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Anatomical structure of the stomach of the common pheasant (*Phasianus colchicus*)

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Abstract

In this article, an analysis of the normal anatomy of the stomach of the common pheasant (*Phasianus colchicus*) is presented. The material covered 20 female common pheasants from poultry breeding. A necropsy of the deceased animals was performed, and then the stomachs were removed, analyzed, and measured for length, width, thickness of the walls, and characteristic anatomical features. The measurements were made using a caliper. The presented results include the stomach and proventriculus, focusing on their specificity, such as the strongly developed muscular membrane of the type II stomach, characteristic of granivorous birds, which reflects the diet of pheasants. In the discussion, the stomach structure of the pheasant was compared with other birds, emphasizing how diet influences the varied morphology of organs. These studies are preliminary and should be expanded to a larger group of animals, taking into account the aspect of sex. However, they constitute a basis for further development of the normal and comparative anatomy of the common pheasant.

Running title: Stomach of the common pheasant

Keywords: animal anatomy, bird, stomach, common pheasant

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Introduction

The anatomy of birds has long represented a distinct branch of anatomy due to significant differences in body morphology. The primary reason for this is the fact that birds belong to a separate class, similar to fish [1,2]. The main cause of this specificity lies in the systematic classification of birds within the taxonomy of their class. It is worth noting that for the scientific community, a key point is that birds, as vertebrates, represent a group comprising over 10,000 diverse species [3], which vary significantly in body size – from very small to very large forms (**Tab. 1**). Additionally, a crucial aspect is the dietary diversity of birds, which includes herbivorous, carnivorous, and omnivorous species [4]. It is important to highlight that birds are the only group to have mastered survival methods in contrasting environments such as air, water, and land. This diversity influences the unique anatomy of different bird groups.

In general, the structure of birds' stomachs is similar across species. However, differences arise depending on the bird's lifestyle, size, and environmental changes. After passing through the esophagus, the proper digestion process begins. The food enters the glandular stomach, known as the proventriculus. The proventriculus has a fusiform, rounded rhomboidal shape. It is constricted on both sides, neighboring the esophagus on one side and the muscular stomach, known as the gizzard *(ventriculus)*, on the other, connected by the gastric isthmus *(isthmus gastris)*. In some birds, the proventriculus also contains a proventricular diverticulum *(diverticulum proventriculare)*. Authors differentiate bird stomachs into Type I, found in carnivorous birds with a poorly developed muscular layer *(lamina muscularis)*, and Type II, with a well-developed muscular layer. The glandular stomach's function is to secrete mucus, pepsin, and hydrochloric acid. Food does not remain in the proventriculus for long and passes directly into the muscular stomach, where the proper chemical and physical processes take place. The gizzard is characterized by extensive musculature compared to the stomachs of mammals. Its structure is firm, and the organ has lateral flattening, giving it the appearance of a disk. The stomach has a body *(corpus)*, and at its center is a shiny, very strongly attached central tendon *(centrum tendineum)*, which serves as the attachment point for the stomach muscles. Additionally, we can classify the cranial sac *(saccus cranialis)* and caudal sac *(saccus caudalis)*, which are separated by cranial and caudal grooves *(sulcus cranialis et caudalis)*. The muscles surrounding the stomach form a functional framework, allowing for very strong contractions that replace chewing, compensating for the lack of teeth. The muscles are: the thick cranio-ventral muscle *(m. crassus cranioventralis)*, the thick caudo-dorsal muscle *(m. crassus caudodorsalis)*, the thin cranio-dorsal muscle *(m. tenuis craniodorsalis)*, and the thin caudo-ventral muscle *(m. tenuis*

