Morpho-histological Study of the Digestive Tract and the Annex Glands of *Chinchilla laniger*

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Abstract
No detailed histological study of the segments of the digestive tract and of the post-diaphragmatic annex glands of *Chinchilla laniger* is available in the literature, to our knowledge. The study presented draws attention to the morphological characteristics of the digestive tract and their involvement in the digestive process, with important implications for the composition of formula diets. Histological study of the digestive tract and annex glands (liver and pancreas) of *Chinchilla laniger* shows no major differences from other mammals. The walls of the oesophagus, stomach and intestine are composed of four layers: the mucosa, sub-mucosa, muscularis mucosa and serosa (the fourth layer of the oesophagus being called the adventitia). A noteworthy feature of the species is the generous development of the caecum in proportion to body size, a characteristic shared with other rodent species.

Keywords: annex glands, *Chinchilla laniger*, digestive tract, histological study.

1. Introduction

The chinchilla is an animal that is very easy to rear, maintain and breed; it is very playful and has excellent fur. It is very well rated in the international market and for many breeders, even amateurs, it represents a very profitable possibility [1].
Due to the fact that the chinchilla has high quality fur, edible meat, a vegetarian diet and few special requirements, it is considered to be "*the* fur animal *par excellence*" [2].
Success in breeding chinchillas is highly dependent on correct feeding [3]. It has been observed that between 75% and 86% of the diseases characteristic of this species is attributable to poor nutrition [4]. Feeding represents the most important factor in determining body development [5], fecundity and disease resistance. Immunoglobulin levels have been reported to be 1.5 times higher during spring than during autumn and winter if feed is correctly provided [6,7].
The feeding regime also determines the degree to which the organism can tolerate toxic substances and unfavourable environmental conditions [8]. Incorrect feeding has more rapid and serious consequences for the young since their metabolic rate is higher, and less equilibrated, than that of the adults [3,9,10].
The objective of our detailed histological study of the digestive tract and the post-diaphragmatic annex glands of *Chinchilla laniger* was to give special attention to any morphological particularities and their significance for the digestive process.
The results should prove useful for specifying correct rates of feeding and for deciding how best to regulate the nutrition of animals maintained in an intensive breeding system. The digestive tract is involved in the digestive process as follows: deglutition of food (oesophagus); mixing of the

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food with gastric secretions, attrition and homogenisation and biochemical cleavage of macromolecular nutrients into simpler components (stomach), with further cleavage to produce simple absorbable monomers taking place in the small intestine [11].

2. Materials and methods

The biological material was taken from 14 healthy adult individuals (7 male and 7 female) of *Chinchilla laniger* from the SC Falnic SRL farm in Timisoara, Romania (Europe). The individuals were humanely killed using overdoses of intramuscularly administered ketamine. Samples of oesophagus, stomach, small intestine, large intestine, liver and pancreas were taken from each individual. Histological preparations have been made by the method [11].
The images were taken using an Olympus CX41 microscope.

3. Results and discussion

Oesophagus

The oesophagus is a digestive conduit, approximately 9 cm long, stretching from the pharynx to the stomach. The lining mucosa has a thick even stratified squamous epithelium, and has layers of smooth muscule cells. The mucosa, slightly wrinkled, is composed of a stratified squamous epithelium and lamina propria.
The following cell types can be observed in the epithelium: cuboidal basement cells with intensely basophilic cytoplasm, arranged in a single layer on the basement membrane; large polyhedral cells, arranged in several layers, and glandular cells. On the luminal surface the epithelium is covered in a thick mucus layer which facilitates bolus passage. The adventitia is the external layer made up of connective tissue. The lamina propria of the mucosa is represented by a thin layer of loose connective tissue containing two cell types with a defensive role. The muscularis mucosa is thin and formed of two layers of smooth muscle cells.
The sub-mucosa is a thick layer of loose connective tissue containing collagen fibres, fibroblasts and numerous blood vessels with large lumens (arterioles, capillaries and venules). Here and there mucus-secreting glands are visible as tubes with large lumens, showing as circles or ellipsoids in cross section, lined with simple cuboidal epithelium.
The muscularis externa is made up of two layers of striated muscle fibres with the circular muscle layer on the inside and the longitudinal on the outside (Figure 1).

