Microscopical features of the digestive tract in the rhea (Rhea americana americana, Linnaeus, 1758)

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The rhea are birds belonging to the order Rheiformes distributed throughout the South American continent. Recently, these birds are given full attention due to its size, its reproductive behavior and by be characteristic of being typical birds of the cerrado biome. The aim of this study was to describe the microscopic structures of the digestive system of the rhea due to the growing interest of this bird for scientific and conservation purposes. The digestive tract of five animals aged 2 to 6 months from the Multiplication Center of Wild Animals - CEMAS Federal Rural University of the Semi-Arid - UFERSA, Mossoró-RN, were used in this experiment for microscopic analysis. We observed that the rhea was lined by stratified squamous epithelium, exhibiting salivary glands, hyaline cartilage and taste buds. In the esophagus, longitudinal folds were symmetrically arranged in the mucosa. The proventriculus also presented folds and was lined by single cylindrical epithelium containing tubular glands. In the ventricle (gizzard) the glands were scattered in the lamina propria underneath the single cubic epithelium. These glands were smashed in the surface of the epithelium releasing mucus. The duodenum was formed by a pseudostratified squamous epithelium containing long villi. The jejunum was lined by simple columnar epithelium revealing long villi. The ileum showed villi with varying height-coated and was lined by cylindrical simple epithelium. The cecum folds were lined by single columnar epithelium containing tubular glands. Both, the cecum and colon-rectum revealed small and large longitudinal mucosal folds covered by a single cylindrical epithelium. No major microscopical differences between rhea and other birds were observed, however, the differences may be due to age, species or inherent in eating habits. This analysis will contribute to a better understanding of the physiological processes related to the nutrition and management of rhea during their growth.

Key words: Digestive, rhea, microscopy, morphology

1. Introduction

The rheas are taxonomically classified as animals belonging to the family of ratites, Rheiformes order, family, Rheidae, genre: Rhea Species: Rhea americana and Rhea americana American subspecies. According to [1] and [2] in natural environments, adults and chicks feed on insects and plants, and small vertebrates and small stones, these birds become important in the view ecological point, because contributing to the reforestation through the natural spread of seeds and pest control in pastures.

The interest by commercialization aimed at the consumption of rhea meat is increasing according [3], [4] and [5], as well as the interest in his creation for scientific and conservation purposes, factors that justify that studies about behavior, morphology, sanitary, reproductive and feeding about these birds are developed. Among the ratites, the rhea [6], the ostrich [7], and emu [8] are the most researched birds. [9] divided the organs that make up your digestive tract as beaks, oropharyngeal cavity (salivary glands, tongue, pharynx), esophagus, proventriculus, ventricle, small intestine, large intestine, cecum, colon, rectum and cloaca. This study will look on the microscopic description of the parts that make up the digestive system in rhea.

2. Material and method

Five emus, aged between two and six months, were intended for microscopic analysis and histological characterization of the structures that compose your digestive system. The animals used in this study died by naturally causes and were proceeding from the Multiplication Center Wild Animals - CEMAS Federal Rural University of the Semi-Arid - UFERSA, Mossoró, RN, registered in the IBAMA as scientific breeding under number 1478912. The animals were incised medially in cranial-caudal direction from the apex of the jaw to the base of the cloaca to expose the viscera. Small samples (measuring approximately 0.5 cm) of the tongue, esophagus, proventriculus, ventricle, small and large intestine were collected for microscopic analysis. The samples were immersed in fixative solution of 10% formaldehyde solution buffered with 0.1 M sodium phosphate, pH 7.2 at 4 ° C. After fixation, the material was dehydrated in a series of increasing concentrations of ethanol (70-100%) and cleared in xylene, followed by inclusion in paraffin histologic - Erv-plast. Cuts were obtained on a LEICA 2165 microtome with a thickness of
5mm and stained with hematoxylin-eosin and Masson Tricômio. The collection of material, histological sections, as well as the preparation and staining of slides were performed using the methodology described by [10].

The nomenclature used for names of identified structures was based on the Handbook of avian anatomy: Nomina Anatomica Avium published by the International Committee on Avian Anatomical Nomenclature [11], World Association of Veterinary anatomists [12]. The results were compared with the referent literature on studies of the digestive tract of birds in general and other ratites.

3. Results

The analysis of the digestive apparatus components: tongue, esophagus, proventriculus, ventricle, small and large intestine of rhea to indicate that this was composed by 4 layers or tunicas: mucosa, submucosa, muscular and serosa. The mucosa showed the superficial epithelium with numerous mucous glands, lamina propria of loose connective tissue and the muscular of the mucosa composed by smooth muscle.

