
MORPHOLOGICAL CHARACTERISTICS OF THE SMALL INTESTINE OF THE AFRICAN PIED CROW (*Corvus albus*)

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ABSTRACT

The gross and histo-morphological characteristics of the small intestine of the African pied crow are described in this study. The general gross morphology of the small intestine of these birds follows the basic model of the avian small intestine, except that the jejunum of the African pied crow was organized in the form of cone-shaped spiral coils. The cone-shaped jejunum had centripetal coils, a sigmoid flexure and centrifugal coils. The histology of the wall of the small intestine of the African pied crow revealed four layers of tissues; the mucosa, submucosa, muscularis and serosa. Morphological modification of these tissue layers was observed, and is thought to be a necessary adaptation for rapid breakdown and absorption of food.

Keywords: African pied crow, Avian small intestine, Morphological modification, Absorptive surface area

INTRODUCTION

The African pied crow, characterized by a glossy black plumage interrupted by a large area of white feathering from the shoulder down to the lower breast, is commonly found in close association with human settlements in many African countries (Hartwig and Morel, 1997). These birds are carinates (flying birds) and are voracious eaters. The African pied crow is capable of consuming more than half its own body weight of food per day (Allen, 1968). It is presumed that the energetic cost of flight increases with greater digesta load; and so in most flying birds the size of the digestive tract, and consequently, the digesta it carries may be minimized (Guillemette, 1994). The small intestine is the primary site for enzymatic breakdown and absorption of carbohydrates, amino acids and fatty acids (Riesenfeld *et al.*, 1980; Southgate, 1995; Klasing, 1998) thus; it

may play an important role in increasing the digestive rate and minimizing the digesta load. Morphological modification of the small intestine is a necessary specialization for rapid breakdown and absorption of the digesta.

Some reports have been published on the morphology and morphometry of the small intestine of some species of birds (Casotti, 2001; Działo-Szczepańczyk and Wesołowska, 2008; Lavin *et al.*, 2008; Wang and Peng, 2008), but there is a paucity of information on the morphology of the digestive tract of the African pied crow. It is known that environmental diversification of the habitat of birds and their consecutive ways of nourishment, as well as the sorts of food they feed on constitute a source of great variety in the structure of their digestive tract (Działo-Szczepańczyk and Wesołowska, 2008). Furthermore, anatomical differences may account for variations in drug absorption when

drugs are administered via the oral route in animals (Dorrestein and Van Miert, 1988; Kararli, 1989). Therefore, the present study was designed to provide basic information on the gross and histomorphological characteristics of the small intestine of the African pied crow.

MATERIALS AND METHODS

Experimental Animals: Ten adult African pied crows used for this study were obtained from the Zoological Garden, University of Nigeria, Nsukka. The birds were sacrificed by euthanasia. Euthanasia was achieved by administering 500 mg/kg body weight of phenobarbitone to each bird via the intravenous route.

Gross Anatomy: Following death, the small intestine was dissected and studied in terms of its shape, physical appearance and in-situ topographical relationships. Gross photographs were captured with a Yashica 7.1 mega pixels digital camera.

Histological preparations: Segments of the small intestine representing the duodenum, the jejunum and the ileum were cut and fixed by immersion in Bouin's fluid for 48 hours. Later, these specimens were dehydrated in graded concentrations of ethanol, cleared in xylene, and embedded in paraffin wax. The 5 µm thick sections were cut, mounted on glass slides, and stained with hematoxylin and eosin for light microscopy. Photomicrographs were captured using Moticam Images Plus 2.0 digital camera.

RESULTS

Gross Anatomical Features: The small intestine of the African pied crow was composed of three segments namely, the duodenum, the jejunum and the ileum.

Duodenum: The duodenum appeared as a U-shaped tube with proximal descending and distal ascending parts separated by the pancreas. The duodenal loop was located in the caudal part of the left side of the abdominal cavity. Two bile ducts and two pancreatic ducts

opened very close to each other, into the distal end of the ascending duodenum.

Jejunum: The jejunum of the African pied crow was organized in the form of cone-shaped spiral coils. The cone-shaped jejunum had centripetal coils, a sigmoid flexure and centrifugal coils. The centrifugal coils of the jejunum were embedded within the core of the cone-shaped structure, while the centripetal coils were on the external surface (Figure 1). The sigmoid flexure formed the apex of the cone.

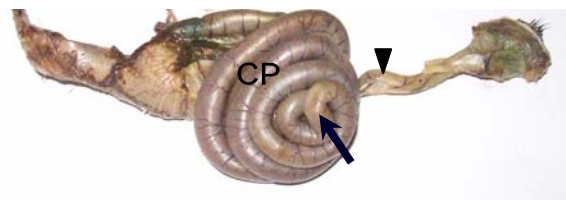


Figure 1: The digestive tract of the African pied crow showing the centripetal coils (CP) and sigmoid flexure (arrow) of the cone-shaped jejunum. Note the short ileum (arrow head)

Ileum: The ileum appeared as a short segment that continued from the jejunum to the point of origin of the ceca. The demarcation between the jejunum and the ileum was marked by the cranial mesenteric artery.

