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Descriptive Comparison of Gastrointestinal Tract Histology of Various Avian Species based on their Natural Diet

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Proventriculus

ABSTRACT

Many animals species develop their gastrointestinal tube with special features to accommodate their natural diet to survive under adverse conditions including the nutrient absorption capability. Information related to the histologic description of various bird species' digestive organs based on their diet and its significance is yet limited. This study aimed to present a descriptive explanation of gastrointestinal organs of a changeable hawk-eagle (*Nisaetus cirrhatus*) and oriental honey buzzard (*Pernis ptilorhynchus*) as carnivorous, a southern cassowary (*Casuaris casuaris*) as an omnivorous, and a domestic chicken (*Gallus gallus*) as granivorous. In the current study, proventriculus (glandular stomach) and intestinal segments were microscopically examined and compared to understand the special histological features among avian species due to their important roles to digest the ingesta. The dissected specimens were preserved in 10% non-buffered formalin, then were processed through the common standard procedure of tissue processing and eventually stained with haematoxylin-eosin. Microscopic observation showed variation in shape and size of proventricular glandular architecture among raptors. The intestine muscular layer of the cassowary also showed distinct thickness among birds. These results of the study preliminary proved that variation in diet might affect the histologic features of avian gastrointestinal tracts.

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1 Introduction

Around the world, there are approximately 8,600 kinds of birds (Al-Saffar and Al-Samawy 2016a), and places the second in the number of species among vertebrates (AbdElnaeem et al. 2019). The digestive organs are responsible for mechanical and chemical digestion, along with the absorption of water and foods (Hussein et al. 2020). In birds, the stomach is appraised as the most active organ in the digestive system (Al-Saffar and Al-Samawy 2016b). The bird's stomach presents the glandular and the gizzard (Umar et al. 2021). The proventriculus (glandular stomach) is characterized morphologically and functionally, which is influenced by the type of food taken (Al-Saffar and Al-Samawy 2015). Vegetable matter, animal matter, and both are the three important terminologies frequently used for classifying avian diets. According to Lopes et al. (2016), on the behalf of feeding habit, birds can also be classified into three categories i.e., granivorous, carnivorous, and omnivorous. Further, the size of the proventriculus is varied with the type of feeding habits and it was reported relatively tiny in granivorous but massive in carnivorous (Duke 1997; Al-Saffar and Al-Samawy 2015). The proventriculus also has a secretory function and releases HCl which helps in food digestion and protection from the microorganism (Zhu 2015). Further, the small intestine is the principal place for enzymatic activity and also for the absorption of amino acids, fatty acids, and carbohydrates (Igwebuike and Eze 2010; Mnati et al. 2021). It tends to be longer in granivorous and herbivorous birds as compared to the carnivorous (Duke 1997). Further, even among the various kinds of birds, there is a variation in the length and weight of the organs (Kausar et al. 2019).

Therefore, this study was designed to provide the basic histology information of the proventriculus in changeable hawk-eagle, oriental honey buzzard and domestic chicken, and intestine in southern cassowary and domestic chicken.

2 Materials & Methods

In the present study, a changeable hawk-eagle (*Nisaetus cirrhatus*), an oriental honey buzzard (*Pernis ptilorhynchus*), and a southern cassowary (*Casuarius casuarius*) were collected from Wildlife Rescue Centre (WRC) Jogja. These birds were necropsied based on the standard procedure applied in the center. At the same time, the domestic chicken (*Gallus gallus*) was obtained from the laboratory of Veterinary Histology, Faculty of Veterinary Medicine, Universitas Brawijaya, Indonesia, and proceeded through the standard procedure. During the procedure, No birds were otherwise harmed. During this study, proventriculus of changeable hawk-eagle, oriental honey buzzard, and domestic chicken were isolated and used for the histology examination.

Furthermore, from southern cassowary and domestic chicken, a segment of the intestine was obtained and proventriculus and intestine are preceded into histology. These organs were preserved by using 10% non-buffered formalin as a fixative. Then, these organs were dehydrated and cleared to pull out all the liquid from the tissue (Kusumarini et al. 2017) and sectioned in paraffin block for 5 μ m thick. Afterward, these organs were stained with Hematoxylin-Eosin for general identification and histology study.