TABLE 1 Body length and wingspan of selected bird species

SPECIES	BODY LENGTH (CM)	WINGSPAN (CM)	SOURCE
Barn Swallow (*Hirundo rustica*)	17-21	32-34.5	Roth [5]
Common Starling (*Sturnus vulgaris*)	19-22	31-44	Maybury et al. [6]
Helmeted Guineafowl (*Numida meleagris*)	40-71	60-90	Yakubu et al. [7]
Domestic Chicken (*Gallus gallus domesticus*)	30-40	70-90	Endo et al. [8]
Tawny Owl (*Strix aluco*)	37-43	81-96	Solonen [9]
Domestic Duck (*Anas platyrhynchos domesticus*)	50-65	80-95	El-Ghazali et al. [10]
Common Pheasant (*Phasianus colchicus*)	50-75	56-85	Wilcove [11]
Peregrine Falcon *(Falco peregrinus*)	34-58	80-120	Ydenberg et al. [12]
Wild Turkey (*Meleagris gallopavo*)	70-125	125-144	Maruyama et al. [13]

caudoventralis). The inner surface of the stomach is lined with a folded mucous membrane *(plicae et sulci ventriculares)* covered by a simple cuboidal epithelium *(epithelium simplex cuboideum)*. The secretion produced by the tubular glands *(glandulares pyloricae)* has a distinctive property — it hardens, forming a cuticular layer *(cuticula gastrica)* about 1 mm thick that covers the stomach's mucous membrane. This layer helps the stomach grind food, replacing the chewing process. The food then passes into the pyloric canal *(canalis pyloricus)*, which resembles a slit, and subsequently through the pyloric opening *(ostium pyloricum)* into the duodenum. Authors also describe the presence, in some bird species, of a pyloric torus *(torus pyloricus)* and a pyloric bulb *(bulbus pyloricus)*. It is important to emphasize that the presence or variation of anatomical structures may differ depending on the taxonomic classification of birds [1,14-16].

The common pheasant is a medium-sized bird species belonging to the Phasianidae family [17]. Its body mass can range from 0.5 to 3 kg, with an average weight of 1.2 kg in males and 0.9 kg in females. The wingspan ranges from 56 to 86 cm [18].

Pheasants are omnivorous birds. They consume seeds, berries, small fruits, roots, green plant parts, small invertebrates such as snails, and small vertebrates. They often pick up gravel from roadways, where the particles serve as gizzards [19,20]. Currently, in Poland, the pheasant is not considered a threatened species. It is primarily known as a wild-game animal.

Pheasant meat is considered a luxury meat. It is highly nutritious due to its high protein content and relatively low fat levels. Compared to the meat of broiler chickens, ducks, or geese, pheasant meat contains significantly more monounsaturated fatty acids. It has also been found to have high levels of vitamins B6, B12, and niacin, as well as elevated levels of selenium and phosphorus [21].

Interest in pheasant meat is likely to increase with the growing affluence of society and higher food preferences among people. Therefore, understanding the anatomy of this species' stomach is essential for the advancement of agricultural and veterinary sciences.

The aim of this study is to present the normal anatomy of the common pheasant's stomach and to compare this organ with the stomachs of other animal species.

Materials and methods

The study was conducted on 20 female common pheasants of varying ages. The research material consisted of carcasses obtained from a specialized ornamental poultry breeding facility. The material was acquired post-mortem, thus ethical committee approval was not required. Part of the material was immediately frozen and stored until later dissection, while the remaining carcasses were preserved in a 10% aqueous formaldehyde solution.

All carcasses were in very good condition, allowing for detailed examination and analysis. Each specimen had its abdominal walls incised. The stomach was then removed after cutting the esophagus and pylorus just before the duodenum. The stomachs were sliced open, cleaned, and irrigated with tap water, and then dried with paper towels. After preparation, measurements were taken in several different ways.

Measurements were made using calipers with an accuracy of 0.01 mm. First, the diameter of the esophageal opening and the number of folds in that area were measured. Then, the length, width, and thickness of the proventriculus wall were measured. The number of proventricular papillae and the number of folds in the proventricular isthmus were counted. The diameter and width of the gastric isthmus were measured. Measurements were then taken on the stomach, including its length, width, and height. The muscles considered were: the cranial-ventral thick muscle, the caudal-dorsal thick muscle, the cranial-dorsal thin muscle, and the caudal-ventral thin muscle. Their width and height were measured. The volume of the stomach was determined using a syringe with an accuracy of 1 ml and tap water. The number of gastric folds and the number of gastric rugae of the stomach were counted, and the length of the stomach lumen was measured. The pyloric channel and its opening diameter were measured. Finally, after removing connective and adipose tissue, the proventriculus and stomach were weighed on a laboratory scale with an accuracy of 0.01 g.