On the other hand the submucosa was composed of loose connective tissue with glands, blood vessels and nervous plexus. The muscular was composed by two layers of smooth muscular fibers, the inner circular and outer longitudinal. The most external layer was the serosa or adventitia formed by loose connective tissue. In longitudinal section of the tongue the stratified squamous epithelium was observed. The tongue showed several salivary glands opening to the outside through ducts (Figure 1A,B), presence of taste buds and a band of hyaline cartilage (Figure 1C and 1D). In transversal section the esophagus was composed by longitudinal folds arranged between the mucosa and submucosa coated by nonkeratinized stratified squamous epithelium, lamina propria of loose connective tissue and numerous mucous secretion tubuloacinosa glands were evident. The submucosa was discrete and consisted of loose connective tissue. The muscular layer showed an inner circular flyer relatively thick and a highly thin outer longitudinal (Figure 1D and 1E).

![Fig. 1 Microscopy of the tongue and esophagus of rhea. In (A) observe the squamous stratified epithelium (Ep), hyaline cartilage (h) and salivary glands (Gs) in the tongue. In (B) the opening of the salivary glands duct to the outside (arrows), mucosal of the muscular layer (★) and the hyaline cartilage of the tongue (arrow). In (C) the salivary glands (gs) in major increase and the light of the duct (arrow). In (D) the gustative papillae (pg), connective tissue of the mucosa (★), submucosa (●) and muscular layer (●) of the tongue. In (E) note the stratified squamous epithelium nonkeratinized (arrow), loose connective tissue (TC) and the longitudinal folds (PL) of the muscle in esophagus. In (F) observe the tubuloacinosa glands in the esophagus. Hematoxylin-eosin.](image)
The gastric proventriculus was folded and coated by simple cylindrical epithelium and branched tubular gland with tubular aspect coated by columnar cells of mucous secretion and clear cytoplasm and nucleus in the basal portion. The lamina propria was thick with dense connective tissue. The typical muscular of the mucosa was formed by smooth muscle fibers. In the submucosa layer many tubuloalveolar glands with lobular arrangement and that flowed into a central duct (Figure 2) were observed, being composed and branched by acidophilic cells. The muscular layer showed two sublayers: one thick inner circular and other thin outer longitudinal, separated by blood vessels and myenteric plexus. The serosa was composed by loose connective tissue and mesothelium.

![Fig. 2 Microscopy of the gastric proventriculus of the rhea.](image)

The gastric ventricle showed many tubular glands coated by simple cubic epithelium arranged in the mucosa. The mucosa was coated by thick keratinoid substance with soft pink color. The muscular layer showed very thick and the serosa layer was tipical (Figure 3).

![Fig. 3 Microscopy of the gastric ventricle of the rhea.](image)
The duodenum was formed by long villi coated by pseudostratified squamous epithelium composed by typical goblet cells. The mucosa layer was thick when in comparison with the serosa layer. The submucosa was composed by loose connective tissue (Figure 4). The jejunum, similarly to duodenum, showed long villi coated by pseudostratified squamous epithelium composed by typical goblet cells. The submucosa was thin and the muscular and serosa layers were typical. The lamina propria was composed by loose connective and contained some tubular glands. In the ileum the villi showed variable height coated by simple columnar epithelium composed of very goblet cells. The muscular layer of the mucosa was thin. The muscular and serosa layers were typical (Figure 5).

**Fig. 4** Transversal section of the rhea duodenum. In (A) the lumen is represented by (*), observe the serosa layer (arrow) and the external muscular layer (●). In (B) the duodenal villous (arrowheads ►►) acidophilic in the apex and the mucosal of the muscular layer (●). In (C) is identified few globet cells (●) and pseudostratified epithelium (ep). Masson’s Trichrome.

**Fig. 5** Microscopy of the jejunum and ileum of rhea. In (A) the jejunum villous in the mucosa (arrow) and Lieberkuhn crypt (▲). In (B) lamina propria (arrow), the myenteric plexus (*) and the longitudinal muscular layer (●). In (C) the ileum villous (*) and Lieberkuhn crypt (▲). Hematoxylin-eosin.

The mucosa of the caecum and the colon-rectum was formed by folds coated by simple columnar epithelium with tubular glands coated by the same epithelium with goblet cells. The submucosa was thin and formed by loose connective tissue. The muscular and serosa layers were well defined (Figure 6A, B). The lamina propria was composed of the loose connective tissue and were identified several polymorphonuclear leukocytes, especially in the rectum. The muscular layer as observed for the others components was very thin (Figure 6C).