Figure 1. Oesophagus (HE 20X): 1. –stratified squamous epithelium; 2 – chorion; 3 – submucosa; 4 – oesophageal gland; 5 – muscularis externa; 6 – capillary blood

The oesophagus passes through the cervical area and the thoracic cavity, and after passing through the diaphragm enters the stomach at the cardiac sphincter. In the cervical region it lies dorsal to the trachea. The microscopic sections show the organ structure as made up of four layers: mucosa, submucosa, muscularis externa and adventitia.

Stomach

The stomach is located in the abdominal cavity, retro-diaphragm and retro-hepatic in a vertical position. It has an oval aspect with two arches: the small arch, posterior and right oriented, and the large arch, ventral and left oriented; two extremities (left and right) and two orifices: the cardiac, for communication with the oesophagus, and the pyloric, for communication with the small intestine. The stomach wall is made up of four concentric layers: the mucosa, sub mucosa, the muscularis externa and the serosa. This structure is common to other mammals [12,13,14].
The mucosa is composed of the epithelium and the lamina propria. The simple epithelium is formed of columnar cells. It is folded into the lamina propria, forming the gastric pits into which the gastric glands discharge, the majority of these being of simple tubular type (Figure 2). The lamina propria of inter-glandular connective tissue is reduced and supports a rich network of capillaries. The gastric glands have narrow lumens

bounded by a single-layered epithelium, in which are to be found, at the neck of the gland, replacement cells which are small with spherical nuclei; chief cells, with intensely staining nuclei and richly granular cytoplasm (indicating their secretory function); and polyhedral parietal cells lying along the length of the gland.

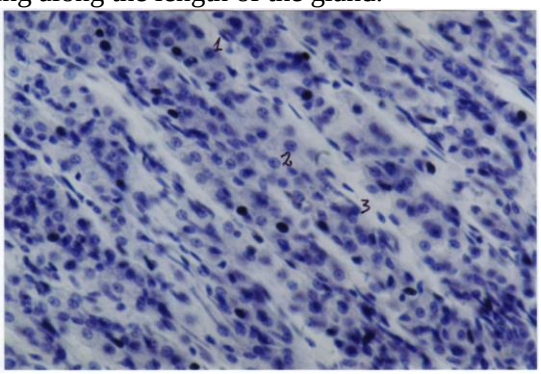

Figure 2. Gastric glands (HE 20X): 1 – primary cells; 2 – parietal cells; 3 – capillary

The muscularis mucosa is positioned beneath the lamina propria and is made up of two layers of smooth muscle cells. The submucosa is well developed, being made up of smooth muscle cells arranged in three layers: inner oblique, middle circular and outer longitudinal. The serosa, also called the tunica externa, provides a surface for the stomach.

Small Intestine

The small intestine is a long uniform segment, divided, as in other mammalian species, into duodenum, jejunum and ileum [15]. The duodenum is a relatively short segment (approx. 12 cm) into which the secretion ducts of the pancreas and liver drain [16].

The jejunum, due to its length of approximately 90 cm, is thrown into numerous interlinked sequential folds, and is linked to the abdominal cavity by the large mesentery.

Histological sections of this organ show that its wall is made up of four concentric layers: mucosa, submucosa, muscularis external and serosa. This structure has also been observed in other mammalian species [17].

The mucosal and the submucosal layers form a series of folds named the Kerkring valves. The mucosa has many intestinal villi. These show a rectangular shape in section, being thin and very long, and bearing a simple columnar epithelium, the cells of which have, at their apical poles, a conspicuous brush borders. At the base of the villi the epithelium extends into the simple tubular Lieberkühn intestinal glands.

The villi surfaces are covered in absorbative cells, the simple columnar epithelium bearing a brush border (Figure 3).

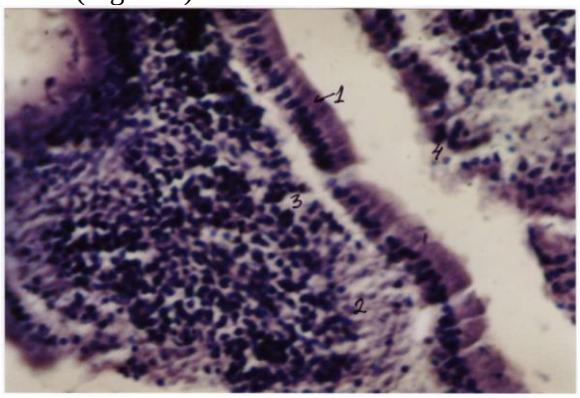

Figure 3. Intestinal villi (HE 20X): 1 – simple columnar epithelium; 2- chorion; 3 – lymphoid infiltrate; 4 – white blood cells in transepithelial migration

The epithelium is made up of enterocytes (absorbent cells). The basal nuclei of these cells are spheroidal with evident nucleoli and heterochromatic granules.