The stomachs were also classified according to type I – with poorly developed muscularis layer and type II – with a well-developed muscularis layer (Kobryń and Kobryńczuk 2004). The material was evaluated for anatomical structures and morphological changes. Photographs were taken with an iPhone 13 mini (Apple, Cupertino, CA, USA) and then processed using Preview Version 11.0 editing software (1056.2.4), Copyright© 2002–2023 Apple Inc. (Apple, Cupertino, CA, USA).

Results

The stomach of the pheasant is anatomically complex. It consists of the proventriculus and the stomach, which form a single integrated structure by connecting at the gastric isthmus (**Fig. 1**).

The esophagus, as it approaches the proventriculus, gradually narrows. The average diameter of this connection was 3.73 mm. Additionally, longitudinal, short folds can be observed in this area, with their number ranging from 4 to 6. The majority of examined specimens had 5 folds (41%), while the fewest had 4 folds (33%). The proventriculus itself has a rounded, spindle-shaped structure with an average length of 28.54 mm and a width of 13.01

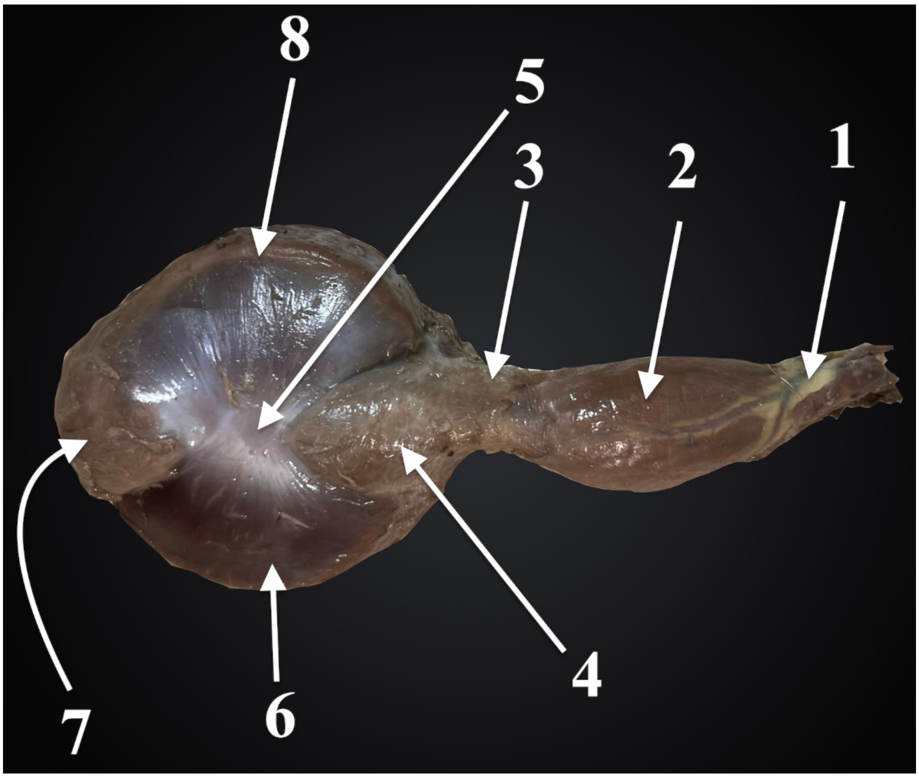

FIGURE 1 Pheasant stomach – left side *(facies sinistra).* 1 – esophageal opening. 2 – proventriculus. 3 – gastric isthmus. 4 – cranial sac. 5 – tendinous center. 6 – caudal-dorsal thick muscle. 7 – caudal sac. 8 – cranial-ventral thick muscle