3 Results

The results of the present study revealed significant differences in the proventriculus of the selected birds and these variations depending on the feeding habit (Figures 1 & 2A, B). Further, the results of the study suggested that the mucosa layer in the proventriculus of changeable hawk-eagle and oriental honey buzzard is thinner than domestic chicken (Figures 3 A & B). The shape of the submucosa gland in the submucosa layer showed irregular structure in domestic chicken, while it was oval-shaped in changeable hawk-eagle and diamond-shaped in oriental honey buzzard. Furthermore,

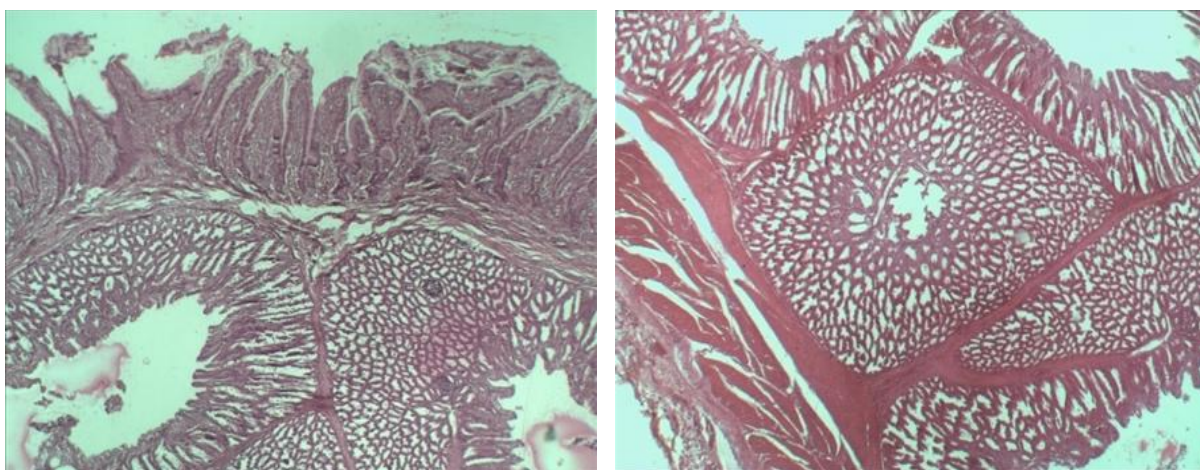


Figure 1 Thin section of the domestic Chicken Proventriculus (40x)

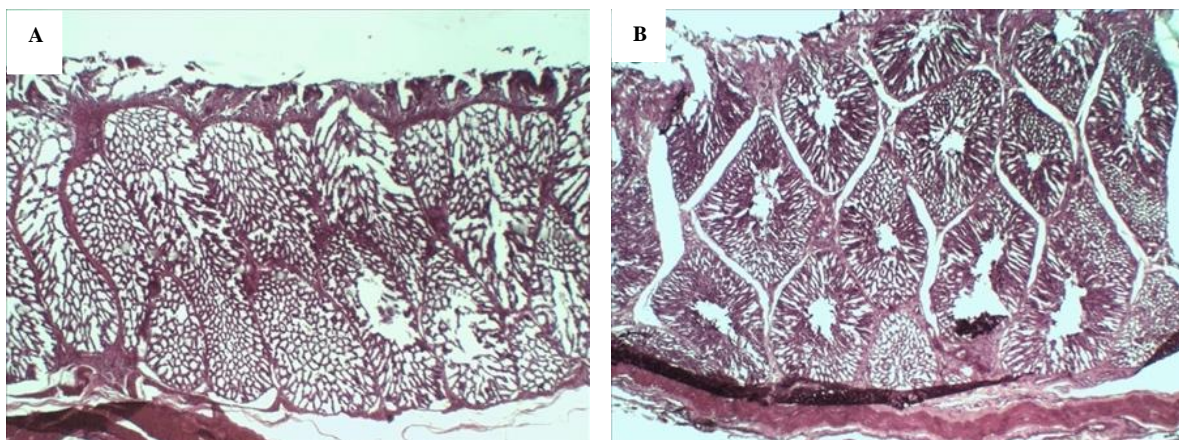


Figure 2 Thin section of (A) Changeable-hawk eagle proventriculus, and (B) Oriental honey buzzard proventriculus (40x)