Histological features: The histology of the small intestine of the African pied crow showed that the wall of each of the three segments of the small intestine were composed of four tissue layers namely, tunica mucosa, tunica submucosa, tunica muscularis and tunica serosa (Figure 2).

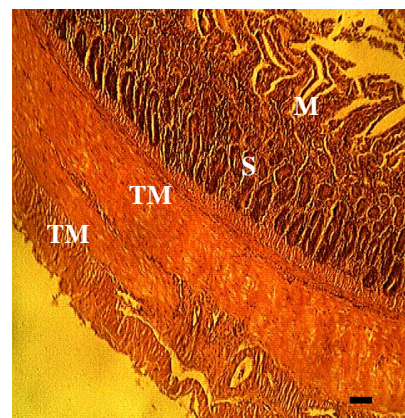


Figure 2: Photomicrograph of the ileum of the African pied crow showing the tunica mucosa (M), tunica submucosa (S) containing glands, and tunica muscularis (TM) of the intestinal wall. Scale bar = 60 µm

Tunica mucosa: The tunica mucosa was modified into many finger-like projections, the villi. Each villus was lined by an epithelium while its center contained connective tissue. The villi of the jejunum were numerous, long and wavy (Figure 3), while the villi of the ileum were short. The lamina epithelialis mucosae of all components of the small intestine of the African pied crow were simple columnar epithelium with brush border. This epithelium contained many goblet cells especially in the ileum (Figure 4).

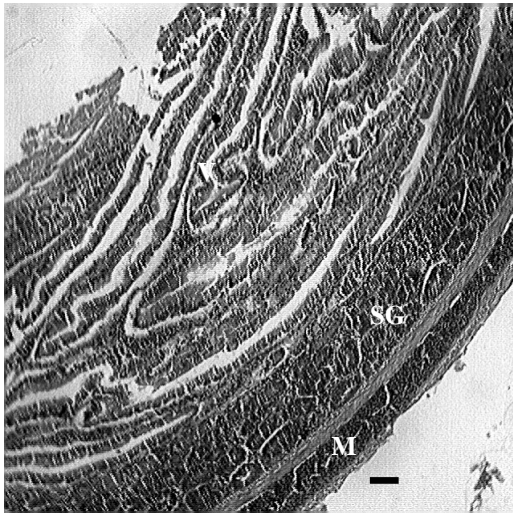


Figure 3: Photomicrograph of the jejunum of the African pied crow showing numerous long villi (V), submucosal glands (SG), and tunica muscularis (M). Scale bar = 60 μ m

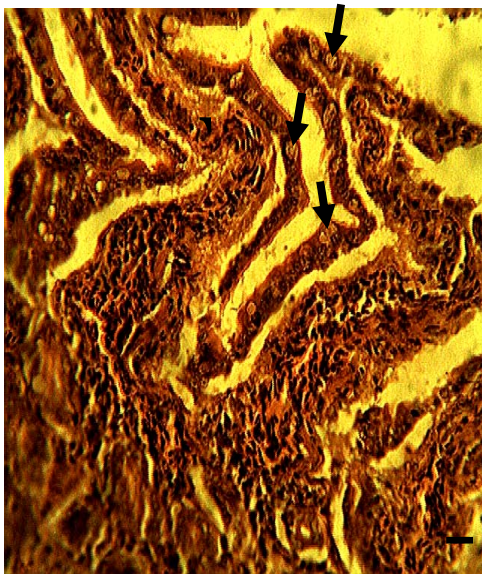


Figure 4: Photomicrograph of the mucosa of the ileum of the African pied crow showing villi (V) lined by simple columnar epithelium and goblet cells (arrows). Scale bar = 15 μ m

Goblet cells were not very prominent in the duodenum and the jejunum. The lamina propria mucosae consisted of a loose connective tissue located just beneath the epithelial layer. The lamina muscularis mucosae was absent, and the connective tissue of the lamina propria mucosae was continuous with the connective tissue of the tunica submucosa.

Tunica submucosa: The connective tissue of the tunica submucosa and lamina propria mucosae of the duodenum (Figure 5), jejunum (Figure 3) and ileum (Figure 2) was laden with many intestinal glands and blood vessels.

Tunica muscularis: The tunica muscularis was made up of an inner circularly arranged layer of smooth muscle fibres, and an outer longitudinally arranged layer of smooth muscles (Figure 6). Blood vessels and nerve plexuses were present within the muscularis. This layer appeared thickest in the ileum (Figure 2) and thinnest in the jejunum (Figure 3).

Tunica serosa: The tunica serosa (Figure 6) was a thin layer of connective tissue whose external surface was lined by mesothelium, a simple squamous epithelium.