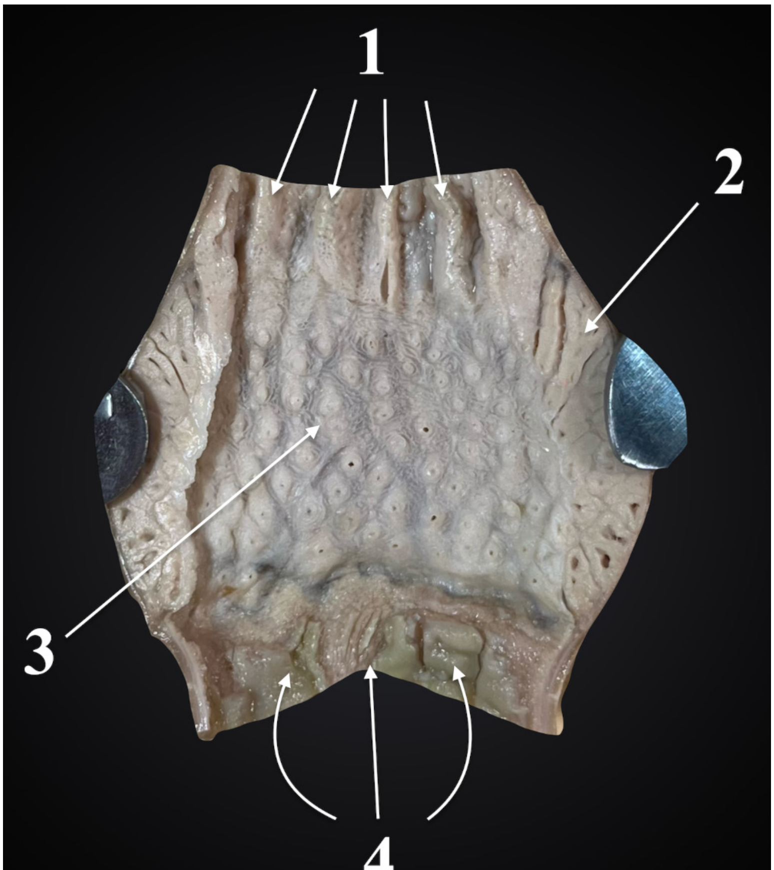

FIGURE 2 Longitudinal section of the pheasant proventriculus. 1 – folds of the esophageal opening. 2 – proventriculus wall with visible strong muscular layer. 3 – proventricular papillae. 4 – beginning of the gastric isthmus with folds