Leucocyte migration, from the lamina propria towards the lumen, can often be observed. The connective tissue of the lamina propria, located in the axis of the villi, is made up of loose connective tissue in which fibroblasts, collagen fibres, clusters of smooth muscle cells, an extended network of capillaries with large lumens and a rich leucocyte population (especially of polymorphonuclear neutrophilic leucocytes, acidophiles and lymphocytes) can be seen.

The inter-glandular lamina propria encloses, like the lamina propria located in the axis of the villi, a rich leucocyte infiltrate, as well as many blood capillaries with large lumens.

Beneath the lamina propria, is a well-developed muscularis mucosamade up of two superposed layers of smooth muscle cells: internal-circular and external-longitudinal.

The sub-mucosa tunic is formed of loose connective tissue and provides support for the vascular and nerve network. The musculature has two layers of smooth muscle cells: internal-circular and external-longitudinal.

The ileum has smaller villi, a greater number of goblet cells and well-developed lymphoid tissue. This structure has been observed by [13].

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Large intestine

The large intestine is divided, as in other mammals, into three segments: caecum, colon and rectum. As a particularity of this species, the caecum is very well developed. This characteristic has also been described by [15], for the Coypu.
This segment is haustrated (Haustra) forming two concentric loops and is approximately 60 cm long. Microscopic study reveals that the caecum wall is organised in four layers: the mucosa, submucosa, muscularis mucosa and serosa. This is the structure that has been observed in other mammals [18].
The mucosa and the submucosa form a series of longitudinal folds with the mucosa being a simple columnar epithelium. The cells have intensely basophilic spheroid or oval nuclei, e at the base of the cytoplasm, and on their apical pole bear clear microvilli. A small number of goblet cells can be seen among the columnar cells of the epithelium.
The lamina propria is formed of loose connective tissue in which are to be found many lymphoid and simple tubular glands that pass through the thick lamina propria as far as the the muscularis mucosa; these open onto the mucosal surface. The simple epithelium contains a large number of goblets in comparison to the mucosa of the small intestine.
The muscularis mucosa is reduced to two thin layers of smooth muscle cells.
The submucosa is made up of loose connective tissue and is characterised by a massive development of lymphatic follicles. The muscularis externa is organised in two concentric layers of smooth muscle cells: internal-circular and external-longitudinal.

Colon

Microscopic sections of the colon reveal the presence of numerous plicae, which are formed by the mucosa and submucosa. The wall is organised in four superposed layers: mucosa, submucosa, muscularis and serosa. The mucosa is made up of the epithelium and lamina propria (Figure 4); the epithelium is simple columnar type with an evident brush border.

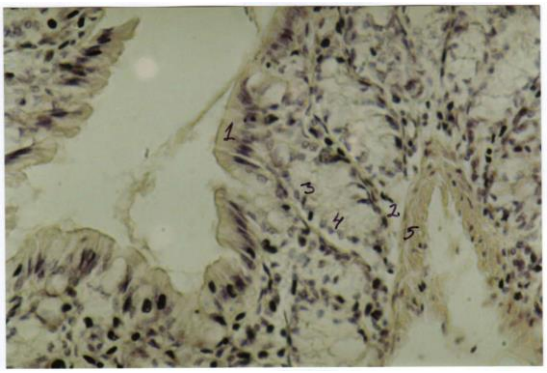

Figure 4. Colon (HE 20X): 1 – epithelium; 2 – chorion; 3 – glands; 4 – goblet cells; 5 – muscularis mucosa

The absorbent cells are tall with long oval intensely basophilic nuclei, situated in the inferior part of the cells. The lamina propria includes the tubular intestinal glands, the surface of which is made up of mucus-secreting goblet cells. .
The submucosa is formed of loose connective tissue which includes collagen fibres, fibroblasts and many blood vessels and lymphoid formations (Peyer's patches).
The muscularis externa is organised in two layers of smooth muscle fibres: internal-circular and external-longitudinal.

