in the last several years, interest in the species as a possible biological control for troublesome aquatic vegetation. Bailey and Boyd (1970), Bailey (1972) and Stevenson (1965) conducted studies on spawning and rearing and the feasibility of introducing the animal for weed control. Their highly optimistic preliminary results led to the introduction of the animal into many lakes in Arkansas. However, because it is an exotic species, being native to southeast Asia, its early introduction into lakes created controversy among state Fish and Game Departments (Anon., 1972).

Bailey and Boyd (1971) also conducted gross morphological investigations on the digestive tract of the white amur. The present study was undertaken to examine the histology of the digestive tract.

METHODS AND MATERIALS

The eight amurs (ranging in length from 25 to 80 cm) used in this study were obtained from the Joe Hogan State Fish Hatchery, Lonoke, Arkansas. After removal from the fish, the digestive tracts were cut into esophageal, apparent stomach and intestinal portions. The tissues were rinsed in saline, cut into 2-mm-thick sections and fixed in either AFA or Zenker's fixative. After 72 hours the tissues were dehydrated with alcohol, cleared in xylene and embedded in paraplast. Sections were cut by a rotary microtome to 10-micron thickness. After being affixed to slides the sections were stained with either hematoxylin and eosin or Mallory's triple connective tissue stain (Humason, 1972).

RESULTS AND DISCUSSION

Morphologically it appeared to the writers that the digestive tract could be subdivided into esophageal, stomach and extremely long intestinal regions (Fig. 1). This is contrary to Bailey and Boyd (1971) who concluded that there is no distinct stomach region. Caeca, present in many fish, are lacking. Histologically, however, the findings support those of Bailey and Boyd in that the gut appears fairly undifferentiated, except for the esophageal region, from one end to the other. This is true in all size ranges studied.

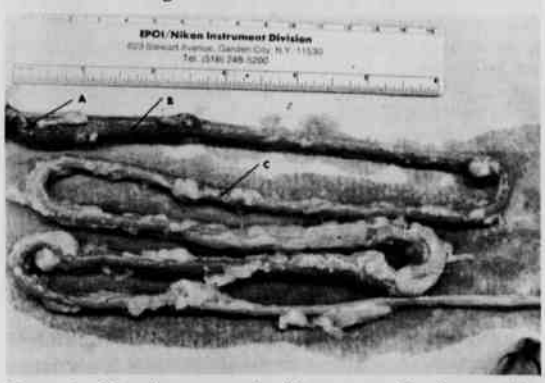

Figure 1. Digestive tract of white amur. Esophagus (A), stomach (B) and intestinal tract.

The digestive tract of the amur is typical of that of vertebrates in that it is composed of four layers: mucosa, submucosa, muscularis externa and serosa (Patt and Patt, 1969). As in many fish, the surface of the entire gut consists of numerous transverse folds that project into the lumen (Fig. 2). These folds include all of the mucosa and part of the submucosa. In the esophageal region the folds are so developed that they practically occlude the lumen. In some areas of the gut (e.g. esophagus) the folds are uneven in height, and branchlike pits are observed at the base of the folds throughout the length of the tract (Fig. 2).

The mucosa is composed of epithelial tissue and an extremely thin lamina propria and muscularis mucosa. The epithelium is pseudostratified throughout the length of the

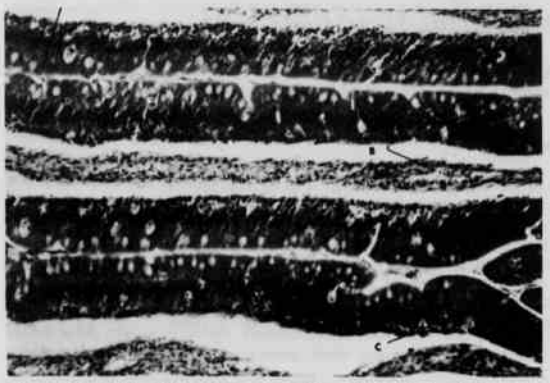

Figure 2. Folds (A), submucosa (B) and pits (C) of digestive tract. 100x.

Figure 3. Pseudostratified epithelium (A) and goblet cells (B). 950x.

Figure 4. Lamina propria. Smooth muscle fibers (A) of muscularis mucosa are shown. 950x.

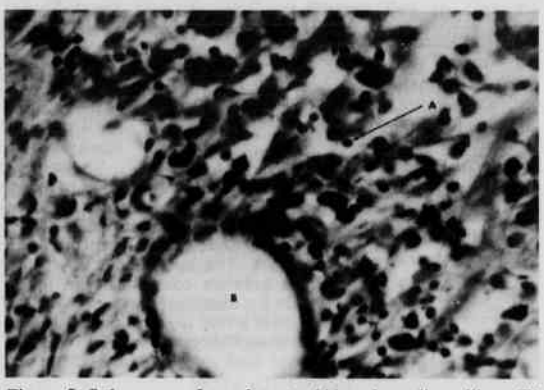

Figure 5. Submucosa. Lymphocytes (A) and small capillary (B) are shown. 430x.