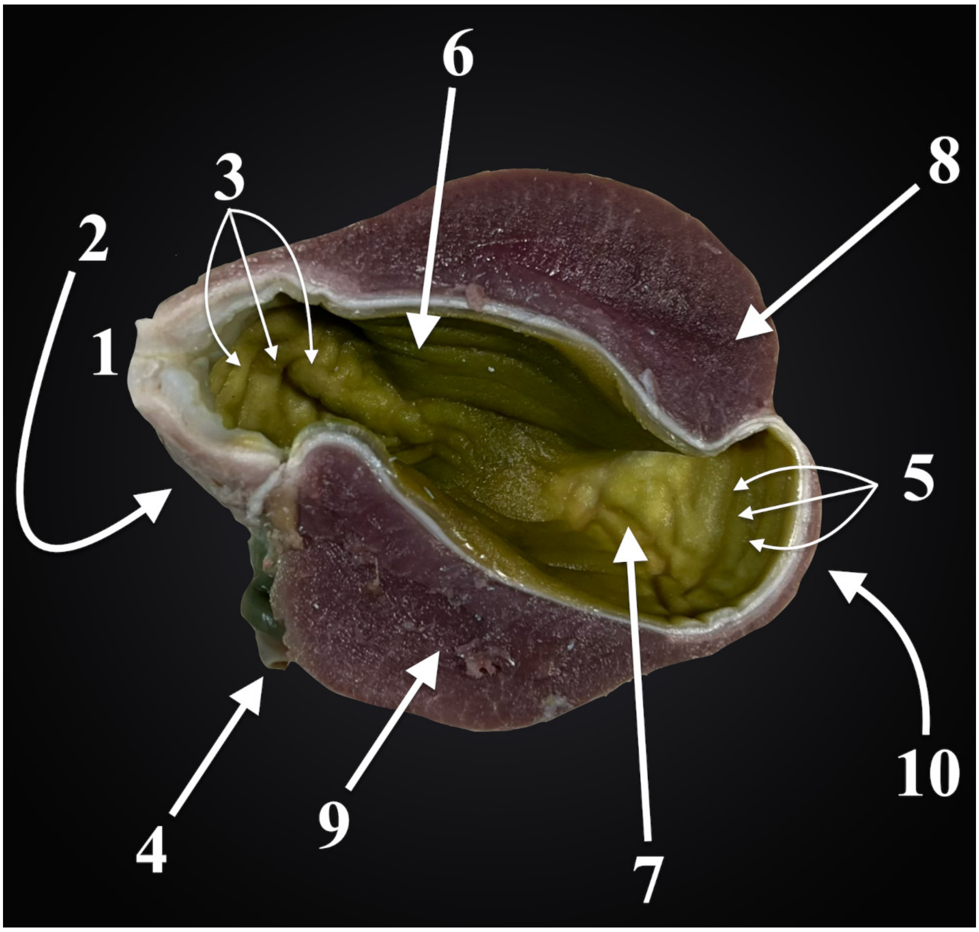

FIGURE 3 Longitudinal section of the pheasant's stomach (gizzard). 1 – end of the gastric isthmus. 2 – cranial-dorsal thin muscle. 3 – cranial sac. 4 – beginning of the duodenum. 5 – caudal sac. 6 – cavity of the stomach. 7 – lumen of the stomach and gastric folds. 8 – caudal-dorsal thick muscle. 9 – cranial-ventral thick muscle. 10 – caudal-ventral thin muscle

mm. The average wall thickness was 2.71 mm. In longitudinal section, the proventriculus displays the aforementioned folds and numerous proventricular papillae (**Fig. 2**). Their number ranged from 28 to 62, with an average of 43. Food then moves to the isthmus, which has an average width of 7.45 mm and a diameter of 4.94 mm. This visible narrowing of the proventriculus before transitioning into the stomach can be seen with the naked eye. The lumen of the isthmus also shows folds, although they are significantly less pronounced than in the upper part of the proventriculus. The number of these folds, ranging from 0 to 8, indicates a wide range of variability, though the average was 5.44. Due to its well-developed muscularis, the pheasant's proventriculus was classified as type II.

Immediately after the isthmus, the stomach, known as the gizzard, begins. It is a relatively flat, disk-like structure that is smooth and firm to the touch. Dissection studies revealed the presence of two sacs – the cranial sac and the caudal sac. Additionally, at the center of both the left and right sides of the stomach, there is a tendinous center that serves as an attachment point for the stomach muscles. The average measurements of the pheasant gizzard in the study were 47.35 mm in length, 40.19 mm in width, and 25.02 mm in height. Notably, in only one of the examined carcasses did the width of the stomach exceed its length. The stomach muscles encircle the gizzard from almost all sides, all originating and ending at the opposing tendinous centers. The caudal-dorsal thick muscle spans the width of the cranial sac and the beginning of the caudal sac, with average dimensions of 39.02 mm in width and 13.61 mm in height. Similarly, the cranial-ventral thick muscle covers a comparable area on the opposite side, with a width of 33.36 mm and a height of 13.59 mm. Additionally, the sacs are surrounded by two other muscles: the cranial-dorsal thin muscle and the caudal-ventral thin muscle (**Fig. 3**).

The width of the first muscle (cranial-ventral thick muscle) averaged 18.59 mm, with a height of only 1.78 mm. Measurements for the second muscle (caudal-dorsal thick muscle) were as follows: width 21.47 mm and height 1.56 mm. The ratio of the height of the cranial-ventral thick muscle to the caudal-dorsal thick muscle was 1:0.9985, and the width ratio was 1:0.8549. For the cranial-dorsal thin muscle and the caudal-ventral thin muscle, the height ratio was 1:0.878 and the width ratio was 1:1.154.