**Fig. 6** Microscopy of the colon and colon-recto of rhea. In (A) observe the villous and the simple cubic epithelium (ep) of the caecum. In (B) the crypts of Lieberkuhn (cl) with caliciformes cells arranged around it. In (C) the colon-recto with longitudinal folds, polymorphonuclear leukocytes and the muscular layer as observed in the small intestine. Hematoxylin-eosin.
4. Discussion

In the tongue of rhea was checked buds and salivary glands as those cited in Australian parakeet [13, 14, 15] and [16] in rhea, when mentioning that the tongue is covered by keratinized stratified squamous epithelium, forming the dermis. However, in the Australian parakeet [15] did not identify the presence of lingual papillae, taste buds and serous and mucous acini. These results are contrary that observed to rhea in our study. In studies with partridges [17] tongue, cited that it is coated by stratified squamous epithelium, composed by many salivary glands. The presence of a hyaline cartilage along it is extension. A similar situation was observed in the rhea, except for the presence of hyaline cartilage along the tongue. This could be associate the age of the animals used in our study, but does not deprive us to consider that this is a feature of the species. The presence of Pacinian corpuscles in the Australian parakeets tongue were reported [15], which were not observed in the rhea. The same type of stratified squamous epithelium and the presence of salivary glands, as observed in the rhea was observed [18, 19].

The esophagus was composed by innumerable folds arranged longitudinally and coated by nonkeratinized stratified squamous epithelium, similar to describe in chicken by [20,21, 22], and in ostrich [23, 7]. In the lamina propria, loose connective tissue with numerous tubulacinosas glands of mucosal secretion exhibiting cylindrical secretory cells whose cytoplasm was clear and the nuclei in the basal portion was flattened. The muscular of the mucosa was evident. It is noteworthy that the longitudinal and circular muscle layers showed two bands with different thick. In studies describing about anatomy of the chicken and the others domestic birds [24], was cited that the esophagus epithelium in duck and pigeon is distinctly cornified, this author reported the existence of a “rare” submucosa and muscular layers in the chickens. These results are contrary to obtained by others groups [23, 7] and by our research group in rhea. In comparison with the amount of tubulalveolar glands observed in the Australian parakeet [15], in rhea the amount is most. This characteristic can be adapted to the kind of the feed mode and the extension of the esophagus that participate actively in the placement mechanism of the food to the proventriculus. The amount of most glands was cited in chicken [13] and in ostrich [23, 7]. In rhea not was observed the presence of the crop, according to cited in ostrich [25]. The function of the crop shall be exercised by proventriculus and ventriculus [26].

The proventriculus in rhea showed histological components similar to found in ostrich [27, 23, 7], red-capped cardinal [28] and in partridge [17], except by existence of pseudostratified epithelium coating the glands ducts in rhea. It should be noted that the results obtained for rhea differ of reported in chicken [29] that found was cylindrical simple epithelium in the stomach and that cited in chicken [18, 19] that epithelium is simple columnar.

The ventricle in rhea was formed by most tubular glands with cubic simple epithelium coated by thick keratinous substance and showed thick muscular layer and typical serosa. These results are similar to describe in ostrich by [27, 23, 7].

The duodenum, jejenum and ileum in rhea showed differences in their villous height. The duodenum had extensive villous with stratified squamous epithelium. The jejenum had long villous with simple cylindrical epithelium and the ileum was villous of the variable height. The same characteristics were reported in ostrich [23, 7].

The caecum and colon-recto showed the mucosa layer formed by large longitudinal folds coated by simple cylindrical epithelium with most glands. The lamina propria layer was composed by loose connective tissue and were identified polymorphonuclear leukocytes, especially in the rectum. In studies describing the spiral folds of caecum of the ostrich [30], cited that histologically the caecum showed the mucosa composed by folds and muscular and submucosa layers similar to the observed in our study. In rhea not was identified distinction between colon and recto. Thereby we used the same terminology proposed by others authors [31, 32].

The characterization of the intestinal segments described concerning to the microscopic elements of the intestinal segments of the birds [23], related that in the intestinal villous are coated by simple cylindrical epithelium similarly to observed in our research in rhea. The description performed to the digestive components of the rhea in our research are according with the same characteristics reported in rhea [9], in ostrich [23, 7]. In rhea were not observed major morphological differences in comparison to results described by the literature about the microscopy of these digestive components. The some structural differences observed may be due age or alimentary habit of the rhea. The results obtained in our research can serve as the basis to understanding of the physiological and nutritional process of this bird.

References


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