DISCUSSION

The small intestine of the African pied crow is similar to that of other avian species in that it is composed of the duodenum, jejunum and ileum. However, the gross morphological organization of the jejunum differed from what has been reported for most birds. The jejunum of the African pied crow is made up of cone-shaped spiral coils. The cone-shaped spiral coils of the jejunum may be an adaptation to maximize the utilization of available space in the abdominal cavity, and provide larger surface area for digestion in the African pied crow. The spirally coiled jejunum appeared more compact than would have been the case if the jejunum were arranged as loose coils along the edge of the mesentery. This cone-shaped spiral appearance of the jejunum of the African pied crow is similar to what has been reported of the jejunum of the pigeon (Sack *et al.*, 2002).

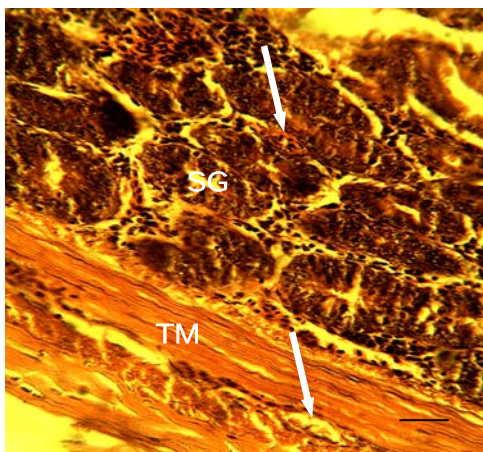


Figure 5: Photomicrograph of the submucosa and muscularis of the duodenum of the African pied crow showing submucosal glands (SG) and tunica muscularis (TM). Note the blood vessels (arrows). Scale bar = 15 μ m

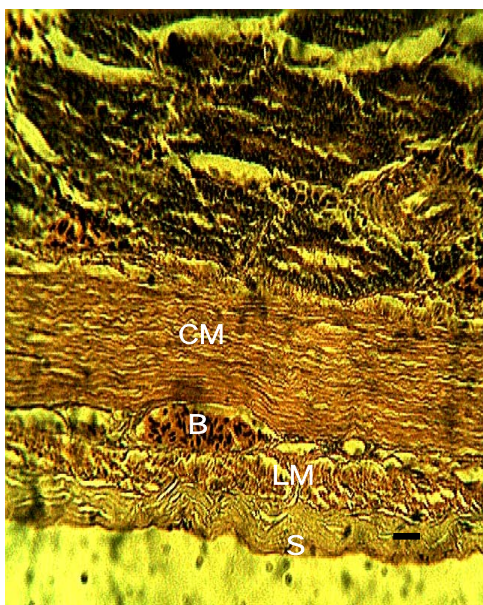


Figure 6: Photomicrograph of the muscularis and serosa of the jejunum of the African pied crow showing inner circular muscle layer (CM), outer longitudinal muscle layer (LM) and tunica serosa (S). Note the blood vessel in the tunica muscularis (B). Scale bar = 15 μ m

The histology of the wall of the small intestine of the African pied crow revealed four layers of tissues. This agreed with the report of previous author on the histo-morphology of the avian small intestine (Banks, 1993). The tunica mucosa is characterized by the presence of many villi. These villi presumably provide for an increased mucosal surface area for enzymatic breakdown and absorption of the digesta thus,

increasing the digestive rate and minimizing the digesta load. Minimizing digesta load may be important for flying birds because it has been demonstrated that takeoff and maneuverability during flight can be impaired by heavy masses (Norberg, 1995; Nudds and Bryant, 2002). Most of the free mono- and disaccharides and amino acids are completely absorbed in the small intestine (Riesenfeld *et al.*, 1980; Southgate, 1995; Klasing, 1998) Furthermore, the small intestine is the major site of absorption of such minerals and electrolytes as calcium, phosphate and potassium, as well as such vitamins as B₆ (Heard and Annison, 1986; Van Der Klis *et al.*, 1990). The lamina epithelialis mucosa of the small intestine of the African pied crow is comprised of simple columnar epithelium with brush border and goblet cells especially in the ileum. Whereas the brush border (microvilli) may serve to further increase the absorptive surface area, the goblets cells secrete a mucous substance that plays a very important role in lubricating the tract and facilitating the movement of the digesta.

The tunica submucosa of all three segments of the small intestine of the African pied crow contained glands. The submucosal glands of the small intestine of the African pied crow may serve to secrete large amounts of the various digestive enzymes that facilitate breakdown and absorption of the digesta. It has been demonstrated that enzymes (e.g., disaccharidases, peptidases) that breakdown nutrient polymers and nutrient transporters (e.g. the Na⁺ -D-glucose transporter) that absorb subsequent monomers are in the greatest quantity in the small intestine (Southgate, 1995).

The tunica muscularis and tunica serosa of the African pied crow are similar to those of other birds. The contractile activity of the smooth muscle fibres of the tunica muscularis is responsible for peristalsis that aids in propelling the digesta and other materials contained in the lumen of the small intestine.

In conclusion, morphological modification of the small intestine of the African pied crow may be a necessary adaptation for rapid breakdown and absorption of food

materials, thus, minimizing the digesta load and the energetic cost of flight.

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