The interior of the stomach is characterized by strong folding. In its lumen, both circular folds running along the stomach and transverse folds can be observed. Longitudinal folds were identified in all analyzed stomachs, with their number ranging from 20 to 41, averaging 29. Transverse folds were not always present, but in most cases, they were found in numbers ranging from 5 to 8. The lumen of the pheasant's stomach had an average length of 41.97 mm, and its volume was approximately 12 ml. On the right side of the cranial sac of the stomach is the pyloric opening, which begins with a truncated channel resembling a fissure. The average length of this structure is 9.46 mm, and it ends with a pyloric opening with a diameter of 5.56 mm.

The average mass of the proventriculus was 3.15 g, while the stomach had an average mass of 16.99 g. This means that the proventriculus constitutes 18.54% of the total weight of the pheasant's stomach.

Discussion

The research presented in this study concerns the anatomical structure of the common pheasant's stomach. While anatomical descriptions of this species can be found in the literature, they are usually presented in a general manner. Additionally, other studies, primarily focused on histology, also provide information about pheasant anatomy [22,23]. There is also a publication that details the vascularization of the pheasant's digestive system, which provides a significant complement to the knowledge of the anatomical structure of this species [24].

This study focuses exclusively on the detailed anatomical description of the common pheasant's stomach. Until now, no studies of this kind, including measurements related to the anatomy of this bird, have been available. The research revealed all the anatomical structures typical of herbivorous birds, known as granivores, as described by Kobryń and Kobryńczuk [15]. The pheasant's stomach was classified as type II, with a well-developed muscular layer, confirming that the pheasant's diet is primarily plant-based [25].

The domestic goose *(Anser domesticus)*, Japanese quail *(Coturnix japonica)*, guinea fowl *(Numida meleagris)*, and pigeons (Columbidae) have a stomach structure similar to that of the pheasant. Their stomach consists of a proventriculus and a gizzard, with a gastric isthmus also present. In these species, the proventriculus takes on a spindle shape, located on the left side of the midline and dorsally to the left liver lobe [26-31]. Most authors, when analyzing the proventriculus in granivores, use terms such as spindle-shaped, small organ, elliptical enlargement, and tubular structure [32]. Studies on companion and exotic birds show similar conclusions to those for domesticated birds. Species like the blue-and-yellow macaw *(Ara ararauna)* and the domestic canary *(Serinus canaria forma domestica)* exhibit the same anatomical structures without significant differences [33-35].

The gizzard has a rounded, laterally flattened shape, consistent with descriptions from other authors on the anatomy of domestic birds. It consists of a body and sacs, and is surrounded by strong muscles that enable the mechanical processing of food. The gastric mucosa is covered with a greenish-brown cuticle, as described by other authors in species such as pigeons and guinea fowl [31,36].

In their research on the diet of the golden pheasant *(Chrysolophus pictus)*, primarily found in China [37], the research group led by Baohua et al. [38] conducted comprehensive measurements of the stomach. The average length of the proventriculus was 74.5 mm, while the stomach measured 60 mm in length, with a width of 49.2 mm. It is worth noting that the study included both male and female specimens (52 males and 10 females). According to Lei and Lu [37], the proventriculus accounted for 10.58% of the total stomach mass in the golden pheasant, compared to 18.54% in the common pheasant.

Conclusions

It has been demonstrated that the digestive system of the pheasant includes the proventriculus, the gastric isthmus, and the ventriculus (gizzard). The proventriculus in the pheasant is classified as Type II, typical for herbivorous birds. No proventricular diverticulum was observed. Two pouches were identified in the ventriculus: the cranial and caudal pouches. All four muscles typically found in the bird's gizzard were confirmed. The presence of a pyloric bulb was not detected. Muscle analysis revealed that the thick dorsal-caudal muscle is larger than the ventral-cranial muscle, while the thin cranial-dorsal muscle has greater height but less width than the thin caudal-ventral muscle. In most cases, the length of the ventriculus exceeded its width, adopting a shape similar to that described in domestic poultry. This study is a preliminary investigation, and its findings should be verified through research conducted on a larger sample of animals, including male specimens. Nevertheless, it lays the foundation for further development in the study of normal and comparative animal anatomy.

Ethical approval
The conducted research is not related to either human or animal use.

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Conflict of interest statement
The authors declare no conflict of interest.

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