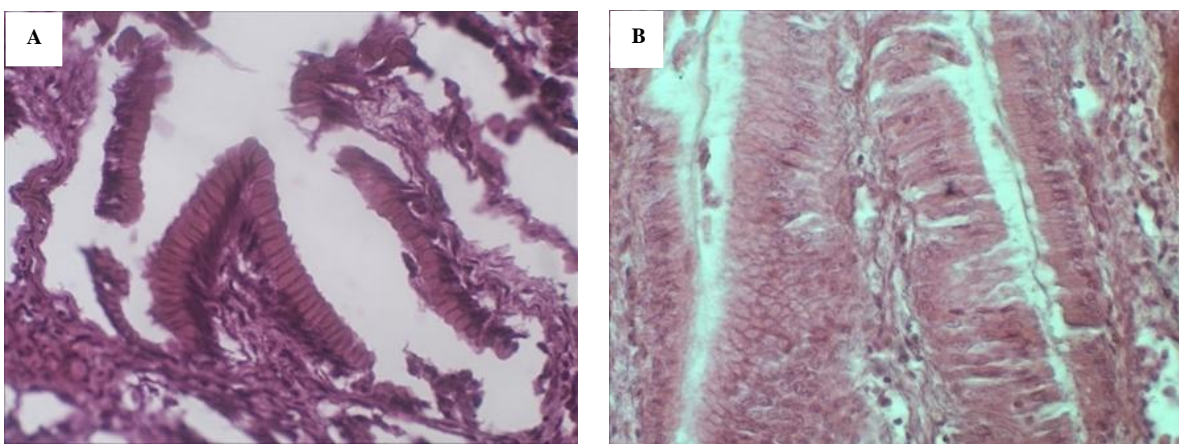


Figure 3 (A) Mucosa layer of Changeable-hawk eagle and (B) Mucosa layer of Domestic chicken (400x)



Figure 4 Duodenum of Domestic Chicken (40x)

the size of the submucosa gland is also varied in each species, and it was enormous in chickens whereas both in domestic chicken and changeable hawk-eagle, the epithelium in the mucosa layer is simple columnar. We believe that the intestine is

a part of the duodenum. We find the Brunner's gland in domestic chicken and southern cassowary is denser. On the other hand, the tunica muscularis in southern cassowary is thicker than in domestic chicken (Figure 4 - 6).

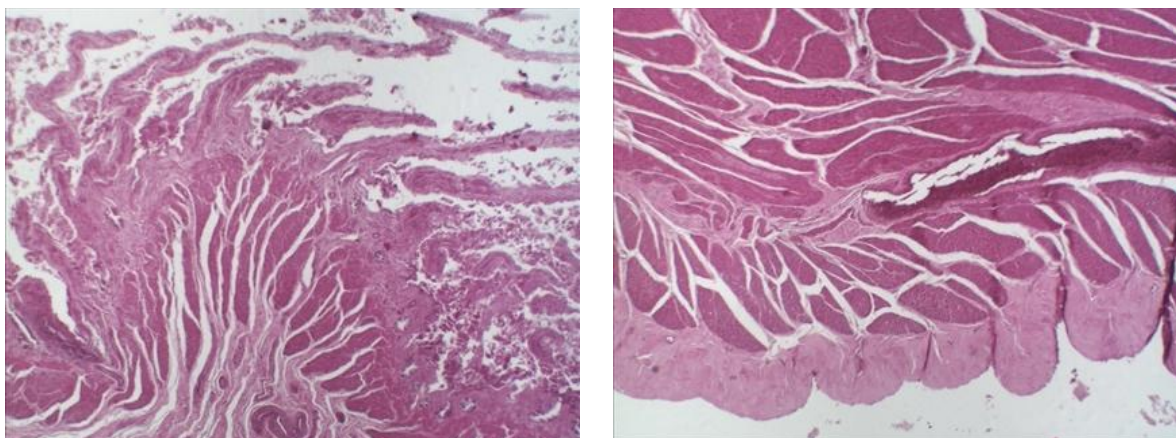


Figure 5 Duodenum of southern cassowary (40x)