Pancreas

The pancreas is positioned on the large arch of the stomach and the beginning of the duodenum. It is made up of disseminated lobes.

The lobes are composed of secretion units, serous acini which represent the exocrine part of the organ. They are sphere-like, slightly oval, small in size and of dark aspect. They are lined with conical cylindrical cells with spheroid nuclei. The cytoplasm is rich in granular secretion. Among the serous acini there are a few cells organised in cords attached to the blood capillaries (Figure 5). These are the islets of Langherhans, which have an endocrine function. This structure has been described in mice by many authors [19].

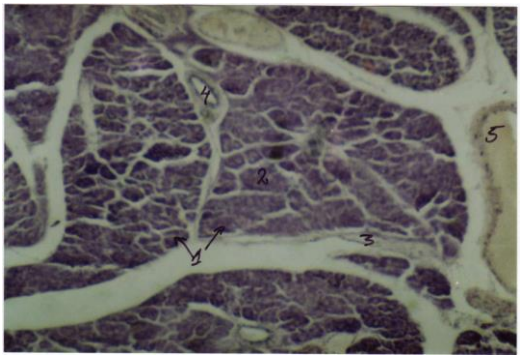

Figure 5. Pancreas (HE 20X): 1 – pancreatic lobules; 2 –acinus; 3 – interlobular connective tissue; 4 – blood vessels; 5 – secretory ducts

The secretion is collected at lobe level, in canals lined with simple cubical epithelium. The inter-lobular drainage canals, with their larger lumens are lined with simple columnar epithelium.

Liver

The liver is situated posterior to the diaphragm, having two sides (diaphragm and visceral) and a membranous integument. The diaphragm side is convex, and the visceral one has the hepatic hilus, where the vessels and nerves enter and the extra-hepatic billiary ducts exit. The gall bladder lies on the visceral side in a depression.

The liver integument has two edges: posterior and ventral. The posterior edge has the oesophageal notch and the caudal vein notch, and the ventral edge has deep notches that divide the liver into five lobes: right, square, left, left intermediary and caudate.

Microscopic study of the permanent histological preparations reveals the hepatic parenchyma organised in hepatic lobules. These have a pentagonal or hexagonal shape and are made up of hepatocyte cords which converge towards the central-lobular vein.

The hepatocytes have a polygonal aspect, small dimensions and have one or two nuclei and the nucleolus is either centrally positioned or eccentric (near the nuclear envelope). Hepatocyte cytoplasm shows significant granulation suggesting intense secretory activity.

Between the hepatocyte cords lie the sinusoidal capillaries, which have large lumens lined with endothelial cells. Among the endothelial cells there are a few long cells with long oval deeply staining nuclei. These Kupffer cells (macrophages) have a defensive function.

Inter-lobular hepatic canals are found in the inter-lobular spaces; these are lined with simple cuboidal epithelium, one or two arterioles and a venule with a large lumen (Figure 6).

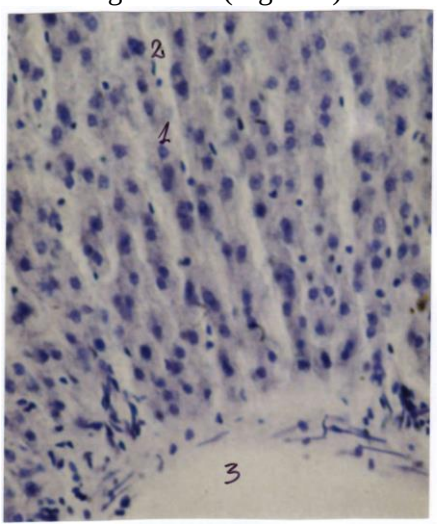

Figure 6. Section through liver lobule (HE 40X): 1 – cords of hepatocytes; 2 – sinusoidal capillary; 3 – central lobular vein

4. Conclusions

After histological study of the segments of the digestive tract and annex glands (liver and pancreas) of the chinchilla conclusion is that these structures do not present significant differences in comparison with other mammals.

As a particularity of this species, the caecum is very well developed.

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