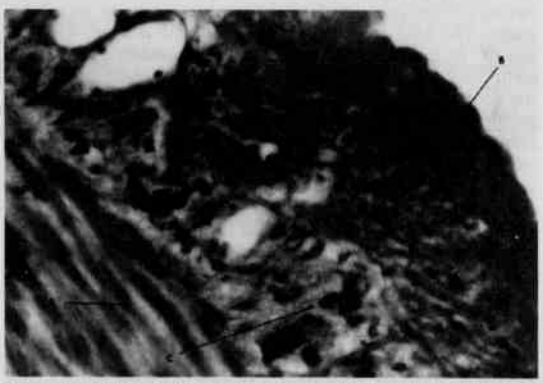

Figure 6. Muscularis externa. Inner circular layer (A) and outer longitudinal layer (B) are shown. Auerbach's plexus (C) is seen between the two muscle layers. 100x.

Figure 7. Muscularis externa. Compact nature of innermost smooth muscle layer (A) is shown. Connective tissue (B) can be seen separating the fibers. The difference between smooth muscle (A) and striated muscle fibers (C) also is shown. 430x.

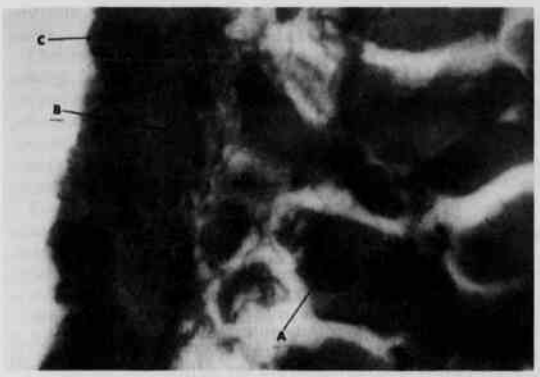

Figure 8. Striated muscle fibers cut in cross section (A). Photograph also shows serosa which consists of connective tissue (B) and thin mesothelium (C).

tract and rests on a thin basement membrane. Many goblet cells are present, particularly in the posterior part of the tract (Fig. 3). The thin lamina propria is composed of loose connective tissue and the muscularis mucosa consists of only one or two layers of scattered smooth muscle fibers (Fig. 4).

The submucosa is composed of dense irregular connective tissue. Part of the submucosa is included within the folds that project into the lumen of the gut. There seems to be a very high concentration of lymphocytes in this area and numerous small arteries, veins, capillaries and nerves are observed (Fig. 5).

The muscularis externa consists of an inner and an outer layer of smooth muscle fibers. The thicker inner layer consists of circularly arranged fibers, whereas the thinner outer layer is composed of longitudinally arranged fibers (Fig. 6). Loose connective tissue is scattered throughout the muscularis externa and separates individual muscle fibers, except next to the submucosa where the fibers are compact and contain little intercellular connective tissue (Fig. 7). A large amount of nervous tissue, called Auerbach's plexus, is found consistently between the inner and outer layers of muscle tissue (Fig. 6).

The esophageal region shows an exception to this general arrangement, in that the inner layer is further subdivided into circularly arranged sublayers of smooth and striated muscle (Fig. 7). Furthermore, in this region the outer layer of the muscularis externa is composed of longitudinally arranged striated muscle fibers (Fig. 8). The amount of this striated muscle tends to decrease toward the distal end of the esophagus.

The serosa is typical in that it is composed of a thin layer of dense, irregular connective tissue and is covered by a single layer of simple squamous mesothelium (Fig. 8).

The rather constant histologic character of the entire length of the gut provides few clues as to the sites of actual digestion and absorption. It is hypothesized that both of these functions occur throughout the length of the tract. The presence of goblet cells along the length of the tract supports this hypothesis. Bucke (1971), studying the pike, reported that the goblet cell secretions function in digestion, absorption, protection and lubrication. Other digestive enzymes might be released by merocrine cells along the length of the gut. Studies on absorption and digestion would be very helpful in determining the accuracy of the hypothesis.

SUMMARY

1. The digestive tract of the white amur appeared macroscopically to be divisible into an esophagus, stomach and intestine. However, except for the esophageal region, no such divisions could be noted microscopically.

2. There seem to be no histological differences among the size categories studied.

3. The one feature that appears to be characteristic of the entire gut is the numerous transverse folds that project into the lumen.

4. The digestive tract of the amur is like that of other vertebrates in that it is composed of four layers: the mucosa, submucosa, muscularis externa and serosa. The mucosa is composed of pseudostratified epithelial tissue and an extremely thin lamina propria and muscularis mucosa. Goblet cells are found throughout this layer of the gut, being most numerous in the posterior portion. The submucosa is composed of dense irregular connective tissue. The muscularis externa consists of an inner and an outer layer of smooth muscle fibers. However, in the esophageal region this layer also contains some striated muscle. The serosa is composed of a thin layer of dense irregular connective tissue and a single layer of simple squamous mesothelium.

5. It is hypothesized that digestion and absorption take place along the entire length of the gut.

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