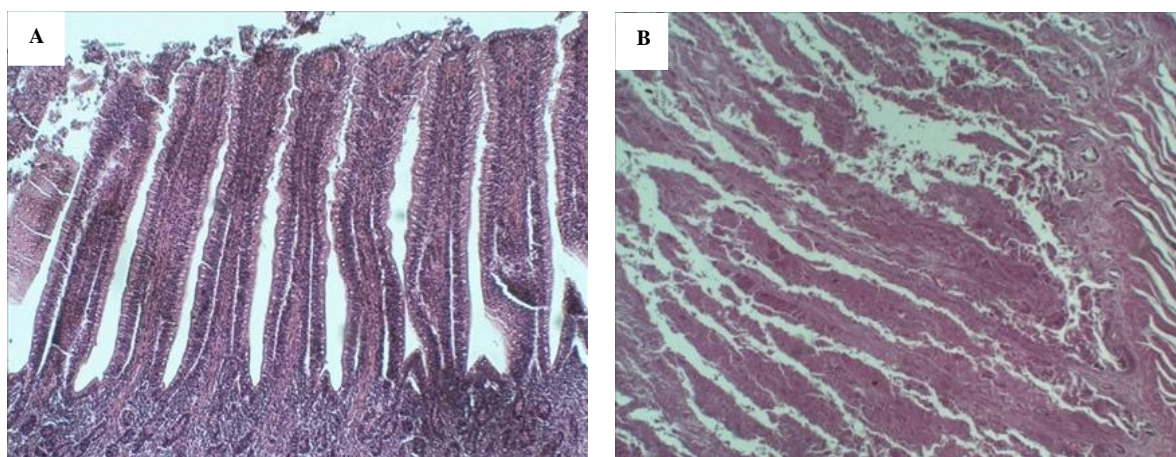


Figure 6 Duodenum Villi and Brunner's Gland of (A) Domestic Chicken and (B) Southern cassowary (100x)

4 Discussion and conclusions

Microscopic examination of proventriculus histology revealed that the chicken proventriculus layer is structured by mucosa, submucosa, muscularis, and serosa (Taher et al. 2020). The proventriculus of the chicken shows a mucosa layer that consists of simple columnar epithelium on its surface. This observation was similar to the result observed by Nasrin et al. (2012), where the author reported that the surface of the mucosa layer contains simple columnar epithelium. In the current study, it was reported that the mucosa layer of the changeable hawk-eagle is also simple columnar but lower in height than the chicken. The wall of the glandular stomach consists of submucosa glands or proventricular glands (Deka et al. 2017), which form irregular shapes in chicken, oval-like in changeable hawk-eagle, and diamond-like in oriental honey buzzard where each tubule was separated by connective tissue. The size of the glandular sub-mucosa, called adenomere, is varied, where chicken has the most significant size than others. These shape adenomere variation findings may lead to the different functions of the stomach between diet habits of birds.

The duodenum, where food molecules are absorbed (Alshamary et al. 2018), is constructed by four tissue layers i.e. tunica mucosa, tunica submucosa, tunica muscularis, and tunica serosa (Igwebuike and Eze 2010). In this study, domestic chicken villi form finger-like projections, whereas in southern cassowary these are more dynamic and longer. The Brunner's gland was denser in domestic chicken, and it can be easily recognized in the tunica submucosa. While in the southern cassowary, the Brunner's gland is slightly challenging to find. However, the tunica muscularis of the duodenum in the southern cassowary looks so thick, which consists of more muscular tissue than in the domestic chicken. Based on the results of this study, it can be concluded that there were apparent differences in some histological visually descriptive between species with different diets.

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